

The impact of a mixed income model on the South African CSIR: A recipe for success or disaster?

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THE INCREASING SHIFT TOWARDS EXTERNAL contract research income (in contrast to grant income) as the primary means of funding public research institutions and universities has extracted a high toll on these institutions and on their stakeholders. Although this policy has the benefits of increasing the relevance of public research institutions to broader research and development (R&D) objectives, and of improving the competitiveness of the public R&D sector, data from the financial performance of the South African CSIR over a long period indicates that it has had the simultaneous but adverse effects of reducing research capacity, decreasing the social return from public funds and increasing the cost of research to the public sector. The continuing use of external research income as a key performance measure is highly problematic and will further undermine the science and technology quality of our research institutions. Although a return to exclusive grant funding is also not the answer, the use of a mixed income model requires the simultaneous adoption of a set of research management practices to prevent the recurrence of the problems faced by the CSIR over the last four years.

Introduction

Performance management of public research institutions (PRIs), such as South Africa's Council for Scientific and Industrial Research (CSIR), is not an exact science; despite sustained discussion and debate, and several excellent reviews and guides to the field,¹⁻⁴ the most effective means of ensuring the delivery of an efficient social return from public funds invested in such organizations is not universally agreed.

It is with some interest that we note a recent editorial in *Nature*.⁵ Referring to the 2006 budget speech by the U.K.'s chancellor of the exchequer, Gordon Brown, the editorial comments:

One metric highlighted in the budget statement, external research income, seems a reasonable basis for departmental funding, as this income correlates very well with the peer review that was done in the assessment exercise....

And later in the same editorial:

One way forward for the UK government would be to let reliable metrics, such as total external research income, replace

much of the Research Assessment Exercise process....

Is this indeed the answer? Is external research income a reasonable or unreasonable basis for departmental (government) funding? The historical financial statistics for the CSIR over the period from 1955 to 2005 provide an interesting case study for the management of PRIs within a mixed income policy framework. In this article, the data are used to question the proposals made by the *Nature* editorial, and provide some rather different interpretations of the impact of mixed income environments on PRIs. We conclude with a set of recommendations for research management within PRIs. Although the experience of the CSIR is specific to a single science council operating within the South African National System of Innovation, we consider that these recommendations are more generally applicable and address a research management issue which is both important and highly topical.

Evaluation approaches

Given the uncertain nature of research, it is extremely difficult to set meaningful, quantitative and unambiguous performance measures for grant-funded institutions. Various approaches have been used including *ex post* and *ex ante* evaluation methods; the encouragement of mixed income models (income from both grant and contract sources); an increased allocation to competitive and directed funding streams (as opposed to performance-based block funding); and qualitative performance targets using the balanced-scorecard framework.

In South Africa, a balanced-scorecard approach was introduced in 2001 and has been used with relatively little change over the last five years.⁶ The scorecard includes the five main key performance indicators (KPIs) of 'stakeholders and customers', 'finance and investment', 'organizational', 'learning and growth', and 'organizational demographics'. Each KPI is further split into a number of sub-categories, which are in turn assigned quantifiable measures. All PRIs under the management of this system (most of the principal science councils

and agencies in South Africa) are required to complete an annual summary of performance against the pre-determined targets, for assessment by the Department of Science and Technology and the relevant line department. This assessment is in turn linked to the forthcoming budget cycle; in other words, the annual grant funding is adjusted according to performance as measured through the KPI framework.

Given the relative size of the budgets for the South African PRIs within the national context and the evolving literature relating to performance management of the higher educational sector,⁷ it is surprising that this sector of the R&D community has not been the subject of more extensive public debate and review. Indeed, relatively little has been published on the CSIR or other science councils in this regard, with the most recent articles, at least to our knowledge, on the role of such bodies and their impact on social and economic development last appearing in 1995⁸ and 1993.⁹

This situation is now changing, however; there is a growing body of research managers who are concerned about, and interested in, best practice management techniques for the national system of innovation. In particular there is an increasing use of evaluation techniques within the higher educational institutions and an increasing emphasis placed by such institutions on external contract income. As a result, it is urgent and important to open the debate on the impact of mixed income policy models on our institutions at this stage in the evolution of our system.

Motivation for a mixed income model

Across the world, PRIs operate under a range of income models, from being wholly funded by government grant to almost entirely funded by contract research or project. For instance, in a limited study undertaken by the CSIR in 2002, the ratio of grant to contract income was found to range from 72% (Institute for Research in Construction, National Research Council of Canada) to 25% (TNO Nutrition and Food Research Institute, the Netherlands). The trend in the 1980s was most certainly towards increased contract and reduced institutional or grant funding,⁴ with the motivation for this change in the management of the PRIs being as follows:

- Grant funding was not considered sufficiently competitive; by introducing a higher proportion of income from competitive funding streams, it was argued that the overall quality, efficiency and output from PRIs would be increased. Evaluation processes for competitive

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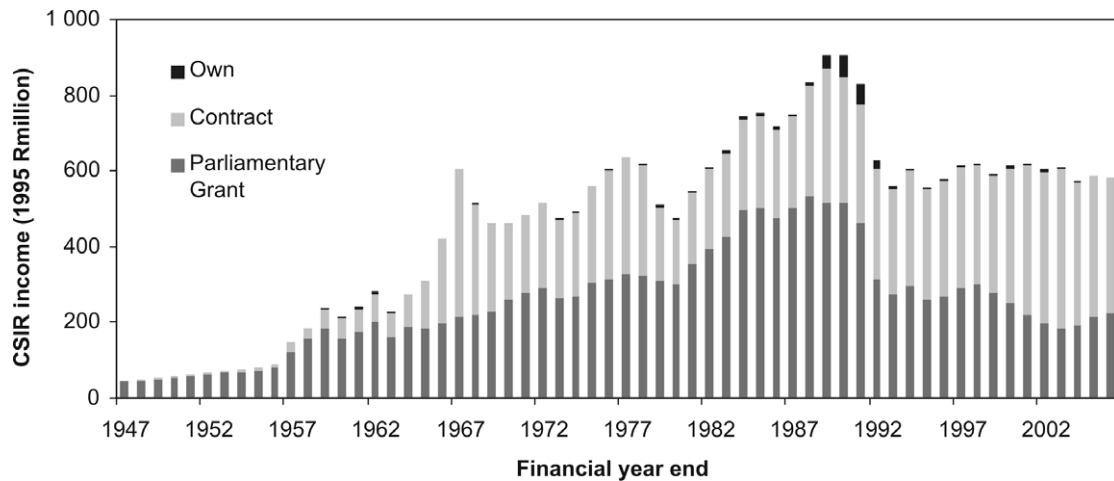


Fig. 1. CSIR income over the period 1947 to 2006, adjusted to constant 1995 rands, segregated according to the categories of 'grant', 'contract' and 'own' funds, and excluding disbursements to other PRIs.

funds are mostly based on peer review, which provides a powerful mechanism for ensuring higher research quality.

- Contract or project funding increases the relevance of PRIs; left to their own devices, the perception was that such institutions become separated from the needs of the real world. The direct result of forcing such organizations to compete in selling their skills and knowledge products would be to ensure that such skills, services and products were more relevant to the needs of the market and the stakeholders.
- Contract funding spreads the load of maintaining a country's R&D infrastructure and capacity. PRIs become less reliant on government funding and can afford to retain the same capacity at lower overall cost to the public sector.

Despite the massive implications that such policy decisions have had on PRIs in terms of their organizational strategies, structure and research content, the impact of the decisions in the South African context has drawn very little analysis, with one notable exception.⁹ In the latter article, the authors questioned the arguments in favour of the transformation of the CSIR to a market-orientated, technological research establishment. They further concluded that this transformation had failed to achieve its main objective, namely to build a support service for the private sector, but in the process had severely damaged 'scientific endeavour within the CSIR and in the country as a whole'.⁹

In our article, the reasons for the shift towards a mixed income model as described above are not challenged directly. Instead, changes in research capacity, financial turnover per employee and remuneration within the CSIR as a result of this framework are investigated, and a number of observations of importance to

public science and technology policy are made.

Historical financial and employee statistics for the CSIR

The CSIR has operated under a mixed income model since 1955, as shown in Figs 1 and 2. The information has been adjusted for inflation and is expressed in constant 1995 rands. Disbursements to other PRIs in the form of grants have been excluded and the total income is reflected as the sum of parliamentary grant (performance-based block funding), contract income and 'own' income, where the last refers to income from investments and royalties. Where possible, all effects due to the separation of various entities from the CSIR (such as the former Foundation for Research Development and the Medical Research Council) have also mostly been excluded.

Several interesting observations can be drawn from the data. First, it is noted that highest income in real terms was attained in the year 1990, and has since mostly declined. The precipitous decline in the early nineties was partly due to the high inflationary environment of this period

and the rapid decrease in grant income as a result of changes in resource prioritization at a national level.

Second, grant income has started to increase again in real terms, having reached a low of R185 million (adjusted to 1995 rands), last seen in 1959. In the last three years, grant income has increased annually by an average of 7% and is now 39% of the total CSIR income. Further comment on the impact of the relatively low levels of grant income versus total income is made in what follows.

Finally, income from 'own' sources has never been a significant component of turnover, despite considerable emphasis by the organization over the last fifteen years to increase its return on research expenditure from royalties and other forms of income from its intellectual property. This experience is not dissimilar to that of many PRIs which followed a strategy of attempting to obtain increased third stream funding from the registration and sale of intellectual property. Success with this strategy still belongs only to a rather small and perhaps elite set of global institutions.

In comparison with the financial data,

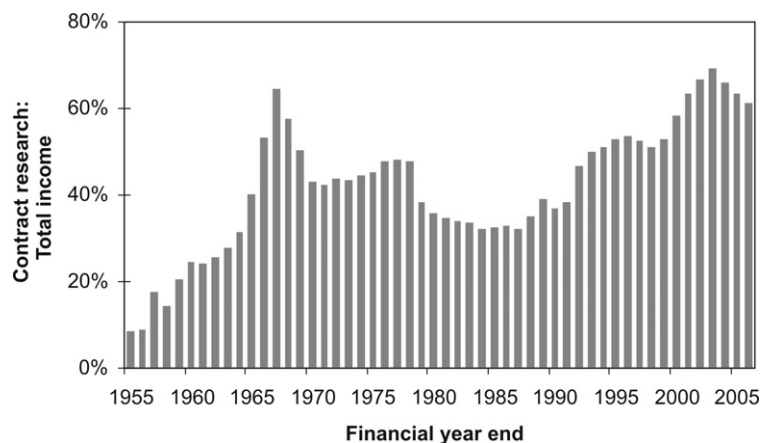


Fig. 2. Proportion of the CSIR's external contract to total income from 1955 to 2006. Contract income peaked as a proportion of total income in 1967 and again in 2003.

the pattern of employment within the CSIR over the same period shows a different trend (see Fig. 3). The total number of CSIR employees peaked at 5000 in 1984, but has declined subsequently to a total of 2179 in 2006. This decline has severe implications for policy analysts. An important objective for any government is to build and strengthen a country's science and technology (S&T) base. The radical decline of the CSIR's employee numbers, even in a period of increasing total income (1987 to 2006), is alarming and contrary to such an objective.

Further analysis reveals that employee numbers correlates well with grant income (see Fig. 4; the correlation coefficient $R^2 = 0.85$ over the period 1955 to 2006), but not with contract income ($R^2 = 0.22$). This result is indeed surprising. Contrary to a widely held assumption and to a key intended outcome of the mixed income model, encouraging or even forcing PRIs to earn contract income does not retain research capacity within an institution. Capacity in the CSIR was lost nonetheless, and in the same proportion as the decrease in grant income.

It could be argued that this loss of capacity was necessary to transform and modernize the CSIR. Strategic priorities do change and expertise in certain areas may no longer be required by the public sector. However, this has not generally been the experience of the CSIR; while in some cases the shedding of S&T capacity was entirely justifiable, in many cases the institution and sometimes the country lost key strategic S&T capacity, which may have been of little direct interest to the market, but was of high relevance to the role of the public sector within the research and innovation value chain (such as early stage applied research in aerospace and energy).

Employee 'productivity' and remuneration

Employee productivity is normally central to a performance management system within any organization. Within a public research institution, however, it is hard to both define and to measure. The input side is relatively straightforward; there are remuneration costs, infrastructure costs and running expenses. But the outputs are difficult to quantify in a meaningful way. Most PRIs are non-profit organizations; there are no shareholders, no equity capital and no mandate to generate a financial return on the investment. The CSIR, for instance, operates at an almost constant and only slightly positive margin (between 0 and 5%); its costs mostly match its revenue and it produces mostly knowledge-based products

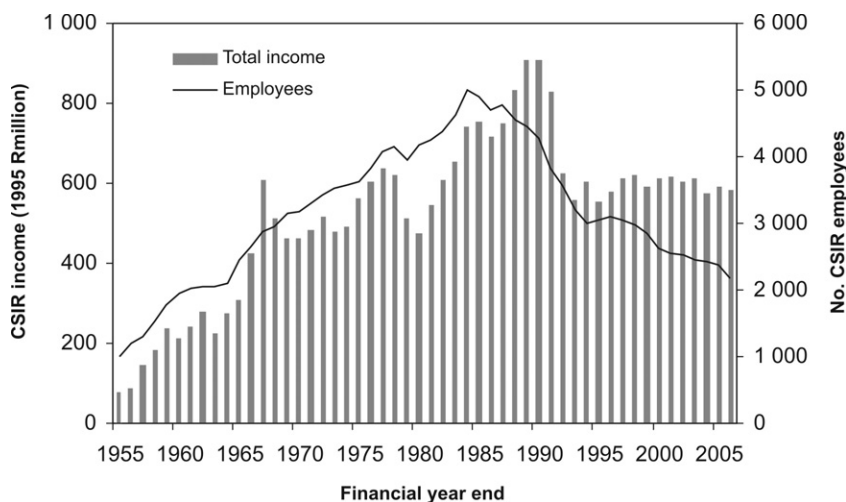


Fig. 3. CSIR employees and total income. Employee numbers have declined consistently from a maximum of 5000 in 1984.

(such as scientific articles, client reports, new designs and patents), whose economic value is extremely difficult to quantify, at least in the short term.

In this situation, employee productivity, as employed in the traditional sense by commercial enterprises, is a mostly meaningless concept. However, use is made of certain indicators in order to approximate the productivity equation including scientific publications per researcher and turnover per employee (defined as TPE). The latter is a function of two critical parameters as follows:

- Typically, employees of PRIs sell time to projects; the harder they work, the more time they can sell and hence the higher the TPE.
- In addition, more senior and experienced employees are able to charge at higher rates with the result that the more skilled the resource base of an organization, the higher the TPE.

We noted above that in the mixed income environment of the CSIR over the period 1955 to 2006, employee numbers correlated only with grant income. In a period of declining grant income, em-

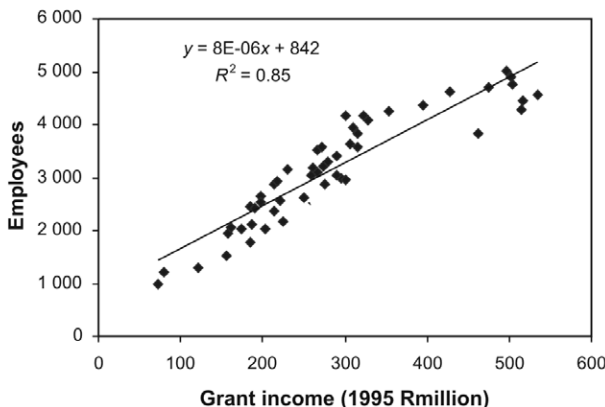
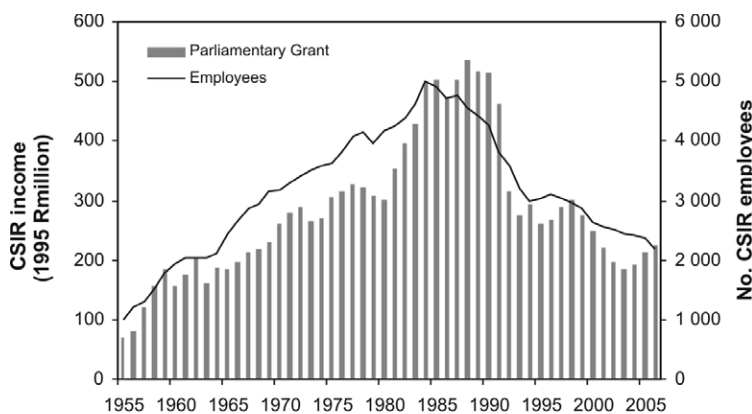


Fig. 4. CSIR employees and grant income. Employee numbers appear to correlate only with grant income; contract income does not retain research capacity.

ployee numbers decreased, although total turnover remained relatively unaffected in real terms (at least over the period 1976 to 2006) and, as a result, TPE must have risen. Surprisingly, this is true only in relation to contract research income. TPE is uncorrelated with either total income or grant income ($R^2 = 0.11$ and 0.06 , respectively), but TPE does correlate with contract research income, expressed in real terms ($R^2 = 0.85$; see Fig. 5).

It has already been noted that a mixed income policy reduces overall research capacity; the second consequence of the policy is to increase TPE. It could be argued that this is a positive consequence or even benefit of the mixed income model; putting the 'squeeze' on PRIs forces such organizations to 'cut out the dead wood'. Undoubtedly some of the increased TPE is due to the shutting down of non-productive units; however, a second component of the increase is due to the higher cost of more specialized and experienced engineers and technologists.

Within a more competitive environment, the institution is required to focus its expertise, to build and retain more specialized resources within niche areas. The culture of the institution, including its business model and employee profile, shifts from a public sector or public service culture to something more typical of a private sector contract research company. This change is particularly evident in the salary structure (see Fig. 6). Increased contract income may well drive higher TPE, but this is achieved only through higher average salaries associated with the needs of specialization, the loss of research independence and direct competition with higher-salaried private sector research organizations.

Although not explored in this article, the salary differential between public and private sector research organizations is well documented through annual salary surveys of research professionals in other countries (such as the United States). This differential varies across professions and regions, but is typically 15–25% for the same qualifications and levels of experience, with university staff being at the highest end of the differential. In South Africa, a recent but as yet unpublished salary survey lists the differential between private sector and academic salaries as being of the order of 30%. It is therefore not surprising that salaries within mixed income PRIs will rise in response to the policy change.

There is a third, and more alarming, explanation for the strong correlation between contract income and TPE, and the lack of any significant correlation

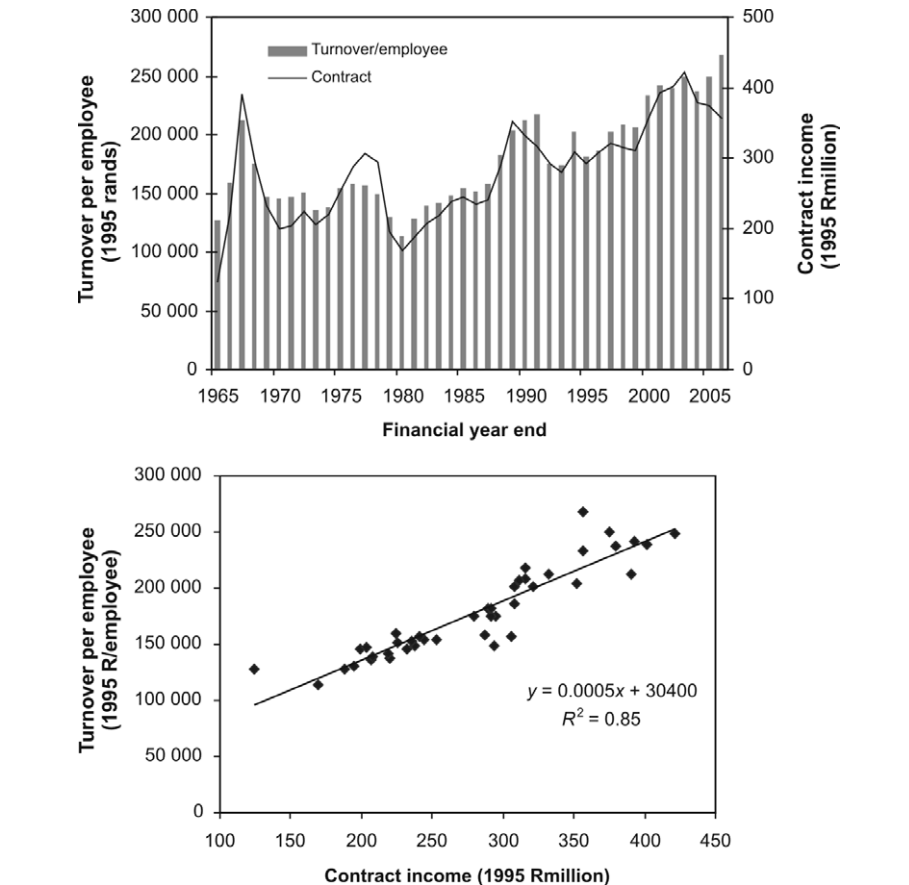


Fig. 5. Turnover per CSIR employee and contract income over the period 1965 to 2006. Turnover per employee rises linearly in response to increasing contract income.

between total income and TPE. Grant income is typically subject to *ex-post* evaluation and is more loosely managed relative to contract income. The latter is often managed at a project level where each project is subject to thorough *ex ante* evaluation (through the project proposal), interim evaluation against key deliverables and milestones, and detailed *ex post* evaluation (very often before any final payment is made). As a result, mixed income models almost by default imply the combination of a tightly controlled, highly competitive project management

environment with a more loosely controlled, almost vague, portfolio management system. In this situation, the delivery of grant-funded research projects against their specific goals can be jeopardized. The temptation to under-perform on these projects, in order to ensure that the contract research income is secure, is too great to ignore. In other words, grant income cross-subsidizes contract income.

Discussion

The promotion of a mixed income policy to the point where contract income

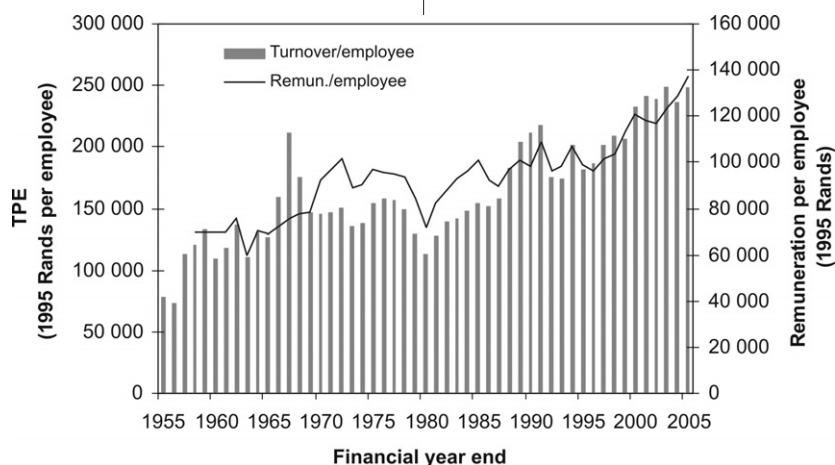


Fig. 6. Turnover per CSIR employee and remuneration. Higher turnover is closely linked with higher salaries.

is a significant component of total income appears to fundamentally change the nature of PRIs. An analysis of the historical financial and employee data for the CSIR since 1955 has highlighted several unintended and negative consequences for the organization and for the National System of Innovation, as follows.

- Employee numbers correlate strongly with grant income only and *not* contract income; higher grant income both in net terms and especially as a proportion of total income, appears to lead an expansion in research capacity (and *vice versa*). In other words, institutional growth happens only in a climate of increasing grant income.
- Within the context of static or even declining grant income, increasing contract research income raises turnover per employee, probably as a result of the closure of less productive units, a shift towards more highly paid staff and a cross-subsidization of contract work by grant income. The last at least partly explains the observation that turnover per employee is heavily dependent on contract income. In a situation where grant income is not subject to the same client evaluation, it is predictable that a level of cross-subsidization will take place.
- However, the increased turnover per employee does not increase the PRI's profitability or sustainability; instead it is driven by the rising remuneration costs (measured as a higher remuneration per employee). In simple terms, it appears that the nature of the institution approaches that of a private sector contract research organization, including the latter's salary scales.
- The higher salaries increase the cost to government of the procurement of its research needs and services; although the initial motivation for mixed income institutions may be well intentioned, the unexpected consequences are to drive upwards the unit cost of research labour, drive down the impact from public-funded R&D and reduce research capacity, especially in areas of high strategic importance but low market relevance.

The above adverse consequences, which have arisen from the CSIR's mixed income environment, supported by a strong management strategy in the 1990s to transform the CSIR into a 'market-oriented technological research establishment',⁹ are drawn from the historical data and do not include other consequences which have been highlighted through separate processes. For instance, the CSIR Institutional Review of 2003 noted that:¹⁰

While the CSIR and its different Business Units have shown considerable and laudable initiatives that have led to progress in regard to increasing external revenue, the Panel was of the view that external revenue has sometimes been pursued as an end in itself. This has entailed activities that have been de-linked from the CSIR's science base and indeed, at times, activities have been undertaken at the expense of the science and technology base.

Thus, the major finding of the panel is that the science and technology base is currently not strong and that, in some significant areas, the science and technology base has been considerably weakened since the previous review in 1997.

Following this review, the CSIR implemented a widespread organizational transformation, aimed at strengthening the science and technology base, and improving the research output of the organization. Changes have been made to the process through which the parliamentary grant is allocated, to the performance management framework of the CSIR's units, to its culture and even its brand. The organization's objectives now include stretching targets for publications, for human capital development and for a more balanced research and innovation portfolio, covering strategic basic research, applied research and experimental development, in addition to the existing activities in technology transfer and knowledge application. Without intending to highlight any single change initiative as more important than its companions, the following key principles have emerged from the transformation process, and serve as an important reminder to the management of any public research institution:

- An exaggerated focus on external income will put pressure on a research organization to move away from its mandate; as is well known, 'he who pays the piper calls the tune'. After fourteen years of pushing for external income growth, the CSIR was deeply involved in activities which were a long way outside its mandate.
- External income will rarely, if ever, pay for a re-investment in the science and technology base of a PRI; if public funds are limited, over time, this base will be undermined and could disappear entirely. It is therefore important that grant funds are specifically ring-fenced (dedicated) for maintenance of the science and technology base. In the CSIR, the research portfolio is now actively managed to ensure the appropriate balance between research (strategic basic and applied), experimental

development, and technology transfer/commercialization.

- The key imperative for a PRI operating under mixed income is to manage the nature of its external contracts, which must be research contracts, and not contracts covering consulting or the procurement of knowledge-based services.
- Grant funding must be as tightly managed as external research income; in order to avoid the dissipation of these funds, and at worst the cross-subsidization of external contracts, grant-funded projects must have a clear set of science and technology outputs which are regularly monitored and evaluated. Many of the problems described above arise from the simultaneous existence of tightly controlled external contracts and more loosely managed grant income.

Conclusion

Evaluation is clearly a powerful tool for determining new policy, for guiding resource allocation decisions and for meeting requirements in respect of public accountability for the expenditure of public funds. However, the evaluation approach must be consistent, well structured and valid. The replacement of such complex undertakings as the Research Assessment Exercise of the United Kingdom by the simple parameter of total external research income, is fraught with problems; judging from the CSIR's experience, such an approach will undermine, and not improve, the scientific and technological quality of PRIs.

1. Ruegg R and Feller I. (2003). A toolkit for evaluating public R&D investment. National Institute of Standards and Technology, Gaithersburg, MD, NIST publication NIST GCR 03-857.
2. Jordan G.B., Streit L.D. and Binkley J.S. (2003). Assessing and improving the effectiveness of national research laboratories. *IEEE Trans. Engng Manage.* 50, 228-235.
3. Lyall C., Bruce A., Firn J., Firn M. and Tait J. (2004). Assessing end-use relevance of public sector research organisations. *Research Policy* 33, 73-87.
4. OECD (2003). *Governance of public research: Toward better practices*. OECD Publications Service, Paris.
5. Editorial. *Nature* 440, 581; 2006.
6. Gering M., Masemola P. and Kahn M. (2003). *Reviewing the SETI scorecards*. Department of Science and Technology, Pretoria.
7. Bunting I. and Cloete N. (2004). Developing performance indicators for higher education: a South African case study. Centre for Higher Education Transformation, Cape Town. Online: <http://www.chet.org.za/pubs/>
8. Clark J.B. and de Wet G. (1995). New frontiers for science and technology in South Africa: a platform for change. *S. Afr. J. Sci.* 91, 113-121.
9. Lutjeharms J.R.E. and Thomson J.A. (1993). Commercializing the CSIR and the death of science. *S. Afr. J. Sci.* 89, 8-14.
10. CSIR Review (2003). *A summary of the main findings and the main thrust of the CSIR review report*. CSIR, Pretoria.

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