A 'rule of 3' to revive Greek science, research and innovation

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If research and technology are to become the driving force for turning Greece into a productive society, evidence-based governance, strategic restructuring of infrastructure and a substantial inflow of fresh human capital is urgently needed.

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In 1998, Antonio Tabbuchi, in his *Plato's gastritis* essay[1], stated upfront opposition to Umberto Eco's thesis that at times of acute crises, intellectuals are useless to society[2]. Eco claimed that the only meaningful thing an intellectual can do when his house is burning is to call the fire brigade[2]. Tabbuchi posited that intellectuals should do better than that, be less passive and use more of their investigative skills to create even more turbulence and thus contribute to the exposure and resolution of the problem. Greece's house is now definitely burning, and intellectual forces in sciences (ourselves included), who have indeed remained passive or, at best, have for years monotonously 'called for the fire brigade', should actively transform this crisis into radical and reforming judgments and decisions—which, by the way, reflects the true meaning of the Greek word 'crisis' (κρισις, or *krísis*).

The causes of the recent economic and social crisis in Greece can no longer be misinterpreted. Greek policies for economic growth and social justice have been ill for decades. Despite the large amounts of European structural funds put into the Greek economy, opportunities for building a modern European state were ungrudgingly expended by short-term, short-sighted politicians, with very little return for the country and its people; instead, these funds were made useful only to aid the tumorous growth of corporatism, cronyism and clientelism that is now an established mentality of the Greek state and its people, as difficult to combat as cancer. Austerity is the consequence, not the cause, of the disaster. Maintaining a large, inefficient public sector in the hope that governmental spending can support employment and market growth is a failed model that has exacted an enormous cost on national prosperity. A smaller and efficient de-politicized public sector (that is, disengaged from political party biases) can indeed be a cure, especially when balanced with supportive reforms and measures for the expansion of innovation and entrepreneurship. While the problem is not exclusively Greek and will probably get out of control in other European countries as well, in Greece it has violently surfaced, most probably due to the small size of the country, the established idiosyncrasies and ethea of the average Greek citizen, the limited qualified human resources retained in the country and the complete lack of national strategic planning for transforming modern Greece from a consuming society to a producing society.

Mirroring the systemic inability of the public sector to deliver goods to the population, the arena of national research and innovation is also suffering chronic illness. Greece stands out worldwide for allocating a disappointing 0.6% of its gross domestic product to research[3], despite producing a large number of scientists and engineers[4] (**Fig. 1**). This amount includes approximately €200 million per year for investments in research and development from its National Strategic Reference Framework programs[5]. Nevertheless, the output and rewards stemming from this modest investment hardly live up to their respective expectations, however modest these may be. While markers of scientific success are usually presented as adequate, they are often focused on average calculations and do not take into account the substantial deviations that lie beneath[6]. Although there are indeed several niches of scientific excellence that still remain in the country and still compete at the international level[7], there are many research units that perform at embarrassingly low levels of productivity but still absorb disproportionately large amounts of funds. Not only are public funds often allocated well below any standard of excellence or innovation potential, but also they are awarded to organizations or industries that have never undergone any standardized evaluation. The lack of a centralized, long-term scientific policy, combined with a deteriorating infrastructure, delinquent research administrations and a rigid but often vague legal framework, further sustains this stagnant and outdated research structure.

What must be done then? We offer a few basic ideas here that we believe go beyond the several versions of laws recently introduced to 'reform' the research and innovation landscape in Greece. While these ideas are straightforward and have long been implemented in several fellow European countries and beyond, for Greece they still require almost revolutionary political and public will.

Evidence-based policy-making

Policy-making should become evidence based and administration should become

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de-politicized. Across the globe, evidence-based policy-making is now increasingly being used to achieve better results in selecting, funding and implementing public programs. For example, the European Commission has initiated a "Science meets Parliaments" program that brings scientists and policy-makers from the European and national levels together to promote a culture of evidence-informed policy-making. In Greece, political decisions are still made on the basis of a combination of mental fixations, populist proclamations and lobby pressures. This results in erratic, short-sighted choices that fail to address critical problems and poorly serve the public as a whole. It is now time that rigorous, objective evidence be introduced into Greek policy-making at all levels, to achieve government effectiveness and better policy outcomes.

After evidence-based decisions on strategic long-term policies are made, and once funding instruments and budget allocations to 'thematic' research areas are set by the government, research evaluation, funding and management of resources must be heavily de-politicized. A cross-ministerial, independent and fixed-term Hellenic Research Council must be established and must operate on the basis of objective and stringent criteria of excellence and integrity. This new council should have full control over decisions on evaluation processes and allocation of funds, and its decisions must be implemented by an independent executive body, which should manage research actions. Procedures must be put in place to ensure the council's scientific excellence, integrity and autonomy (for example, international research bodies can be mobilized to help assemble and evaluate it).

In the decade to come, where reforms of the mentality of Greeks toward science, research and innovation are deemed necessary for the survival of the Greek state, procedures for making research deliver its many goods to society should avoid overt bureaucracies, often used to cover up corruption, and this should be as simple as 'ABC': 'A', for the already outstanding and excellent research that Greeks should invest heavily in; 'B', for the very good research that needs to be supported for another term and then be re-evaluated and prolonged 'A' or be allowed to die; and 'C', for research that should be allowed to die (at least in its capacity as a fundable unit).

More importantly, repercussions and consequences should be clearly defined and there must be accountability when outputs do not meet targets. So far, evaluation procedures hardly ever lead to any meaningful remedy action. For example, the latest 2014 evaluation of research institutes by an international committee set up by the General Secretariat for Research and Technology had no effect whatsoever on the restructuring of the institutional landscape, re-adjustment of allocation of funds, or replacement of inefficient personnel or structures, which thus rendered the process completely futile and pointless. Remarkably, despite the fact that the evaluation committee functioned with high international standards, its results were never fully disclosed publically. We urge the new Ministry of Education and Research to publish the full evaluation and let the taxpayers know how it will affect the future planning of their investments.

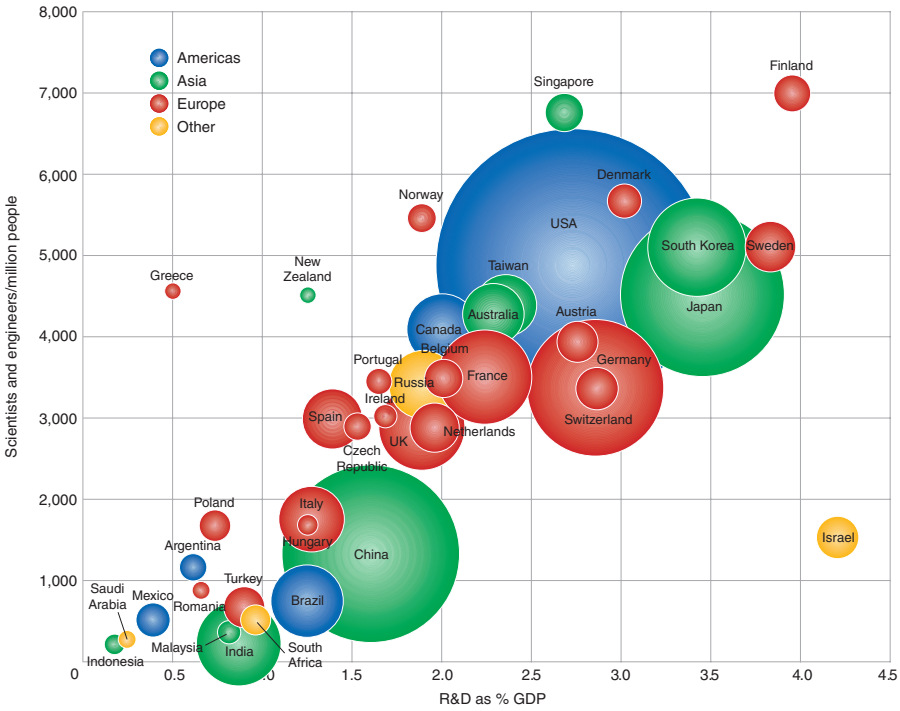

Figure 1 Research and development budgets in 2011, by country. Size of circles indicate the relative amount of research and development (R&D) spending by each country. GDP, gross domestic product. Originally published in ref. 4.

Reformation of the research landscape

The research landscape in Greece must be restructured to support excellent research and innovation. Already-existing research units must be strategically reoriented to produce critical masses of infrastructure and human capital. Ambitious new units in cross-disciplinary and emerging fields must be developed. Synergies and partnerships should be sought with top centers abroad toward the establishment of joint research centers that will help Greek research delve into these emerging fields and technologies. Particular attention should be paid to the restructuring and integration of research infrastructure, especially in universities, where there is an abundance of scientists and students, often with limited access to functioning high-end technological facilities. This type of healthy research ecosystem, if combined with the development of sound technology transfer and entrepreneurial incubators, should allow Greece to develop comprehensive innovation cycles that lead to the efficient translation of research results into 'value-added' products. For this approach to materialize, stable long-term strategic planning is required, as is substantial public and private investment.

Support of new talented researchers

The Greek research area must be flooded with talented, independent researchers who are provided the necessary infrastructure and start-up funds to give them a viable and honest chance to create new niches of excellence. We propose financing 250 new researchers (50 researchers per year for 5 years), with €1 million each, including internationally competitive salaries for the principal investigator and team, to establish new laboratories and infuse Greek research organizations with new ideas, skills and expertise. The estimated cost of €250 million, which would be spread over a decade (i.e., on average, only €25 million per year would be required for the entire program), would offer benefits that far exceed the initial investment, both in the attraction of further competitive funding as well as in the creation of new, high-quality jobs. It must be emphasized

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that the research and innovation arena should not be an area for social policies that consider researchers as mere employees performing a public service. Instead, it should be an area with very strict rules and expectations for the researchers and their institutions, which must be made to deliver rather than to gain social goods that are not linked to their productivity and performance.

Additional new funding instruments must be established, similar to recent successful examples of European Union Framework programs, such as national European Research Council–type grants, European Research Area Chairs, Small and Medium Enterprise–oriented instruments and public-private cooperation grants. It should be noted, however, that public support of private entities should require real research-and-development interest and potential, which is currently scarce (but, as always, with notable exceptions) and must be further developed and substantiated before any big funds are 'dystopically' invested.

These ideas are also in line with the proposals of the 22 Nobel Prize laureates who wrote the 2012 "Support for Greece" letter[8]. In that letter, these prominent scientists proposed the use of existing structural funds and the promotion of close cooperation between major European science and technology centers and existing Greek clusters of excellence, focusing on areas in which Greece already has a strong presence in the European landscape, to sustain its scientific structures, build up its own technological future and secure a competitive economy in the long run. As might be surmised, no memorable action has been taken along these lines, from Greek policymakers or, of course, from European policymakers.

Roger Kornberg (winner of the Nobel Prize in chemistry in 2006) reaffirmed the potential of Greece to become a scientific and technological center of excellence in Europe. During his presentation at an event organized by the Greek Presidency of the European Union on 3 July 2014, he claimed that if Greece were to allocate as little as $50–100 million per year on the basis of exceptional merit, to the most worthy people and to centers of excellence, "the return on such an investment will, in time, exceed that obtainable by any other means and will lead to the creation of tech industries of all kinds. It will transform every aspect of national activity, from information to energy to industrial production to agriculture to biomedicine and more."[9]

Given the track record of the political leadership in reforming the Greek research and innovation landscape over recent decades, our expectations that the political system by itself can make the difference remain still very low. We are therefore of the opinion that real change will require strong engagement of scientists toward radical reforms. Productive members of the research and innovation community will need to come together and self-organize into an opinion-leading body to provide high-level consultation to policy makers and to push toward reforming current structures, procedures and mentalities. We posit that it is the responsibility of all concerned, whether Greeks in Greece, the numerous Greeks of the diaspora or the many Philhellenes around the world, to passionately act against today's disappointing national output in the hope that these initiatives will propel Greek research toward substantial scientific, economic and social returns.

COMPETING FINANCIAL INTERESTS
The authors declare no competing financial interests.

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