University-Industry partnerships with a focus on BRIC countries: A systems perspective on the good, the bad and the ugly

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Abstract: National Innovation System (NIS) is the term used by scholars and policy makers to describe the emerging scientific and technological structures and processes of a nation that influence economic and social development. The last decade has seen a growing research interest in the innovation systems of different economies in order to better understand the factors that determine their economic and social development. This paper addresses the complex industry-university relationship using as theoretical framework the NIS concepts and as an analytical method, System Dynamics (SD) which is specifically designed to evaluate complex systems. Later, some international comparisons between Brazil, Russia, India and China (BRIC) are introduced in terms of industry-university partnerships.

Introduction

National scientific systems aim at developing scientific knowledge through an understanding of the natural world. This information about the world is then used to generate technology, here defined as the ability of a country to manipulate the natural world.

Nowadays, Science and Technology are unquestionably the two primary drivers in the road of development for most countries in the world. When it comes to investment in science and technology, the traditional path has been the investment in university-based research. More recently, however, countries such as the United States have used a hybrid system where the government invests in partnerships involving university and industry researchers. This partnership is appealing in that new products are constantly developed, many of them generating national competitive advantage and increasing economic growth. Although results might seem promising, even a superficial analysis can demonstrate that the industry-university relationship is everything but simple. National innovation systems are complex environments, having multiple players with an intricate set of relationships. Within such a complex set of relationships, even well-intended plans can lead to a number of unintended, sometimes adverse consequences.

In this article we analyze the complex industry-university relationship and its good, bad, and ugly consequences with the use of an analytical method specifically designed to evaluate complex systems, namely System Dynamics (SD). Frequently used to evaluate complex socio-technical systems such as organizations and society, SD uses archetypes or patterns which serve as a means for coping with real-life situations.

Historical perspectives on the university-industry relationship

Although the university-industry relationship is now starting to develop in Brazil, its history in the United States goes back to at least the beginning of the 20th century. For example, around 1930 Carl Compton, then president of the Massachussets Institute of Technology (MIT), convinced local companies to turn collaborations with MIT for technology development as one of the centerpieces for their corporate strategy (Branscomb et al., 1999). With such an early vision about the tight collaboration between university and industry, it was not much later that researchers at MIT started developing the basis for collaboration models that guide the way universities around the US and the world still use for these partnerships. Among them are the rules for consulting such as the one-fifth rule, models for funding distribution regarding patents, and incentives for faculty members in relation to firm formation (Etzkowitz and Webster, 1999).

These initial efforts were crucial for the MIT model to start displacing the traditional Harvard model by an innovative role, wherein basic research and teaching are combined with industrial innovation as part of the core university mission. Other early models include the model by Research Corporation, founded by Frederick Cottrell, who initiated the concept of using income generated by patents to seed-fund new research projects.

Since this early period, much development has happened, now on a bigger scale. For example, in the late 1950s the government of North Carolina invested a substantial amount of funding to create the Research Triangle Park (RTP). Comparable to the biomedical equivalent of the Silicon Valley, the RTP is now a major source of research development, its integration with the local universities (Duke University, University of North Carolina, and North Caroline State University), bringing a large amount of funding to each of these universities through a number of ongoing collaborations.

In 1980's, the Bayh-Dole act changed the settings on how the US dealt with intellectual property arised from Federal government-funded research. The Bayh-Dole act allows universities to have ownership of a discovery in relation to the government, whereas prior to its enactment, government had been accumulating over 30,000 patents with only approximately 5% of those ever being commercially licensed.. As one of its consequences, over the last two decades, more and more academic researchers are now writing business plans, raising funds, leasing space, and recruiting staff (Krimsky et al., 1991).

As an example of partnerships in particular industries, in 2004, an initiative was taken by the US Federal and Drug Administration with the intent of modernizing drug development for the pharmaceutical industry by calling for partnership programs. This concern raised by the growing social expectations about drug safety and efficacy while the decaying of industry's productivity. By 2006, there were results already from programs created by the University of Arizona, Duke University, MIT and the University of California at San Francisco (Woodcook and Woosley, 2008).

The partnership from an innovation systems perspective

What is an innovation system?

Until the 60s the university-industry relationship was seen as a linear process, that is: Scientific information generated at universities would be converted into technical knowledge by industry firms, ultimately generating products launched into the market and generating revenue for those firms. Starting with some initial reports from the Organisation for Economic Co-operation and Development (OECD) in the 60s, the idea that universities and industry were linked in a linear fashion started being questioned and in the 80s those lines of thinking evolved into an understanding that these partnership have a completely non-linear relationship.

This non-linear development is clear in that scientific knowledge might also be generated by industrial firms while technology might be created at universities. With the increasing complexity of New Product Development (NPD), processes have become highly complex, thus requiring adjustments along the multiple phases of NPD that involve both experience from the side of industry as well as science from the perspective of the university in a constant forward and backward motion pattern. This process has been named an "innovation system." Innovation in the sense that every product, be it a good or a service, newly created and succesfully introduced into a market is an innovation. The system counterpart is applied in the sense that all of those elements non-linearly linked in the university-industry relationship are understood as part of system.

The starting point for the approach is the actor, or the economic agent, such as the university, the industry or the government. Actors engage in activities, an example being universities creating novel information and engaging in Research and Development (R&D), understood as creative work undertaken systematically with a view to increase the stock of knowledge and its use to devise new applications (Eurostat, 2008). The industry counterpart then innovates and diffuses technologies, while government creates legislation in order to facilitate the other processes. Actors are linked to other actors and activities. Some examples of these kinds of linkages include resource funding, cooperation agreements, co-publishing, commercialization of intellectual property, and flows of knowledge and capacities through the movement of people in between institutions. As a result of activities and linkages, there are short-term outcomes, such as increased sales and profits, as well as long-term outcomes such as economic and social development.

The problem faced by both scholars and policy makers is choosing where, why, and which elements to trade-off. Since economic resources are scarce, they must deal with allocations that are at the least, complex, in which, by the way, the interface less represented is the university-industry link (Veugelers, 2007). The systems approach in this sense, claims for linkage measures to help explain the apparent inability to transform scientific and technological knowledge in the university system into something of business value.

The good, the bad, and the ugly

When it comes to the evaluation of innovation systems, simply characterizing the university-industry relationship as something either good or bad is certainly an oversimplification of a much more complex phenomenon. More than one or another, we shall characterize it as having all these aspects in one: The good, the bad, and the ugly. (Figure 1)

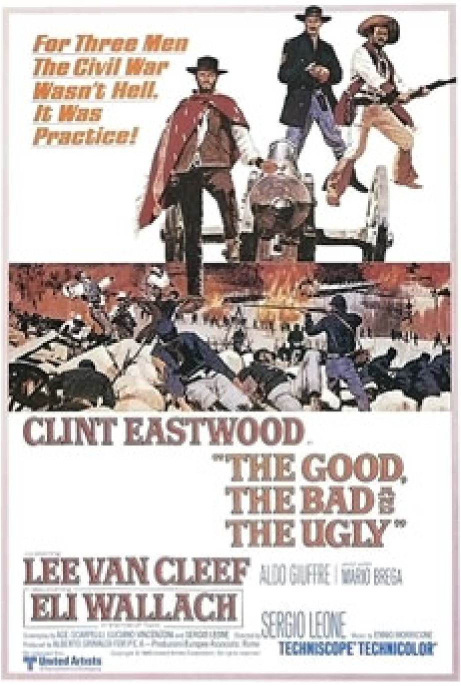

Figure 1. Classic movie on the good, the bad and the ugly

This relationship is good to the extent that industry can invest funds in the university and thus supply an additional source of growth. This investment is required, since the idea that government funding would be enough to sustain the growth of academic research is unrealistic to say the least. This external funding can then be used for a variety of purposes, including the exploration of new fields that might not be of interest to government agencies, the training of new researchers who would otherwise stay out of the research field, for building infrastructure, among other capacity and infrastructure building activities.

This relationship can therefore be represented by what in SD we call a reinforcing loop (Figure 2). In this loop, industry provides funding to the university, which then returns information and knowledge, which is then used to generate profit and further funding.

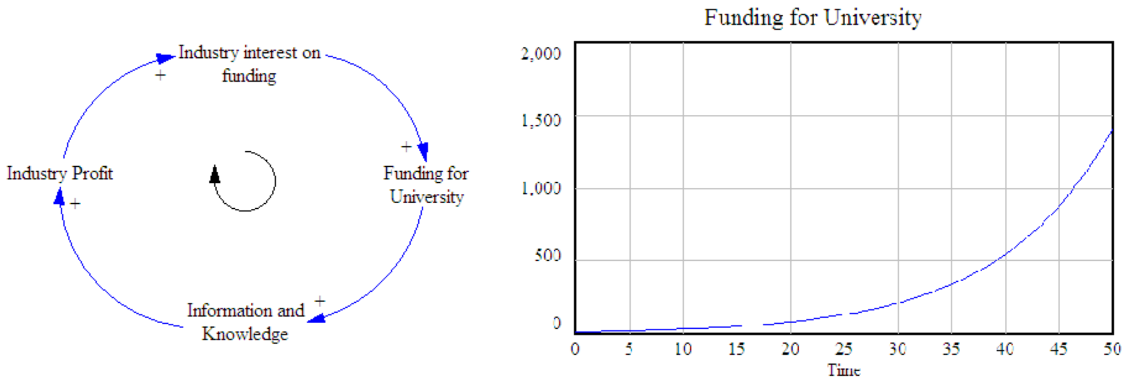

Figure 2. Industry Profit - University Funding Reinforcing Loop

The bad in the relationship is the almost exclusive tendency of the industry to focus their funding on projects that can generate a profit in the shortest possible time period. This criterion automatically excludes, for example, medical conditions that are mostly prevalent among the lower economic classes, such as leishmaniose, Chagas disease, and tuberculosis. Another problem is the focus on research with a potential for generating intellectual property, with far less investment in Basic Research. Although they are unquestionably the basis for generating major shifts in the industry, the risk associated with this such research is much greater, with a need to sometimes fund hundreds of projects before one might become a profit blockbuster.

From SD perspective, the bad in the relationship can be represented with two reinforcing loops in a pattern known as the "success to the successful" (Figure 3). In other words, if funding is initially provided from the industry to a project that generates profit, more funding will be diverted to that type of project over time, leaving projects that do not generate a profit. A potential solution for this dilemma is that the government provide additional funds to these neglected areas, alone or in partnership with industries.

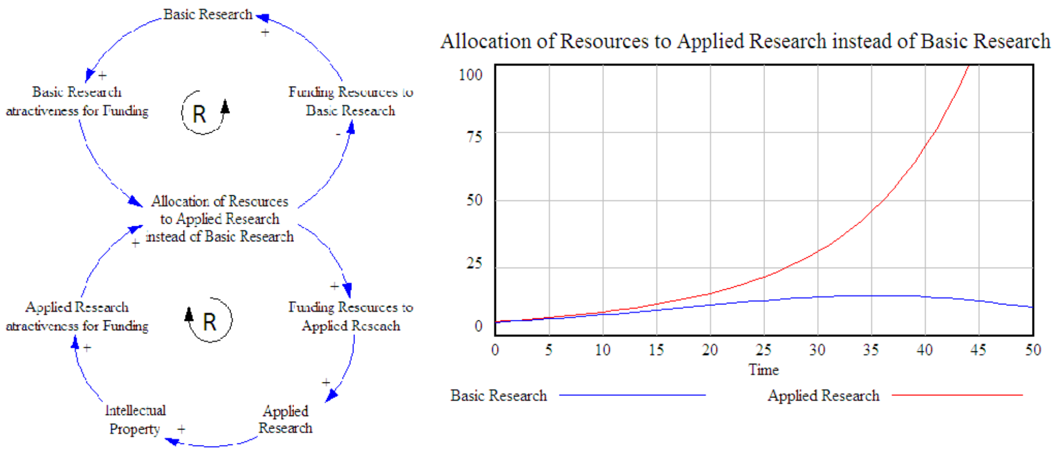

Figure 3. Systems perspective on Funding Resource Allocation - Applied vs Basic Research

And finally, the ugly in this relationship can be represented by issues related to conflict of interest. In this scenario, it is easy to see that in a situation where researchers have a major financial incentive to report results that are favorable to the industry, they will do so even in situations that might not be "scientifically ethical." For example, in a clinical study comparing a drug from a company that funds their research versus the drug of another company, a researcher would have plenty of incentives to report that their sponsor has the ~~best~~ better product. From SD perspective, this conflict of interest represented by a partiality in the evaluation of scientific results can be represented by the pattern known as "limits to success" (Figure 4), with one reinforcing and one balancing loop. In other words, the impartiality is achieved to the extent that the conflict of interest is regulated. In this scenario, stronger regulations, should add norms to disclose conflict of interest when it exists as well as establish norms to judge research that bears less conflict of interest.

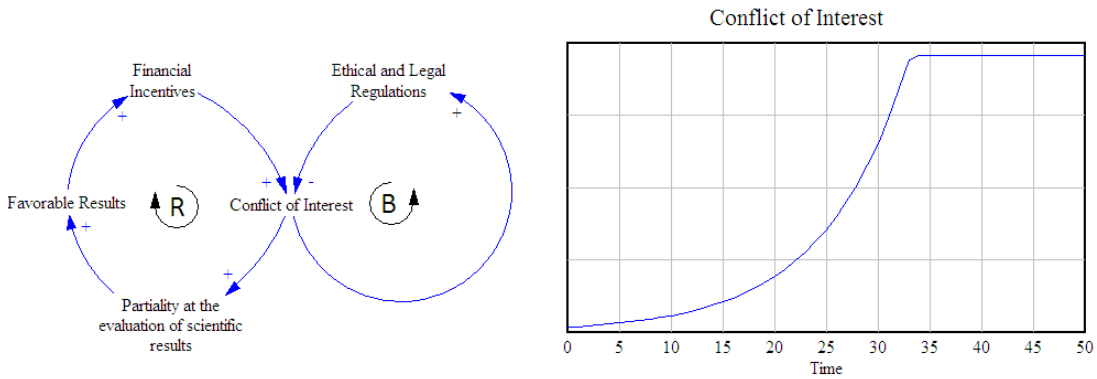

Figure 4. Balancing and Reinforcing loops on scientific evaluation

International comparisons in University-Industry relationships

The growing support of the Brazilian government in the last decades is recognized as one of the major reasons for the country to gain importance as an emergent economy (Russo, 2009). Over the last years, Brazil has seen an improvement in their university-industry relationship, with approximately 80% of their research projects being developed in public universities and research institutes (Bound, 2008), while their private sector is one of the strongest in the world.

Among the incentives, R&D has been strongly promoted by the last few Brazilian governments. Some industries, such as Oil and Energy, are forced to devote a percentage of their revenue towards R&D. Other governmental initiatives have also focused on strengthening the partnership. For instance, in 2005 the 'Portal Inovacao – PI'[1] was officially launched as a result of a university-industry partnership among the Federal University of Santa Catarina and the Brazilian Ministry of Science and Technology. The PI aims at improving the visibility of experts and competencies in the country by extracting data from the Lattes Database – a large government-funded *curriculum vitae* database. It also aims at assisting the private sector in finding experts in specific areas of research at universities, research centers and also in other firms in order to create partnerships that may result in new technologies and innovations.

When Brazil is analyzed in the context of Latin America as a whole, the whole region has been increasingly invested more on R&D, Brazil being one of the few countries in the region that has maintained a steady growth in government support for strengthening university-industry partnerships. This continuous support is illustrated by a doubling in government investment between 2000 and 2007. In fact, Brazil is responsible for more than half of all R&D funding in Latin America and the Caribbean, however, a closer look will show that the distribution of resources and investment in R&D is heavily imbalanced.

Figure 5. World map. (*Image Copyright Planetary Visions Limited*)

The current strengthening of university-industry partnerships seen in Brazil has been similar to those overseas in other BRIC (Brazil, Russia, India, China) countries, an acronym originally made by Goldman Sachs (Goldman-Sachs, 2007).

China's R&D expenditure has been growing steadily in the last decade despite their yet strong use of imported technologies. This has led to an improvement on their university

[1] http://www.portalinovacao.mct.gov.br/pi/)

and research systems, producing around 350,000 engineers every year. Their patenting system is, however, still lacking in a number of areas, which might prevent further investment (OECD, 2009).

India's innovation on the other hand, is not driven by government initiatives, large firms or government-funded R&D programs, but instead by their high-quality engineers and scientists which are estimated to be around 2.5 million students/year graduating in the fields of information technology, engineering, and life sciences. India, however, still has challenges overcoming their split higher education system, where universities are primarily focused on teaching and where government laboratories are focused exclusively on research. Also worth mentioning, India currently struggles with a weak yearly spending on their overall educational system as well as its efficiency (Bound, 2008, Goldman-Sachs, 2007).

Similar to China, Russia's growth in the past years has also been strongly dependent of imported technologies. After the economic opening of the former Soviet Union, there are only a few cases of university-industry partnerships, despite the strong position on industries such as the Oil and Gas ones (Khvatova, 2008).

Despite a good performance in comparison with BRIC, concerns arise when Brazil is compared with our neighbors up in the north. While Brazil invests around 1% of GDP in R&D activities, the US invests more than twice this figure. Many analysts believe that this higher investment has significantly contributed for the current position of the US as a leader in technology development (Ricyt, 2008). In the US, research universities receive income from different sources, from funding and research grants to royalties and donations (Eurostat, 2008).

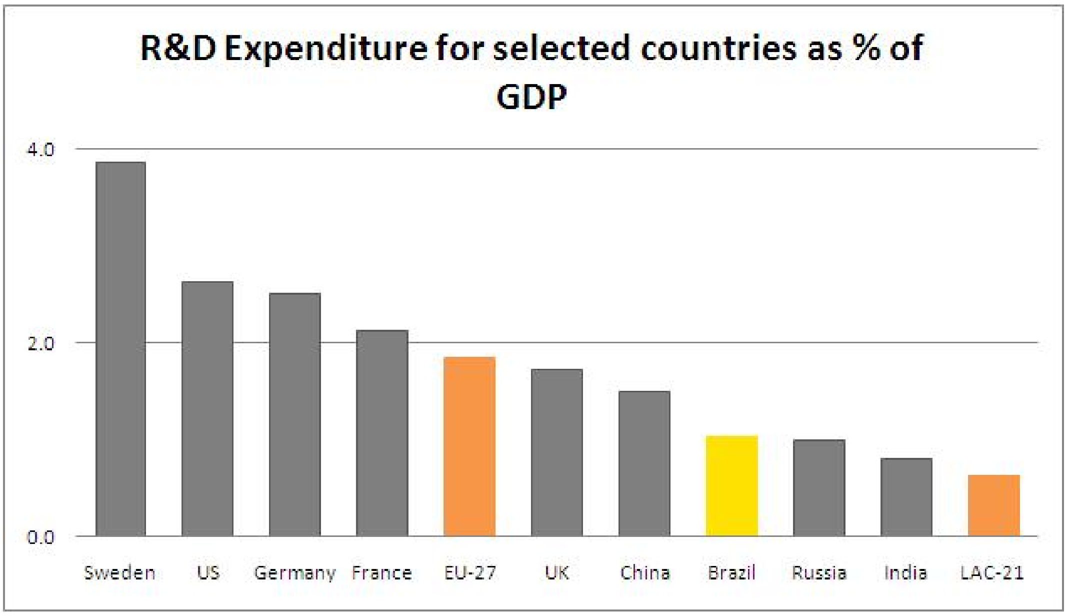

Figure 6. R&D Expenditure for selected countries

Europe on the other hand presents a greater degree of heterogeneity in R&D expenditures. Although their average expenditure is close to 2% of the GDP, three countries (Germany, France and UK) account for around three quarters of total R&D

investment. (Eurostat, 2008). The relationship between university and industry has increased in the last few years, although the EU still lacks a common European framework, with several policy initiatives having been initiated by the EU Commission in order to improve the knowledge transfer between university and industry.

What can we learn from this?

Several countries around the world do believe that partnerships between universities and industry are beneficial and generate growth. The level of maturity each region and country have are spread apart, with some governments only now starting to create a specific agenda.

From the current theoretical model of National Innovation Systems, Brazil seems to benefit from a strong industry system combined with government initiatives and regulations to improve knowledge transfer between universities and industries, this greater picture leading to an overall improvement in the generation of innovation.

Other BRIC countries such as China and India have relied extensively on their human resources as reflected by the large numbers of high quality graduates and post-graduates and in developing specific sectors demanding for research. Finally, in countries such as Russia the need for developing the Oil and Gas sectors have contributed for the creation of stronger links between universities and industry.

In contrast to BRIC, OECD countries have demonstrated a strong and steady leadership in establishing links between university and industry and are way ahead on the "innovation race" by having a more mature innovation system. Specifically, the US have extensively promoted research and intellectual property created at universities since the beginning of the twentieth century, also facilitating the mobility of researchers to industry.

Conclusions

In this paper we have outlined the importance of university-industry partnerships from an "innovation system" point-of-view. Initially by discussing the historical precedents based on the US experience, followed by pointing out the good, the bad and the ugly that might be present in the partnership by using an analytical tool - System Dynamics - and finally, by briefly describing how several countries make decisions in relation to these systems.

We conclude that Science and Technology depend on both Basic and Applied Sciences and that countries have develop mechanisms and policies that in some cases the prevalence of one over the other might be problematic. This issue must be carefully analyzed, especially when dealing with university-industry partnerships where both parties should benefit.

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