A case study on obstacles to the growth of biotechnology

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Abstract

Why has a biotechnology industry developed much faster in some countries than in others? Studies indicate that public funding for research is not sufficient for the establishment of a strong biotech industry. What should countries and regions do then, in order to become globally competitive in the area? In this paper I concentrate on the upstream section of biotech growth – the creation of new biotechnology companies – and take a closer look at the case of Portugal, a country where the industry has long been at an embryonic stage. It becomes apparent from the analysis that generalist, top-down measures to stimulate general technological development may not be appropriate to foster a sector composed of many unique characteristics. Evidence from several countries suggests that there is a group of specific factors which all have to be in place simultaneously to allow the emergence of a biotech industry. A careful analysis of the Portuguese example – when set against the background of European and Global biotech – may help regions such as southeast Asia and southern Europe define their paths to bio-competitiveness.

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1. Introduction

Biotechnology has been increasingly recognized as a crucial element for the economic growth of countries and regions, regardless of their stage of development [1]. The horizontal character of biotech allows it to bring innovative solutions to numerous industries, including the pharmaceutical and health

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sectors, agriculture, protection of the environment, and many other areas. However, the emergence of biotechnology as a major economic force has been deeply asymmetric across the globe, and even among the most industrialized nations [2–4]. In the United States, for instance, the availability of private investors and the entrepreneurial capacity of scientists and engineers, along with a strong push from established industries – namely the Pharmaceutical industry – have been pointed out as key factors that have taken biotech to a point where it has become a major economic force, employing about half a million people, directly or indirectly. In most of Europe and Asia, on the other hand, the absence of quite such a favorable set of conditions has kept biotechnology at a somewhat less advanced stage of development [5–10], a fact which has prompted most governments to take measures with the intent of fostering the growth of the sector. In the process, the development of biotechnology in these regions has become largely policy-dependent, and it is becoming increasingly crucial for national and regional governments to understand exactly what measures to take in order to make their biotech industries competitive.

Dependence on policy measures may account, at least partially, for significant differences in the size of the biotech industries – at least as far as the number of New Biotechnology Firms (NBFs) is concerned – of countries with comparable economies (Table 1). NBFs are usually seen as the basis of a

Table 1
Number of NBFs in several industrialized countries and its relation to population size and gross domestic product (GDP)²

<table>
<thead>
<tr>
<th>Country</th>
<th>Population ($×10^6$)</th>
<th>Companies</th>
<th>GDP ($×10^9$)</th>
<th>Companies/Population ($×10^5$)</th>
<th>Companies/GDP ($×10^{11}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>19.5</td>
<td>190</td>
<td>528</td>
<td>9.74</td>
<td>35.98</td>
</tr>
<tr>
<td>Belgium</td>
<td>10.3</td>
<td>69</td>
<td>297.6</td>
<td>6.70</td>
<td>23.19</td>
</tr>
<tr>
<td>Canada</td>
<td>31.9</td>
<td>417</td>
<td>923</td>
<td>13.07</td>
<td>45.18</td>
</tr>
<tr>
<td>Denmark</td>
<td>5.4</td>
<td>75</td>
<td>155.5</td>
<td>13.89</td>
<td>48.23</td>
</tr>
<tr>
<td>Finland</td>
<td>5.2</td>
<td>76</td>
<td>136.2</td>
<td>14.62</td>
<td>55.80</td>
</tr>
<tr>
<td>France</td>
<td>59.8</td>
<td>239</td>
<td>1054</td>
<td>4.00</td>
<td>22.68</td>
</tr>
<tr>
<td>Germany</td>
<td>83.3</td>
<td>360</td>
<td>2184</td>
<td>4.32</td>
<td>16.48</td>
</tr>
<tr>
<td>Ireland</td>
<td>3.9</td>
<td>35</td>
<td>111.3</td>
<td>8.97</td>
<td>31.45</td>
</tr>
<tr>
<td>Israel</td>
<td>6.0</td>
<td>149</td>
<td>122</td>
<td>24.83</td>
<td>122.13</td>
</tr>
<tr>
<td>Italy</td>
<td>57.7</td>
<td>51</td>
<td>1438</td>
<td>0.88</td>
<td>3.55</td>
</tr>
<tr>
<td>Japan</td>
<td>127.0</td>
<td>60</td>
<td>3550</td>
<td>0.47</td>
<td>1.69</td>
</tr>
<tr>
<td>Netherlands</td>
<td>16.1</td>
<td>85</td>
<td>434</td>
<td>5.28</td>
<td>19.59</td>
</tr>
<tr>
<td>Norway</td>
<td>4.5</td>
<td>21</td>
<td>143</td>
<td>4.67</td>
<td>14.69</td>
</tr>
<tr>
<td>Portugal</td>
<td>10.1</td>
<td>14</td>
<td>182</td>
<td>1.39</td>
<td>7.69</td>
</tr>
<tr>
<td>Spain</td>
<td>40.1</td>
<td>28</td>
<td>828</td>
<td>0.70</td>
<td>3.38</td>
</tr>
<tr>
<td>Sweden</td>
<td>8.9</td>
<td>199</td>
<td>227.4</td>
<td>22.36</td>
<td>83.55</td>
</tr>
<tr>
<td>Switzerland</td>
<td>7.3</td>
<td>129</td>
<td>231</td>
<td>17.67</td>
<td>55.84</td>
</tr>
<tr>
<td>UK</td>
<td>59.8</td>
<td>331</td>
<td>1520</td>
<td>5.54</td>
<td>21.78</td>
</tr>
<tr>
<td>US</td>
<td>280.6</td>
<td>1457</td>
<td>10,082</td>
<td>5.19</td>
<td>14.45</td>
</tr>
</tbody>
</table>

Data is from years 2001 to 2003, depending on the country, and is only meant to provide a general indication. As mentioned in the text, the definition of NBF may vary from country to country.


b Not counting biotech subsidiaries of larger companies.
biotechnological industry and the measure of its vitality [11–15]. In Spain, for example, the approximate number of NBFs in 2002 had been reported as 28, whereas Canada, with a comparable economy and population size, was supposed to have 417 at the time [16,17]. Differences of some magnitude could also be observed within Europe, for instance between Italy and France (51 and 239 NBFs, respectively) or between Norway and Finland (21 and 76) and even between regions of the same country, as in the case of Germany or France [18,19]. One problem with these comparisons is the difficulty in defining what a NBF is and the different criteria that can be used, from country to country, in that definition. Nevertheless, we assume that the criteria are at least similar between countries. It may therefore be relevant to analyze the development of nascent biotech industries in several countries or regions, and try to describe how different policy measures, each in their specific political and economic backgrounds, may determine the success or failure of the sector.

It may be particularly useful to take a closer look at countries in which a strong biotech sector has yet failed to emerge, despite the existence of some conditions which would, in principle, favor the industry. Using Portugal as an example, it should be possible to identify critical factors that should be taken into account by government policies, as well as by entrepreneurs and investors, in countries that intend to boost their life science industries.

In this paper I reflect on a limited group of conditions and policies that are in place in different countries, and on how the comparison between them may help explain Portugal’s relative failure – and possibly that of a few other countries as well. Since I am focusing primarily on a negative example, this paper is to a great extent speculative, especially when it comes to pointing out the underlying causes of failure. My aim is simply to try to identify critical policy issues and perhaps point the way to future, more detailed studies comparing the biotech industries of various countries.

2. Portugal

Portugal is a EU member country with a population of 10 million and an area of 92,000 km². About one quarter of the population is concentrated within a 100 km radius around the capital, Lisbon. Along a 350 km coastal strip from Lisbon going north, there are eight large universities (seven public, one private), each with well over 10,000 students and all including several life-science-related research schools or departments. Additionally, several autonomous research centers exist, namely around the Lisbon and Porto metropolitan areas. These various poles are all connected by several modern highways and two international airports. Portuguese research institutions have been evaluated systematically by international panels of independent experts, in a procedure that has been hailed as an example of quality assurance and improvement in science. The majority of the country’s largest R&D institutes specialize exclusively in the Life Sciences or related areas. During the nineties, considerable emphasis was put on the allocation of human resources for R&D, and by the turn of the century Portugal showed the all-time highest rate of increase in the number of new S&T doctorates of any OECD country (16% per year by 2000 in the life sciences) [20,21]. This evolution had an effect on scientific production, as the number of papers published by Portuguese authors in biotech-related, peer-reviewed international journals increased four-fold in 10 years [22]. Additionally, the fraction of the national budget allocated for R&D has tripled (though still below EU average), and successive governments have stated that biotechnology is a strategic priority for the country [23,24]. Lastly, public perception of biotechnology seems to be positive in Portugal, relative to other European countries [25].
Given this set of circumstances, one could possibly expect Portugal to be a country where a biotechnology industry would have arisen almost naturally. Indeed, of all technology-based sectors of modern economies, biotech is probably the one that relies most closely on the existence of strong, dynamic research bases concentrated on relatively small areas [26]. Empirical evidence shows that in the United States, for instance, the appearance of biotech clusters happened almost exclusively in the vicinity of renowned academic centers with expertise in the life sciences, notably Boston and San Francisco but also San Diego and Raleigh/Durham [27,28]. Even within Europe there are regions such as Scotland and Bavaria where a relatively mature biotech industry has grown out of an initial setting where high-quality academic research was the main strength [29]. Conversely, few reported cases exist of regions where a strong biotech industry grew without the initial supporting role of academic centers of excellence.

However, the reality so far is that there are no clear signs of a biotech bloom in Portugal. As happens with several other regions, particularly within Southern Europe, the reasons for this apparent “failure” are difficult to assess entirely and the blame has often been put on the unawareness of investors, the lack of entrepreneurial spirit of scientists and the absence of large established pharmaceutical corporations in the country. A careful analysis of these and other factors may help politicians and decision-makers, in Portugal and elsewhere, design measures that will foster the development of biotech to its full potential.

3. The science base

Although investment in science cannot be seen as the only – or even the main – force behind regional innovation systems [30,31], it is clearly an important factor in the case of biotechnology [11,32]. As mentioned above, significant improvements in the Portuguese science base have become obvious over the last 15 years. In particular, the number of PhD graduates has grown dramatically, as has the quality of the scientific production (as measured by international peer-reviewed publications, [22]), while strict measures have been put in place in order to organize the scientific system and reward the institutions which perform the best research [21]. In many aspects, the life sciences have been a privileged sector within this process, as a large portion of the investment made in improving local research and generating specialized human resources has been dedicated to the area. This is perhaps the main reason why considerable expectations have been generated internally in what concerns Portuguese biotechnology and how the sector could be a relevant force in the country’s future development.

A more careful look at how Portuguese science has evolved, however, may provide some indications that more has to be done, even at this upstream level, in order to transform growth in science into growth in innovation. One crucial aspect that has helped define and foresee science policy measures in several countries is the existence of a certain critical mass of knowledge and competences in specific areas of application, which in turn may influence the orientation of policy efforts [33]. For instance, in countries such as New Zealand, the early development of a biotech industry has been largely determined by the existence of sectors – namely meat and dairy production – which are traditionally strong and can benefit directly from local biotechnological innovation [8]. Measures to promote biotech-related R&D within these sectors, taking advantage of established industrial strengths, are now spilling over to other biotech application fields, such as pharmaceuticals. As a result, clusters of small biotech companies have emerged, for instance around Auckland (a city about the same size as Lisbon), whose biotech community is estimated to have now a market cap of about $440 million [3]. Malaysia, on the other
hand, aims to take advantage of its biodiversity and its leadership in the production of palm oil to become a biotech hub; the application of techniques such as DNA microarrays to determine and study the genome of oil palm is now a national R&D priority. Other countries have opted to define biotech priorities based on current and predicted market trends, as well as on local knowledge strengths and societal issues. Taiwan, for instance, is encouraging local firms to focus specifically on the development of applications for Chinese herbal medicines and of drugs for regional health problems such as stomach and liver cancer [3]. In the case of Portugal, the improvement in the science base so far has not been accompanied by a clear definition of priorities concerning specific areas of research application. The country’s scientific achievements seem to be a consequence of individual excellence and not of a policy-determined focus in particular fields. Neither the government programs designed to promote innovation, nor the grants available for researchers from public funds state any preference or orientation towards specific areas of application (as opposed to areas of knowledge) [21,23]. This may give rise to a dispersion, or lack of focus, in Portuguese R&D, which makes it more difficult to design efficient measures for the promotion of biotech. Interestingly, similar drawbacks have been observed in the R&D programs of other southern European countries such as Italy (in particular, concerning the country’s Target Project on Biotechnology, launched in 1998 [6]). Such situations may be surprising if one observes that both Italy and Portugal do have specific economic niches where biotechnological innovation could become crucial. For instance, Portugal produces most of the World’s cork, which means that efforts could in principle be made to study and exploit the genome of the cork tree and/or the organisms with which it interacts (following examples such as the Malaysian oil palm case). Other important crops in Portugal include vine, eucalyptus tree, pine tree and olive tree. However, no significant efforts to explore the genome of these plants seem to have taken off in the country.

4. Start-ups and venture capital

According to the *Informations Sekretariat Biotechnologie*, in 2001 there were 14 biotech companies in Portugal [17]. Taking into account existing literature, it is possible that this number included non-core biotech companies, particularly firms that are not performing biological/biomedical R&D [34]. All biotech companies started in Portugal in the last 10 years are small (30 employees or less) and privately owned [35]. A survey of publicly available information for ten young biotech companies based in Portugal shows that most of these companies provide services (consulting, contract research, etc.) and only a small minority boast the existence of a proprietary product or technology (Table 2). This may indicate that Portuguese bio-entrepreneurs have had to resort to short-term revenue activities instead of – or in parallel with – going through the often long and cash-burning development cycle of novel biotechnological products. This in turn would be typical of a situation where there is little availability of long-term, high-risk financing solutions.

Venture Capital (VC) investment is a key driving force in the growth of biotech worldwide [36] and one which tends to act more efficiently at a local scale [37]. VC investments seem to be more successful in countries such as the US where there is a mature stock market [38,39], among other conditions related to entrepreneurship [40]. Perhaps partially as a consequence of this fact, VC is overall scarce in Portugal, with investments totaling about 145 million in 2003 [41] and available funds surrounding 500 million. For comparison, Singapore, a country with less than half the population of Portugal, has about $6 billion in VC funds [3]. Of all the past Portuguese VC investments, only a very small portion went to the
biotech or medical fields; for the second semester of 2003, for instance, they accounted for only 1% of all investments [41]. Considering the public investment made in the life-science base, one would expect good biotech business ideas to have appeared, which could attract investors. This does not seem to be the case: according to the Portuguese Association of BioIndustries (APBio), only four significant investments have been made by Portuguese VC firms in local biotech-related start-ups between 1998 and 2002, despite government initiatives to allocate large amounts of money for venture capital [42]. On two of these deals the investors later sold their shares back to the entrepreneurs and did not enter further rounds of financing. On the three deals for which the financial details were disclosed the amounts invested were 1 million, 200,000 and 40,000 (all four companies are still in business, however) [42]. One issue that is often pointed out by entrepreneurs as the leading cause for this problem is the lack of knowledge of Portuguese venture capitalists in regard to biotech. None of the Portuguese VC funds claim to have any degree of specialization in biotech-related areas, nor do they appear to include any partners, employees or associates with significant experience in the biotechnology investment cycle. Many funds define sectors such as tourism, paper, packaging, consulting and the leisure industry as their main targets [43,44] and some openly declare that they avoid early-stage businesses and/or high-risk fields such as biotech. But why should Portuguese investors focus on biotech when the number of existing companies is so small and no clear success stories exist yet? This type of question appears to have led to a vicious circle where reluctance towards specialization on the investor’s side leads to only a few projects becoming companies, and vice-versa. Thus it appears that government actions aiming at the creation of VC are not playing a role in triggering the development of biotech in Portugal. A similar situation seems to have happened in countries such as Italy, where funds were created which only invested abroad, while the local start-ups attracted foreign investors. Lack of local VC investments in biotech has been pointed out as one of the main causes of Italian biotechnology’s relative failure when compared to the other larger European countries [6], and the same might be said, at least until the late nineties, about Spain [45] and Greece.

At the opposite end of the spectrum, some countries have implemented aggressive measures to circumvent this type of problem. In Singapore a US$700 million Biomedical Sciences Investment Fund has recently been created with a clearly-defined strategy of investing in foreign, well-established biomedical ventures, while simultaneously funding local, early-stage start-ups and Singapore-based international joint-ventures [3,10]. Biotechnology in Singapore has undergone an impressive growth in

<table>
<thead>
<tr>
<th>Company</th>
<th>≤50 employees</th>
<th>Consulting</th>
<th>Contract R&amp;D</th>
<th>Other services</th>
<th>Own IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
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</tr>
<tr>
<td>B</td>
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<td>D</td>
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<td>G</td>
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<td>H</td>
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</tr>
<tr>
<td>I</td>
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</tr>
<tr>
<td>J</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Technology-transfer/commercialisation of IP, start-up incubation, quality-control activities, clinical/environmental tests.
recent years, with more than 25 new companies appearing, and a biomedical manufacturing output of US$4 billion, expected to reach US$7 billion by 2005. In Finland, the government’s will to turn the country into a biotech powerhouse during the nineties has led to the creation of at least five major VC funds focusing on biotech. One example is BioFund Management Ltd, which invests exclusively in the Life Sciences and currently manages around $182 million. This type of fund, together with strong public financing for the biosciences, has made Finland, with its population of just over 5 million, the home of 10% of Europe’s biotech companies [46]. Another good example of the role that VC may have on the regional emergence of biotechnology may be the case of Medicon Valley – the cross-border “bioregion” spanning the greater Copenhagen area, in Denmark, and the cities of Malmö and Lund, in Sweden. While in the mid-nineties there were barely any VC funds investing in biotech in Scandinavia, after the creation of Medicon Valley over 30 different life science-dedicated funds have appeared in the region and local start-ups are benefiting from an estimated $650 million available from local and foreign VCs. The immediate result is that, in an area that is home to 3 million people, there are now more than 100 biotech start-ups [47]. Thus it does not seem impossible to design policy measures that cause an accelerated growth in the amount of dedicated VC available, even when starting from close to zero. In fact, in countries that today are economically less developed, recent measures may come to produce analogous results: Malaysia, for instance, is creating a $260 million Bio-Valley as part of a strategic plan that will use biotechnology as one of the five core technologies that should transform the country into a highly developed nation by 2020 [3].

5. Industry push

Another commonly mentioned factor that may be important for the growth of biotech is the presence of large industrial players that seek innovation and new technological solutions. The typical example is the large pharmaceutical industry, which sees NBFs as a window to cutting-edge technologies [48–50] and often invests in (or collaborates with) the smaller start-ups, bringing both credibility and funding to the latter. Portugal’s pharmaceutical industry is small and mostly dedicated to the manufacturing and distribution of products, rather than to R&D efforts. The general awareness of the sector towards biotech is thus small, which resembles the situation of other countries such as Spain, and notably Italy, where even large chemical and pharmaceutical corporations have historically shown little interest in the new technologies [2,51]. The problem in Portugal may not be limited to lack of interest from pharma, as much of the country’s economy is based on traditional industries which employ low-skill workers and lack connections to scientific research and technological innovation [34].

One possible way around this problem is to attract large foreign companies to the country. These would potentially generate specialized employment and foster the local emergence of new firms (who will act as suppliers, for instance) thereby kick-starting new industries at the regional level. In this respect, Portuguese authorities have learned from the success of Ford–Volkswagen’s plant Auto-Europa – based in Palmela, south of Lisbon – which throughout the nineties triggered the generation of new businesses and led the automotive sector to reach an impressive slice of the country’s GDP. The government has created the Invest in Portugal Agency (Agência Portuguesa de Investimento – API) with the purpose of attracting more such investments from large multinationals. However, reasonable doubt remains on whether a similar strategy – namely attracting large pharmaceutical firms – would boost the
biotech sector. Drawing from the example of Ireland in the early nineties, one is led to believe that might not be the case: a sharp government focus on bringing foreign multinationals to Ireland led to new technologies being transferred mostly to foreign hands, at least initially, instead of being developed and commercialized fully by Irish NBFs [2,29]. The Irish government then shifted to promoting the launch of biotech start-ups, a strategy that has so far proved to be more successful – with a population of less than 4 million, Ireland has now more than 30 new biotechnology firms.

6. Government support

In the absence of capacity from private players to invest significantly in biotech, governments typically take measures to promote the appearance of technology-based firms through the creation of specialized programs, subsidies, grants and fiscal benefits. In Portugal some of the initiatives that have been put in place can clearly benefit small emerging biotech companies – for instance, strong financial support is being given by the government to the recruitment of PhD graduates [23], which may allow start-ups to greatly improve the quality of their teams without the need for substantial funding. Other initiatives, while designed to support technology-based firms in general, have yet to prove adequate for specific areas such as biotechnology. One program, named IDEIA (Apoio à Investigação e Desenvolvimento Empresarial Aplicado – Support to Applied Corporate Research and Development), aims to foster joint projects between universities and technology-based firms [23]. In principle this could be a vehicle for the creation of biotech spin-offs stemming from academic inventions. However, program rules demand that the participating companies show a high ratio of financial autonomy and the capacity to cover at least one third of the total project costs (including those undertaken by the academic institution) with their own money assets. Additionally, companies must be at least 2 years old. These requisites may practically rule out participation from small emerging companies. Biotech firms may find it particularly difficult to benefit from such programs, as the critical period for engaging in collaborations with universities should be precisely the first few years and financial autonomy typically takes long to achieve. Through another program called NEST (Novas Empresas de Suporte Tecnológico – New Technology-Based Enterprises) [23] the government provides seed money for start-up companies in the same amount as the entrepreneurs’ own investment, provided that the companies are able to attract venture capital backing. In addition NEST gives special, no-interest loans to venture capital firms who wish to invest in the technology-based companies – up to 80% of each amount invested. Thus NEST addresses the problem of low VC investment in technological ventures by making it more attractive for VC firms to put money in this type of project. However, the crucial problem of the lack of specialization and knowledge of investors in regard to areas like biotechnology remains unattended. Especially since NEST does not provide any support for non-Portuguese VC firms, meaning that the program will hardly serve as a direct facilitator of investments by foreign, specialized funds in Portuguese biotechnology.

It is clear from these examples that the publicly declared intention of having biotechnology as a national priority has not been translated into any sort of special – even dedicated – treatment of the sector when it comes to the design of specific policies and programs. In contrast, the growth of biotech in a number of countries can be traced back, in part, to dedicated initiatives. As an example, the Australian government has created programs such as the Biotech Innovation Fund, which allocates financial support specifically to the so-called pre-seed stage of life science start-ups. As a consequence, the growth
rate in the number of NBFs in Australia was of 30% in 2000 and 2001 [3]. Due to the horizontal character of biotech, many countries have created cross-disciplinary governmental boards to deal with the sector. Governmental support for the life sciences in Portugal has come mostly from the Ministry of Science and Technology (now Ministry of Science and Higher Learning – MCES). This has naturally resulted in a much needed boost for basic science and academic research [21] but industrial R&D was somewhat neglected. It is possible that the development of biotechnology would benefit strongly from a more dynamic inter-ministerial collaboration and from the creation of cross-ministerial boards and programs. Indeed that has been the option of a number of European and Asian governments. For example, Singapore established a Biomedical Research Council in 2001. In 1995, while Malaysia created a National Biotechnology Directorate (BIOTEK), the Taiwanese government founded the Biotechnology and Pharmaceutical Industries Programme Office and the German federal government launched the high-profile BioRegio competition [3,18].

7. Entrepreneurship

It is common for researchers and practitioners to point out the lack of an entrepreneurial culture or mentality as a reason for the slow development of new industrial sectors [6,9,52]. Indeed this may be particularly relevant in biotech, since the sector is largely made up of small companies launched by individual entrepreneurs with specific knowledge or skills. The United States is usually seen as a country where entrepreneurial attitudes are more common and failure is well accepted, in comparison to other regions (see for example Suzuki et al. [52]). This often leads to the conclusion that lack of entrepreneurship is one important factor holding back European and Asian biotech.

The UN’s Global Entrepreneurship Monitor (GEM) finds that Portugal falls within the group of “low entrepreneurial intensity” countries, meaning essentially that the number of people who have started their own business is lower there than in many other countries, most notably New Zealand, Australia, Korea, Ireland and the United States, which led the same GEM ranking. Other low entrepreneurial intensity countries include Sweden, Belgium and the Netherlands [53]. Curiously however, the Gallup Eurobarometer on entrepreneurship finds that Portugal is the country where a larger percentage of people would like to be self-employed, beating all its European counterparts and the US (which came in second place) [54]. This suggests that the problem with entrepreneurship in Portugal may not be one of pure mentality or culture, but rather of organization and policy. In fact, the GEM also finds that the Portuguese are among the people who most often blame organizational problems and lack of financial support for hindering entrepreneurial initiative.

Perhaps as a reaction to this type of observation a multitude of initiatives have been put in place in order to stimulate high-tech entrepreneurship in Portugal. Some are top-down measures, including the programs mentioned above, while others are bottom-up initiatives promoted by researchers, universities and private companies. Interestingly, and despite all the investment that has been made on the life sciences (relative to other disciplines), none of these initiatives seems to give any type of particular emphasis to biotech projects, with the exception of one Business Plan competition (“Bio-empreendedor Ibérico”) organized by the Portuguese Association of BioIndustries – an association of mostly small private companies and institutes. Thus it seems that there is a lack of communication between two groups of entities: those that are focused on promoting entrepreneurship and those which perform biological/biomedical research and/or understand its economic value.
8. Intellectual property

One crucial aspect in the development of a biotech business plan is Intellectual Property (IP) and its protection through the use of patents [55]. Because the filing of patents by Portuguese inventors has traditionally been infrequent – a problem shared by countries such as Italy and Spain – the Portuguese government’s National Institute for Industrial Property (INPI) has created IP-support offices (called GAPI) in conjunction with some universities and innovation-related entities [56]. These offices are analogous to entities that have long existed at the largest American and European universities [57], and may play a role in facilitating innovative attitudes among scientists and their institutions by diffusing common practices in IP protection and management. It is important to note, however, that none of the GAPI employ more than a very small group of people (teams of one to three), and that the vast majority of these employees are not specialists in any technological field (such as biotech). Additionally, none of the offices is located in life-science research institutes or claims to have any particular orientation towards the area. This may be one of many reasons why the country’s recent progress in scientific productivity has not been followed so far by a rise in the number of international patents filed [58]. Perhaps as a reaction to this situation, a number of small, private companies have recently appeared with the aim of promoting technology-transfer and IP protection in the life sciences. This seems to be yet another clear example of how generalist top-down government measures have failed to meet the needs of a sector, and have thus led to narrower-scope, bottom-up initiatives. It remains to be seen whether these bottom-up actions will have any effect in directing future government measures, but it is interesting to note that, within Portugal’s limited patent production, biotech and pharmaceutical inventions currently represent an overwhelming majority.

9. Discussion

It is hardly possible to pin-point one single factor that is absolutely crucial for the appearance and early growth of a biotechnology sector. However, by analyzing the recent history of a few different countries, namely in Europe and Asia, one can distinguish a handful of features which, if not sufficient, do seem to be necessary for entrepreneurial projects to bloom. In this context Portugal is an interesting case since some of the conditions that are considered necessary for bio-entrepreneurship seem to be in place, namely:

- Fast growth in the amount of human resources allocated to science;
- Overall high quality of the science base (publications, evaluation criteria...);
- Existence of centers of excellence in the life sciences;
- Declared political will to consider biotech as a priority;
- Good public acceptance of biotechnology.

These conditions, even when put together, must not be sufficient for the emergence of a biotech industry, as the sector is all but absent in the country, like it is in other regions where similar conditions are present [45]. But looking at the opposite examples of countries where biotech has indeed emerged as a major economic force, one can observe that these same conditions are still considered essential. The difference may be that a larger set of requisites is fully met in those more successful regions. The
example of Finland may be illustrative since Finnish biotech has arguably been one of the most remarkable cases of growth in Europe, at least when it comes to formation of NBFs. A close look at documents such as the Invest in Finland report on biotechnology [46] shows that, on top of each of the above-mentioned conditions, the country’s strength is based largely on four other factors:

– An efficient system to transfer technology between academia and the industry;
– A clear definition of research goals by governmental funding programs (the programs run by Tekes – the National Technology Agency, in the case of Finland);
– An involvement from traditional or established industries in biotechnology;
– The existence of dedicated venture capital funds to support early stage biotech projects.

Indeed all these aspects have been of crucial importance for the current growth of biotech in other countries – such as Australia, Sweden and Germany [3,18,47] – and are now considered top priorities in the countries that are more aggressively trying to boost their biotech sectors – examples are Singapore, Taiwan, Japan and South Korea. Therefore, it appears that, in spite of significant economical, historical and cultural differences between countries and regions, it may be possible to define a limited number of areas in which policy measures should focus in order to promote the biotechnology industry.

The problem, however, is more profound than the simple identification of key conditions. The important question may be why certain countries have failed or are failing to successfully put these conditions in place, even when realizing their importance. The example of Portugal suggests that one major issue may be the lack of coordination between top-down measures and the bottom-up trends and initiatives of the scientific and entrepreneurial communities. In fact it is clear that, at the same time as government programs often fail to meet specifically the needs of bio-entrepreneurs, many of the ideas launched by individuals or small organizations (i.e. competitions, cross-disciplinary education, and so forth) have little impact or visibility due to lack of government or corporate support. This leads, for instance, to the severe inefficiency, when it comes to biotech, of entities such as technology-transfer offices or state-owned VC firms, as described throughout this text.

It is also apparent that, among the countries where a true biotech industry is not yet established, two different types of attitude currently exist as to the promotion of the sector. On the one hand there is a group of countries which have defined biotech as an economical priority and are taking aggressive measures to boost the sector. This group includes most southeast Asian countries and is characterized by high-profile initiatives specifically directed at biotechnology, such as the creation of inter-ministerial boards, the allocation of large sums of money to promote bio-entrepreneurship, the support to VC investments and technology-transfer systems, accompanied by strong incentives to the science base. Measures taken in this group of countries are also typically defined by attempts to take advantage of local expertise, resources, or economic strengths, to bet on specific niches of the biotech industry.

Another group of countries, including Portugal and possibly other southern European nations, is characterized by the existence of a declared political will towards the promotion of biotechnology, but also by the lack of specificity in the measures taken. In these countries, there is a less pronounced connection between local strengths and policy measures, as far as biotechnology is concerned. In the specific case of Portugal this lack of focus is balanced by visible growth in the science base and by a
generally favorable environment towards biotech – a balance that so far has not been sufficient to give birth to a biotechnology industry.

To conclude, I believe that the comparison between policy measures taken in different countries may be the key to an understanding of why biotechnology has grown at various rates around the globe, and I suggest that further, more detailed research should be performed along these lines. Through my superficial analysis, I have observed that the commonly accepted causes for success in biotech can be reduced to little more than a handful of policy-dependent factors. The promotion of these factors, although not straightforward or easy, should be the priority for countries that see biotechnology as an essential tool for economic development.

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