EVALUATING SCOTTISH ENTERPRISE’S CLUSTER POLICY IN LIFE SCIENCES: A DESCRIPTIVE ANALYSIS

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Abstract

Innovation processes and knowledge management are highly relevant phenomena for the development of emerging industries such as biotechnology. Public policy in this area addresses either market or systemic failure. The market failure approach recognises that innovation and the market for intangible assets are characterised by uncertainty, information asymmetries and imperfect appropriation of returns. As a result, the system is unlikely to reach equilibrium and efficiency unless the government intervenes to promote investment and grant protection over intellectual property.

On the other hand, systemic approaches recognise that the performances of single actors do not uniquely depend on the way markets operate, but also on a complex network of interactions at different geographical levels. Consequently, an interdisciplinary analysis - open not only to economic theory, but also to social, legal, and political considerations - is required when evaluating the performances of specific policies.

To begin with, this paper aims to define a taxonomy of public policies directed to promote innovation and the exploitation of advanced technologies at a national and regional level. Later, as this work is part of a broader project assessing the effectiveness of a number of policies implemented in Scotland over the past few years to create a biotechnology cluster, some initial considerations will be made in relation to the existence and functioning of agglomeration and network dynamics within the local industry.

1. Introductory Notes

The development of a biotechnology cluster has been one of the high profile initiatives undertaken by Scottish Enterprise (SE) over the past few years, lying between the advanced longstanding US model and those of other European countries. This work originates from a wider project undertaking an in-depth evaluation of SE's policies in this area and covers a broader range of measures than traditional investment performance and cost-benefit analysis. Consistent with systemic approaches on industrial policy, I assume that the performance of single actors does not uniquely depend on the way markets operate, but also on a complex network of interactions at different geographical levels. These forms of interactions involve a number of public and private institutions, ranging from academic departments and research centres, to private firms dedicated to basic research, service providers (for example, managerial, legal, financial consultancies), investment groups, multinational companies, and government bodies.

Scotland invests a great deal of public money in basic and applied research. In 2003, the Scottish Executive spent over £270 million on science - much of which this goes to fund research and gives birth to a remarkable number of start-ups, and is home to the third largest cluster of biotechnology companies in the UK. However, only a small number can be considered successful core-biotechnology businesses, that is, firms whose activities rely on the application of cutting-edge bioscience mainly for the discovery of new drugs. A considerable number of Scottish biotechnology companies remain at an embryonic state of development. They have only rarely been able to attract enough venture funds to project themselves beyond the start-up stage and enter strategic alliances with multinationals corporations (MNCs).

Technological change and innovation in life sciences are perceived as critical to create an economic powerhouse in Scotland with important repercussions on the national economy. Success in this area means increasing private investments, creating more opportunities for skilled workers, and attracting big pharmaceuticals’ interest in the biosciences and related technology generated in Scotland, a small
nation possessing one of the best research bases in Europe. With around the 10 percent of the UK population, Scotland produces 13.2 percent of the UK’s first life science degrees, 61 percent of the UK’s pharmacy degrees, 30 percent of the UK’s microbiology PhDs and 31 percent of the country’s postgraduates in genetics. There are over 200 Scottish-based contract research organisations where researchers work in areas such as new therapies for cancer and heart disease through to understanding the causes of Alzheimer’s disease, stem cell research, and bioinformatics.

Interviews with managerial and scientific directors of some 30 Scottish dedicated biotechnology companies (DBFs) were planned to reflect not only the effectiveness of some of SE’s policies, but also the current state of advancement of some of Scotland most promising biotechnology ventures, their current needs and vision for the future. Seventeen interviews (see table 2) have so far been carried out and they provide the empirical basis for the theoretical arguments developed in this paper.

The paper is organised as follows. In sections 2 and 3 I explain why SE’s policies in life sciences are based on a “cluster strategy” and review the different meanings attached to it. I primarily aim to deal with the problem of structural and lexical ambiguity within which cluster strategy is discussed and implemented and explain the process through which it has been employed by SE to promote economic growth in Scotland. Section 4 is dedicated to a general discussion about economic policy in the area of knowledge intensive industries and approaches the topic of promotion of technological change and innovation from alternative perspectives. Also, I review SE’s activities as part of the larger strategy designed and undertaken by the Scottish Executive to attain a “Smart & Successful Scotland” (see figure 1). In section 5 I discuss the initial findings of my survey and put particular emphasis on the attempt by SE to create a local network and epistemic community capable of generating and exploiting new ideas and technological advancements. Finally, in section 6 I will draw pertinent conclusions.

2. The Emergence of Cluster Strategy in Biotechnology

In the UK context, Scotland has pioneered the implementation of cluster thinking to exploit better its development potential in a number of industrial sectors. The adoption of the cluster approach is based on Michael Porter’s work as a consultant for SE in the second half of the nineties and the launch of SE’s cluster strategy in November 1999. Five industrial sectors were identified as those where Scotland could achieve a competitive advantage based on the characteristics of local skills and productive factors, demand conditions, sectoral structure and the dynamics of national and international competition: biotechnology, microelectronics, tourism, food and energy. Later, the scope of the strategy was expanded to include other sectors.

SE’s Framework of Action for biotechnology initially consisted of a £40m investment to grow a biotechnology cluster in Scotland in collaboration with the local industrial and scientific community and a number of ambitious targets were set to be met by 2003 when the strategy would have been evaluated and reviewed. Since the strategy launch, SE’s approach to the biotechnology cluster included organisations engaging not only in advancing knowledge in bioscience and exploiting the technological outcomes, but also in producing medical devices and providing general support and supplies.

The key targets to be met by 2003 were: to reach the number of 100 DBFs located in Scotland, to increase the number of support and supply organisations (including medical device producers) to 280, to double employment from 12,000 to 24,000 jobs, to build critical mass, to improve companies’ performance and build strategic linkages and value added networks within and beyond the boundaries of the local communities.
Over the past few years, the pharmaceutical industry has undergone substantial and systematic transformations which account for important modifications in industrial practices and the emergence of new players. Bioscience developed along various technological trajectories and new companies were created that reproduced the same model: elaborating and codifying knowledge often developed by public research organisations (PROs) or other DBFs. National systems and individual companies have reacted quite differently to these stimuli. Government bodies have adopted distinctive policies affecting new patterns of division of labour; additionally public regulation has touched on the modalities in which new drugs are distributed to final users (safety and price). Incumbent firms have been compelled to explore new opportunities and adapt organisational and technological competences to the new regime. This process has entailed a significant shift in companies’ strategic priorities from the perspectives of the new sources of core scientific and technological knowledge and of the incentives and rules of action that they have to put in place in order to remain competitive. DBFs perform critical activities, and understanding the process of industrial and technological change as based on the interaction among new players and incumbents seems indispensable to explain present and future dynamics of healthcare industries.

Based on these kinds of considerations, industrial dynamics associated with the emergence of biotechnology are often analysed through the lenses of regional districts and systems of innovation. Having been inspired by Porter’s (2003) “diamond” theory, SE and the Scottish Executive saw the opportunity to employ cluster strategy to enhance Scotland’s competitive performance in fast growing areas where Scotland had an important tradition of basic research and academic education, putting a lot of emphasis on cooperative work and interaction at a local level. The focus was on growing an endogenous industrial base of strongly connected and interacting players who, being backed by public understanding and support would rely on local skills and assets to raise the national profile in key industries and project Scotland into the new century with a renewed and sustainable capacity to be innovative and capitalise on its knowledge base.

3. On the Notion of Cluster and Regional Innovation Systems

3.1 Different Theoretical Approaches

As argued earlier, SE’s policy on biotechnology relies on recognition of the systemic and cooperative nature of the contemporary geography of innovation. From a theoretical viewpoint, we should analyse and appraise those policies by drawing on theories of innovation and technical change, social networks and industrial clustering (Gordon and McCann 2003). In this section, I will briefly overview some of the most significant theoretical contributions in those areas, starting from industrial clustering and will highlight key similarities and complementarities with sociological explanations of innovative network dynamics.

Much of the contemporary geography of innovation is interpreted as resulting from the common effort of small enterprises working in clusters and entrepreneurs reciprocally linked in a regional network. A first body of explanations concerning the achievement of better performance relies on the so-called Marshallian or agglomeration economies. They include: (i) an advanced division of labour which leads to the possibility of compensating for the absence of economies of scale and scope with flexibility while also having access to providers of intermediate goods and services located within short distance (Enright 1999); (ii) the creation of a market for skilled labour which develops as a result of the demand for specific skills by an increasing number of organisations; (iii) the improvement of physical infrastructure; (iv) the production of entrepreneurial skills and the rapid dissemination of valuable information. While the agglomeration of sectoral activities takes place progressively in a specific location, external economies contribute to enhance each firm’s
competitiveness, defined as the “capacity of a firm to survive, gain, maintain and expand its market share on product markets” (Van Dijk 2003, p. 176).

Subsequent to Marshall’s pivotal work, other approaches were developed that can be grouped into four different categories\(^1\): (i) pure economic modelling, commonly referred to as “modern economic geography” – e.g. Krugman (1991), Krugman and Venables (1995, 1997), and Fujita, Krugman and Venables (1998); (ii) theories of the “innovative milieu” – e.g. Von Hippel (1999), Maskell (2001), Malmberg and Maskell (2001), Powell (1990, 1998) Lorenz and Foss (2003), Nooteboom (2003)\(^2\); (iii) socio-economic theories that emphasise the social embededness of economic relationships and point to formal and informal institutions as examples of effective cross-firm coordinating mechanisms for the flow of both physical and intangible assets - Saxenian (1994), Powell (1990), Pilon and DeBresson (2003); and (iv) the Porter’s (2003) theory of national competitive advantage encompassing factors’ conditions, demand conditions, related and supporting industries and firm strategy, structure and rivalry\(^3\).

The “innovative milieu” approach draws on Marshall’s argument concerning information and knowledge spillovers to develop a knowledge-based theory of spatial clustering. The key argument is that clusters are the territorial configuration that enhances learning processes as a result of the free circulation of unwritten information and easier access to tacit knowledge through interaction between holders and users.

“All the best known studies on localised knowledge spillovers seem unanimous in concluding that knowledge spillovers … are important and strongly bounded in space. The (unverified) story that is usually told assumes that the employees and managers of firms near to universities (where leading-edge research is done), as well as close to a number of other innovative firms, will be the first to be acquainted with the results of important discoveries, or to obtain the accessory knowledge that is necessary to exploit those discoveries, thus gaining an innovative edge over distant rivals. More precisely, this story can be broken down into a three-step logical chain: 1. knowledge generated within innovative firms and universities is somehow transmitted to other firms; 2. knowledge that spills over is a public good...; 3. knowledge that spills over is mainly tacit... in other words, it is a public good, but a local one” (Lissoni and Breschi 2003, p. 980).

In relation to this definition, I shall make a number of remarks. Firstly, knowledge spillovers defined in this way can be interpreted as external economies of three different kinds: (i) pecuniary economies, in the sense that, as knowledge floats in the air as a public good, some organisations free-ride on investments made by other organisations; (ii) knowledge flows on a firm-to-firm basis, which is usually the result of a reciprocal commitment to exchange valuable knowledge, whether or not this exchange is regulated by a contractual agreement; (iii) systemic economies, in the sense that individual organisations consciously decide to be part of formal/informal

\(^1\) Here I refer to theoretical works and not to the considerable amount of empirical work that has been produced testing the arguments used and the conclusions achieved by the different research streams.

\(^2\) Some works are strongly critical of this perspective – e.g. Breschi and Lissoni (2001).

\(^3\) Porter’s approach looks at nations and draws on interrelated factors such as the size of the demand relating to specific products or of the supporting industrial base within the local context. It also highlights the importance of the coupling between the strategic options of competition and cooperation and has the merit of analysing national competitiveness from the viewpoint of specific industrial sectors. However, this research project focuses on public policy for the development of regional and inter-regional networks, with specific emphasis on those processes concerning the exploration and exploitation of knowledge. I will then concentrate on a number of approaches that guarantee a deep level of analysis of relevant issues.
networks whereby knowledge circulates as a free good but everyone contributes to increase the knowledge base via proactive behaviour. Above all, the survival of the system and the advantage that each organisation receives originate from two concomitant factors: the knowledge available should not be too different from the competence bases of the organisations involved, otherwise it would be too expensive and ineffective for them to acquire that knowledge; at the same time, a certain degree of variety and the incorporation of new ideas should be allowed, in order to avoid remaining locked into obsolete trajectories.

Secondly, it seems important to stress that the definition provided by Lissoni and Breschi (2001) seems to rely on a “vertical” or “linear” model of systemic innovation. As highlighted by a number of theoretical (Von Hippel 1999; Maskell 2001) and empirical works (Hara 2003) information and knowledge do not flow uniquely vertically, but also horizontally (among potential competitors or firms in diversified segments) and back from users (who very often end up being the key innovators) to inventor and producers.

Finally, in some circumstances and within specific locations, knowledge may not be available to every potential user but just to a limited number of them. Indeed, some users are “naturally excluded” (Zucker et al 1995a and 1995b) due to the protection offered by IP rights (in order to preserve individual incentive to innovate). IP then adheres to a specific location as a consequence of human beings’ immobility and can be transferred only when the possessor starts-up a new venture or moves to a different organisation.

Other approaches stress that the consideration of external economies does not add much to our understanding of industrial clustering unless we also refer to social and institutional sources of competitive advantage. For example, as Saxenian (2000) puts it:

“the concepts of agglomeration and external economies cannot explain why clusters of technical skills, suppliers, and information produced a self-reinforcing dynamic of increasing industrial advances in Silicon Valley while producing relative decline along Route 128” (p. 204). In her view, “the simple fact of spatial proximity evidently reveals little about the ability of firms to respond to the fast-changing markets and technologies that now characterise international competition” (p. 204)... “Silicon Valley has a regional, network-based industrial system that promotes learning and mutual adjustment among specialist producers and complex of related technologies. The region’s dense social networks and open labour markets encourage entrepreneurship and experimentation. Companies compete intensively while at the same time learning from one another about changing markets and technologies through informal communication and collaborative practices” (p. 205).

Saxenian’s reference to “dense social networks” opens the door to a number of key considerations. To begin with, the existence of regional networks seems to imply that not all relationships occurring at a regional level happen via pure market mechanisms. Rather, economic relationships are mediated by a substratum of social links whose nature shapes firms’ strategies and organisational routines. It is a matter of cultural history, cohesion and diversity (Pilon and DeBresson 2003), of an idiosyncratic evolution and different patterns of coexistence with formal institutions (Bachmann 2003) and political players (Beccatini 1998), of social attitudes towards change and adaptation (Saxenian 1994), in some cases of personal connections and shared values (Lorenz and Foss 2003) that lead to the formation of informal practices such as trustworthy behaviour, standards for establishing reputation and identifying unacceptable behaviour, a widespread propensity towards open, and flexible mind-sets.
A crucial function of support to the development of network and social capital is played by informal institutions such as trust. For Buckley and Casson (1996) co-operation produces efficient outcomes only “when a given amount of mutual forbearance generates the largest possible amount of social trust” (p. 422). Trust may help economic agents reduce transaction costs. For instance, in the presence of information asymmetries, trust may contribute to smooth the transaction by avoiding costly bargaining over prices and the safeguard clauses. Trust stimulates the process of diffusion of intellectual property while reducing the risk of opportunistic exploitation of intellectual property and helps the pooling of complementary knowledge and productive resources.

Because of the difficulties of gathering information in the market, the partners may also rely on the consideration of factors such as reputation. Long-term working relationships amongst firms and individuals may help them get to know each other and make clear their reciprocal intentions. An interesting scenario is represented by the network of scientists in the biotechnology industry described by Zucker et al. (1995a and 1995b). Here, new ideas freely circulate since shared norms of social behaviour have facilitated the adoption of trustworthy attitudes. Emotional bonds (e.g. long-term friendship) contribute to create a type of trust based on direct and reciprocal identification. The use of boundary-spanning social networks by DBFs seems to enhance both learning and their flexibility in ways that would not be achievable within autonomous hierarchies. Likewise, American biologists seem to appreciate that opportunistic behaviour increases the risk of exclusion from the network, whereas trustworthy behaviour seems to have a positive impact upon the intensity of circulation of key information within the network.

This discussion is somewhat related to evolutionary and “dynamic-capability” theories that look at regional systems through the lenses of “learning-communities” and regard them as vehicles used by firms for getting access to new knowledge and competences that enhance competitiveness. Indeed:

“innovation processes depend on links between individual firm behaviour and collective coordination in terms of markets, institutions and knowledge” (p. 181) and “particular importance is placed on the availability and diffusion of knowledge as well as on how institutions, organisations and coordination mechanisms help coordinate individual behaviour” (McKelvey 2003, p. 182).

Insofar as industrial dynamics in biotechnology are characterised by both technological and systemic complexity, industrial firms need to master an increasing number of technological and scientific knowledge bases, and must develop complementary capabilities in relation to a growing number of interrelated activities (Coombs and Metcalfe, 2000). As a consequence, firms tend to rely on assets and capabilities possessed by other organisations. Inter-firm collaborations are considered effective when competitive advantage requires the synergistic combination of resources which a firm is not able to develop autonomously in a timely and cost-effective way or to buy via spot contracts. If firms were to get access to complementary assets by uniquely using spot contracts, the exploitation of synergies may not be independent from transaction costs, including “dynamic” ones (Langlois 1991), especially when intangible assets of a tacit nature are involved. For this reason, full appropriation of added value may be easier in situations where firms agree to “reduce the cognitive distance between them and to mutually align themselves in order to appreciate each other’s needs and capabilities and to adapt their own needs and capabilities accordingly” (Madhok 2002, p. 285).

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5 Similar results are obtained by Saxenian (1994). However, her work focuses more on the coupling between porous boundaries at the firm-level and competitive attitudes.
3.2 On Public policy: Preliminary Considerations

In many countries public bodies engage in supporting the biotechnology industry using arguments such as market failure as well as increasing returns. Physical infrastructure has been created – incubators and science parks – where new ventures can focus on core activities and network with firms undertaking similar or complementary activities. Investments have been made in basic research and grants have been offered to start-ups (e.g. Small Business Innovation Research awards in the US or the Smart Award in the UK). Governments also try to affect organisational arrangements internal to the industry by promoting distinct research foci (Germany, Japan) public/private partnerships (Scotland, Sweden, Japan) and the formation of scientific and industrial networks or formulating different regulations in terms of IP protection and public safety.

Interestingly, some authors (Enright 1999, Bresnahan and Gambardella 2004, Beccatini 1998) emphasise the difference between clusters’ birth and growth. Although findings cannot be carried over from one industry sector to another, according to Bresnahan and Gambarella (2004) who discuss cluster dynamics in ICT, cluster formation responds to “old economy” factors, such as inputs (e.g. skilled labour) and demand conditions. At least initially, economic policy should be directed to create the proper context for entrepreneurship, that is, easy access to markets in the absence of constraining regulatory and fiscal barriers. Later, “once clusters are founded, they do deliver the kinds of opportunities emphasised in the increasing-return framework” (ibid. p. 857).

4. On Public Policy

4.1 The Rationale behind Public Policy in This Area

As this work aims to evaluate SE’s policies in biotechnology, in this section I address the topic of economic policies directed to innovation and technology exploitation. I shall initially stress that much of the debate in this area is centred on factor conditions and incentives to innovate. Mainstream economics tend to describe those incentives as dependent on the appropriability of the returns generated by investments in R&D. Science and technology are generally treated as information. The major source of difficulty lies in the public good aspect of these intangible assets (Metcalfe 2000). At first, a trade-off exists between preservation of incentives associated with appropriability and external economies originating from diffusion. On the one hand, investors will demand a sufficient degree of protection to exploit IP to their own advantage. However, information (knowledge) may not be entirely codified or it may be accessible only to people endowed with the background necessary to

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6 Apart from Scotland, attempts to develop biotech clusters have been taking place in other European (England, Germany and France) and Asian (Japan) countries, and single states and counties in the US (e.g. Phoenix, San Antonio, Maryland, etc). The level of public engagement, however, varies across locations.

7 Many European countries have adopted similar initiatives, in some cases by relying on the European Investment Fund Start-up Facilities (Ernst and Young 2003).

8 For example, in the Bioscience Innovation and Growth Team’s report Bioscience 2015 (“Improving National Health, Increasing National Wealth”) Tony Blair states that bioscience and biotechnology offer “new medical opportunities that challenge traditional patterns of diagnosis, healthcare and disease prevention; the UK… has an opportunity to be at the forefront of research and development in these exciting areas”. As a result, expenditure on the science base is “now set to grow at a rate of the 10 percent year on year reaching £2.9bn by 2005-06”. The bioscience is seen as “vital for our vision of building a knowledge-driven economy and is critical for the development of the pharmaceutical industry”.

9 The twofold relationship between market structure (i.e. firms’ size and number and degree of concentration within specific sectors) and innovation rates has attracted a great deal of interest and is relevant insofar as it relates to competition policy. However, it is not strictly relevant for the present discussion and will not be addressed in great detail.
understand it. In addition, spillovers generate positive externalities and there may be a substantial difference between private and social benefits. Consequently, policy makers tend to favour the diffusion of information (including uncodified knowledge). In the end, the characteristics of the resulting regime of appropriability will depend on the combination between the degree of non-transferability and protection granted over IP (Teece 2001).

Another problem associated with innovative activities is the high degree of uncertainty and transaction costs. On the one hand, the innovative pace characterising high-tech industries can be dramatically fast and firms may have to deal with the risk of technological obsolescence. Uncertainty may reduce expectations of achieving satisfactory results and produce substantial variations in the technological and economic context, thus increasing dynamic transaction costs. On the other hand, prior to disclosure, the transfer of implicit knowledge through markets entails information asymmetries and measurement problems. For both codified and tacit knowledge, information asymmetries arise because the seller has no interest in disclosing details about the effective correspondence between real values and the market prices (i.e. Arrow’s “information paradox” (1962)).

Innovation and competition-related issues, however, have a significantly different meaning when analysed in a Schumpeterian or evolutionary framework. Indeed, the above discussion is on the ability of different degrees of competition and of public intervention to deal with market failure in the context of competitive races for innovative solutions. The focus is on agents’ pre-competitive concerns and incentives to innovate and presupposes that, given a certain institutional and regulatory environment, markets will eventually reach equilibrium. Quite differently, Schumpeter’s focus is on competition that originates from innovation.

“Change implies static inefficiencies, which do not represent the rationale for public intervention. On the contrary, static inefficiencies are the necessary cost of sustaining variety and must be incurred if economic systems are to develop and evolve. The main concern of the policy maker is therefore that of ensuring a balance between creative destruction and order, which is to be interpreted as coordination of the system rather convergence to a centre of gravity.”

Furthermore, “innovation is a process which involves flows of technology and information between the productive domain, the market and the research sector, and between heterogeneous agents, endowed with complementary assets and competences” (Cusumano 2000, p.5).

Not only is the theoretical framework different, but also it moves away from a vision where the focus is on R&D investments and the key question is how to strike a balance between avoiding free-riding and/or imitation and promoting or subsiding the generation and diffusion of knowledge. As noted by Metcalfe (1997), policy in this area touches on firms’ behaviour and the availability of innovation opportunities.

“Technological opportunities are characterised by plurality in the kinds of knowledge which contribute to technological advances, cross disciplinarity, and plurality in the range of institutions in which relevant knowledge is generated. The firm may be the final determinant of innovation opportunities but it is embedded in a wider network of knowledge generating and disseminating institutions.” (p. 414).

Firms are embedded in complex systems of interactions that shape their ability to gain access to knowledge and take advantage of enhanced competences. Biotechnology (particularly in life sciences) is an industry where connectivity, trans-
disciplinarity and reflexivity define the new regime for scientific and technological innovation (Cooke 2003). Consistent with the “triple-helix” model, a number of public/private organisations participate in the innovative process organised via different governance modes. DBFs play the key function of elaborating, implementing, codifying and commercialising new discoveries and “know-how” (McKelvey and Orsenigo 2001). The central feature of public policies is the relation between firms and the set of institutions and relationships which shape technology development and commercialisation. These policies aim “to improve the connectivity between firms and their appropriate technology support system” (Metcalfe 2000, p. 415).

4.2 Scottish Enterprise’s Framework for Action

According to SE’s 2003-04 “Framework for Action” (see www.scottish-enterprise.com), the agency’s long-term strategy to promote the growth of a Scottish biotechnology cluster consists of seven crucial areas of activity: (i) commercialisation of the research base; (ii) accessing finance for start-up and growth; (iii) improving business support and infrastructure; (iv) attracting inward investment; (v) building international connections and trade development; (vi) improving skills and developing the labour pipeline; (vii) strengthening vital networks.

Information about the nature and the rationale behind SE’s activities (see table 1) has been generated by extensive discussions with SE’s executives, participation at public conferences (e.g. Edinburgh 2nd Bioscience Forum), from SE’s website and the literature (Hood and Peters 2003; Cooke 2003) available. The above discussion, I suggest a taxonomy of policies working in two-dimensions: differentiating between cluster policies affecting “old” and “new economy” factors (Bresnahan and Gambardella 2004) or distinguishing innovation policies whose rationale is market failure from those resting on systemic failure (see figure 1).

It could then be possible to argue (see figure 1) that activities (i), (ii), (iii) and (vi) tend to fall into the category of those influencing “old economy” factors in the attempt to boost entrepreneurial attitudes. Their rationale is market failure. Although SE does not have the power to legislate and regulate (these pertain to the Executive, the British Government and the EU), its activities in these areas mainly consist of direct support to individuals and businesses. For example, it provides financial support to scientists who want to commercialise their proprietary IP. In this case, SE intervenes mainly to offset underinvestment in highly uncertain activities whose costs of due diligence threaten to slash expected profits. However, it is also possible to recognise elements of a systemic approach insofar as these funds change the relationship between academics and academia and offers the possibility of engaging in commercial activities while remaining affiliated to their universities. SE also helps existing start-ups gain access to public money by running the Scottish “Smart and Spur Awards” and the “Co-investment Fund”. It invests in infrastructure such as incubators, science parks, manufacturing facilities. Finally, SE draws attention to the skills needed by industrial community and creates networks whereby firms can get easier access to key people. Generally speaking, this kind of interventionist stand can be interpreted as having been directed to make capital, infrastructure and skills more accessible to the local scientific and industrial community so as to stimulate the emergence of indigenous ventures in the attempt to reach that critical mass of people, organisations and skills that will trigger incremental dynamics.

Activities (iv), (v) and (vi) qualify as systemic and “new economy” policies. Apart from actions directed to raise Scotland’s profile and attract foreign investors, a number of initiatives aim to strengthen national and international networks. Local networks such as Nexus, BioDundee, West of Scotland Bioscience Network, Edinburgh Bioalliance are active in bringing different key players together and facilitate collaboration and technology transfer. SE also works closely with existing organisations, such as the
Bio-Industry Association Scotland (BIAS) or Medical Devices Scotland (MDS). Other important initiatives are: the Scottish Biotech Forum, whose strategic goal is to promote the development of the sector and make of Scotland a major player in international arenas; and the Scottish Stem Cell Network, a multi-disciplinary forum that aims to bring together people with different but complementary skills in order to stimulate cross-fertilisation in an area where Scotland has a great potential.

SE has also been active in stimulating international cooperation and access to global markets in the attempt to stimulate the creation as well as the growth of new ventures. It has launched a series of initiatives to establish contact with countries and regions with bioscience and biotechnology bases (Maryland, Korea, and Sweden). SE also organised showcases for Scottish companies in countries such as Japan and Canada. Scottish Development International (SDI) is another initiative promoted by SE which helps companies gain access to world-class people, world-class technologies and potential business partners. The programme has so far helped 120 companies in setting up commercial and collaborative agreements with foreign companies for an estimated £18m of newly created value. Finally, Globalscot is an international network that acts as a gateway to dedicated online web services, giving access to business information about Scotland and fellow members (about 720) worldwide.

5. Evaluating Policy Performances

As argued earlier, national systems and individual companies reacted differently to the molecular biology and genomics revolution and biotechnology is best analysed from the viewpoint of knowledge-management and information flows that inform agents’ actions and allow the system to work efficiently in the presence of a growing tendency towards functional specialisation. Technology and IP transfer increasingly involves a plurality of actors (PROs, DBFs, MNCs) whose core technological competencies range from combinatorial chemistry to molecular biology. Technological and organisational trajectories are affected by exogenous factors (regulations, macroeconomic cycles, health policies, public concerns) as well as endogenous factors (firm strategies).

Compatibly with evolutionary economics, firms' scope for action is then seen as limited by the selection mechanisms imposed by their environment providing the link between endogenous and systemic dynamics (McKelvey 2003). Firms will adapt their behaviour to the characteristics of the environment and their ability to act upon it affects the implementation of autonomous strategies. This ability may in turn be dependent on the way core activities and relationships with key partners are organised, requiring more emphasis on firms' reliance on collaborative and interactive behaviour. Public policies can then be evaluated on the basis of systemic approaches and their effect on single firms' performance.

The extent to which this analysis concentrates on “new economy” policies depends on the stage of development and structural features of the local industry base. SE claims that Scotland’s biotechnology sector punches now well above its weight in the global marketplace. Since 1999, highlights within the Scottish biotechnology community include an average growth rate per annum of more than 20 percent. This expansion has led to a situation where over 500 organisations (100 are classified as

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11 As argued earlier, this is to be kept distinct from market failure approaches in which innovation activities and the market for intangible assets are characterised by three basic factors: uncertainty, information asymmetries and imperfect appropriation of returns. As a result, the system is very unlikely to reach equilibrium and efficiency unless the government intervenes to promote investments and grant innovators legal protection over their intellectual property.

12 Jack Perry, CEO of Scottish Enterprise, speaking at the annual Biotechnology Scotland dinner at the EICC on the 12th of February 2004.
DBFs) are currently operative in biotechnology-related activities and employ between them some 26,000 people. However, the majority of Scottish DBFs are small in size (none has more than 50 employees) and a considerable proportion of those involved in drug discovery struggle in the early phases of discovery and pre-clinical trials. They seem to suffer from the paucity of private venture funds in Europe, the absence of Scottish VC firms dedicated to biotechnology, the lack of managerial talent required to develop sustainable businesses, and the distance from the head quarters of MNCs - which complicates the search for strategic partners (Hood and Peters 2003). Nevertheless, the figures above suggests that an industry base is beginning to emerge and policies oriented towards the provision of a suitable infrastructure and financial support for newly created ventures seem to be paying off.

SE now wants to move towards a stronger focus on growing businesses to promote incremental dynamics. Ascertaining the existence and the functioning of well established links and networks within and beyond the Scottish biotechnology cluster is a primary concern. Firstly, network dynamics may help deal with the limits imposed and take advantages of the flexibility guaranteed by their size (scale and scope economies). Secondly, as DBFs play a critical role in the implementation and commercialisation of IP, SE’s effectiveness is to be assessed in terms of its capacity to generate external economies that can be key to the achievement of DBFs’ strategic goals (particularly through access to complementary assets and capabilities). For that reason, a survey involving the CEOs and executives of Scottish DBFs13 was aimed to assess how significant and effective have SE multi-activities been in support of local businesses, especially via the establishment of local and international networks.

5.1 Results: General Considerations
A first set of questions in the survey looked at the nature of firms’ activities and core competencies. The results show firms at different stages of development and adopting distinct business approaches. Most the companies in the sample have an international focus, in the sense that they are looking for co-developers within as well as outside Scotland and they sell (or plan to sell) their products and services worldwide. In particular, companies engaged in drug discovery seem from the very beginning concerned with finding customers and commercial partners in Britain, Europe, North-America and Asia. This seems particularly true of companies that have been in business for five to ten years: nearly all of them (88 percent) have so far managed to enter international markets or signed licensing agreements with MNCs. Companies active in drug discovery and formed more recently – over the past two years – tend to have a narrower focus. With the exception of Strakan, which along with Ardana Bioscience qualifies more as a small pharmaceutical company than a DBF, none of the companies interviewed that engage in drug discovery and development have so far managed to bring any product to the market (either directly or via collaborative and licensing agreements).

However, among those involved in drug discovery, there was a sharp differentiation between: i) companies implementing “virtual” business models - i.e. outsourcing a considerable proportion of R&D to be then commercialised either autonomously or in partnership with other organisations14; ii) DBFs that concentrate exclusively on specific research projects; and (iii) companies involved in key complementary activities that internalise both R&D and commercialisation activities. As we shall see,

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13 Thirty companies were originally selected (of which one went bankrupt in the meanwhile). These were all core biotech companies formed after 1994 and operating in life sciences – i.e. therapeutics and diagnostics.

14 Ardana Bioscience and Strakan are interesting examples of companies outsourcing a considerable proportion of R&D activities and other services.
the adoption of distinct business models translates into differential relationships with the local environment and evaluations of cluster policy (as well as different rates of success in advancing through the different stages of drug development).

Another important source of differences in companies’ ability to carry on autonomous research projects and generate revenues from product commercialisation relates to whether companies operate in the domains of diagnostics or therapeutics. Diagnostics are characterised by a lower degree of complexity and uncertainty arising from both R&D (e.g. toxicity tests) and commercialisation activities (e.g. regulations). Generally speaking, the time necessary to bring products to market seems to be shorter (compared to 10 to 12 years in drug discovery) and the amount of the investment required less important (1billion USD is a figure frequently referred as necessary to fund the discovery and development of a new compound, including clinical trials and approval by public agencies). Approximately 40 percent of the sample has core competences in developing diagnostic tools or doing toxicity analysis by relying on bioscience and biotechnology. Six companies currently generate revenues from product/service commercialisation or royalties from IP licensing and their markets tend to be geographically diversified.15

Finally, the companies’ interviewed were relatively small - all qualified as SMEs (Small and Medium Enterprises) – which does not seem to have strong effects on relative performances – i.e. revenues or number of products brought to market. In other words, companies of a similar size tend to have significantly different performances.

5.2 On External Economies and Networks: A Descriptive Analysis

Before engaging in any descriptive analysis of external economies and network dynamics, it is worth making some basic observations concerning Scottish DBFs’ location choices. To begin with, nine companies (53 percent of the sample) chose to be located close to the PRO where their core IP (or a significant proportion of it) was originally or is currently developed. This seems to happen either because the founders were not willing to relocate elsewhere for personal reasons or because they prefer to maintain and continue to exploit existing links with their departments and find Scotland a suitable location for taking innovations to market, e.g. because of the regulatory environment. In addition, when a new venture exploits some IP developed within academia, the deal with the university’s commercialisation unit frequently entails setting the company in the same location (e.g. Cypex in Dundee). Five companies decided to relocate to Scotland and motivated by the attractiveness of the location in terms of: i) public support (public venture capital, physical infrastructure); (ii) links with the local scientific community; iii) friendly regulatory environment; iv) presence of key customers or partners; and v) closeness to key research laboratories. In relation to public support, two companies indicated that SE’s support was crucial in affecting their decision.17

Fifty-three percent of the sample (three quarters of the companies formed after 1999) has to some extent taken advantage of public venture funds available through the different schemes listed in section 4.2. Regardless of the criticism attracted by this

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15 Axis-Shield is the most significant example.
16 For example, although StemCellUK Ltd was originally formed in Melbourne (Australia), in 2000 the management decided to move back to Edinburgh thanks to favourable regulatory environment.
17 The decision to locate here because of the characteristics of the environment and the quality of the public support offered may be necessary to achieve critical mass. However, I should also signal that some information collected in relation to the dynamics of the local labour market seems lead in the opposite direction. In particular, although people previously employed by companies that failed sit in the board of directors of new start-ups, some interviewees express concerns with a consistent trend of migration of skilled and experienced executives south of the border.
A considerable proportion of firms relied on and benefited from it in their early stages of development. Often, access to these schemes requires that companies locate in Scotland and this constitutes another important explanation for start-ups' location choices. Also, 47 percent of the sample is located in science parks or spaces made available within university campuses, which helps them save on both fixed and variable costs.

On the subject of labour dynamics, given Scotland's excellent record in academic-training in bioscience, no company in the sample had problems in accessing human resources with a satisfactory degree of training in bio-scientific disciplines and they stressed the usefulness of SE's schemes and networks set in place to recruit people with specific skills. As a result, the majority of companies recruited their personnel among Scottish graduates and post-graduates. However, some also search more widely for people with a specific profile and their laboratories gather together a number of different nationalities. According to transaction cost economics, the availability of skilled labour may have a positive impact on companies' cost-structure in terms of the investments necessary to search and reward them, while knowledge-based views of the firm suggest that the adequate quality of the skills may help in the process of competence-building.

Nevertheless, a number of companies complained about the paucity of technical and practical skills as well as new recruits' lack of business and commercial acumen and this situation may have negative consequences in terms of new-firm formation and growth (Bresnahan and Gambardella 2004). In the former case, Scottish DBF's seem to demand that particularly young graduates are trained in more practical activities in addition to theoretical scientific disciplines, a part being addressed by programmes such as PreBio. In the latter case, it may be necessary to stimulate greater interdisciplinary and flexibility in the job market, whereby people with experience benefit a greater number of companies as they change job more frequently. However, the Scottish cluster has so far not reached the critical mass to allow people to take advantage of a growing number of employment opportunities and attract talented people from abroad. For this reason, a number of interviewees pointed to the need to focus on growing two or three successful and sustainable ventures to function as anchor organisations whose presence may generate positive externalities. First, Scotland's image will be promoted abroad and will help attract new talent. Second, these companies may provide people with managerial training and this may benefit other organisations.

Finally, as indicated by the managers of some DBFs engaging in basic research\textsuperscript{18}, they may operate as hubs, virtual pharmaceutical companies, that take advantage of the concepts developed by other organisations\textsuperscript{19}. Some of the programmes supported by SE, such as the "co-investment fund", work in this direction and they are considered more suitable for companies in more advanced stages than proofs of concept\textsuperscript{20}, whereas international networks (SDI and GlobScot) provide commercial links with an international focus and the potential to attain economies of scale and scope.

\textsuperscript{18} For example, Invinity Ltd and Amoebics Ltd.

\textsuperscript{19} As argued earlier, companies like Ardana and Strakan seem to have moved in this direction with some success. Other companies, such as Laxdale, seem to follow the same path. However, it should be noted that not all successful Scottish companies active in this area adopt this model (e.g. Cyclacel) and, therefore, it would not be appropriate to draw premature conclusions in relation to the suitability of different models.

\textsuperscript{20} Often companies in the post-start-up phase find it difficult to get finances: VCs consider them too small and risky – i.e. the cost of transaction associated with concluding a deal seem far too high compared to expected returns – and public venture money is invested in proofs of concept or it is not enough to finance sustainable growth (particularly if related to drug development).
The Scottish cluster also seems to have developed a thick and efficient network of intermediaries such as lawyers and business consultancies. DBFs are especially concerned with IP protection, which highlights their key role in codifying and shaping science into technology as well as confirming the theory that not all knowledge freely floats within the network. Also, unlike in other countries such as Italy where part of the industrial structure is organised on the basis of clusters, banks here are generally perceived as being too large, too conservative and, hence, too international in their focus. SE, however, seems to provide help by means of its financial schemes as well as by putting companies in contact with VCs and angels. Finally, some companies also work with organisations providing specialised services (e.g. contract research, clinical trials and bio-manufacturing) or are themselves providers of specific products/services.

Most companies (88 percent) seem to be part of a formal network or trade association, which offers people the possibility to build and arrange more intense and, sometimes, informal kinds of interaction. In turn, informal connections hold the potential to be transformed into formal collaborative agreements between two or more organisations.

For many firms in the sample informal relationships are essential to gather information about potential partners and indeed some of these have been transformed into formal agreements. From a socio-economic perspective, this may be interpreted as if networks and information flows are used by firms not only to identify user needs and partners with complementary capabilities (which emerges very strongly from the survey), but also to detect free-riders and un-trustworthy players. In this sense, Scottish DBFs seem to rely on trusted mediators that facilitate the approach to other organisation (and SE is one of those). Although experienced managers tend to rely on their personal networks often established by their long-term exposure in the market place, younger companies seem keener to use contacts provided by SE’s representatives or academic links.

Moving to the topic of formal collaboration, to date 82 percent of the sample has entered collaborative (research partnerships or co-development) or long-term commercial agreements that were essential to the implementation of their strategy with either PROs (76 percent) or other private companies (50 percent) located in Scotland. In some cases the number of collaborations involving specific organisations such as Cyclacel Ltd in Dundee or the Roslin and Moredum institutes in Edinburgh, seems to indicate that they may begin to play the role of anchors (however, more quantitative evidence is required to draw conclusions). Managers’ experience in establishing connections seems also to affect companies’ capability to enter into alliances and commercial relationships locally and internationally. In this domain, the difference between companies whose corporate culture is based on collaborative approaches and are willing to exploit the support and synergies potentially available in their own environment, and those more reliant on their own resources and social capital appears to be more evident.

Biotechnology seems to be an industry where companies specialise in distinct technological trajectories. Thus, they are sometimes compelled to find users and collaborators elsewhere (Prevezer 1998). Fifty-three percent of the sample has ongoing commercial relationships with foreign companies and these involve licensing agreements with MNCs and are generally characterised by a higher degree of formality. As highlighted by some interviewees, standardisation and formality is a must when dealing with big bureaucratic organisations located elsewhere. A number

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21 For example, Biovation Ltd

22 Bachnam (2003) explains that the existence of such organisations help the cluster developing those informal institutions that promote cooperative and interactive behaviour.
of examples were provided of links created through the SDI and existing personal connections.

Forty percent of the sample also has scientific or co-development partnerships with foreign organisations. In a number of cases, local connections with academics have been used to establish collaborations with foreign PROs and other private companies. This mechanism works either through personal links or by accessing international collaboration projects. In some circumstances, Scottish DBFs have also been active in acquiring (three cases) or merging with foreign companies (two cases). These strategies seem to be motivated by the needs to i) combine complementary assets; ii) explore advanced knowledge-bases; and iii) enter new markets.

6. Conclusions

One of the core arguments developed in this paper concerns the possibility of employing a two-dimensional taxonomy to classify cluster and innovation-oriented policies implemented by SE in support of the Scottish biotechnology industry. Consequently, attention has been initially concentrated on those activities directed to affect supply and favour access to key inputs such as (skilled) labour, capital and infrastructure. The rationale behind these activities generally relies on static inefficiencies and, in particular, market failure. However, this work also argues that labour market dynamics and easier access to capital hold the potential to reshape the structure of the local industry and stimulate entrepreneurial activities, which may be critical to the development of a sustainable cluster. Empirical evidence seems to suggest that SE’s attempt to improve the existing infrastructure and provide financial support to new ventures has led to the formation of a number of new private ventures. Some of these ventures engage in exploiting the bioscience base to develop new drugs and diagnostic tools, whereas others are moving into complementary activities (contract research, clinical trials, etc). Despite the local industry’s persistent structural weaknesses (see section 5), investments in this area appear to have produced some encouraging results as the number of people and organisations currently active has doubled in the past five years.

A significant pool of skilled labour and intermediaries is also in place, while flows of useful information seem to affect the strategy of a considerable proportion of Scottish DBFs. However, the process does not seem to move in the direction of developing required skills such as technical experience in applied and managerial activities. In addition, location choices can be partly explained by scientists’ immobility and the contractual conditions associated with public grants as well as with knowledge dynamics. Despite encouraging signals, this evidence seems to suggest that talking about the existence of sizeable external (“Marshallian”) economies benefiting the different components of the local industry might be a bit premature.

This paper also takes into consideration measures explicitly directed to promote network and incremental dynamics. Fransman (2001) described the complex system of interactions that led to the birth of Dolly the sheep as one that straddles “the firm, the university, and the government funded research institute in order to facilitate the flows of knowledge that are necessary in the commercialisation of research” (p. 273). A few years later, this work aims to ascertain the extent to which the same sort of organisational model has become part of the industrial culture of an entire national industry and whether public policies in this area had any sizable effect. Although distinctions should be made in relation to a number of factors – i.e. (i) distinct corporate cultures, (ii) stage of business development, (iii) degree of product/service standardisation and (iv) sectoral features – the majority of the companies in my sample seem to regard both collaborative and market relationships within the local cluster as important to preserve and enhance their competitive position.
Interestingly, a number of companies engage in strategic partnerships with other organisations and rely on formal and informal networks to identify trustworthy partners. In this sense, Scottish DBFs’ vision seems also to entail accessing international markets and entering alliances with MNCs and other SMEs engaging in complementary activities. A number of them appear to resort to SE’s programmes in order to achieve their goals.

Having reached these conclusions, the key question of whether similar results could have been achieved by different means – i.e. without resorting to some of the activities described in section 4.2 – remains open. In particular, one could ask whether public policy, as suggested by Bresnahan and Gambardella (2004), should not be concerned only with activities such as investing in education, basic research and general infrastructure, opening markets, and stimulating entrepreneurship by encouraging the success of skilled people (for example through tax incentives). While interventionist schemes have been implemented and obtained comparable results in other European countries (for example, France and Germany), they have also attracted increasing criticisms on the basis of arguments principally relating to: (i) the absence of appropriate and well established ways of assessing costs vs. benefits (including opportunity costs), (ii) the potential crowding-out of private investment, and (iii) the diseconomies often associated with the public management of economic activities. For instance, as far as this study is concerned, many companies in the sample showed some scepticism about SE’s £150million investment in the new intermediate technology centre (ITI) for life science created by SE in Dundee.

In conclusion, while the primary aim of this project is to evaluate the performance of Scottish Enterprise’s support strategy for biotechnology, this paper mainly focuses on the descriptive analysis of some key facts helping our understanding of the forces driving the local biotechnology industry. A forthcoming paper I will address some of these issues in more depth by ascertaining how and to what extent SE’s multi-activity strategy was truly effective in helping Scottish DBFs to grow and be competitive in the marketplace.
Table 1: Sample of policies implemented by SE

| Commercialisation of the research base | The £33m “proof of concept” initiative finances the commercialisation of biotech projects across Scottish Universities and research institutes. To date it has supported 41 projects. A similar initiative (Scottish Health Innovation) promotes the commercialisation of technology generated by the NHS. SE is also active in promoting public/private partnerships: e.g. this year £15m was secured for the most advanced medical imaging centre in Europe. |
| Finance for start-ups and growing businesses | “Smart and Spur Awards”. This is an initiative of the UK government similar to the aforementioned SBIR in the US and it is managed in Scotland by SE. Last year six awards went to biotechnology companies. Recently, SE’s focus shifted from new venture creation to growing existing businesses. The “Co-investment Fund” consists of a £45m public/private equity fund and is intended to help small companies balance their financial position in order to obtain money from banks and private investors. It is matched by the “Business Growth Fund” that provides small loans and equity investments (between £20000 and £100000) to firms satisfying specific criteria. SE also set up an organisation called Connect that organises meetings between companies and potential investors, such as VCs or angels. |
| Business Support and Infrastructure | The Aberdeen Science and Technology Park opened a new £1.25m wing for Davidson House. In Dundee, the first building at the Medpark is now on site. The Glencorse Building at Pentland Science Park was opened, as was the Alexander Fleming Building at the Hannah Research Institute in Ayr. At Stirling University Innovation Park, a 36,000 sq. ft new building was completed in 2002. In 2003 SE Edinburgh and Lothian lunched a new £200m Centre for Biomedical Research based at the new Edinburgh Royal Infirmary teaching hospital and adjacent new Edinburgh University Medical Faculty. It includes a campus that is meant to facilitate the interaction between health services, academia and the bio-pharmaceutical industry. The same a dedicated biomanufacturing campus was opened in Grangemouth. Three new technology and science parks were also created in the Glasgow area. |
| International and trade links | International cooperation initiatives: e.g. Maryland, Korea, and Sweden. Showcases for Scottish companies in countries such as Japan and Canada. “Scottish Development International” (SDI) helps Scottish companies gain access to world-class people, world-class technologies and potential business partners. Finally, “Globalscot” is an international business network and works as a gateway to fellow members worldwide. |
| Skilled labour | The “PreBio” and “Biotech Talent Scotland” programmes. |
### Table 2. The companies in the sample and their core activities

<table>
<thead>
<tr>
<th>Company</th>
<th>Activity</th>
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<tbody>
<tr>
<td><strong>Strakan</strong></td>
<td>A small pharmaceutical company engaged in the research, development and commercialisation of new drugs in areas such as women's health, the ageing male, and skin disorders. Founded in 1995 by CEO Harry Stratford (founder and former CEO of Shire Pharmaceuticals) and Prof John Kanis (Sheffield University), Strakan markets a number of products in the UK and Europe for the treatment of diseases as osteoporosis, angina, acne, immunodeficiency and the management of oncology.</td>
</tr>
<tr>
<td><strong>Ardana Bioscience</strong></td>
<td>A company outsourcing a considerable proportion of R&amp;D and other services. Ardana aims to discover, develop and market innovative products in areas such as Prostatic Disease and Andrology in Men and Infertility and Endometriosis in Women. Ardana Bioscience was founded in 2000 and only this year has raised £20 million in VC funds. Its first product, an androgen replacement therapy, is expected to be commercialised by 2005. VC money collected over the past few years (£34m) will be invested in commercialising products derived from research conducted at the Medical Research Council's Human Reproductive Sciences Unit in Edinburgh.</td>
</tr>
<tr>
<td><strong>Axis-Shield</strong></td>
<td>The company was created in 1999 by the merger of two innovative healthcare diagnostics companies - Norwegian-based Axis Biochemicals, and UK-based Shield Diagnostics. Further strategic growth was achieved by the acquisition of other European companies, which has given the group a focus in Point-of-Care (PoC) testing as well as distribution channels in both the UK and Scandinavian countries. The group now consists of laboratory and Point-of-Care businesses. The company is listed on the London and Oslo Stock Exchanges. Axis-Shield is active in five clinical areas: cardiovascular disease, autoimmune, disease alcohol-related, disease diabetes, and infectious diseases.</td>
</tr>
<tr>
<td><strong>StemCellUk</strong></td>
<td>A company formed in 1994 in Melbourne (Australia) by Dr Peter Mountford and focuses on embryonic stem cells. The company was originally formed thanks to a research project by Dr Mountford at the Genome Research Centre at the University of Edinburgh. As a result, the management decided to take the company out from a virtual status into direct engagement in basic research and to move back to Edinburgh where, also thanks to a particularly favourable regulatory environment, the core of these activities is currently carried out.</td>
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<tr>
<td><strong>Cypex</strong></td>
<td>The company originated from a research project carried out at the medical school of Ninewells hospital. The University of Dundee gave Cypex an exclusive license for the exploitation of a technology allowing for new ways of expressing human enzymes in bacteria.</td>
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<tr>
<td><strong>Invinity</strong></td>
<td>An Edinburgh based (at the Roslin Institute) dedicated biotechnology company focusing on human antibody.</td>
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<tr>
<td><strong>Amoebics</strong></td>
<td>A company based at the University of Edinburgh and with key expertise in biochemistry.</td>
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<tr>
<td><strong>Biovation</strong></td>
<td>A company based in Aberdeen engaging in antibody and protein engineering. Its activity is geographically diversified and its reliance on the local network minimal.</td>
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<tr>
<td><strong>Pro2Kem</strong></td>
<td>Established in Dundee in 2002, the company develops optoelectronic bio-detection systems based around micro-engineering.</td>
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<tr>
<td><strong>LUX Biotech</strong></td>
<td>Based in Edinburgh, the company focuses on the development of screening technologies and products using advanced cell biology, light and optoelectronics.</td>
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<tr>
<td><strong>Diagnostics Scotland</strong></td>
<td>The company, based in Edinburgh, manufactures of monoclonal blood grouping reagents, supplying vital products to hospitals, blood services and other diagnostic companies in over 50 countries.</td>
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<tr>
<td><strong>CXR Bioscience</strong></td>
<td>Based in Dundee, the company aims to accelerate drug development, reduce product attrition, and to attempt “rescue” where appropriate for molecules with unexplained preclinical observations. This is achieved through the innovative application of molecular biology and genetics to improve the predictability and human relevance of preclinical models.</td>
</tr>
<tr>
<td><strong>Laxdale</strong></td>
<td>Based in Stirling, the company develops novel treatments for psychiatric diseases</td>
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<tr>
<td><strong>EctoPharma</strong></td>
<td>A life science company based in Edinburgh. It develops proprietary technology which will be the basis for a new generation of safer pesticides with significantly low environmental impact.</td>
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<tr>
<td><strong>R-Biopharm</strong></td>
<td>Based in Glasgow, the company develops and sells diagnostic kits for food safety.</td>
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<tr>
<td><strong>QCMD and Qnostics</strong></td>
<td>Based in Glasgow. Assessment of nucleic acid technology in the diagnosis, management and control of infectious diseases.</td>
</tr>
<tr>
<td><strong>POCT</strong></td>
<td>Based in Dundee, the company develops and commercialises diagnostics kits.</td>
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</tbody>
</table>
**Figure 1: A Taxonomy of SE’s Cluster and Innovation-oriented Policies**

- **Executive**
- **Scottish Enterprise**
- **National Branch**
- **13 Local Branches**
- **SE Network Management**
- **SE Operations**
- **Service to Business**
- **Service to Business International**
- **Service to Industry**
- **Service to People**
- **Service to the Community**
- **Cluster Teams**
  - Aerospace
  - Biotechnology
  - Microelectronics
  - Software
  - Others

**Cluster Policy**

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<thead>
<tr>
<th>Innovation Policy</th>
<th>Market Failure</th>
<th>Systemic Approach</th>
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<tbody>
<tr>
<td><strong>Old Economy ➔ Birth</strong></td>
<td>- Promote Investment: e.g. Co-investment Fund</td>
<td>- Promote Inward Investments: e.g. Proof of Concept, SMART Award, etc</td>
</tr>
<tr>
<td></td>
<td>- Help Start-ups Commercialise IP: e.g. Proof of Concept, SMART Award, etc</td>
<td>- Develop Hard Infrastructure: e.g. business parks, incubators, etc</td>
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<tr>
<td></td>
<td>- Promote International Cooperation and Market Diversification: SDI, “GlobeScot”, Maryland, Korea, Japan initiatives, etc</td>
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**New Economy ➔ Growth**
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