BUSINESS INCUBATORS AND SUSTAINABLE INNOVATION

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Innovative businesses are often the result of collective action of organisations involved in many-sided market structures, which can be found in and around business incubators or technology centres. Within such frame environments, many group interests beyond those of single producers and their immediate clients exist and interfere. Rather generically, important economic outcomes of innovations are sequences of cost reduction events at the level of economic sectors, where the nature of (sector-wise) technology is influencing the pace of these events. At the conceptual level, we describe the social learning and social innovation process which leads to sustainable innovation by means of the influence exerted by firms on each other within constrained environments such as business incubators. These environments need not to be organized according to any sector logic. We propose that the influence exerted between firms is increasing in firm similarity, in the degree of product complementarity, and also to depend on (mutual) trust relations.

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1 Introduction and motivation

Innovation is an important engine of economic development but it also entails a dual nature. While it enables formidable increase in productivity and comfort, occasionally finding solutions to very hard problems, in the longer term it also creates new problems and holds the potential for more and new types of disasters. Most of these features are difficult or impossible to predict in fine detail. However, the awareness of unforeseen risks is growing in various types of consumer and producer populations around the world. A rather vague but increasingly vociferous request is to stick to "sustainable solutions" in technical, economic, and social terms, meaning to find collectively acceptable and commercially viable ways to impose a sense of "expected medium term stability" of societal development. Examples of the dual nature of innovation abound. Some more extreme cases should illustrate this. Satellite telecommunication is revolutionizing entertainment, monitoring and parts of business. Space debris as an inevitable consequence is posing serious future threats and costs. Improved or even personalized medicines cure ever more diseases but they are posing both, huge challenges and costs of care for the aged, possibly also by proliferating later-life complex illnesses. Deep sea drilling taps formidable oil and gas reserves but is also producing hard to handle spills. Alternative energy solutions to fossile fuels can lead to astronomic future decommissioning costs. We note that, very much in symmetry with the role of sustainability in society as a whole, in the world of firms and markets, the incubation process may be viewed as a "moderator," which attempts to overcome the disadvantages of highly paced, short-term oriented capitalist economies. In sections 2 and 3 a concept for representing the societal forces shaping sustainability and incubation for the innovating firm is described and ways of transforming the concept into concrete tools of assessment and valuation are pointed at.

2 Towards assessing the role of sustainability and incubation

Direct environmental consequences of using processes are already difficult to assess, e.g. think of the large number of variants of bio-fuel processing, which are contained in public science data bases like *Science Daily*. Consequences of using products and services may also be diverse, for

instance by invoking a path dependent mechanism, which may "lock in" earlier but eventually inferior solutions, a point put forward insistently by (Arthur 1989). Given multiple risks, both for the producer and the consumer of innovations, a *branded risk assessment* may be called for. Exactly this may be achieved in a credible way by an incubator network, which allows a multi-party involvement. Brondizio et al. (2009) and Ostrom (2009) teach us – albeit in a more general context – that polycentric systems (implying multi-party involvement) hold the key to sustainable solutions of complex problems involving environmental, social and a series of commercial and economic interests. Following (Ostrom 2009) there are four types of goods, namely [1] *Common pool resources* (example: forests), [2] *Public goods* (example: knowledge), [3] *Private goods* (example: clothing) and [4] *Toll goods* (example: daycare centers), which are mainly characterized by different property or apropriability related considerations. From a perspective which is more concerned with the description of innovation by firms, we stipulate that the new technologies imply multiple and changing roles of goods: Increased *personalization* of private goods may be achieved by heavily drawing on public and private knowledge and commercialization is achieved by different business models, for instance by making use of the role of the toll goods or by means of technology induced zero-price co-offerings as has been put forward by (Anderson 2009).

Apart from these basic considerations, empirical incubation processes assume complex structures and dynamics and are driven by complex motives. In spite of numerous failures, incubation is rather wide-spread today, both within developed and emerging economies. The context based evolution of incubators is leading to situations of "meta-innovation", as is described for the case of emerging Brazil in (Etzkowitz, de Mello, and Almeida 2005).

In the last twenty years best practices for incubation have also been established as described in (Bergek and Norrman 2008), and the need for multi-criteria evaluation and ranking of business incubators is in high demand, see e.g. (Schwartz and Göthner 2009). However, the difficulty of evaluating incubators is related to the difficulty of measuring and assessing organizational creativity as described in (Sullivan and Ford 2009). Density of technological connectivity between firms has an impact on the inventiveness of science based firms, and somewhat surprisingly, venture capital has less influence on innovation intensity than expected, as is found by (Rickne 2006).

The role of branding incubators during and after the eventual success of technology spin-offs is highlighted in (Salvador 2010), the suggestion being that this somewhat special type of branding should be increased. As in any market, in the market for incubator tenants too, there is a need to educate the consumer, to stimulate demand and to cultivate awareness of the competition as is put forward by (Patton et al. 2009), and whenever possible, a "pipeline" for new business ideas should be sustained. This leads us to the domain of Knowledge Management (KM). Following Palacios et al. (2009), obstacles exist to effective KM introduction. Important reasons are named in (Yu 2002): (1) absence of a culture to share knowledge; (2) employees do not know much about KM; (3) no knowledge diffusion and learning; (4) insufficient internal knowledge transfer; (5) obsolete or over-complex technology; being the most important. (1)-(4) relate to insufficient networking and (5) to a narrow minded technology policy, e.g. the best technology from a network neighbourhood is not adopted. Gilsing et al. (2009) are stressing the fact that across different incubation environments, more radical innovations seem to be less often pursued than incremental ones, leading to *under-innovation*. Raymond and St-Pierre (2010) draw our attention towards a frequent situation, where "… the impact of R&D on product innovation is mediated by process innovation."

3 A concept for a process-combining computational approach

In the sequel we will nevertheless attempt to draw up a concept, which is capable, in principle, to assess the role of sustainability and incubation and to evaluate networks of firms within such structures. If appropriate, we also indicate which method can be used to solve the resulting optimization and data analysis sub-problems. Figure 1 collects the items and sub-processes involved in the incubation of firms, which posses the option to produce in a sustainable manner. An incubator may be regarded as a kind of super-firm, with less stringent short terms goals but with complex, and multiple, long term objectives. Both, a single firm and an incubator are subjected to competition but also face aspects of potential cooperation. Both must decide which markets to enter. For some hints of how to model such decisions see (Wawrzyniak and Wislicki 2008).

While a mature or a non-incubated firm will focus more forcefully on price competition and product-line differentiation, an incubator may be thought of enabling more technological competition by its tenants, postponing "classical" competitive activities. Sustainability considerations are not within the shot term commercial goals of the single firm. Entry points for sustainability issues into the incubation-market process depicted by figure 1 may be created by long term actions of organizations within polycentric societal power systems as considered by (Ostrom et al. 2009). Eventually, they may impinge on all market participants to reflect about the outcomes, the private and the collective image effects of producing more sustainable products and by employing more sustainable technologies.

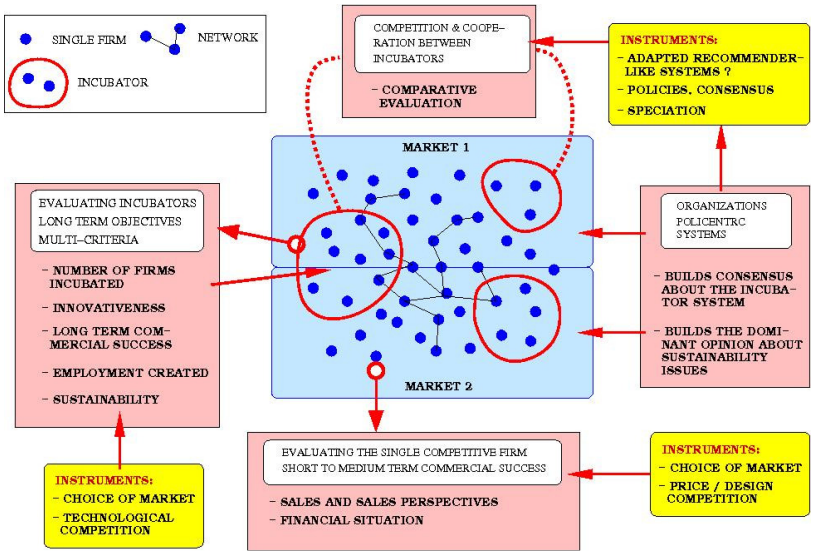

Figure 1: The incubation process and the entry points of sustainability issues and commitments.

At the level of incubator competition and cooperation there is room for designing instruments which for instance propose speciation of incubation services for certain markets and regions in a more principled manner. As described in (Schebesch et al. 2010), more adapted recommender systems proposed for computational marketing may be constructed. In order to finally arrive at a problem representation which more directly allows the derivation of computable models and the derivations of more concrete evaluation procedures for incubators and firms, we next focus on the innovation process, which seems to be central to both incubation and sustainability issues. In figure 2 we represent several sub-processes of innovation. The single firm is attempting to innovate in order to enhance its competitiveness. Innovation can be the result of "classical" in-

house research and development, with costly exploration of new technological and product design solutions. The risk of in-house research can be temporarily lowered by incubation. Cost reduction of processes can eventually induce product innovation. Hence, evaluating the design complexity of technologies and its influence on cost reductions over time, and especially so over past cumulated production as in (McNerney et al. 2009), will be most important in order to assess the pace and regularity of innovation events as a function of its underlying "engineering design". A new technology is represented by the introduction of a new interconnection matrix between process components. Sustainable technology solutions may be characterized by certain types of "recognizable" interconnection matrices. In more recent times, other important aspects of innovation processes such as innovation contests and social innovation are increasingly considered. Two premises lead to the growing relevance of this type of innovation procedures:

-In certain product classes and markets it becomes increasingly difficult to "forecast by expert opinion" what consumers really like.

-Organizational setup and transaction costs decrease dramatically with the spread of the internet and of different types of social forum subnets.

While in general such approaches are clearly useful for automated marketing and forecasting procedures (Schebesch et al. 2010), there is evidence that they can be applied (with adaptations) for innovation processes too, as is outlined in (Terwiesch and Xu 2008).

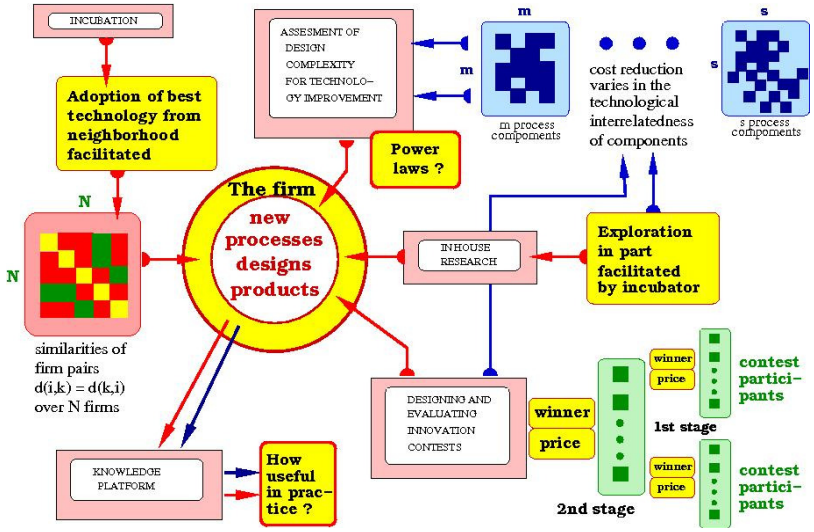

Figure 2: Innovation processes: innovation contests and technological interrelatedness.

The results of an innovation contest may be a process or a product innovation (figure 2, lower rhs process components). The innovation contest requires designing and evaluating a competition for new solutions of posted problems amongst a large number of participants originating from a larger societal context. In order to make these contests more efficient and more credible (i.e. to enhance serious participation), such innovation contests have to be designed to encompass two or more stages, with appropriate mechanisms for picking winners and for paying out prices for attractive or promising solutions. The outcomes of such innovation contests may contain also additional information, for instance with regard to acquaintance with and challenges caused by using sustainable processes and products, i.e. information about the degree of empathy and *goodwill* present in a wider population with regard to *sustainability commitment*.

A final item of figure 2 is the process item called "knowledge platform". While it would be certainly desirable to evolve such a knowledge platform (especially for incubators), there is to

this day no compelling procedure concerning the collection and handling of information about all the mentioned sub-processes of innovation, their variants and success rates, and their relation to sustainability issues. In empirical practice all these sub-processes function separately and different modelling attempts also tend to concentrate on single aspects, for instance on how to best design innovation contests.

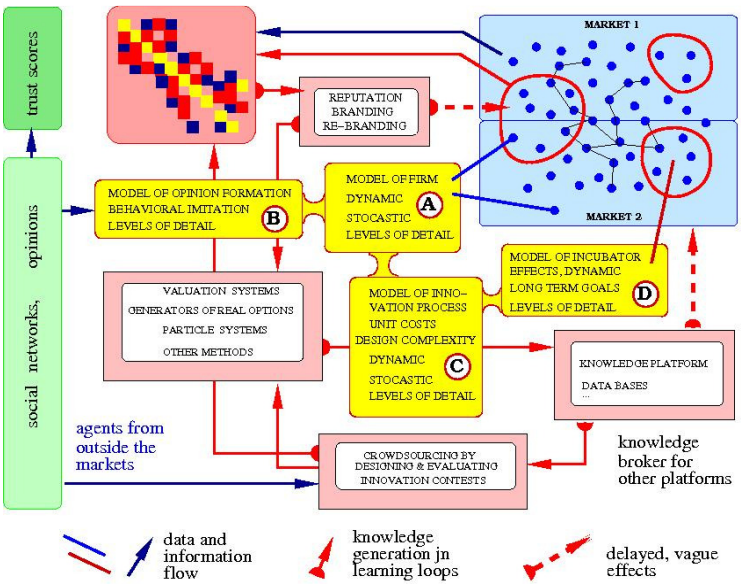

Figure 3: Real-life feedback loops in social learning connected to aspects of innovation, incubation and branding, and behavioural imitation central to sustainability issues.

In figure 3 finally we consider the real-life feedback loops within the process of social learning, entailing innovation (from figure 2), incubation, behavioural imitation and opinion formation, which are central to sustainability issues. These are real life processes occurring by means of more or less formalized mechanisms, differing in composition and, from industry to industry, coming in varying degrees of relative importance.

The figure distinguishes two contexts, namely the two markets with both independent and incubated firms, and, a more general, non-specific, "background" of social networks with agents which may belong to the markets. As innovation processes unfold, incubators and firms start a process of (mutual) trust formation, which results in trust scores (to what extend should firm *i* trust firm *j* ?), which may also help to evaluate firm *j*, for instance concerning for the stage of maturity it has reached within an incubation process. The evolution of trust scores is using information from the markets but also from the "background" social networks of firms. Trust scores are important in order to guide a behavioural imitation or a technological adaptation process. As incubators function like a kind of super-firms, but with a broader and more long-term oriented set of goals (see also figure 1), they are competing and cooperating with each other. The resulting reputation is an example of *social capital*, which may enter a more general assessment and valuation process indicated by the box "Valuation systems" of figure 3. This box contains an entrance named "generators of real options", which highlights the fact that option models for many different scenarios of the stochastic innovation-incubation process may have to be created. Both, the reputation mechanism and the evolving knowledge platform (see also figure 2) do not exert an unconditional influence on market agents, and any possible effect may also be strongly delayed in time. Finally, crowd-sourcing by innovation contests, using agents from outside the

markets, is also inherited from figure 2. The boxes from figure 3 named by encircled letters A,B,C, and D describe processes which can be modelled separately by using dedicated dynamic models. An evaluation would be done by way of (1) massively collecting data about past market-incubation interactions (about firms, incubators, sustainable technology projects, etc.) and (2) attempting to cluster and classify the data by using technological or other constraints, as is described in general approaches to constrained clustering (Basu et al. 2009). A cluster would contain sustainable technology projects with favourable outcomes and another those projects with unfavourable outcomes for the involved firms.

4 Conclusions

We contributed to the conceptual discussion of a complex situation from economic reality, namely the innovation process in the presence of incubation while coping with the implicit societal pressure of adopting sustainable technology, without the latter being of short term commercial advantage to the single firm. We developed a concept for integrating incubation and sustainability issues into real-world process models but, simultaneously, also into a computational concept concerned with the question of how to assess and to value the complex stochastic process resulting from the incubation-sustainability relation.

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