Directional Certainty in Sustainability-Oriented Innovation Management

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1 Innovation as an Ambivalent Mode of Change

What makes innovation representing a particular type of change, behaviour, or problem-solving, so ambivalent? An innovation's economic, ecological, and social effects reveal themselves once its use has begun. Since unintended side effects are discovered simultaneously with the creation of facts, it is always too late to reverse these effects. "Ambivalence is the experience we encounter when, just as we achieve or realize our goals, we discover that it is actually not the goal we had intended, but rather something else, up to and including its hindrance" [23, p. 80]. Two traits in particular, inseparable from the term "innovation," make it a double-edged phenomenon:

1. Innovation refers to a non-constant, non-linear mode of change, and a break with all things available and known, at least in terms of the context of the innovation at hand. Commensurate with the core question "How do new things come into being?", the problem solving potential of innovations is based upon expanding the pool of available solutions – regardless of whether they are new products, technical operations, organizational structures, institutions, etc.
2. Innovations require entering the realm of the unknown. They lack an exact prediction and direction, at least in terms of what we understand from traditional economic optimization, and comprise to consciously take risks which are associated with chances. The revelation of currently unknown options is hence best summarized as "No risk, no innovation!"

The ambivalent, or "paradoxical" structure of innovation arises from the fact that "innovations are reliant on conditions that cannot be fulfilled at the time of the innovation, as something completely new is generated. These are conditions that will rather need to be discovered, manufactured and tested during the innovation itself" [17, p. 14]. In addition to embedding the innovation object into the dominant usage context (seen in "conventional" innovations management primarily as a challenge), and its eventual marketability (recontextualization), which is unknown *ex ante*, an innovation process aiming at sustainability also requires dealing with another uncertainty, i.e. ecological and social side effects (sustainability for the future). This means not only the direct social and ecological effects of a marketable innovation, but also the indirect effects that could possibly stimulate growth, which could overcompensate for a long-term gain in efficiency or ecological consistency. "We have to deal with the paradox that technical innovations can, by solving known problems and fulfilling required needs, also generate new needs and previously unknown problems" [19, p. 149].

But to make the argument, that we should refrain from innovations, would be just as wrong as the constant appeal for a risk-taking mentality as a price for competitiveness and material wealth. From the point of view of sustainable development, it is much more important to complement innovation processes with configuration options which can lead to a decrease in typical modernization risks.

1.1 The Thin Line between Good and Bad Intentions: The Rebound Effect

Rebound effects can appear when a measure seen in an isolated context is established as having a positive sustainability effect, but also creates further effects on other decision levels, or other parts of the system which are seen to negatively influence sustainability. Three kinds of "rebounds" can be distinguished:

Technical Rebound Effects: The introduction of a new product, or process, which appears based on favourable sustainability principles can be seen as counterproductive from the point of view of another sustainability principle. For example, the automotive industry implemented a method for building lighter cars which led to considerable energy savings. The savings in weight were mostly achieved by substituting metal by plastics whose production and disposal can pose new ecological problems (efficiency advantage vs. consistency disadvantage).

Growth Effects: Sustainability innovations in the form of new products, processes, or usage systems can generate counterproductive growth effects if they do not lead to sufficient substitution of previous (less sustainable) solutions. The introduction of the 1.5 litre automobile could lead to many households acquiring this vehicle in addition to their existing "fleet" as a third car. The expansion of wind energy, or photo-voltaic use could induce additional resource and energy flows if the energy market absorbs the additional amount of regenerated electricity instead of accordingly reducing energy from fossil fuels and nuclear power.

Psychological Rebound Effects: Technical sustainability innovations can cause undesired reactions on the level of system use, thus cementing the exact consuming culture originally intended to be changed. Consequences, such as e.g. the introduction of the regulated three-way catalytic converter, which lately prevented an overdue societal confrontation with motorized individual traffic due to its "integrated alibi module," could be induced by the forthcoming series production of the so-called "fuel cell cars." Exactly the environmentally conscious people, who had until now chosen to not own a car, could now, as a result of such technical-ecological reassurances, become car owners. Additionally, car owners who had previously used their car only when there was no other alternative, would now possibly use their car for short "runs" as well.

1.2 Risk Effects

The difference between dangers and risks is, according to [10, p. 30–31], that the latter always represents the results of your own dealings or failures. [16, p. 55] defines two kinds of risk, of which the first is based upon well-known reasons and interrelations. Although its probability of occurrence can only be determined within a certain margin of error, the possible consequences are recognizable and can be reduced through "experience-based precautions".[1] The second kind of risk is characterized by a high level of uncertainty, where even the possible effects themselves are difficult to predict.[2] Similarly, but oriented towards a stronger methodology, is the typology of the German Government's Scientific Advisory Board for Global Environmental Changes (WBGU). It defines six kinds of risk, as shown in Table 1 on the following page[3]:

[4, p. 38] defines three kinds of risk, namely those whose potential for damage are:

- qualitative-punctual ("one strike"), i.e. due to extreme combinations of natural phenomena and very powerful technologies,
- dependent upon an extremely unstable condition of the system being encroached upon, or
- quantitative-cumulative ("little by little"), i.e. through a quantitative increase of individual, relatively harmless "nibbles" that come into being.

Special attention is paid to a possible ecological technology conflict resulting from the playing off the quantitative-cumulative against the qualitative-punctual problematic, in terms of a "efficiency revolution through risk technologies" [4, p. 32]. How accurate this estimate is can be seen e.g. in the use of thermal waste, gene technology, synthetic chemistry and (the return of)

[1] Example: The risk of a core meltdown.

[2] Example: While the possibility of scratching a transgenic plant from a test field is hard to predict, the determinability of the possible consequences of such a genetic transfer is rendered nearly impossible.

[3] See [15, p. 25f.].

Risk Types	**Example**	**Possibility of Occurrence**	**Damage / Effects**
Cyclops	Disease, Droughts, Volcanic eruptions	Unknown	Determinable
Pythia	Release of transgenic plants	Unknown due to unidentified biochemical processes	Unknown
The Sword of Damocles	Major Technologies: Chemicals, Nuclear Power Plants, Massive Dams	Low	High
Pandora's Box	Pumping the biosphere full of toxins due to uncontrolled expansion (e.g. DDT)	Unknown due to spatial and ecological complexity	Unknown
Cassandra	Creeping decay of ecological systems (e.g. climate catastrophes); Great time difference between cause and effect	High	Unknown
Medusa	Over-exaggerated dangers of ionized and electromagnetic radiation from cell phones	Low	Not scientifically provable

Table 1. Risk typology of the German Government's Scientific Advisory Board for Global Environmental Changes (WBGU)

atomic energy. After all, the high efficiency potentials of such technologies are seen by their proponents as contributions to sustainable development. Von Gleich [5] sees quantitative-cumulative risk scenarios as less problematic. In such situations, dealing with the unknown by applying a trial-and-error principle is adequate, at least when an effectual margin of error allows "something to go wrong" once or twice [5, p. 289].

But it should not be forgotten that it is exactly the combination of growth and quantitative-cumulative risk effects which can become a serious problem in sustainable development. All new economic activities imply an ecological price. New innovations, therefore, only earn the title of "sustainable" when the attained environmental savings or burden relief effects outweigh the "investment" of resources, energy, or other ecological costs incurred by the innovation's introduction. This also means: When something new is brought into the world and falls short of its envisioned sustainability effect, it automatically becomes part of the problem, because at its bottom line, it, too, has induced new material flows. This is an *ex ante* highly uncertain balance, therefore, a latent growth risk arises. Even if the balance turns out to be a positive one, an even more difficult problem remains: As the comparably more advantageous innovation achieves a gain in sustainability, it must replace the old, less advantageous solution. Otherwise, the innovation principle instead becomes an addition principle, therefore creating additional energy and material flows. Selection mechanisms might be missing, which in turn actually crowds out previously existing, less sustainable solutions. Even when these circumstances seem to primarily concern investment goods, they can also be relevant to consumer goods, particularly when the innovation (from the consumers' point of view) strongly differs from previous solutions.

On the other hand, another problem arises where available goods and operations are constantly replaced by new solutions due to effective selection: Intact, still useful components in the material sphere lose their value and wind up being thrown out. How can the danger of premature disposal and shortening of the usage and product life cycle be avoided? Here, the acceleration of innovation activities could lead to the cultivation of a "throw away" syndrome. Both scenarios taken together comprise a selection dilemma. The extremely (vague) solution could be: The substitution which is introduced must occur at the exact point in time when the usage life span of the solution to be exchanged has effectively reached its end. But this kind of uncertain undertaking can, in view of its frequency, add up to a largely underestimated risk. The latter is characterized by an integration of no less than three uncertain incidents:

1. Is the new solution at all more advantageous than the old one?
2. Will a substitution occur?
3. Will the substitution occur at the "right" point in time, or will it lead to a counter-productive depreciation?

2 Starting Point for Directional Certainty (Overview)

The often posed requirements for innovation processes with the goal of adequate directional certainty can be broken down to the following realms (among others):

- Limitation of the "effective power" [4, p. 35]; avoidance of technologies whose risks can turn entire generations into test objects;
- "Error leeway" [24]: The innovation being developed should be able to be corrected in case damage or dangers occur after market introduction;
- Reversibility: The innovation should not promote any "lock-in" effects or "structural conservatism" [19, p. 153].

The requirements allowing any consideration at all of such criteria are established at the start of the innovation process. Directional options available during the implementation phase of an innovation tie in with the previously established selection of an innovation object. Whether completed facts arise and which degree of freedom for a change of course or hindrance remains, subsequent to any damage potential occurring, depends on how far the concretion of the innovation objects was anticipated. Adaptation and formation boundaries, which continue to exist after the start of the process, require certain structural characteristics from the innovation process. Here, the four starting points should be considered, which are shown in Fig. 1 and form the subject matter of the following sections.

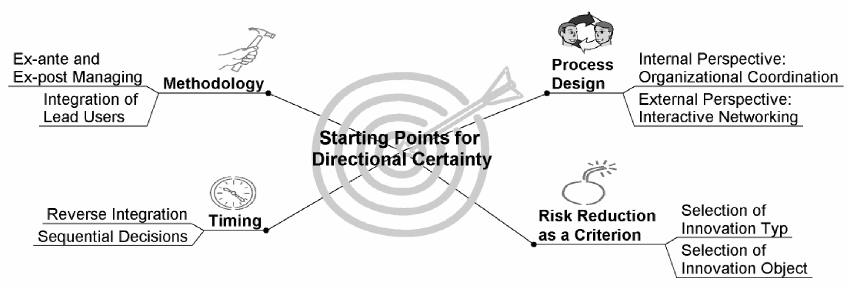

Fig. 1. Starting point for ensuring directional certainty

The process design of innovation projects can be, roughly simplified, represented by internal and external "guard rails." The first subsumes the influence of company-internal actors and measures of innovation management. Here, the organizational integration of innovation activity as well as the resulting innovation climate count. The second guard rail is based upon interaction with company-external actors who are integrated into the process. This differentiation should, however, not be misunderstood; the coordination of the external interactions is also, of course, a responsibility of innovation management. The following will draw special attention to risk reduction criteria as well as timing, due to its particular influence upon directional certainty. Parallel to this, the use of corresponding applied methodologies will be illustrated.

3 Risk Reduction Criteria

The selection of an innovation type spans the categories of product, procedures, service, usage system, organization, and institution. The actual innovation object is a moulding of the selected type. A product innovation in the automotive industry leaves e.g. the question open of whether the innovation object is meant with regard to an airplane, bicycle, or car and, – if a car is in fact meant – what it exactly means for the car. The type selection as well as its development into a specific object, which results at the end of the innovation process, both have great influence upon directional certainty.

In both parts of the decision, the avoidance of structural risks and rebound effects can enter in as additional selection criteria. Thus, an innovation idea, whose theoretically provable sustainability effect only represents a chance compared to its formidable sustainability risks, is best abandoned in favour of an alternative project whose theoretical sustainability effect, although perhaps lower, nevertheless, has fewer risks associated to it. The determination of an innovation project's risk structure can be oriented according to the following criteria.

Ecological Reversibility: When they in principal have an exit option, innovations should avoid "leaving tracks." Here, irreversible ecological damage is meant which remains after a technology, or market, no longer exists: accumulated emissions, resource inputs sealed-up surfaces, left-over waste, buildings, damaged or destroyed biotopes, loss of biodiversity, etc.

Conformity Flexibility: The correctability of a started development path is first of all a question of technical changeability. Here, design characteristics, such as e.g. a module building design or updateability, are meant. With the increasing non-material character of the innovation type (service, systems, organization, or institution), its conformity flexibility is not a technical, but a communicative issue. This includes cybernetic directional characteristics which are based upon social interactions. Participation models can open communication channels as a means to use stakeholder dialogue as an information deliverer or early warning system. Such mechanisms additionally allow a feedback between the operational innovation process and the public "opinion barometer."

Economic Reversibility: The economic reversibility of an innovation project can be increased in two ways. Supply-side "lock-ins" can be alleviated when investment is immobile and product-specific, i.e. irreversible capital is avoided. Demand-side "lock-ins" can be contained when the improvement substitutes for previously existing means and instruments meant for the fulfillment of needs, i.e. it ties down no additional routines and needs.

Avoidance of a high infeed/effective power: When material-technical improvements or, changes are pending, preferable selections from the available ecological solutions are those which have proved to have the best environmental tolerances during the course of their co-evolutionary development history[4]. Additionally, the improvements displaying short space-time impact chains can be a revealed preference. Here, it is important to reduce the divide between the range of human dealings in time and space on the one hand, and the

[4] Examples: Ecological farming; fishing rods made of pieced-together bamboo (instead of glass fiber plastic alloy or carbon fibers); shoes made of leather, linen, and natural rubber (instead of plastic); bicycle guard plates made of wood (instead of plastic, tin, or aluminum).

knowledge of possible consequences of action on the other.

These criteria have consequences even for the selection of risk-reducing innovation types. New products and technical procedures display a direct ecological relevance due to their proximity to the physical-material realm, i.e. they necessarily induce or change material and energy flows. Contrastingly, new services, system solutions, as well as organizational and institutional changes have their starting point in the immaterial realm. Here, material effects reveal themselves only indirectly, notably through changed organizational structures, rules, and attitudes. Their chain of execution is, first of all, further-reaching in terms of cause orientation[5], and, second, more mouldable because the creation of ecologically relevant facts stands at the end of a long, particularly hierarchical causal chain. It is therefore no coincidence that modernization risks, which basically never represent anything more than innovation risks, are mostly dealt with under the category of "technology results assessment." The tendency therefore mostly leads towards product and technical innovations which are systematically connected to risk and rebound effects.

4 Timing in Innovation Processes

4.1 Configuration Boundaries and Decision Sequences

Taking the start of the implementation, i.e. the realization of a concrete innovation object as a time-based reference point, a sequential decision structure results with at least one "before" (*ex ante*) and one "after" (*ex post*) element. Therefore, all previous process phases can be classified into the area of *ex ante* control, whereby those phases dealing with the development of concrete innovation objects would rather be associated with a possible *ex post* control.

Within this time-based rough structure, the differentiation and exact progression of decisions are of great importance: The longer the concretization of the actual innovation object remains open, the greater the chance to react to any potential ecological or social detriments by means of corresponding adjustments. A process which passes through an "experimental phase" has the advantage, that it is more open to learning effects and interactions which can help the stabilization of the (sustainable) innovation direction. In other words: The innovation object should stay "mouldable" as long as possible in terms of having a high sustainability effect. A high level of formability can be achieved when the initial guidelines for the innovation are first limited to a goal corridor which allows adequate room for experiment, adjustment, or optimization. Instead of a premature anticipation of the innovation type or the

[5] Bierter [2], Schmidt-Bleek [18, pp. 67–70], and Stahel [20, p. 155] argue similarly, attributing greater efficiency advantages to new services and system solutions instead of product and technical innovations.

concrete innovation object, the initial problem alone could be formulated to be solved step-by-step over the course of the process. The decision-sequence to be tackled would offer the option to interactively shape each of the concretization steps, i.e. coupling it back to the external "guard rails." This results in a sequence which will be discussed in the following.

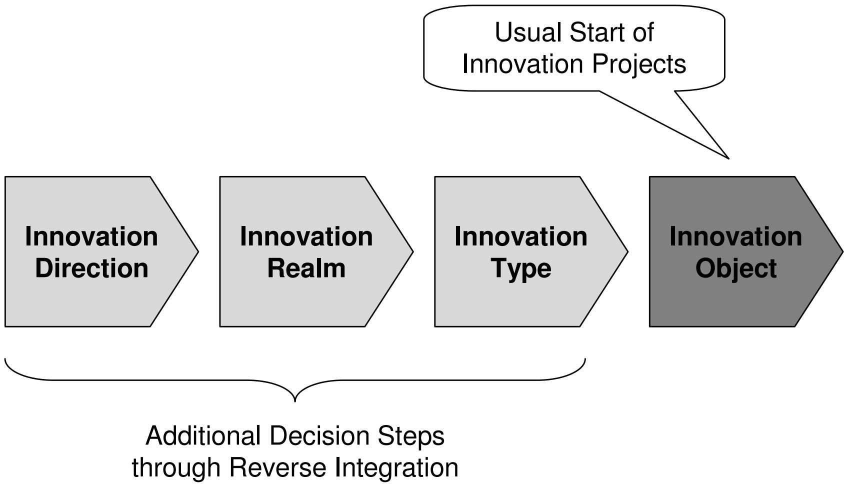

Fig. 2. Decision sequence through reverse integration

This sequential breakdown is identified as reverse integration. It explains how, based upon preliminary fundamental decisions, the "gates" for a certain innovation object are set. In principle, the above sequence can be reapplied from the start for each individual process. This would raise the possibility of routines, which predestine certain innovation types and objects, to be overcome. However, exactly this is normally not the case, as seen e.g. in the automotive industry. For nearly a century, and for the sake of satisfying mobility needs, this branch has offered only those solutions which comply to the type "product" and the object "car." As a result, the preliminary decision phase, which would answer the question of whether other kinds of innovation types (e.g. mobility services) or objects (e.g. bicycles, trams, and trains) would also be a possibility, was simply skipped or ignored completely. A high-tech automotive combine like Mercedes Benz therefore kicks off its innovation processes based upon a nearly 100-years-old method of making fundamental decisions. This is a sure way of blinding out causal and low-risk solutions from the start.

4.2 Reverse Integration

The way out of this strategic dead-end street is the reactivation of all preliminary decision realms, so that the rusty gates (staying with this metaphor) can once again be swung, and alternatives to the obdurate innovation directions can become possible. In particular, a management set on function orientation would have to take on a higher level of abstraction than the one dealing only with the drive and internal design of an already existing object called "car."

The four-level decision sequence shown in Fig. 2 relates to a "formation of circumstances according to their holistic capacity" [25, p. 78]. Through reverse integration, the realization of the innovation object is preceded by three decision steps, which can be seen as levels of an open hierarchical system [9] due to its increasing degree of abstraction. Therefore, more degrees of freedom develop, the higher the abstraction level, where the decision is made to the benefit of sustainable innovation. The cast-in-stone product and technical centrality found in many branches can only be overcome by reconstructing the "overlaying" decision levels. Here, not only could the request for an alternative use system to meet a certain need be made, but also possibly the general usefulness of entire business fields, or a particular business focus could be questioned.

The flip side of the coin recalls that an innovation process which ignores the highest hierarchy levels and starts directly on the level of innovation type "hardly has a chance to go beyond the horizon of previous" innovation practices. It will not reach the "corridors" which characterized the (previous) structures, organizational forms, or usage systems. It remains "tangled" in a web of innovation "routines" which almost never leave the technical dimension. Under these circumstances, only innovation prevents the vacating of an established technological paradigm and instead becomes an instrument of "structural conservatism" [19, p. 153].

This diagram joins the already mentioned conceptual elements and points out the following ideas:

- Increasing concretization – regardless of what stage of the process you are in – principally leads to a steady loss of formability and/or controllability of the innovation object. The target corridor (maintained by innovation management) in which the gradually developing innovation object moves along the timeline, opens itself in the shape of a funnel.
- The longer the process is "stretched out" due to the innovation decision being dismantled into successive concretization phases, the easier will be feedbacks from the external guard rails.
- The transition from the *ex ante* to the *ex post* control (perpendicular lines shown in Figure 3) additionally leads to a qualitative change. The start of the implementation phase is, at the same time, accompanied by the removal of uncertainty, thus, "perfect actualities" are created. A controllability is therefore only possible under certain conditions. The ideal case of an innovation path which could be controlled up to and including the point of market readiness is possible theoretically, but would hardly be encountered in the empirical world, and would also bring up the question of whether the object could still be named "innovation".

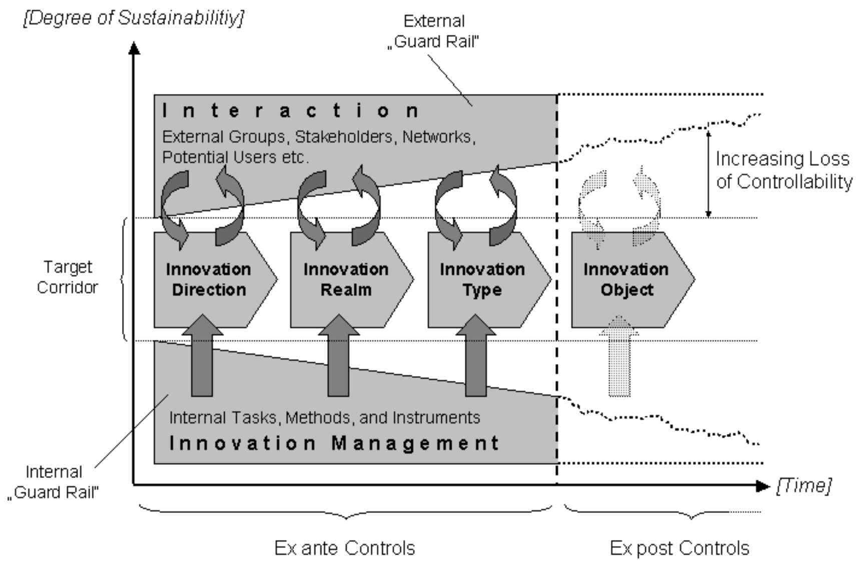

Fig. 3. Phases of an innovation process

Nevertheless, the transition to *ex post* control is not to be interpreted as the "point of no return." Formation options still remain, even if only rudimentarily. Although systematically decreasing controllability forms the inescapable background of each innovation process, it can strongly vary based upon the respective risk characteristics of the innovation object. Consequently, controllability is less a question of "either or" than it is one of "more or less."

The design of the first three decision levels will, in the following, be assigned to *ex ante* control, and the content concretization of the innovation object, i.e. the fourth level, will be attributed to *ex post* control.

5 *Ex ante* Control

5.1 Innovation Direction

The sustainability direction of a plan for innovation does not appear in a vacuum, but rather in close relation to history, competencies, general parameters, as well as additional specific attributes of the innovator. A strategic positioning by the company based upon any relevant market relationship is also included. The direction where the company can innovate to, without having to adjust its own assumption of disposition or overstep any core competencies, depends on the resulting path dependence. Only when this *ability* meets a specific *desire* a tendency towards sustainability-oriented innovation will result[6]. A normative management can deliver the basis for this desire, which Ulrich/Probst [21, p. 269f.] define as "development and implementation of a value system for the company [...], which is capable of establishing and legitimizing future company activities from a superior point of view, and creating a context with a point for all those involved and concerned." Borrowing from Ulrich [22] and Pfriem [14, p. 169ff.], normative management is represented as the highest of all management levels. The foundation of values and norms to be laid here should become effective in the form of orientation knowledge in all company-political activities, thus reaching beyond the "normative management" ⟶ "strategic management" ⟶ "operative management" chain of innovation management.

Along with such a goal-oriented or "offensive-minded" designation of a sustainability-oriented innovation direction, "defensive-minded" moments certainly also come into consideration. The starting point can be the search for solutions to a certain problem. Not only targeted search processes, but also a spontaneously occurring chance in the sense of "technology push" can be the initiator, assuming that the resulting goal direction pertains to "sustainability." Extrinsic impulses (market signals, new laws, Greenpeace "ante portas", etc.) can place external pressure on a company, resulting in an innovation project.

5.2 Innovation Realm

The determination of the innovation realm first implies the question of whether the innovation deals with an internal process, i.e. something concerning the inner workings of a company, or with a market-relevant innovation. In the former case, a determination of the respective company realm would be needed, while a determination of the relevant area of demand, function, or business field would be needed in the latter. For a chemical company desiring a more sustainable product line (innovation direction) in its "textile washing" realm, this could result in initially determining a relevant need, or function, e.g. "clean textiles without chlorine" or "clean textiles due to factor X being raised to increase resource productivity." Within this framework, product innovations would be only one of several possible solutions. An alternative would be the establishment of a new business field to meet such needs by an altered usage system in connection with the service of "clean clothes."[7]

[6] This does not mean that all sustainability innovations in a company must have goal-oriented processes as their result.

[7] For sustainable usage strategies in the laundry realm see Hirschl et al. (2001), pp. 54–57.

5.3 Innovation Type

A change in perspective is encouraged so that the process runs successively ("from above") and the previously determined innovation direction and the innovation realm converge with the implementation of the object (Figure 3). Thus, the next concretization step can be handled unbiasedly with regard to previous routines. From the viewpoint of satisfying a particular need or fulfilling a certain function, systematic and organizational innovations within a spectrum of possible innovation types are ranked equally with technical orientation or new products. Exactly the above mentioned ideas on ambivalence of the innovation principle are closely related to the need of giving such innovation types a high priority in the future whose effects are seen in new services, new usage systems, and a change in the consuming culture. System, organizational, and institutional innovations with low rebound and risk effects seem per se predestined for this.

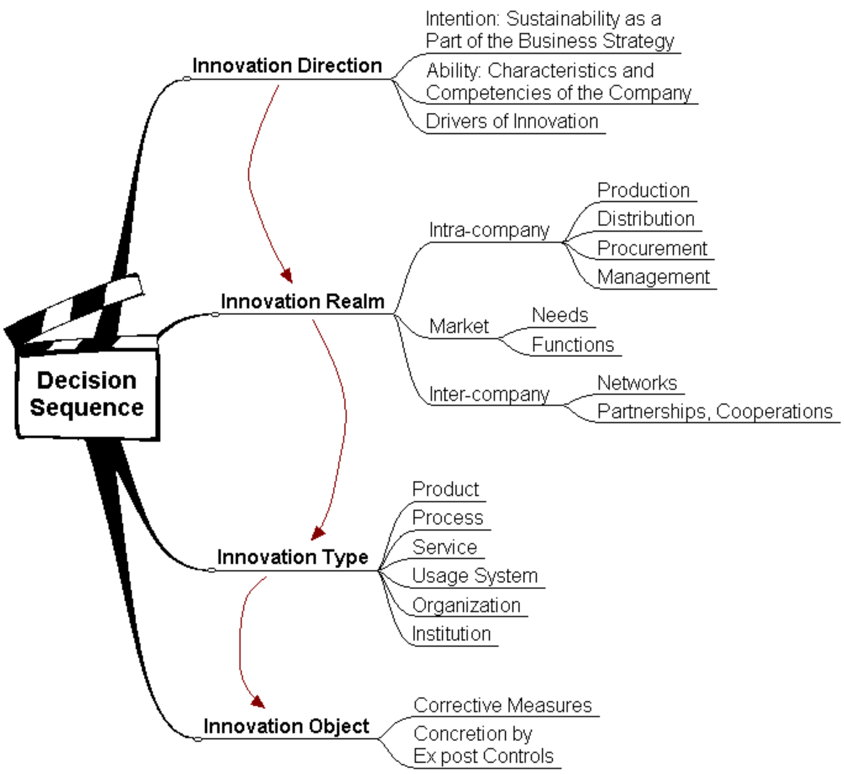

Fig. 4. Sequential innovation process

6 *Ex post* Control

The decision for a certain innovation object marks the last phase before diffusion, and is characterized by a gradual resolution of uncertainty. Over the course of implementation, unforeseeable side effects are discovered on the one hand, from which an intervention/directional need may be derived if needed. On the other hand, this discovery occurs simultaneously with the creation of facts, thus greatly limiting the process controllability. Although this structural ambivalence is in principle unavoidable, starting points for control and directional functions can still be named. It depends on whether the content design within the realm of *ex ante* control was adequately oriented to the risk reduction criteria. Remaining tasks for *ex post* control include (among others):

- Control and monitoring,
- Acclimation, optimization, or substitution of technical and organizational details,
- Cancellation/termination of the project, should side effects occur over the course of market introduction for which an appropriate substitution is not possible,
- “Recalls”,
- Flanking communicative measures which affect user behaviour and allow corresponding learning processes.[8]

The specification of the actual innovation objects also allows adaptability and optimization options for the purpose of increased sustainability effects. When e.g. a chemical producer has decided *ex ante* not only on the development of a new product (innovation type) in the demand field of “clean clothes” (innovation realm), but also on the innovation object “new laundry detergent”, further options still remain *ex post* for the concrete design: Should it be a compact detergent? Should it be offered in powder, or liquid form? Should its use be according to the “building block” system? Which resources and inputs of what origin should be included into the production? How should it be packaged, and based upon what distribution system should it be marketed? What accompanying communication means (directions for use, etc.) can be used to optimize the reduction of its harmful side effects, etc.?

7 Forward Integration through a Test Phase with Potential Users

Many side effects of an innovation are revealed during the course of trial, usage, or market introduction of the object, as the sustainability effect of an

[8] In a broader sense, these measures can also be understood as a stakeholder dialogue.

innovation is highly dependent on user behaviour. To determine the characteristics and routines of a "typical" user of the innovation object, it is possible to add an additional experimental phase to the innovation process. This could take place at the point between the *ex ante* and *ex post* stages and would attempt to create a usage context as close to the real world as possible. For this purpose, "test users" could be involved to reveal any possible negative sustainability effects, most notably:

- Technical,
- Performance-related, and
- Structural or overall system

effects. Particular attention should be paid here to rebound effects, whose occurrence is mainly connected to performance-related and structural aspects.

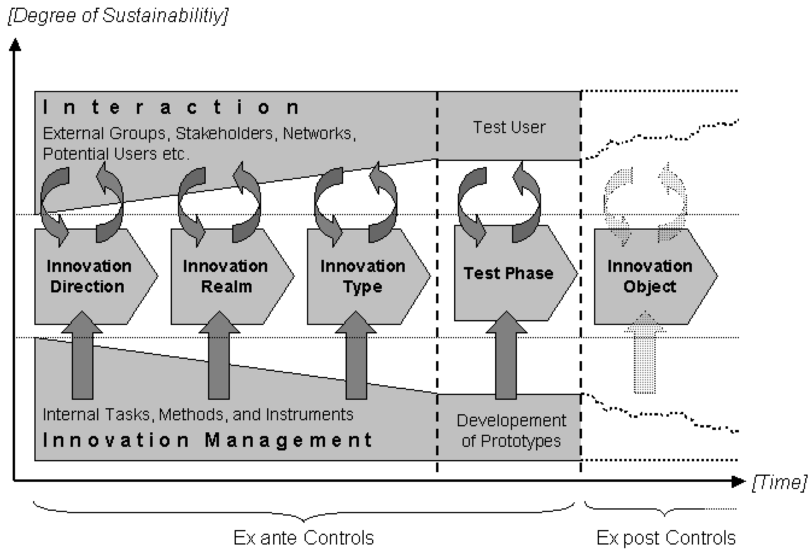

Fig. 5. Adding a test phase to the innovation process

This methodology draws from the "lead-user" approach developed by Hippel [7], but deviates from it in that the potential user must be suited in terms of an anticipation of sustainability effects which are first revealed during the use of the innovation object. Here (and not just out of necessity, as intended by Hippel) trend-setting, particularly interested, or creative users come into play who may turn out to be idea givers, or even inventors. Something just as sensible would be a (coincidental) selection of users who are not seen as "sustainable" lead users, but instead would be unbiasedly confronted with new solutions in the light of sustainability considerations. This kind of "forward integration" [8, p. 337] aims at better determining the behaviourally and culturally determined sustainability potentials and risks of an innovation.

8 Individual Provisions for Directional Certainty (Overview)

In closing, a few measures for increasing directional certainty should be discussed which, along with all previously mentioned phases, can also find application. These include instruments of knowledge management, particularly the acquisition of relevant information, data, scientific analysis, reports, expert opinions, etc., all of which can theoretically evaluate the risk structure of innovation objects being considered. Case studies, practical examples, documented projects of comparable plans as well as the identification of best practices also provide further in-depth information. The sharing of experts' experiences through networking, or cooperation with other companies can also provide additional input on risk determination. An increased usage of new communication media can improve control and monitoring, as the networking of the subsystems affected by the innovation and function areas is of great importance. Feedback which is as instant as possible provides an increase of directional security.

A timely embedding of the innovation process into a communicative exchange with relevant societal actors can increase the cognitive ability in terms of social and ecological damage potentials. Here, a correspondingly moderated "stakeholder dialogue" [3] can serve as a kind of an early warning system. In addition, risk generation and distribution requires a societal legitimization, otherwise conflict-laden negotiation processes may occur. The more timely socially affected groups can be integrated, the greater can be their initial influence "to reasonable consider (social) risks" within a discourse clarification. Each innovation, at the same time, means a transfer of both, chance and risks. An additional need for discourse is therefore displayed, namely for the purpose of clarifying how and to whom a certain, generally acceptable risk may be dispersed. Still, part of the responsibility is transferred from companies to society through participation by external groups. Through such interactive process creation, the innovator creates a double safeguard: First, the possibility of detriment is reduced, as the decentralized, sometimes implicit knowledge of external actors is used as a resource for directional certainty management. Second, the possibility of being the sole person or organization to blame in the case of loss or damage sinks.

Four different levels of social interaction between innovation management and external actors can be specified[9]:

[9] The sequence correlates with an increasing intensity of integration.

1. Coordination of directional certainty in a broader sense; external communication as an early warning system, with which potential dangers and damage can be diagnosed in a timely fashion, so as to countersteer if needed, e.g. information exchange through online and print media.
2. Reflexivity in terms of a discourse clarification about the meaning of sustainability by concrete implementation through an innovation process, for example active engagement of companies in sustainability and risk dialogues such as those found in "Agenda 21" projects.
3. Feedbacks with stakeholders, relevant actors, and societal subsystems as a means to legitimize specific innovations and the overall magnitude of risk transformation; installation of a "social early warning system": e.g. round tables or symposiums initiated and conducted by companies where critical interest groups and NGOs may participate.
4. Integration of lead users and other potential users as co-creators or co-producers of the innovation itself[10]: e.g. regular workshops with users and providers of ideas.

9 Conclusion: Risk Reduction as a Self-Contained Sustainability Principle

The ecologically and socially destructive power of modernization processes, which brought the topic of sustainability into being, is itself a result of previous innovations. Therefore, if it is to serve the purpose of sustainable development, a change of course cannot be achieved while the mode of change remains otherwise structurally unchanged. Even innovations meant to be sustainable can have unintended effects, leave scars, and accelerate growth in consumption. Sustainable strategies can thus sometimes also mean, when in doubt, stepping away from the "roulette wheel". However, this does not mean an outright denial of innovation as an important mode of change[11].

What is needed is an understanding of sustainability which, along with the actual ecological and social contents, also has process-related components of the necessary modes of change as its focus. Here, aspects like controllability, safety, and straightforwardness (in other words: risk reduction) would acquire self-contained goal attributes. Increased directional certainty of innovation processes does not just mean a minimalization of risks in the style of Seveso, or Chernobyl, but those of cumulative growth risks as well. The resulting consequences for operational management can be termed, according to [26], as "innovating innovation." Opening the way for innovation types which involve altered usage systems and behaviours, i.e. those that are more secure due to their immaterial character, depends to a high degree upon the sequential decision structure. A refinement of the classical instruments of innovation

[10] E.g. the "provider/user strategies" of Meyer-Krahmer/Jochem [11].

[11] Alternative modes of change would be e.g. exnovation, renovation, and imitation.

management is not sufficient here. The innovation process as such requires a different structurization, namely one not committed to the optimization of an innovation type which itself does not stand at disposition (mostly a product or production process). Its start should be returned to the decision level which the innovation direction, the innovation realm, and the various options for innovation types are located at (reverse integration). For starters, an additional degree of freedom would be achieved in terms of a potential solution to path dependencies. Also, the process would, in this way, finally become a *process*, namely one that is a sequential result of decision levels with increasing degrees of concretization. At each of these levels, risk reduction can be embedded as an additional selection criterion. Directional certainty then takes on a level of importance which extends beyond mere fine-tuning. Sustainability in innovation activities does not just mean managing existing risks better, but – through the choice of structurally safe alternatives (and when possible) – not letting them happen at all.

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