

The Circle of Innovation

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Abstract. Traditional models of innovation are predominantly linear, featuring only very limited feedback loops. This paper builds on a high-level cycle of feedback between technical innovation and social change. In this grand cycle, technological innovation brings about new products but also new ways of using products and services. These in turn change our organizations and social interactions. The new structures generate new unfilled needs, spurring still more technological innovation. The Circle of Innovation is a simple idea. Yet its implications for companies and for researchers have remained unexplored. This paper discusses the Circle of Innovation's implications. We find the Circle of Innovation (i) implies a new way to classify innovations; (ii) should change how firms assess innovations; (iii) gives a new view of target marketing; and (iv) has implications for sustainable product planning. We conclude in a more conjectural vein that the Circle of Innovation provides a frame for other nonlinear innovation models.

Keywords. Innovation; Social Change; Product Line Planning; New Product Development; Technology Assessment; Creative Destruction.

1 Introduction: Feedback in the innovation process

Traditional models of innovation and its diffusion are predominantly linear and uni-directional, offering feedback loops only in the form of customer satisfaction measures, imitation behavior, or concurrent engineering. This paper discusses a high-level cycle of feedback between technical innovation and social change, enabling connection with newer, more detailed nonlinear models of innovation, and encouraging further nonlinear modeling and analysis.

In the proposed grand cycle, technological innovation brings about not just new products and services, but new ways of producing and using products and services. These in turn lead to new ways to interact and organize, socially and professionally. The new structures generate new unfilled needs, which are opportunities for still more technological innovation. That is, each time technology solves a problem, it generates new ones, in a continuing cycle.

The term "high-level cycle" reflects Schumpeter's macroeconomic orientation as he set forth his seminal view of the loop between innovation and socio-economic change. The present paper ties this macro idea, recounted in Section 3 below, to management ideas that span the meso and micro levels.

The Circle of Innovation is a simple idea. Yet it:

- I. Implies an additional way to classify innovations, namely, those that are new ways of satisfying old wants, and those that satisfy new, unprecedented wants;

- II. Gives a new view of target marketing – a kind of uncertainty principle for innovation, in which we understand that products cannot be aimed at a usage situation, but rather, that the product changes the situation; and
- III. Has implications for sustainable product line planning. The Circle implies firms should assess their own innovative products, predicting what new wants they will generate, in order to be first to satisfy them.

The paper discusses these implications. The grand cycle of socio-technical change means we should augment our thinking about innovation diffusion by considering innovation *reinforcement*, or a Circle of Innovation. We find that Apple appears closest among today’s companies to using the Circle of Innovation as basis for a management strategy.

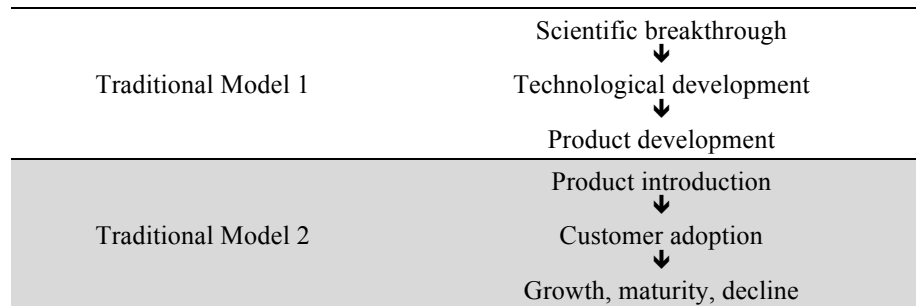
After introducing the Circle of Innovation and some examples of it, this conceptual paper draws on disparate literatures to analyze the circular innovation phenomenon, and proceeds to explore each of the implications numbered above. It concludes by summarizing the findings and (in a somewhat more conjectural vein) diagramming their relation to sustainable product line planning.

This explication of the Circle of Innovation will add value to the practical and theoretical discussion of innovation.

2 Linear and nonlinear innovation models

Table 1 summarizes the traditional linear models of innovation and its diffusion. (See e.g., Godin 2005.) In these models, feedback is gained only via customer satisfaction measures; imitation behavior (Rogers, 1962; Bass, 1969); or “cyclic innovation” (Van der Duin and Hermeler, 2014) and concurrent engineering. Practically speaking, we know there are even more feedback mechanisms than this: Examples include Yelp, TripAdvisor, and Twitter reviews. Yet these are just “small” feedback loops, linking some of the detailed steps in the innovation cycle of Figure 1.

Table 1. Traditional linear models of innovation



In contrast, this paper re-introduces a high-level cycle of feedback (Figure 1) between technical innovation and social change. Its specific contributions relative to prior literature are its focus on private-sector implications, in particular for product line (as opposed to product) planning; its presentation of a new and challenging view of target marketing; and its clarification of the benefits of comprehending the entire Circle, as

opposed to the restricted arcs dealt with by most research on technology management and diffusion.

The Circle of Innovation enables connection with nonlinear models of innovation, e.g., National/Regional Innovation Systems (Lundvall, 2007), Triple Helix (Leydesdorff and Etzkowitz, 1996; Dolfsma and Leydesdorff, 2009; Ivanova and Leydesdorff, 2014), and “technological transitions” (Geels, 2005).

3 A brief history of the idea

Historians concerned with technology (e.g., Lipsey 2002) have noted that productivity-enhancing technical advances enable specialization – which is a kind of organizational change. For example, the plow increased agricultural productivity, enabling family or community members to spend time on supplementary pursuits, including commerce. They then, naturally (though this is not made explicit in the technology history literature) sought better ways to conduct commerce. Further innovations provided the sought-after improvements.

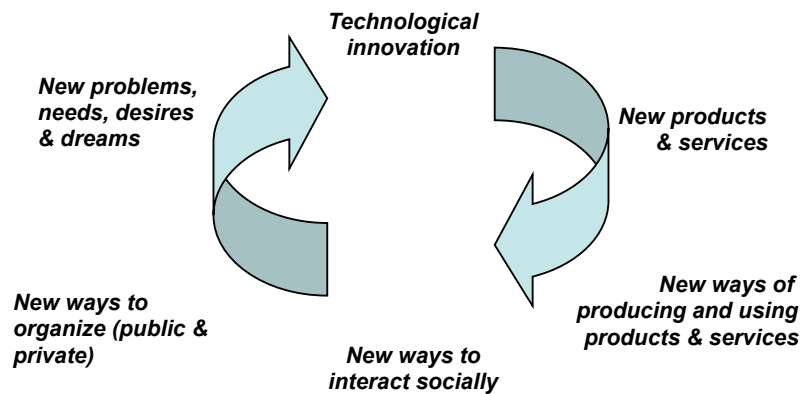


Fig. 1. Technological innovation self-reinforces via socio-economic change.

The foundational advance on the closed loop of demand and innovation is this famous but testy passage of Schumpeter’s (1943):

...in dealing with capitalism we are dealing with an evolutionary process. It may seem strange that anyone can fail to see so obvious a fact which moreover was long ago emphasized by Karl Marx. Yet that fragmentary analysis which yields the bulk of our propositions about the functioning of modern capitalism persistently neglects it....

Capitalism, then, is by nature a form or method of economic change and not only never is but never can be stationary. And this evolutionary character of the capitalist process is not merely due to the fact that economic life goes on in a social and natural environment which changes and by its change alters the data of economic action; this fact is important and these changes (wars, revolutions and so on) often condition industrial change, but they are not its prime movers. Nor is this evolutionary character due to a quasi-automatic increase in population and capital or to the vagaries of monetary systems of which exactly the same thing holds true. The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates.

The passage is rich with implication. Schumpeter considers it “obvious” that capitalism is evolutionary. Evolution (of the Darwinian sort¹) requires feedback between organism and environment, a non-linearity. Though he criticizes economic analyses which ignore this reality, linear models have dominated in academic economics to the present day. Economists’ overarching principle, say Atkinson and Lind (2013), has been “maximize efficiency.” But “the goal of economic policy should not be to maximize static efficiency (the ‘right’ allocation of widgets), but to create inefficiency – in the sense of disruptive innovation that makes widgets worthless.” Flichy (2008), noting that “economists usually exclude [technology] from their field of interest,” said plainly, “The linear science-technology-use schema no longer works today.” Schumpeter (1943) shared the sentiment: “A system which is efficient in the static sense at every point in time can be inferior to a system which is never efficient in this sense, because the reason for its static inefficiency can be the driver for its long-term performance.”

Schumpeter draws the feedback loop between the economy and its environment, and moreover states the “fundamental impulse” driving this interaction is technological and organizational innovation.

Ironically – as he commenced his chapter by citing Marx, whose ideas gave rise to the biggest ideological rift of modern times – Schumpeter did not credit ideology as a co-driver of social change. (Doubly ironic, really, as Schumpeter was berating other economists for ignoring the obvious.) That task fell to George Kozmetsky, an American son of Russian refugees, whose writings emphasized technology and ideology as dual drivers of change (Walters 2003; Phillips 2005; Secret, Gibson and Butler 2011). In the model of Figure 1, ideology is subsumed under “new problems, desires, and dreams.”

Schumpeter’s chapter provides depth and theoretical substance to the casual observation of later writers (e.g., Learner and Phillips 1993; Kelly 2016) that new technologies solve today’s problems and create tomorrow’s. However, Schumpeter offered no advice of specific use to managers.

¹ Elsewhere in his chapter, Schumpeter actually apologizes for resorting to a biological analogy.

Subsequent writers attended to specific arcs of the circle of innovation. Best known is Rogers' (1962) work on the diffusion of innovation to individuals and classes of individuals. Powell et al (1996) and Strang and Soule (1998) looked at diffusion to and across organizations.

Lounsbury and Crumley (2007) continued the latter thread, adding elements of complexity and nonlinearity. The recent growth of complexity science (see e.g., Mitchell 2009) had encouraged researchers to look for and model feedback loops in the innovation process. Geels (2005), for example, pioneered a widely cited thread of "transition" studies, showing how changing technologies and public attitudes cause a shift from one "technological regime" or dominant design to another. Rothwell (1994) showed how "generations" of innovation models have shifted over the years toward greater acknowledgment of interaction loops. However, Rothwell focused his own work on "innovation activity of firms under different socioeconomic and political circumstances" (Kotsemir and Meissner, 2013) without making contact with the wider innovation environment. Indeed, Kotsemir and Meissner note Rothwell's later generations showed a shift from meso- to micro-level.

Most technology and innovation management (TIM) literature addresses only the first link in the Circle of Innovation: Laboratory invention to new product. A few works have addressed two links; for example, Markus and Robey (1988) look at how information technology produces organizational change. Kash (1989) attacked the broadest arc of the circle, documenting how innovations in many technological fields change organizations. Rycroft and Kash (1999) extended this work, delving more deeply into complexity considerations. Yet the loop remained unclosed: These authors did not go on to note that new organizational forms give rise to new needs which must be satisfied by further innovation.

Storytellers know how technological advances change social relations, creating new problems.

A 2008 Tony winner for Best Revival, the swinging '60s farce Boeing Boeing... follows an American lothario living in Paris who's secretly engaged to three different flight attendants. But when the new, faster Boeing jet goes into service, the ladies' schedules get jumbled, and things turn turbulent as all three of them descend on his apartment at the same time, along with an old schoolmate who can't seem to keep his pal's cover stories straight.²

Concepts suggesting the Circle of Innovation are also mentioned in passing in the "Science, Technology, and Society" sub-discipline of the sociology of science (e.g. Bijker and Law, 1992; Pool, 1999). However, neither the entertainers, the economists, the science historians, nor the STS scholars seem concerned with commerce, or the implications of the Circle of Innovation for companies.

² <http://www.theatreinsandiego.com/boeing-boeing/81/>

We do not find prior TIM literature addressing the entire Circle. We surmise this is because the professional interest of most commentators is limited either to the right side or the left side of Figure 1, rather than to the entire loop. One exception, the “constructive technology assessment” thread (Schot and Rip, 1997), laid out implications for governments only, and made no prescriptions for firms.

4 Research gaps

This history shows that the cited studies illuminated important parts of Schumpeter’s loop, but collectively did not fill in all the loop’s segments nor turn the loop into a useful management tool. Schumpeter perceived the circular path between technological change and what he called economic change. His nonlinear formulation was ignored by subsequent generations of economists, who cleaved to linear models with computable equilibria. His work presented guidelines for managers only by broadest implication, without explication.

Market research was long considered (by marketers – see Kotler 2009) to be the feedback mechanism that made capitalism work. Because in the case of advanced technology products customers do not know what they want, Sony and Apple, among others, famously eschewed consumer surveys in favor of launching visionary products to the market, and were successful in doing so.

Although Rogers' (1962) diffusion model does include some "loops, short-cuts or interruptions" (Prager and Posthumus, 2010), the model begins with the innovator segment exhibiting “latent demand” for the innovation, with no identification of the source of this latent demand. The Circle of Innovation enables us to see its source: New needs emerging from new organizational forms, from new social interactions, and from new ways of using old products and services.³

Remaining gaps include:

- No consensus emerged concerning the variables that intervene between socioeconomic change and technical change.
- Connections among any intervening variables were not closely examined.
- The studies failed to see the whole circle, examining only small arcs of the circle, and/or only specific nonlinear epicycles.
- The research focus was intra- or inter-organizational only, or reflected high-level economic thinking without reference to managerial realities or to the interactions of different sectors of society.

This paper will suggest ways to fill these gaps.

³ Rogers’ extensive work with rural populations suggests that some of the latent demand he mentions could stem simply from his informants’ poverty, a source different from the one we propose here. If one defines economic demand as need plus the ability to pay, even conscious need combined with inability to pay would comprise a demand that remains latent.

5 The Circle of Innovation introduced

Figure 1 shows the cycle of innovation and change, from lab to society and back again. Technological change leads to new products and services, which in turn change the way we use products and services. These new usage modalities require changes in the way we organize our firms and institutions. New ways of organizing create new needs, generating demands for still newer technological fixes, and the cycle repeats.

5.1 Elements of the Circle

Schumpeter's loop could reasonably be sliced into three arcs – Technology, Individuals, and Organizations, with innovations and their impacts flowing from T to I to O and back to T. These nomenclatures would be too abstract for the purpose of the present paper, which is to establish elements of the circle of innovation that encourage further research and compel managers' attention. An examination of the literature cited above, filtered through the authors' thirty years experience in technology management, suggests the six arcs (or elements) labeled in Figure 1.

5.2 Establishing the flow between successive elements

Some of the pairwise flows are backed by literature. Others are justified below by means of examples, including a running example of ORCID identifiers for researchers. The examples are chosen for illustrative impact, but readers will discern they are far from unique – in fact, in many cases they are driving forces.

Technological innovation → *New products and service*. This link is extensively dealt with in the New Product Development and Diffusion of Innovation literatures.

New products and services → *New ways of using products and services*. Little research has addressed this link, perhaps because it is so self-evident. Cloud computing changes the way we use computers to manage our work files. Inter alia, we no longer have to worry about version control on multiple devices, and have no need to tote files on USB keys. Other examples include E-commerce and home delivery drones, which change the ways we use retail services: We shop from our desktops, and return merchandise at the post office, not at the store. Mobile apps for bus schedules and taxi booking change the ways we use transportation services, allowing us to spend less time waiting for a bus or cab. The interactive web has completely changed the way we consume media.

New ways of using products and services → *New ways of interacting socially and professionally*. Two words suffice to establish this link: Facebook and LinkedIn. And not just in cyberspace: "Cars are becoming tantamount to computing devices that have as much to do with software as they do with chrome. This is changing how consumers and urban planners imagine transportation systems" (Tett, 2015).

New ways of interacting → *New ways of organizing*. Information and communication technology (ICT) allowed more frequent and better-documented exchanges between industrial suppliers and customers. As a result, transactional relationships evolved into alliances. Companies now employ alliance managers. When technological change is slow – to look at another example – companies can organize in silos, each division comfortable in its niche. "At Apple, by contrast, Steve Jobs would not let divisions have their own P&Ls and demanded that his managers collaborate with other teams"

(Tett, 2015), allowing Apple to own the mobile music market, beating Sony which was less quick to re-organize. A third and more extreme example is Enron. Riding a wave of new financial instruments and an ideology of deregulation, the energy trading company created new organizational forms, including drastic decentralization (really a complete abdication of management control) and off-balance-sheet LLCs, before its demise and bankruptcy.

New ways of organizing → *New needs and desires*. The contractor and entrepreneurial economies, tele-work, and the proliferation of types of laptop, handheld, and wearable computation/communication devices together illustrate this link of the Circle. They generated a need for secure BYOD (“bring your own device”) technology enabling mobile employees and contractors to access company documents while on the go. They generated a need for co-working spaces with amenities for independent workers.

New needs and desires → *Further technological innovation*. The classical technology substitution theory allows for technological substitution at the end phases of the life cycle, but assumes the substituting technology provides the same user benefits as the senescent technology. What is proposed here is that social changes generate demand for new and different benefits, of kinds that were not provided by any existing technologies. These benefits may be sought and satisfied without regard to the life cycle stage of any existing technology. Kelly (2016) refers to “the never-ending discontentment that technology brings. We are... busy making up new itches that we have to scratch, creating new desires we’ve never had before.” Mead (2105) writes, “Birkenstocks, like an iPad, or an eight-dollar bottle of cold-pressed juice, are the covetable answer to a need that hadn’t existed before they came along.” More examples appear in the next section.

6 The Circle of Innovation: Further examples

Table 2 offers diverse examples of innovations making impacts that propagated around the entire Circle of Innovation. It notes, e.g., that Lyft and Uber allow drivers to rate customers online, and vice versa. Drivers use their spare time to earn by taxiing customers, and better customers get better service. Both lose time that could be devoted to unmonitored leisure (Manjoo, 2015).⁴ The Table indicates some people take refuge in retro technologies in order to escape the demands of today’s communication devices. Others (Dishman, 2016) use even newer tech (Basecamp, or Slack) for this purpose.

Research into better electrical batteries has been continual over the decades, but smartphones and electric vehicles have elevated the urgency of further advances in this field. The autonomous vehicle problem is self-explanatory. We will expand on the statin drug situation in a following section, after we highlight additional examples of the Circle of Innovation.

⁴ By the same token, consumers’ growing awareness that their every move is monitored and evaluated signals the death of recreational shopping.

Table 2. Circle of Innovation, short examples

Innovator	Innovation	Social / Organizational change	New problems/demands	Newer or prospective scientific/technological solutions
Uber, Lyft	Mobile web ride service	Customers with high ratings get better service.	Desire to rest or consume without worrying about being rated or scored.	Business models in which customers are not rated. Consumers return to analog tech disconnected from social media (Sarpong et al 2016).
Astra-Zeneca, Pfizer, Merck	Statin drugs for serum cholesterol control	Widely used; fewer heart-attack deaths	Side effects include obesity, cancer, diabetes.	Alternative theories of functions and effects of cholesterol in the body.
Google, others	Self-driving car	Unemployed drivers; shuttered motels	Re-design welfare state &/or job retraining.	Online/mobile education and vocational training.
Apple	Smartphone	Access to information 24/7. BYOD. Tele-work.	Short battery life. Problems of social disengagement.	Apple Watch. Research into better batteries.

6.1 Individual researcher i.d.'s (ORCID)

Advances in information technology facilitated international collaborative virtual research teams and wider access to scientific journals. This, plus the general globalization that is also enabled by new IT, raises research capacity in developing nations. In turn, many more researchers from many more countries produce work publishable in top international journals. Distinguishing among researchers having similar surnames (or names inconsistently transliterated into Western alphabets), never much of a problem heretofore, became an issue and an entrepreneurial opportunity. The universal researcher identifier was invented and promulgated. Publishing companies' author and reviewer databases now need to be modified to carry the extra data field "universal author identifier." The earlier cozy research communities where (as in *Cheers*) everybody knows your name, morphs into a more impersonal but perhaps more productive enterprise.

In this example, summarized in Table 3, technical change led to new ways to use technology, which led to new organizational forms. These in turn created demand for new technological solutions. These newer solutions, once provided, led to still newer usage modalities and a new round of social change in research communities. The wheel takes another turn.

Table 3. Example: Individual researcher i.d.’s and the Circle of Innovation

Each event turns the wheel.
Advances in ICT	Technological innovation
E-journals; Collaboration platforms	New products/services
More submissions from more countries to premier journals	New ways to use products & services
More international co-authorships. More authors with similar surnames.	New social/professional interactions
Online conferences; Global research teams; Bigger research communities.	New ways to organize
Need to uniquely identify researchers with similar names	New needs & problems
ORCID and other identifier systems	Technological innovation; new product/service
Add fields to existing databases, to accommodate researcher i.d. number	New ways to organize

6.2 “Your Phone Is Ruining Your Life: The Real Reason Apple Developed the iWatch”

Apple’s iPad and iPhone changed the way we work. Now a revolutionary wristwatch may extend Apple’s dominant product line. Apple understands most iPhone users are bothered by the buzz of the smartphone and the constant checking of messages. The phones have become invasive. Technology distracts us from the things we should pay the most attention to—family or friends, or something meaningful in our lives. To filter out useless messages and save the important ones, Apple introduced functions in the iWatch to make a different and better quality of life (Pierce, 2015; see also Maxcer, 2015).

Pierce asks, “Can technology fix a socio-psychological problem it created with another piece of technology?” The iWatch uses your level of interest in the information, as demonstrated by your reaction to it, as a cue for the iWatch to prioritize, to get your face out of your tech. Apple introduced a feature called Short Look: An induced pulse on the wrist signals an incoming text message. The duration of the screen display depends on how long you cock your wrist and look at the watch.

Time will tell whether the iWatch truly reflects Circle of Innovation thinking. So far, bloggers are offering preliminary evidence that it does.⁵ CEO Tim Cook has said Apple puts a “maniacal” focus on making “not good products, or a lot of products, but the absolute best products in the world.”⁶ It appears that anticipating possible psychological, social, and organizational consequences of a product is part of what can place it, and its successor products, among the “absolute best products in the world.” We can expect to see more of this from Apple, and to see other companies follow suit.⁷

⁵ E.g., the Oatmeal blog, http://theoatmeal.com/blog/apple_watch

⁶ <http://www.thelowdownblog.com/2015/06/should-apple-get-rid-of-mac.html#more>

⁷ The examples up to this footnote marker are provided by the International Association for Impact Assessment, <http://iaia.org/iaia/wiki/techassess.ashx>

7 The Circle of Innovation: Implications

The Circle of Innovation is a simple idea. But it...

1. Introduces a new classification of innovations.
2. Gives a new view of target marketing.
3. Has implications for sustainable product line planning.
4. Should change how we report the prospective impact of innovation.

7.1 Classifying innovations and defining innovation

The Circle of Innovation suggests a new classification of innovations. Traditionally we classify innovations as Continuous, Discontinuous, or Radical. Now we must add a classifier: Innovations that provide old benefits in a cheaper, more efficient, or more enjoyable way, versus those providing new, unprecedented benefits.

Lab-driven innovations (if we exclude those of a “solution looking for a problem” nature) are meant to improve an existing situation. However, the Circle of Innovation shows that such an innovation can, via social and organizational change, lead to new and possibly unprecedented problems. The latter will be addressed by a second kind of innovation, i.e., one that provides benefits that had never been sought before.

Following ideas of Ijiri and Simon (Ijiri 1990), Phillips (2001, 2011) defined innovation in terms of the experience curve: “Innovation is a non-differentiable point in an experience curve.” This remains vacuously true for innovations that deliver new, unprecedented benefits, as the start of production represents the beginning point of the learning curve.

7.2 The Circle of Innovation and target marketing

Conventional segmentation targets customers’ demographic or psychographic characteristics. Echoing Ted Levitt’s 1983 dictum, “Customers don’t need quarter-inch drills, they need quarter-inch holes,” Clayton Christensen (of “disruptive innovation” fame) said in 2003, target products to the customers’ “circumstances,” or usage scenarios, not to their demographics.

The Circle of Innovation goes beyond Levitt and Christensen; it says, *The product will change the circumstances*. Because innovative products change organizations and create new needs, marketers face an analog of quantum uncertainty: When the product is launched at the target market, the target moves.

As a result, companies must plan products that are robust to changed circumstances. They must anticipate the possible new circumstances and plan follow-on products to fit them. Prior literature hints at this, but does not follow the reasoning far enough to reach the above conclusion. Examples include the ideas of sociological expectations (Berkhout, 2006), and empathic design (Leonard and Rayport, 1997). The idea of scenario-based design (Bødker, 2000 and Carroll, 2000) comes closest, and indeed scenario exercises may be the most fruitful way to plan product lines in the framework of the Circle of Innovation.

Gover (2015) offers an example of how the product changes the circumstances – though in this example the change was unanticipated. Again, ICT was the driver,

enabling the creation of MOOCs. MOOCs were intended to allow any university to economize in offering courses. In an unexpected turn, MOOCs created the media superstar professor, attracting students to tele-study at a progressively smaller number of non-local universities, and then the creation of new training organizations like Coursera and Khan Academy, and even in-house streaming corporate training programs. These things happened in parallel with (and in response to) a growing need for coders and engineers, and rising costs of traditional university education.

Gover remarks that the “linear model [of innovation] is still used in the USA R&D community.” Because the product changes the circumstances, it is clear that business people as well as researchers will have to begin thinking in nonlinear fashion.

7.3 Assessing technology and planning sustainable product lines

“Industrial TA” (Daim et al 2011) is Technology Assessment performed by companies. Companies appear to direct most of their assessment activities to the capabilities they aim to procure, rather than to those they aim to sell. A further implication of the Circle of Innovation is that firms should assess the technologies they intend to release to the market – not just the technologies they wish to procure – and that they should do this for potential profit. By anticipating the new needs that today’s innovation will generate, the innovative company may jump-start the development of further products to meet those needs, bringing the further products to market before competitors can do so. This results in sustainable product lines.

This will not be easy. Side-effects and created problems/needs are likely to be both delayed and systemic, even as firms rush to meet their market windows. The shrinking life span of corporations (Daepf et al, 2015, report the average company lifespan has dropped from 67 years in the 1920s to 15 years today) exacerbates “short-termism” and would seem to make long-baseline technology assessments nearly impossible.

Porter et al (1991) wrote that home appliance maker Whirlpool Corporation succeeded in this in one project and failed in another. Whirlpool tracked other companies’ work on permanent-press fabrics in order to design permanent press cycles for washers and dryers, “beating their competition to market by about a year [and achieving a] substantial gain in market share.” In contrast, “Whirlpool introduced the trash compactor without adequate impact assessment.” Compacted trash proved not easily biodegradable in landfills, and was perceived to be a “hazard to municipal incinerators.” The company introduced new models that mitigated the problems, but these were not very successful in the marketplace.

The Circle of Innovation implies a product planning process similar to that urged by the Responsible Innovation and Sustainable Innovation movements. However, the latter tend to focus on one product at a time. (See e.g., Sutcliffe, 2011) The future-oriented technology assessment demanded by the Circle of Innovation implies the planning of product lines.

Figure 2 assembles the implications of the Circle of Innovation into a rough diagrammatic outline for product line planning in an environmentally delicate, highly regulated, and litigious world. The Figure is intentionally simplistic, for the sake of its rhetorical point. Nonetheless, while ten years ago such a diagram would be dismissed as hopelessly idealistic, it contains no ideas that today’s managers cannot easily accept.

In the Figure, technology assessment is commenced before product launch, with foreseeable social/organizational changes, and their consequent new demands, anticipated to the extent possible. Positive and negative consequences are honestly noted, and classified as to whether they are within the firm’s control, and as to whether they affect only buyer and seller or are systemic, creating externalities.

The firm examines whether tweaks to the product spec, or other measures the company may take, will change these consequences for the better. Failing that, are there follow-on products that can profitably ameliorate negative effects of the present product? (Our earlier example showed that Apple is doing this, though they commenced doing so long after the launch of the iPhone.)

The alternative to killing a potentially profitable product (due to excessive negative side-effects) is to find a niche market for which the side-effects are minimally important. Statin drugs, for example, while evidently not a good fit for the mass market, may benefit people who are known to be at high risk for heart disease and at low risk for (or are too elderly to worry about the future onset of) cancer or diabetes.

Though marketers would not recommend it, every firm’s motto could be “Solving today’s problems, and creating tomorrow’s!” For this reason, innovators must consider and decide whether the problem they’re solving is worse than the problems they’re creating. Needless to say, ethical companies will not deliberately create problems simply in order to market solutions to them.

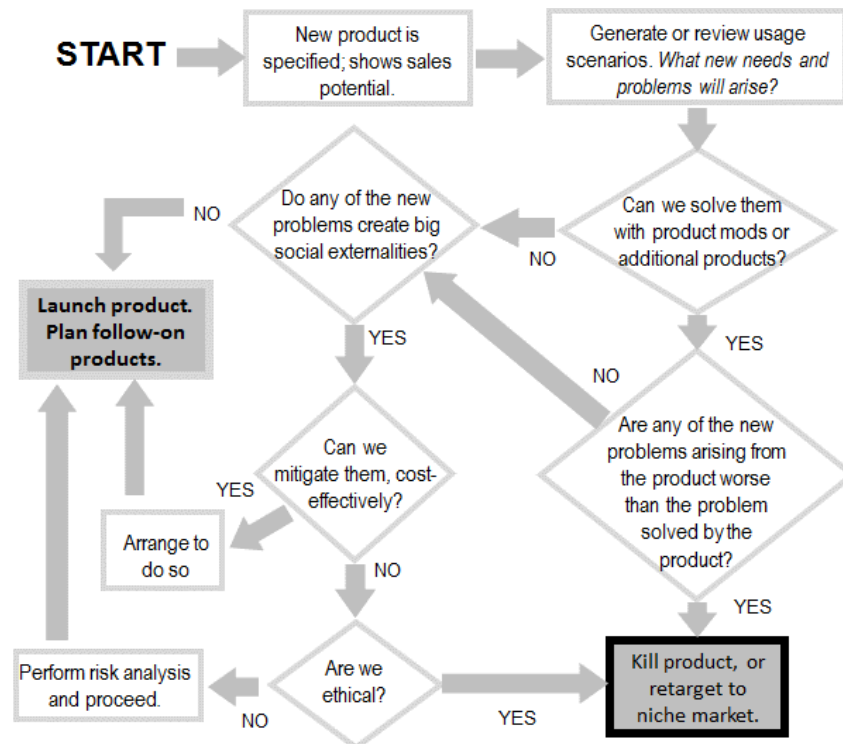


Fig. 2. Guide for planning sustainable innovative products

7.4 The Circle of Innovation implies companies should ask and answer different questions about their prospective products.

It should now be clear that the Circle of Innovation is driven by “side-effects.” New products are aimed at solving discrete problems, usually with little regard for the indirect effects which change usage modalities, social interactions, and organizational structures.

The short-term effect of an innovation (treatment) is usually measured by a test like that suggested by Table 4, with a null hypothesis $H_0: a=b$, and a reported effect size $a-b$. A medical example will illustrate this section’s point.

Table 4. The usual statistical between-group comparison

	Effect	
	Improvement	No improvement
Treatment	a%	(100-a)%
Control	b%	(100-b)%

The Circle of Innovation suggests that unforeseen effects, both positive and negative, are to be expected as a result of the innovation. This implies movement to a test like that shown in Table 5. In such a test, $a+c$ is not necessarily equal to 100%. Two hypotheses must be tested, $H_{01}: a=b$; and $H_{02}: c=0$. Reported statistics should include the decision and significance on the hypotheses; the treatment effect size $a-b$; the baseline incidence of the problem in the population, which is b ; and c , the incidence of actionable side-effects or unforeseen new problems. Even Table 5 fails to capture unforeseen positive effects; doing so is possible in principle but is omitted here for simplicity’s sake.

Table 5. Suggested statistical analysis of innovations

	Effect	
	Marked improvement with minimal negative side-effects	Little improvement, non-trivial negative side-effects
Treatment	a%	c%
Control	b%	0%

A recent paper by Diamond and Ravnskov (2015) provides an important example, in the context of clinical trials of a new class of drugs, specifically statin drugs. Statins are very widely prescribed to achieve a reduction in serum cholesterol levels (*Science* 2.0, 2015), but they have “failed to substantially improve cardiovascular outcomes.” However, manufacturers of statins have used what Diamond and Ravnskov refer to as “statistical deception” to make inflated claims about their effectiveness. It appears that

statins actually produce only small beneficial effects on cardiovascular outcomes, and their adverse effects, including cancer and obesity, are far more substantial than is generally known. This conclusion does not stem from a possible fluke in a single trial. It appears repeatedly across multiple large-scale trials, which are recapitulated in Diamond and Ravnskov (2015).

The kind of reporting recommended in this section enhances not only corporate transparency, but also the ability of forward-thinking managers to adjust target markets and devise follow-on products to minimize the negative impact of the current product's indirect effects.

8 Summary

Kelly (2016) maintains continuous innovation happens because humans are hard-wired for discontent. We will want something more, he says, regardless of our organizational environment. If true, it does not crowd out the idea presented above, that demand for further innovation is an imperative consequence of organizational change. Kelly does add that we could not satisfy our discontent had our technological capability not been augmented by our development of scientific method. Kelly adds, "The problems of today were caused by yesterday's technological successes, and the technological solutions to today's problems will cause the problems of tomorrow."

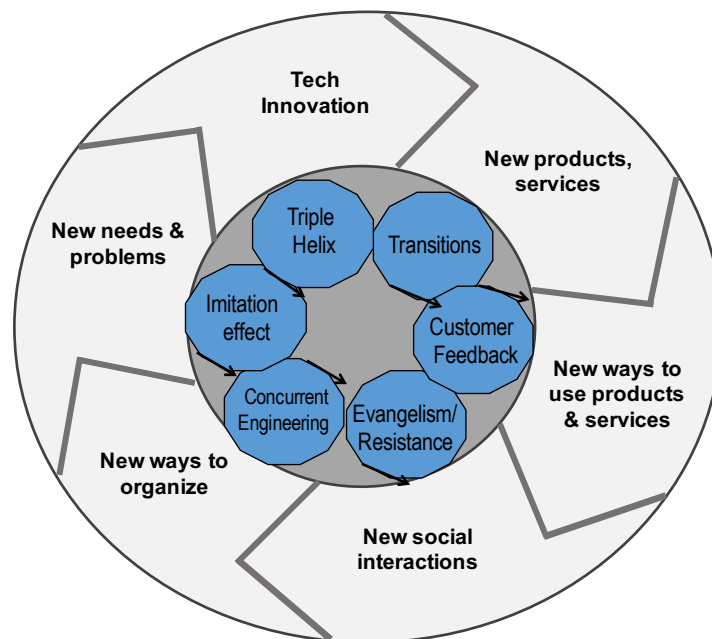


Fig. 3. Nonlinear innovation models portrayed as epicycles within the Circle of Innovation

The Circle of Innovation highlights how innovations change society and lead to demand for further innovations. It suggests a distinction between innovations that

better deliver an existing benefit, and those that deliver a new benefit – and makes it clearer that these are two distinct profit opportunities. As Solis (2014) remarked, “If consumer behavior is evolving as a result of technology, businesses either compete to get ahead of it, they perpetually react to it, or they belittle it.” Better to get ahead of it, immersing the firm in awareness of changing circumstances and moving targets.

The Circle of Innovation provides a feedback mechanism that enables co-analysis with other nonlinear effects such as “triple helix” and “technology transitions.” (Phillips, 2014, characterized the triple helix as an epicycle in the grander cycle of technological, psychological, and institutional change that is the Circle of Innovation.) Figure 3 portrays this idea conceptually. The Circle of Innovation’s cyclical imperative explains why once a society boards the innovation wagon, it can be exceedingly difficult to get off, barring a severe economic crisis. There is much about the Circle of Innovation that appears self-perpetuating.

It closes a loop, as it were, in Rogers’ (1962) theory, by revealing where “latent demand” comes from.

It gives product developers and innovation researchers a conceptual tool for reconciling the zero-one, “go-no-go” linear stage-gate procedure still favored by management, with the nonlinear “yes, but” realities of e.g., the open innovation movement, or market feedback. Figure 3 illustrates a “yes, but” way of thinking.

The Circle of Innovation provides a rationale for sustainable product line planning for the firm, and for a change in the ways we measure the impact of an innovation. These product lines will be based on anticipation (maybe via scenario exercises) of possible ways in which each product will change the circumstances of its own use. That is, the product will not only be used in new psychological, social, and organizational contexts; rather the product will cause change in these contexts. Product line planning will be resilient to this nonlinear effect.

It is difficult to think of a radical innovation – or even a “dynamically continuous” (Goldberg 1997) innovation in that middle ground between incremental and radical innovation, which does not drive the Circle of Innovation. Incremental or trivial innovations and novelties that do not change the way people do things – like eight-dollar bottles of cold-pressed juice – will not propagate through the Circle.

A limitation of the scheme presented here is that the role of ideology in driving the Circle, mentioned in Section 4, is not well-developed in this paper, remaining as grist for further research. Future research should also better establish the six elements of the Circle (or argue about their number and names) and their connections to each other. Formal links among the non-linear models of Figure 3 also remain to be established.

It is hoped that the Circle of Innovation will add value to the theoretical discussion as well as guidance for private sector action.

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