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Circular Business Model Innovation: Inherent Uncertainties

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ABSTRACT
Circular business models based on remanufacturing and reuse promise significant cost savings as well as radical reductions in environmental impact. Variants of such business models have been suggested for decades, and there are notable success stories such as the Xerox product–service offering based on photocopiers that are remanufactured. Still, we are not seeing widespread adoption in industry. This paper examines causes for reluctance. Drawing on a hypothesis-testing framework of business model innovation, we show that circular business models imply significant challenges to proactive uncertainty reduction for the entrepreneur. Moreover, we show that many product–service system variants that facilitate return flow control in circular business models further aggravate the potential negative effects of failed uncertainty reduction because of increased capital commitments. Through a longitudinal action research study we also provide a counterexample to many of the challenges identified in previous studies, which could be overcome in the studied case. Copyright © 2015 John Wiley & Sons, Ltd and ERP Environment

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Introduction

CIRCULAR BUSINESS MODELS (CBMS) CONSTITUTE ONE POTENTIAL WAY FOR INDUSTRY TO PROFITABLY ACHIEVE A RADICAL increase in resource productivity. Reported profitability levels and resource efficiencies from product–service systems (PSSs) with remanufacturing suggest that material and energy reductions of 80 per cent may be within reach (Nasr and Thurston, 2006; Pearce, 2009; Nasr, 2011), while profitability is reported to be significantly higher than in original equipment manufacturer (OEM) production (Gray and Charter, 2007; Pearce, 2009). Meanwhile, there are indicators that business model innovation is necessary to reap the benefits from recycling and environmental product innovation (Hall and Wagner, 2012).

We focus on circular business models based on remanufacturing and reuse (in contrast to recycling). The business case for reuse and remanufacturing is at the abstract level quite straightforward. Increasing the utilization of already produced components and products can increase net value creation in the value chain. By reusing used

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products directly or still salvageable components as inputs in a remanufacturing process, a significant share of the value added in the original manufacturing process is saved or preserved in the remanufacturing process.

Given the daily efforts in industry to reduce cost and improve competitiveness and profits, why is CBM not on every OEM's agenda? The shift towards CBM must look less attractive than PSS/remanufacturing proponents suggest.

The purpose of this paper is to examine the challenges of circular business model innovation that create relucatance for OEMs.

We contribute to the business case for remanufacturing and PSS literature by suggesting two propositions regarding the challenges of CBM innovation.

(A) CBM poses significant challenges to proactive assessment of critical business model assumptions, implying higher investment risk.
(B) Many PSS variants, while solving the return flow challenge, adversely affect the investment risk.

The rest of the paper is structured as follows. In the next section, we explain the key concepts on business model innovation and validation. The third section describes CBM challenges identified in previous literature. The fourth section describes a case study, which illustrates the two propositions of the paper (above), as well as our finding that many CBM barriers identified in prior literature could be overcome in practice in at least one case. The fifth section presents the argument for why the two propositions above are likely to hold in most CBM cases. The discussion in the sixth section relates the findings to prior literature and comments on the limitations of the paper. The final section highlights implications for future research as well as for practicing investors and entrepreneurs.

Key Concepts

The term *business model* refers to the conceptual logic of how the firm creates and appropriates economic value (Björkdahl, 2009; Osterwalder and Pigneur, 2010). Value is created by a solution to a problem of a customer at a cost less than the value of the solved problem (Hsieh *et al.*, 2007). Value is appropriated, or captured, by charging the customer a price for the solution to the problem. At a more detailed level of analysis, there are several ontological frameworks (e.g. Chesbrough and Rosenbloom 2002; Amit and Zott, 2001; Osterwalder, 2004). For instance, Osterwalder's ontology of business models includes specific offering or value proposition, customer needs and segments, cost structure, revenue model, channels to reach customers, and customer relations, as well as key activities and resources controlled by the firm and outsourced to partners.

Learning about market conditions is an important part of *business model innovation*, i.e. the process of devising and realizing a novel way to create and appropriate economic value (Blank, 2005; McGrath, 2010; Govindarajan and Trimble, 2010). An oft-recommended approach (see, e.g., Blank and Dorf, 2012; Ries, 2011; Govindarajan and Trimble, 2010; Furr and Ahlstrom, 2011; Sarasvathy, 2001), is to iteratively refine and test the new business model before and during a gradual and small-scale market launch, and then heavily invest in scale once key assumptions have been verified. This process, hereafter called customer development, can be conceptualized as the potential business model consisting of a set of hypotheses of market conditions, for which the entrepreneur systematically designs and runs comparatively cheap tests or experiments to evaluate the hypotheses (Tripsas and Murray, 2004; Furr and Ahlstrom, 2011; Blank and Dorf, 2012; Eisenmann *et al.*, 2012). These tests can be as concrete as early pilot sales of the offering (to gauge demand) or as intricate as a stakeholder interview study (to gauge partner, channel or very early customer hypotheses). We will show that it is more difficult to achieve satisfactory results from this hypothesis testing approach for circular business models as compared with linear business models for analogous products (Proposition A).

We define a *circular business model* (CBM) as a business model in which the conceptual logic for value creation is based on utilizing economic value retained in products after use in the production of new offerings. Thus, a circular business model implies a return flow to the producer from users, though there can be intermediaries between the two parties. The term circular business model therefore overlaps with the concept of closed-loop supply chains, and always involves recycling, remanufacturing, reuse or one of their sibling activities (e.g. refurbishment, renovation, repair). When feasible, reuse and remanufacturing are often preferable to recycling for economic reasons, as much of the value added still remains with the components (Nasr and Thurston, 2006). Business model circularity is determined by the fraction of new products that come from used products. The proposition in this paper applies to circular business models built on reuse and remanufacturing of used products for offerings competing with or substituting for previous uses of the product.

A circular business model can be contrasted with a *linear business model* (LBM), which today constitutes the status quo in most manufacturing industries, barring some limited use of recycled materials and remanufacturing of spare parts. In a linear business model, the conceptual logic for value creation is based on a material flow where (only) virgin material enters the value chain upstream and all product value except raw material value is added through manufacturing and user behaviour (cf. Vargo and Lusch, 2004).

It is reasonable to expect many CBMs to contain offerings where the ownership over the product is retained, because the retained ownership facilitates the return flow of used products to the producer (Östlin *et al.*, 2008; Sundin and Bras, 2005). A *product–service (PS) offering* is an offering that consists of use of or the result from the product (cf. Tukker, 2004): for instance, when the customer pays for access to a functioning bicycle or per kilometre travelled. The PS offering here implies retained ownership of the product by the producer after sale and during use. PS offerings constitutes a (large) subset of the *product–service system* (PSS) concept (see, e.g., Mont, 2004; Tukker and Tischner, 2006), but excludes business models based on add-on services to traditionally sold products. Our case describes a business model containing a PS offering, and the PSS variants referenced in Proposition B are of the same type.

CBM Challenges in Previous Literature

Hitherto, strategic issues associated with a move towards a CBM have primarily been described in the literature on PSSs (e.g. Goedkoop *et al.*, 1999; Mont, 2004; Morelli, 2006; Tukker and Tischner, 2006; Aurich *et al.*, 2006). This literature in turn builds on a number of related fields such as functional sales (Lindahl and Ölundh, 2001; Sundin and Bras, 2005), functional products (Alonso-Rasgado and Thompson, 2006; Alonso-Rasgado *et al.*, 2004) and service/product engineering (Sakao and Shimomura, 2007).

While our contribution in this paper to a large extent elaborates on the challenges of CBM innovation, it should be noted that there is no lack of potential benefits. Previous literature has identified several drivers of implementing a CBM, especially of the PS type. These include cost savings in manufacturing (Walsh, 2010; Stahel, 2010), differentiation potential to meet low cost competition (Besch, 2005; Heese *et al.*, 2005), enhanced customer relations (Walsh, 2010), improved customer behaviour understanding (Firnkorn and Müller, 2012), improved margins (Pearce, 2009), reduced environmental impact (Mont, 2004) and increased brand protection (Seitz, 2007). Michaud and Llerena (2011) showed by experimental auctions that willingness to pay is not necessarily measurably lower for remanufactured products as long as environmental information is provided. However, in addition to the potential benefits, there are also a number of challenges and limitations identified with CBM.

Customer Type Restrictions

Pearce (2009) stresses that only certain types of customer are suitable for remanufactured products. He outlines six types of customer that are suitable for remanufacturing: These are customers who (1) need to retain a specific product for their processes, (2) want to avoid reapproving a product, (3) make low utilization of new equipment and are price sensitive, (4) want to continue using a discontinued product, (5) want to extend the life of a used product or (6) are environmentally interested. These customer types may overlap and some types of remanufactured product are more suitable for some types of customer.

Requires Technological Expertise

Remanufacturing requires considerable expertise and knowledge of the product, since the product is to be restored to original or better condition. The product may also require redesign (Berchicci and Bodewes, 2005), not least to become suitable for remanufacturing. It is thus often most suitable for OEMs (Pearce, 2009).

Return Flow Challenges

It is widely recognized in the PSS and remanufacturing literature that efficient product retrieval is a challenging but critical aspect of remanufacturing (Pearce, 2009; Seitz, 2007; Besch, 2005; Ravi and Shankar, 2005; King *et al*., 2006; Östlin *et al*., 2008). One particular challenge is the predictability and reliability of the return flow (see, e.g., Östlin *et al*., 2009). This creates difficulties in capacity planning. For example, for Xerox, one of the hardest challenges of the remanufacturing operations is to have the right amount of labour available at the right time, since the rate of photocopier returns is not stable or really predictable in advance (King *et al*., 2006). According to Sundin *et al*. (2009) and Östlin *et al*. (2008), the return flow issue can be mitigated via closer customer relations and retained ownership of the products by the OEM.

Product Category Restrictions

Some types of product are not suitable for remanufacturing. Sundin *et al*. (2009), acknowledging an unpublished paper by Andreu (1995), suggest the following attributes of the product: it has a core that can be used in the restored product, it fails functionally rather than by dissipation, the value added of the returned components is high relative to market value and original cost, it is factory built rather than field assembled, the process technology is stable, and the product technology is stable. The last attribute can be contrasted with the Xerox remanufacturing case, in which case product technology development is used for price discrimination, selling offers with older technology to more price sensitive customers (King *et al*., 2006).

Risk of Cannibalization

The introduction of a CBM may lead to decreased sales if the new, longer lasting products reduce sales of the previous products (Guiltinan, 2009; Michaud and Llerena, 2011).

Fashion Vulnerability

Being (un-)able to respond to fashion changes is another potential issue with introducing a CBM (Mont *et al*., 2006). In industries, such as many consumer markets, where the attractiveness of an offer is partly based on aesthetic attributes of the product, remanufacturing places increased demands on product design for modularity and/or timelessness.

Capital Tied Up

If the offer is to be rented out, rather than sold, a financial risk transfers from the customer to the producer (Mont *et al*. 2006; Besch, 2005). One suggested solution to this is to use long term contracts spanning several years (Besch, 2005), but this might reduce the attractiveness of the offer to certain types of customer.

Operational Risk

As the selling firm takes over some of what was previously the business of the customer, liability and operational risk of the firm increases (Kuo *et al*., 2010). In contrast to capital tied up, this disadvantage occurs irrespective of retained ownership of the products.

Lack of Supporting Regulation

Kuo *et al*. (2010) concluded that a major barrier to implementing a PSS is lack of support from related policy, laws and regulations. Stahel (2010) points out that CBMs are disproportionately affected by the tendency for taxes to be levied on labour rather than raw materials.

Partner Restrictions

There might be considerable challenges associated with creating the required understanding and incentives for key partners, such as retailers or service partners, as the move to a CBM influences and must be compatible with the business models of these firms as well as the initiating firm (Mont *et al.*, 2006). In general, lack of channel control is often mentioned as a critical barrier to increased service contents of a product offering, such as a move towards a PS offering (see, e.g., Wise and Baumgartner, 1999). For remanufacturing, the more differentiated the material recovery, the greater the need for collaborative partner networks (Rizzi *et al.*, 2013).

The barriers and their (partial) solutions might interact in non-obvious and complex ways, as is so often the case in the study of social phenomena. Further, these barriers have never been analysed in the context of systematic customer development for CBM (as described in the previous section). We address this through a case study in the next section.

Illustrative Case Study

We here describe the story of how a small bicycle firm developed a CBM, launched a successful pilot test of the new offering and eventually decided to postpone a wider market launch. The case serves two purposes for our paper: it assesses empirically the severity of many challenges previously identified in the literature, and it serves as an illustrating example when we derive our propositions (A and B).

A Note on the Methodological Approach

For reasons explored in this paper, a move towards CBM is not occurring frequently in industry today. Luckily, we got the opportunity to study such a move when a small entrepreneurial firm asked for our help to guide them and work with them in their development and test of a CBM. We classify the study and designed it as a longitudinal action research single case study. One of the authors, together with a third researcher, worked closely with the owners to help develop and implement the new business model following the principles of customer development (Blank and Dorf, 2012). Meanwhile, the other author followed as an observer, systematically collecting data about the developments and perceived challenges in the project. These data consisted of six snapshots of the owner-managers' concerns and uncertainties regarding the current business model hypotheses (resolved and unresolved) at each snapshot time throughout the yearlong project. These were collected via 1.5–2 h semi-structured interviews with the entrepreneurs. Additional related data were collected from six important decision making meetings over the year. Recordings of all meetings and interviews were used to validate the field notes and transcribe significant passages. In parallel, ten structured interviews were conducted with the directly involved researcher, focusing on the perceived challenges and problems with the CBM at various times throughout the year.

Throughout the project, the directly involved author developed a deep understanding of the specific firm and the particular CBM to be evaluated and implemented. This insight came from actively working closely with the owner-managers in the business model innovation project. Supplementary data collected in this way include a market segment survey (n = 104), eight prospective customer interviews, two interviews with dealers and 24 follow-up interviews with six paying customers.

The Company

Unicykel is a small Swedish bicycle manufacturer. They produce about 6500 bicycles per year under the brand Nishiki with about nine employees, generating a turnover of roughly € 5 000 000. The bicycles are designed to be stylish, sporty and of high quality with a price range from € 500 to € 5000. Unicykel design the frames and rims themselves to ensure the bicycles have the right feel, expression, sportiness, style and high quality.

How the Project Came to Be

In 2011, the two owner-managers wanted to develop an electric bicycle. This segment was large and growing in Europe and was deemed to have good potential also in Sweden. The electric bicycles that were sold in Sweden were lower quality import models that had set the market price to about € 1000 but had also created discontent among bicycle store owners and customers because of problems and warranty claims. The two entrepreneurs estimated that a high-quality electric bicycle would get a price of € 2000 to € 2500, but with this price volumes would be too low to motivate the enterprise.

Unicykel saw a PS-type business model as a way to let customers avoid the high investment and perceived high risk of purchasing a technically advanced, relatively unproven and expensive product. Remanufacturing was a way to decrease costs without lowering quality.

The first project step was to create a set of initial business model hypotheses, which were then tested against potential customers, resellers and other actors. Two researchers helped Unicykel in this process, including performing some of the hypothesis testing and corroboration activities such as early customer interviews, early dealer interviews, suggesting a model for cost and revenue calculations for multiple return-flow cycles etc.

Customers and Market

Target customers were believed to be car commuters or commuters using public transport rather than cyclists. The logic was that some of them could be potential cyclists but did not like hills, headwinds, arriving sweaty at work, spending too much time cycling and maintaining the bicycle. The value proposition was an electric bicycle subscription where bicycle, maintenance, service and winter tires were included. This was believed to remove every reason for not commuting by bicycle except rain for distances up to at least 10 km, since one easily can maintain an average speed of 20 km/h on an electric bicycle and hence timewise often beat both car and public transport commuting. One of the owners said

> One merit is that this is a new market – a new market segment that we haven't worked with before.... New customers we can sell something more expensive to [through the subscription].

To learn more specifically about the assumed target customer segment, a questionnaire was sent out to 2000 commuters. From a response of 104 persons, 10 target customers were selected for personal interviews and test cycling. Two dropped out, so eight interviews/tests were finally performed. The potential customers' responses built confidence at Unicykel that this was the right initial target customer segment and that quite a large potential share of that segment really would want to commute by bicycle/more healthily. Several of them responded during the interview that they would like an invitation to participate in the coming pilot test.

The hypothesis about subscription price and terms was heavily discussed. A long contract period would give financial security. A monthly running subscription on the other hand would ensure that subscribers were satisfied customers. Pros and cons of subscriptions in other businesses were checked with the Swedish Consumer Agency. It was learnt that one of the most annoying issues for customers is a long contract period for subscriptions. Customers' responses were also quite clear regarding short subscription contract periods. The two owners of Unicykel decided to run a monthly subscription, since it seemed relatively easy to find customers, and they thought it to be better to have a pool of subscribers who really used the service and get early signals about its attractiveness through early drop-outs than to have a higher financial security but with the risk of having unsatisfied customers.

Dealers

Dealer role, relation and compensation was a sensitive topic. Unicykel was afraid to disturb the relations by introducing a subscription. Typical issues were the following. Would this new customer segment and its repeated dealer visits create additional sales of bicycle accessories and clothes for dealers? Should the dealer have all customer contacts? How should the information flow be organized regarding service issues, maintenance booking, flat tires, stolen bicycles etc.? Finally, it was decided that the dealers should be compensated with the same amount as their margin for a bicycle in the € 800 price range, and to divide that compensation in two parts – one when signing up a customer to a subscription and one when delivering the bicycle. By this, the idea was to create a flexible system where others could sign up customers for subscriptions and the dealer could still earn good money also when only delivering the bicycles. In addition, dealers would no longer have to tie up capital and take financial risk in a stock of bikes.

To get more information about customer relation, distribution and service options, the two best local dealers were interviewed. It turned out that they were quite enthusiastic about the business model and wanted to participate in a pilot test.

Costs of Providing the Offer

The cost structure was unclear due to unknown subscription durations, costs and frequencies of refurbishing and remanufacturing over time. An economic spreadsheet model was developed, where the temporal distribution of costs and revenues could be simulated and calculated to net present value and return on investment. One of the owners then estimated service and remanufacturing costs and frequencies, subscription prices and feasible product and subsystem life lengths. It seemed quite possible to reach profitability expectations within the subscription price range the potential target customers had indicated during the target customer interviews, but the part-owner concluded

> It is a business model that takes time to verify. Meanwhile, the capital put in keeps growing without us knowing whether it will deliver or not. It will take many years before we can confirm if the remanufacturing cycle corresponds to my forecast. And meanwhile, we just add more of these bicycles to the market.

The Pilot Test

Most aspects of the pilot were tested according to the envisioned business model. Six participating consumers paid the monthly fee. The dealers distributed the bicycles, changed to winter tires, and handled adjustments and maintenance. Since a service increases the operational risk compared with a product, some changes were made to the bicycle to try to minimize such occurrences and to minimize the cost were they to appear. Typical measures were run-flat tyres, a special brake solution where exchange of pads would require a minimum of time, and a hub gear instead of a derailleur gear for lower maintenance. Throughout the pilot, customer perceptions were monitored via interviews and a regular survey. They were very positive.

Unicykel does not expect too much of a problem regarding fashion vulnerability. On the one hand, there seemed to be easy technical solutions to upgrade the looks of bikes retroactively. On the other hand, the framing of the offering might decrease the need. One of the owners reflected on the fashion topic:

> I believe the subscription as sales format will remove this need for continuous and often unmotivated product renewals. I think that with a subscription, the product's look will come later in the customer's priority list when getting a bicycle. And we can find other ways to renew bicycles as well. Ways that don't affect the possibility to remanufacture.

Decision to Cease

After almost a year on the project, Unicykel's two owners still express uncertainty about scaling up the business model. The main reason is that the lifetime cost depends on how the product is used, on subsystems' quality and suitability for their respective task, and on the electric bicycle's future attractiveness vis-a-vis alternatives on the market. Neither is fully controlled by Unicykel but depends on users and competitors and suppliers, who run linear business models. Unicykel can build knowledge here by collecting statistical data from many subscribers over a long time period, but this is financially risky with retained ownership or other types of dependence on remaining value in the e-bikes. Unicykel may also neutralize some fashion aspects at the time of product and service design, but only so much as they can predict and parry future technology advancements and design hypes. One of Unicykel's owners said

> This is the biggest risk that has arisen actually. It is considerably bigger than I thought from the start. ...One must limit the number of sold subscriptions until one can confirm that it [the cost assumption] corresponds. And that takes a pretty long time. So one cannot just go ahead at full speed. And one can't optimally price the subscription for quite a while. We must safeguard and calculate upwards on several parameters.

Analysis

The preceding section described the development of a CBM at the bicycle manufacturer, along with the challenges that were identified and overcome during the yearlong project. This section will analyse these challenges in relation to challenges identified in previous literature, and then focus on the inherent characteristics of a CBM that make the least required risk necessary to pursue a CBM higher than for the corresponding LBM.

Challenges from Previous Literature in the Case

While operational risk (cf. Kuo *et al.*, 2010) came up in discussions in the early stages of the project, in each specific situation there turned out to be fairly cheap technical solutions to each potential issue. Thus, increased operational risk did not appear as a major disadvantage in this case.

Fashion vulnerability, one of the disadvantages brought up by Mont *et al.* (2006), was not viewed as a major problem by the owners. However, the project duration was too short to verify this judgment against sales data.

The cooperation of external partners was initially viewed as a critical and problematic business model hypothesis in the case, as was hypothesized in the similar CBM project described by Mont *et al.* (2006). However, as the case project progressed beyond the comparatively early stages reached by Mont *et al.* (2006), contacts with the dealers indicated that this could be made a non-issue. Further, the pilot test of the offer seemed to validate this dismissal. In the case, the issue of partner restrictions turned out to be easier to overcome in practice than was implied by theory. However, reactions from external partners on the supply side were not examined, as remanufacturing did not occur over sufficiently long time and volume.

Many return flow challenges (see, e.g., Seitz, 2007; King *et al.*, 2006; Östlin *et al.*, 2008) could be avoided due to the PS-type subscription model in the CBM. The capacity planning problems associated with the predictability of the return flow brought up by King *et al.* (2006) remained unresolved, albeit considered only a minor issue (as judged by one of the owners).

The disadvantage of increased amounts of capital tied up as working capital in the CBM (see, e.g., Besch, 2005; Mont *et al.*, 2006) remained and increased in perceived importance over the course of the project. The solution suggested by Besch (2005), i.e. the use of very long contract periods, was considered and investigated in the project, but seemed likely to cause reduced demand and was therefore dismissed.

Based on these results, we conclude that several hitherto described challenges of CBM can at least sometimes be surmounted in practice (including channel resistance, securing return flow and likely fashion vulnerability and operational risk). However, the research design made us unable to examine certain CBM challenges previously reported in the literature. These were the following. (1) Lack of awareness (cf. Kuo *et al.*, 2010), since we influenced the awareness in the firm. (2) Product category restrictions, as reported by Sundin *et al.* (2009), since the case was specifically chosen to fit within product category restrictions. (3) Customer type restrictions, as described by Pearce (2009), since the investigated offer was aimed at consumers and not the type of industrial business-to-business customer implicitly assumed in that enumeration. Two additional reviewed challenges that did not constitute problems in the case are open to interpretation regarding applicability. (4) Risk of cannibalization, as reported by Guiltinan (2009), was avoided since new offer was aimed at a new customer segment. (5) Lack of supporting regulation, as reported by Kuo *et al.* (2010) and Stahel (2010), could of course always be viewed as a barrier to low risk profits.

The Problem of Risk in Circular Business Model Innovation

The case ended on a sober note: the owners were reluctant to do a wider market launch because they considered the CBM a risky investment. They concluded that, even if the e-bikes were considered attractive today, that still left unresolved the question of long-term costs to ensure market demand. Their concern regarding future attractiveness was not primarily about fashion but rather about future e-bike technology, function and economy, and there seemed to be no way to corroborate the critical assumption of long-term demand and cost structure beforehand. This illustrates our first proposition in the introduction: *(A) CBM poses significant challenges to proactive assessment of critical business model assumptions, implying increased uncertainty and therefore investment risk*. Below we analyse the inherent characteristics of CBM that cause this to be a general issue.

We define business risk (R) as the product of the pre-investment probability of malinvestment and the magnitude of risked resources. We denote the (conditional, after hypothesis tests) probability for the business model innovation to succeed[1] by p, and the probability of malinvestment as $1 - p$. We denote the magnitude of risked resources by M. In other words, we will show that

$$R_{\mathrm{cbm}} > R_{\mathrm{lbm}} \Leftrightarrow M_{\mathrm{cbm}}\left(1 - p_{\mathrm{cbm}}\right) > M_{\mathrm{lbm}}\left(1 - p_{\mathrm{lbm}}\right) \tag{1}$$

To support Inequality (1), we will first show that $p_{\mathrm{cbm}} < p_{\mathrm{lbm}}$ by showing that it is more difficult to reduce uncertainty by proactive business model hypothesis testing in the case of a CBM as compared with an LBM. We will then show that $M_{\mathrm{cbm}} > M_{\mathrm{lbm}}$ because invested resources remain at risk until the business model has been validated on the market, and this takes longer for a CBM. Towards the end, we show that PS-type business models with retained ownership act as a lever on the risked resources (M) for a CBM (Proposition B).

The Problem of Proactive Uncertainty Reduction

This section shows that $p_{\mathrm{cbm}} < p_{\mathrm{lbm}}$. In summary, we will show that proactive uncertainty reduction for business model innovation can be conceptualized as evaluation of critical business model hypotheses before investing in scaling up the business model. When a CBM and LBM are compared for the same physical product, in the case of a CBM important business model hypotheses predict the state of affairs farther into the future. It is more difficult to design and run quick and non-launch tests to evaluate hypotheses regarding a more distant future than it is to evaluate hypotheses regarding the shorter run. It is thus more difficult to proactively evaluate critical business model hypotheses for a CBM than an LBM. Proactive hypothesis evaluation increases the chance of final hypothesis veracity, because the business model will be *iteratively refined* until the most critical hypotheses are corroborated by the tests (Blank and Dorf, 2012; Ries, 2011). If this is not feasible, the decision maker is left with a less refined set of business model hypotheses, implying a lower chance of success (p). Below, we explain each step of the argument.

In the conceptualization of business model innovation presented in the second section a business model was viewed as a set of hypotheses about market conditions. In an established business model these hypotheses are corroborated by market success; in a new potential business model they are not. To reduce uncertainty before a market wide launch, the firm may devise and run tests to corroborate critical assumptions – proactively test business model hypotheses (see, e.g., Furr and Ahlstrom, 2011). In practice, these hypotheses are often split into a multitude of categories, including among other things customer needs, customer segments, customer offering feature priorities, channels, key partners, resources and activities, cost structure and revenue streams. For the sake of clarifying our argument, we will aggregate these into two types of hypothesis – revenue and cost hypotheses. This is a reasonable simplification, as the exact choice of categories is somewhat arbitrary, and revenue and cost hypotheses together capture a large share of the business model concept. Our argument relies on the differences in time horizons between CBM and LBM hypotheses, and our propositions will translate to other more detailed categorizations to the extent that differences in time horizons do.

Two effects contribute to the fact that cost and revenue hypotheses of a CBM need to predict market conditions for a longer time horizon than for an LBM based on the same physical product. First, the cost structure in a CBM is dependent on the economic value remaining in products after use – a hypothesis regarding a future state of affairs

[1] By success we mean that investment at least breaks even, including risk free opportunity costs of committed resources.

farther away in time from (initial) procurement than one-way manufacturing. The cost structure hypothesis of an LBM only needs to predict costs for one-off manufacturing of the product. Second, the revenue hypothesis of a CBM needs to predict customer demand not only for initial sales but also for sales after recirculation. The revenue hypothesis of an LBM only needs to predict demand for initial sales, which are by definition closer in time (with the product held constant between CBM and LBM). In essence, the business case for a CBM is based on the hypothesis that some parts of products are economically valuable not only at the time of initial sales, but also at a later date. This holds regardless of retained ownership of the products by the OEM or traditional ownership transfer of the product to customers at the point of sale.

We illustrate this phenomenon at a principle level in Figures 1 and 2. Note that we have simplified the picture by ignoring costs related to downstream supply chain management (such as channel compensation and promotional marketing). These are affected in the same way as the depicted cost hypotheses by the longer time horizons of CBM hypotheses, but would unnecessarily muddle the illustration of the core principle. Figure 1 displays the cost and revenue hypotheses of an LBM ($H^{t=1}_{cost}$, $H^{t=1}_{rev}$). The subscript denotes the hypothesis category (revenue and cost) and the superscript the point in time that the hypothesis predicts. Figure 2 displays the hypotheses of a CBM. The dashed boxes highlight the increased temporal extension of the hypotheses of a CBM, with the extended range depicted as additional independent cost and revenue hypotheses for each additional cycle. The solid arrows show material flows.

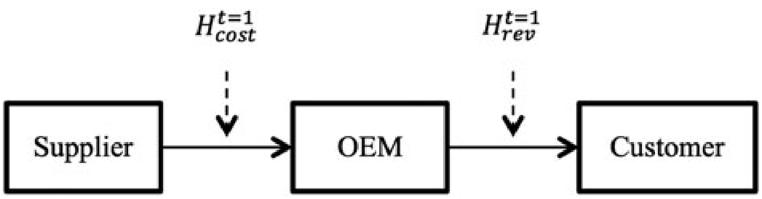

Figure 1. The cost and revenue hypotheses of a linear business model.

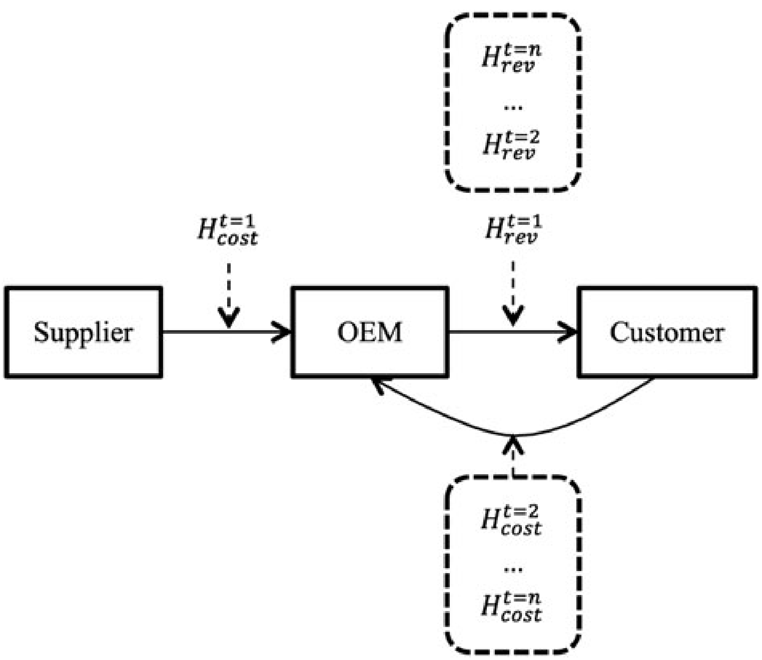

Figure 2. The cost and revenue hypotheses of a circular business model. Temporal extension of hypotheses highlighted by dashed boxes.

The fact that critical business model hypotheses are more stretched out in time causes problems for CBM from a risk reduction perspective. It is more difficult to design and run quick and non-launch tests to evaluate hypotheses regarding a more distant future than it is to evaluate hypotheses regarding the shorter run. This happens because costs and revenues are determined by underlying factors that may change over time. One such underlying factor is product attractiveness at a certain remanufacturing cost compared with competitors and substitutes. Product attractiveness in turn is affected by developments in, for instance, technology (Pearce, 2009), fashion (Mont *et al.*, 2006), complements and in the case of CBM wear of the components from previous use (see, e.g., Pearce, 2009; Seitz, 2007; Besch, 2005; Ravi and Shankar, 2005; King *et al.*, 2006; Östlin *et al.*, 2008). All of these are potential causes of product obsolescence. For instance, consider the cost effects of a battery technology revolution under the CBM in the case. While it is possible to design in some flexibility in the products (e.g. by means of modularization), it will never create the design freedom of the one-way value chain of an LBM. Thus, while a CBM might create many benefits such as decreased material costs and decreased environmental impact, it implies a higher difficulty to proactively evaluate critical business model hypotheses, and this implies less corroborated hypotheses at the time of the business model investment decision (lower p).

Thus, we can conclude the inequality

$$p_{\text{cbm}} < p_{\text{lbm}} \Leftrightarrow (1 - p_{\text{cbm}}) > (1 - p_{\text{lbm}}) \tag{2}$$

The Magnitude of Resources at Risk in CBM Innovation

To show that $M_{\text{cbm}} > M_{\text{lbm}}$ we will argue that it takes longer to conclusively corroborate a CBM than the corresponding LBM based on the same physical product. In essence, we will show that, under conditions most favourable to a CBM, the first materials loop of a CBM ties up the same resources as the corresponding LBM and that a CBM needs at least an additional loop to be corroborated. This is an elaboration on previous findings on tied up capital in CBMs (Mont *et al.*, 2006; Besch, 2005).

We begin with the notion of fixed and variable costs. Fixed costs correspond to costs that are independent of the production of one additional offer. These include product development, and might include investments in production capacity such as machines and, dependent on the institutional setting, long-term employees. Because products that are to be remanufactured often need to be especially designed for disassembly, remanufacturing and upgradability, it is plausible that fixed costs will be slightly higher for a CBM than for an LBM. You could view this additional cost as the price of a real option to recirculate your products cost effectively. However, for the sake of argument we will assume that fixed costs are constant between the CBM and LBM for corresponding physical products. Variable costs include any costs associated with delivering an additional offering, such as costs for materials and sales.

The total magnitude of resources (M) invested before a business model is corroborated as successful is the sum of fixed costs plus variable costs times the corroboration time. Corroboration time can here be measured in number of offerings sold, or approximated by calendar time under constant sales. This is summarized in the following equation:

$$M_{\text{bm}} = \text{fixed costs } + \text{variable costs} \times \text{corroboration time} \tag{3}$$

If we consider only the first cycle of a CBM, before any products are returned to the producer, we may view it as a special case of an LBM. As long as no extra investment needed to be made to prepare for recirculation, the magnitude of invested resources is at this point in time ($t = 1$) equal between a CBM and an LBM ($M_{\text{cbm}}^{t=1} = M_{\text{lbm}}^{t=1}$). However, whereas an LBM can be considered validated as successful (or not) once a certain number of products have been sold on a one-off basis, a CBM is not validated until at least some recirculated products have been (successfully) sold. As long as the economic sustainability of the CBM is dependent on at least some degree of recirculation, this means that there is an extra step to traverse to validate a CBM. In other words, *corroboration time* is higher for a CBM than for an LBM.

Variable costs are probably much lower during the second cycle for a CBM – after all, decreased component expenses is the main economic argument for a CBM. However, return flow challenges that may imply costs have been identified (see, e.g., Pearce, 2009; Seitz, 2007; Besch, 2005; Ravi and Shankar, 2005; King *et al.*, 2006; Östlin *et al.*, 2008). The magnitude in invested resources at risk during the subsequent cycle(s) can be expressed as

$$\Delta M = \text{ variable costs} \times \Delta\text{corroboration time} \tag{4}$$

where Δcorroboration time describes the additional cycle needed to validate the CBM after it has been validated as an LBM. Because M_{cbm} includes both the first cycle (corresponding to M_{lbm}) plus the additional, albeit cheaper cycle (s) (ΔM), the total magnitude of invested resources in validating the business model is still larger than for an LBM. Thus, we can conclude the inequality

$$M_{\text{cbm}} = M_{\text{lbm}} + \Delta M \Leftrightarrow M_{\text{cbm}} > M_{\text{lbm}} \tag{5}$$

This gives support to Proposition A.

Impact of Retained Ownership

When ownership is retained, the magnitude of invested resources at risk increases with the business model corroboration time. Fleet size is a function of corroboration time, and we know from earlier in the paper that corroboration time is higher for CBM than LBM. Because the fleet size is multiplied by product cost, which can be viewed as a constant here, retained ownership acts as a lever on the effects of longer corroboration time on M. In mathematical terms, the impact of retained ownership becomes an additional variable cost before market validation of the business model, illustrated as the third term in Equation (6). Note that fleet size is an implicit function of corroboration time (specifically number of products put on market).

$$M_{\text{PS-type}} = \text{ fixed costs } + \text{variable costs} \times \text{corroboration time } + \text{fleet size} \times \text{product cost} \tag{6}$$

Equation (6) shows that the issue caused by retained ownership can be understood as a leveraging effect on M. This supports our second proposition (*(B) Many PSS variants, while solving the return flow challenge, adversely affect the investment risk*).

Discussion

A range of challenges that may create cause for reluctance about CBMs, identified in this case, have also been identified in previous literature. The occurrence and severity of these challenges vary across challenge type, businesses, products, customer segments etc. While the presented case could not corroborate the occurrence of all of them, it could corroborate the occurrence of some of the previously identified challenges. However, it also found that some challenges were not critical in the studied setting. The most important contribution from this paper, however, is the finding that validating a CBM always has a higher business risk than validating a corresponding LBM. The reason is that such a validation cannot be achieved without a second (or third etc.), and hence later, sale, and this second cycle requires resources exposed to risk. In addition, we have shown that retained ownership increases the impact from failure, since the stock of resources at risk grows during the validation time with additional sales.

Two of the challenges identified in previous literature, fashion vulnerability and capital tied up, clearly relate to the business risk during business model validation we have focused on in this paper. The other challenges from literature are more relevant once a CBM is validated and operational. In fact, fashion vulnerability and capital tied up correspond quite well to the two underlying factors we identify in this paper. Our conceptualization highlights the need to extend the ideas of fashion vulnerability beyond changing customer preferences due to fashion, to also include changes in preferences due to technology, function and economy. This paper hence contributes to previous research by analytically grounding and extending the fashion vulnerability claim as well as separating CBM challenges related to business model validation and those related to business model operation.

We here conceptualize business risk as consisting of a probability factor and an impact factor. In relation to the challenges herein described, these factors have been managed in LBMs through design concepts such as planned obsolescence (London, 1932; Guiltinan, 2009), and then with the purpose of *increasing* the business risk for the buyer, since this can be beneficial under an LBM. Limited product life, limited upgradeability and limited reparability help avoid market saturation in several businesses today. We therefore find reason to believe that research on design concepts with the aims of *reducing risk of ownership* can reduce the business risk gap between the LBM and CBM. For instance, more robust and long-lasting designs can reduce the probability of product obsolescence, while technical, functional and aesthetical modularization can reduce both the probability and the impact of product obsolescence. We therefore suggest this as an avenue for further research.

One underlying assumption for our argument that a CBM has a higher business risk than a corresponding LBM is that the fixed and variable costs per physical item are not lower in the CBM than in the corresponding LBM. This is in turn based on the definition of the 'corresponding LBM', in which the products the value propositions are built upon are very similar between the two contrasted types of business model (i.e. CBM versus LBM). This is a reasonable estimation today, especially when PS offerings are based on LBM products. Indeed, costs per item are often higher for CBM due to the higher complexity in designing for refurbishing and remanufacturing, and due to the required return logistics. However, it may turn out that this underlying assumption will not always hold in the future, especially when research on design concepts for CBM risk reduction have been further explored. We can thus speculate that, in the future, new CBM-based products could potentially be less costly to design due to robust and highly modular subsystems and components in technical, functional, aesthetical and even economical dimensions (lower fixed cost). In the same way, they could potentially be less costly to produce, for instance due to higher subsystem and part volumes (lower variable cost) than corresponding LBM-based products.

From a methodological point of view, our finding that validating a CBM has a higher business risk than validating a corresponding LBM is not derived from the single case study. The observed reason for reluctance in the studied case (perceived risk of premature launch given limited and seemingly unattainable information) triggered our search for differences in the nature of the CBM and LBM that caused this reluctance. From these differences, we have built the theoretically grounded argument that validating a CBM has an inherently higher business risk than validating a corresponding LBM. We therefore believe that our findings are generalizable to all CBMs compared with their corresponding LBMs (i.e. based on the same or very similar products). More specifically, the two propositions are generalizable to the same degree that the process of uncertainty reduction in business model innovation through proactive validation of the most critical business model assumptions is generalizable.

Conclusion

The purpose of this paper has been to examine what characteristics of circular business models (CBMs) create reluctance when considering its implementation. Previous literature has suggested a number of challenges with CBMs. In the empirical case we found that many of these could be overcome in practice. However, some could not be overcome because of their inherent connection to fundamental differences between CBM innovation and LBM innovation. The challenges possible to overcome were operational in nature, while the challenges impossible to overcome were related to difficulties in proactive assessment of business model hypotheses. One of these challenges, fashion vulnerability, should be extended to incorporate technical, functional and economical vulnerability aspects as well. The difficulty of proactively evaluating hypotheses differs by technologies and markets, but it is never easier in a CBM than in the corresponding LBM due to the longer timespan of key business model hypotheses. This is particularly problematic when combined with the larger magnitude of risked resources before market validation caused by many PSS-type business models, where the manufacturer retains ownership of the products. These issues are likely to constitute a major source of reluctance for managers considering a shift from an LBM to a CBM.

Our findings suggest that managers need to adapt to the difficulty of risk management for investments in CBM innovation. For instance, it may often be necessary to dedicate significant effort to devise ways of reducing the probability and impact of product obsolescence. That being said, for many businesses CBM innovation may still provide a good risk adjusted return on investment, a topic not examined in this paper.

As a topic for further research, we believe that ways to reduce CBM innovation risk might be a valuable and fruitful direction. Two promising avenues are product design for increased product adaptability to an unknown future, and business model design for risk reduction in PS offerings that are based on retained ownership.

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