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Spinning straw into gold: Innovation recycling, innovation sourcing modes, and innovation ability in Sub-Saharan Africa

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Abstract

As innovation is inherently risky and uncertain, it is common for firms to suspend or abandon new product/service development projects that cannot achieve pre-defined objectives. Multiple cases exist where firms have attempted to resume the development of an innovative product or service after previously suspending or abandoning it prior to completion. Research on this important innovation recycling activity is surprisingly scarce, despite its critical role in mitigating risk in the context of high environmental uncertainty. We draw our inferences from Sub-Saharan Africa (SSA), where innovation resources are relatively limited and environmental uncertainty and institutional voids prevail, a context that encourages the use of innovation recycling. This study examines how innovation recycling influences a firm's innovation ability and the moderating impact of innovation sourcing modes using a knowledge-based view of the firm and arguments from transaction cost economics. We retrieved data from the World Bank Enterprise Survey and the Innovation Follow-up Survey of 1076 firms located in eight SSA countries (Ghana, Malawi, Namibia, South Sudan, Sudan, Tanzania, Uganda, and Zambia) spanning from 2011 to 2014 to test our conceptual model. Our findings show that (1) innovation recycling has a positive influence on a firm's innovation ability and (2) this relationship is moderated by different innovation sourcing modes. These findings enrich the theory and imply that firms operating in developing countries need to develop innovation recycling by focusing on sourcing knowledge within, rather than across, firm boundaries.

KEYWORDS

innovation recycling, innovation sourcing, knowledge-based view

1 | INTRODUCTION

Many innovation activities are suspended or abandoned before their original aims are met (Boulding et al., 1997; Shepherd et al., 2011; Tsinopoulos et al., 2019). This is particularly true for entrepreneurial and innovative firms (Shepherd et al., 2013) and for those operating in dynamic and complex environments (Deeds et al., 2000).

Frequently cited reasons for suspension or abandonment include a lack of financial resources and experience, a refocus of organization objectives, and general market factors (Greco et al., 2020; Mohnen et al., 2008). Unfortunately, detailed information concerning suspended and abandoned innovation activities is not widely available as organizations are often unwilling to provide it.

Innovation recycling refers to an attempt made by a firm to finish an unfinished new product or service whose development was previously suspended or abandoned. Our literature review suggests that very few empirical studies have explored this issue, and yet innovation recycling is an integral part of the innovation process and an important source of knowledge creation impacting firms' innovation ability (i.e., a firm's ability to introduce new or significantly improved products/services). Recycling allows firms to use the knowledge accumulated during prior innovation attempts, which affects firms' ability to generate new ideas and concepts and develop them into marketable and effective innovations (Elmquist & Le Masson, 2009; Yi et al., 2013). However, little is known about the effects of innovation recycling on innovation ability, which is vital for organizational success. This raises our first research question: How does innovation recycling affect a firm's innovation ability?

Another limitation of extant research concerns the contextual factors potentially influencing the effectiveness of the innovation recycling strategy. The creation of value from innovation recycling is dependent on the type of innovation sourcing used as firms must combine and exploit resources to extract value (Grant, 1996). Innovation sourcing refers to a firm's approach to obtaining new knowledge for its innovation activities (Veugelers & Cassiman, 1999), which also helps upgrade the firm's knowledge base (Hu et al., 2017; Leoncini, 2016). Although recent literature acknowledges that openness (Tsinopoulos et al., 2019) can influence the effectiveness of learning from prior innovation activities, including failures, research is still lacking in identifying how different types of innovation sourcing modes complement (or hinder) innovation recycling and, in turn, innovation ability. This raises our second research question: How do different innovation sourcing modes affect the relationship between innovation recycling and innovation ability?

Prior research on innovation failure is skewed toward firms in developed markets. At the same time, research into innovation recycling is becoming critically important in developing countries, such as those in Sub-Saharan Africa (SSA). Since 2012, SSA has exceeded other global regions in terms of having more countries ranked highly as innovation achievers (The Global Innovation Index, 2017). Meanwhile, SSA provides a drastically different context compared with those of richer countries, including a paucity of feasible innovation ideas, a relatively low level of technological development (Barasa et al., 2017), a considerably low level of investment in innovation due to its low resource munificence (George et al., 2016), and persistent institutional voids (George et al., 2016). Such contextual factors intensify the uncertainty and risk surrounding innovation, increasing the possibility of innovation activities being suspended or abandoned.

Drawing on the knowledge-based view (KBV) of firms and arguments from transaction cost economics (TCE), this study investigates how engaging in innovation recycling can enhance firms' innovation ability and how this relationship is affected by various types of innovation sourcing. To test our model, we used data from the World Bank Enterprise Survey (WBES) and the linked Innovation Follow-up Survey (IFS) on 1076 firms located in eight SSA countries (Ghana, Malawi, Namibia, South Sudan, Sudan, Tanzania, Uganda, and Zambia) from 2011 to 2014 (The World Bank, 2021).

This research contributes to the innovation literature in three ways. First, it expands the innovation research agenda by looking beyond the current dominant focus on initial new product development (NPD) and innovation failure as terminal points, addressing the incomplete theoretical specification and empirical analysis of the innovation recycling phenomenon. Specifically, it examines

Practitioner points

- This research suggests that innovation recycling significantly improves a firm's innovation ability.
- Managers should periodically reflect on past innovation failures as a part of their formal innovation project management review process.
- This research suggests that the benefits innovation recycling brings to innovation ability is best combined with an in-house R&D instead of sourcing the R&D activities fully or jointly with an entity outside the firm.
- Managers need to create new knowledge while protecting the uniqueness of the knowledge accumulated in previous innovation effort in the process of innovation recycling, which requires a high degree of control over the learning process and a proper mechanism guarding against the risk of opportunistic behaviour.

the influence of innovation recycling on innovation ability. As a result, it adds to the stage-gate system proposed by Cooper (2008) by demonstrating the possibility to resume innovation process and its associated benefits. This research postulates that comprehensive information reduces the uncertainty of recycled innovation. This examination of reapplying experience from failed innovation to fuel subsequent innovation recycling activities makes a precise and detailed contribution to the existing literature on innovation failure.

Second, this research contributes to the KBV literature by further developing our understanding of the impact of innovation recycling on innovation ability through an exploration of the moderating effects of three knowledge sourcing modes: insourcing, hybrid sourcing, and outsourcing. From a KBV perspective, a focus on innovation recycling is of interest since it has unique knowledge specificity, newly defined deliverables, screening criteria, and knowledge appropriability concerns. The KBV suggests that new knowledge can be obtained both within and outside firm boundaries (Cohen & Levinthal, 1990). It can provide firms with supplementary means to develop an improved knowledge stock to identify and comprehend problems from prior failures, improve the management of the NPD process, and recover losses. At the same time, it remains unclear how different innovation sourcing modes can facilitate or impede the effect of innovation recycling on innovation ability. Each innovation sourcing mode has its advantages regarding knowledge transfer and providing control over vital strategic assets and capabilities (Appleyard & Chesbrough, 2017). Accordingly, each mode is different in how it influences the effectiveness of innovation recycling in relation to innovation ability.

Third, this research allows us to understand the immense challenges that firms face when conducting innovation recycling while operating in the weak institutional environment of SSA and when significant firm-level variance exists in the selected innovation sourcing mode. Although numerous studies have examined abandoned and suspended innovations, the majority have done so in the context of advanced economies where the relatively mature and stable institutional environment reduces uncertainties and encourages experimentation (Elmquist & Le Masson, 2009; Madsen & Desai, 2010; Maslach, 2016). These studies have limited implications for innovation recycling in developing economies due to the disparity in context, which, in turn, may cause significant variations in the effectiveness of creating, sharing, and transferring knowledge. Our research is particularly relevant given that frugal innovation is emphasized within the developing countries located in SSA.

2 | INNOVATION RECYCLING IN SUB-SAHARAN AFRICA

Innovation recycling reduces the information asymmetry firms face in uncertain innovation environments. It can provide comprehensive information derived from preliminary market/technical assessments, market study/marketing research, business/financial analyses, in-house/customer product testing, trial sale and production, and pre-commercialization business analyses (Cooper, 1990; Cooper, 2008). Therefore, it results in fewer risks and uncertainties than developing entirely new innovations. Moreover, innovation recycling can provide an abbreviated development path to take advantage of the opportunities inherent in suspended or abandoned projects. Recycled projects can also begin at a much later point than new ones and are associated with a potentially shorter path to market (Chesbrough & Chen, 2015).

The ability to retrieve knowledge gained in earlier NPD attempts and apply it to innovation recycling to create new knowledge varies depending on the innovation sourcing mode employed. Those who produced the knowledge themselves (e.g., those within the same firm) face fewer challenges in knowledge transfer compared to others, such as members from outside the firm (e.g., outsourcing partners), who may experience issues when reusing NPD knowledge produced by insiders (Markus, 2001). For example, outside members may have difficulty selecting the documents most appropriate to their needs from those available (Blair, 1984). It may not be clear to them whether past documented NPD knowledge is current or out of date. Furthermore, they may lack the contextual knowledge required to understand and make sense of the documents (Markus, 2001).

For resource-constrained SSA-based firms, innovation recycling can be used as a primary strategy for making optimal use of current resources and capabilities, based on several reasons. First, the nature of the causes that usually lead to the abandonment of innovation projects suggests that innovation recycling is feasible. According to Oyelaran-Oyeyinka et al. (1996), 44% of survey respondents among SSA-based firms abandoned innovations due to financial problems. Furthermore, 42% abandoned innovation projects due to a lack of availability of other inputs, while 12.7% abandoned their projects due to a lack of machinery. Therefore, it appears that financial and other resource constraints play an important role in abandoned innovations, which can later be recycled.

Second, human capital development lags in SSA countries as firms are burdened by an undersupply of skilled and qualified talent due to insufficient and outdated education and training systems in the labor market (Wang & Cuervo-Cazurra, 2017). This negatively affects firm flexibility to move on to other innovation realms and recruit personnel specialized in new innovation areas. Innovation recycling has the potential to resolve this issue by enabling the continuous employment of personnel involved in prior failed innovation projects.

Furthermore, for firms in SSA countries, political instability, commodity price fluctuations, and poorly upheld laws can increase the default risk (Barasa et al., 2017; Julian & Ofori-dankwa, 2013). This increased risk prevents firms from accessing financial services provided by risk-averse domestic banking institutions (George et al., 2016), particularly when working on fundamentally new and uncertain ideas with few quality control assessment records. Thus, the rate of false negatives (i.e., incorrect suspension or abandonment of NPD projects with great potential) may be high due to a lack of a control system, such as the stage-gate system, in place during NPD. Recycling provides attractive opportunities for firms to make the best use of these false negatives to enhance innovation ability.

Challenges also remain for firms that want to obtain external funding due to the high information asymmetry investors face when evaluating innovation opportunities in countries with poor institutional quality (Barasa et al., 2017). The evaluations of and feedback on abandoned and suspended innovations provide relatively comprehensive information regarding the quality and value creation potential of these initially developed ideas. Such feedback assists external stakeholders in making investment decisions (Hu et al., 2017). In the eyes of external investors, innovation recycling could therefore be more appealing than brand new innovation projects that do not have quality control records. In both cases, innovation recycling represents a viable and useful approach in SSA.

3 | CONCEPTUAL MODEL AND RESEARCH HYPOTHESES

The KBV can help explain how innovation recycling can affect innovation ability. According to the KBV, knowledge is a crucial asset and a source of competitive advantage (Grant, 1996). It states that for a firm to enhance its innovation ability, it should adopt knowledge-based practices (Grant, 1996; Shu et al., 2012; Teece, 1998). The KBV also argues that firms can effectively recombine existing knowledge to create new knowledge that can lead to the development of new products (Kogut & Zander, 1992). As a result, an increase in a firm's knowledge reservoir fuels subsequent firm innovation (Calantone et al., 2002; Danneels & Vestal, 2020; Tsinopoulos et al., 2019).

We further argue that the effectiveness of innovation recycling is dependent on the mode of innovation sourcing used. Specifically, based on ownership, three sourcing modes exist with respect to the development of innovation activities (Arnold, 2000; Frenz & Ietto-Gillies, 2009; Wieland et al., 2020, (1) insourcing, wherein firms fully internalize innovation activities by relying on their own resource endowments; (2) hybrid sourcing, wherein joint innovation efforts are developed with an external partner or another firm of the same parent company; and (3) outsourcing, wherein external organizations are contracted.

Figure 1 illustrates the conceptual model. It depicts innovation recycling as being directly related to innovation ability and shows that this relationship is contingent upon the different innovation sourcing modes (i.e., insourcing, hybrid sourcing, and outsourcing). We explain the hypothesis development below.

3.1 | Innovation recycling and innovation ability

Innovation recycling positively influences innovation ability for three reasons. First, innovation recycling captures important knowledge from the experiences of prior innovation activities to help firms identify problems in their established routines and operating procedures

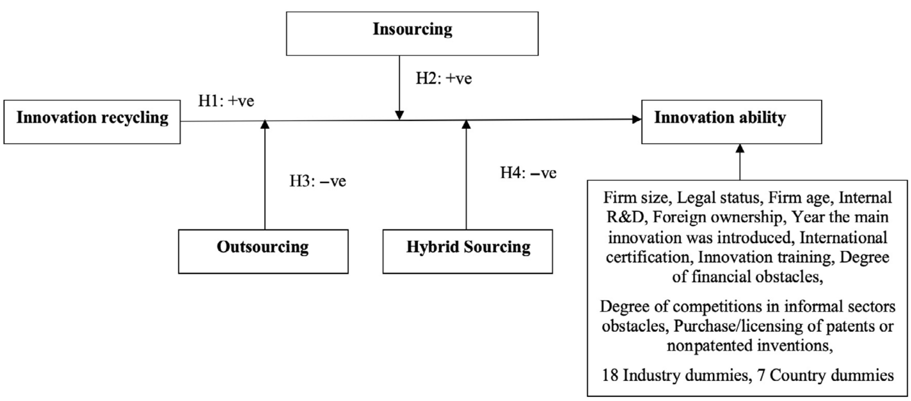


FIGURE 1 Conceptual model.

(Maidique & Zirger, 1985; Meyers & Wilemon, 1989). Firms may make abandonment and suspension decisions due to a lack of knowledge regarding a failed innovation project (Maslach, 2016). Innovation recycling provides the opportunity for firms to investigate the causal effects behind failure. It allows firm integrate learning outcomes from prior experience into new routines and procedures while retesting their new routines and procedures in the outside world (Maslach, 2016). This all leads to greater innovation ability.

Second, innovation recycling is essential in developing the innovation strength of a firm. Experiencing non-routine and shock events can contribute substantially to a firm's subjective stock of knowledge (Cope, 2011). The substantial information, learning, and knowledge obtained from experiences of failure are accumulative insofar as they can be transferred between projects, other teams, and functional areas (Cohen & Levinthal, 1990; Elmquist & Le Masson, 2009). Innovation recycling allows firms to break free from path dependency in the innovation process, such as by revising previously ineffective innovation practices, correcting mistakes, and augmenting skills and knowledge about the innovation process (Cope, 2011). The knowledge gained from innovation failure can be applied to other ongoing or planned innovations, thereby preventing a firm from repeating the same mistakes (Maidique & Zirger, 1985), which improves its innovation ability.

Third, as innovation recycling resumes the original progress, savings can be made from the initial screening and preliminary assessment of new ideas (Cooper, 1990) as well as from activities related to the building, developing, testing, and validating of new innovation ideas (Cooper, 2008). This reduces the resource-related friction faced in innovation recycling and shortens the overall development time of new products/services, thereby improving innovation efficiency and ability. Based on these arguments, we predict the following:

> **Hypothesis 1.** Innovation recycling is positively associated with innovation ability.

3.2 | The moderating role of innovation sourcing mode

3.2.1 | The moderating effects of insourcing

Innovation recycling is an important source of knowledge creation. It allows firms to use and adapt the knowledge accumulated during prior innovation attempts, helping them generate new ideas and concepts, experiment with solutions for potential opportunities detected in the market, and develop the solutions into marketable and effective innovations (Elmquist & Le Masson, 2009; Yi et al., 2013). Specifically, innovation recycling relies on sharing experiential knowledge related to prior failures, the tacit and complex nature of which makes knowledge exchange exceptionally difficult (Choi et al., 2011; Kogut & Zander, 1992).

In addition, earlier work indicates that the specificity of knowledge increases the possibility that the knowledge will be exploited through internal expansion (such as through insourcing) rather than through collaborative mechanisms, thereby protecting it from imitation by outside partners (Pisano, 1990; Weigelt, 2009). Here, knowledge specificity is defined as the extent to which knowledge is unique to the firm that creates it (Carayannopoulos & Auster, 2010). In addition, knowledge specificity is frequently associated with research and development (R&D) (Helfat, 1994). Specificity occurs due to the evolution of routines that create new knowledge, and such routines are embedded in and unique to individual firms (Carayannopoulos & Auster, 2010; Poppo & Zenger, 1998).

Hence, innovation recycling aligns well with insourcing mode to create efficient and cost-effective internal value chain activities. Insourcing provides firms with a relatively high degree of control and autonomy over the experience-based learning process (Cannon & Edmondson, 2005) and can also quickly gather support for innovation recycling decisions. Accordingly, insourcing is well suited to enhancing the effect of innovation recycling on innovation ability. The reasons for this are outlined in more detail below.

First, it provides easy access to frequent communications (Allred & Swan, 2014; Felin & Zenger, 2014) that facilitate the sharing of tacit experiential knowledge (Huang et al., 2009). Frequent communication is required to identify the causes for abandoning and suspending innovations (Beneito, 2006). The KBV conceptualizes firms as institutions for developing and integrating knowledge (Grant, 1996; Kogut & Zander, 1992). The control and coordination provided by insourcing foster knowledge development and facilitate knowledge transfer in ways that outsourcing cannot (Macher & Boerner, 2012). Specifically, the insourcing within a firm relies on the same sets of common languages, habits, routines, established practices, and institutional environments, which eases the coordination costs on knowledge integration for innovation recycling. It also enables innovation recycling to benefit from a more efficient management of frequent dialogues. This not only reduces time cost associated with experience-based learning process, but also minimizes the impact of the deficient communication infrastructure in SSA (African Economic Outlook, 2017).

Second, insourcing offers a high degree of control over potential opportunistic activities (Yang et al., 2010). It protects a firm's specific assets (Williamson, 1981) in its innovation recycling efforts. This is particularly relevant to the weak appropriability regime, high level of uncertainty and underdeveloped market-supporting institutions in SSA (Allred & Swan, 2014). Innovating firms may want to minimize their transactional costs (Dyer, 1997; Williamson, 1981) by using insourcing to protect knowledge rather than cooperating with external entities or fully subcontracting innovation projects (Parmigiani, 2007).

Third, insourcing can minimize adaptation costs, which is particularly relevant to SSA, where high transaction costs persist due to the high level of uncertainty (Spithoven & Teirlinck, 2015). Insourcing allows for the easy modification of managerial controls. Employment contracts are highly flexible and amendable upon agreement within a firm (Cuervo-Cazurra et al., 2018). During innovation recycling, creation of new jobs and or changes to the monitoring systems can be easily accommodated.

Fourth, internal sourcing practices "tolerant compensation systems" against contractual sourcing with external entities, in which the outcomes are not the only determinant of rewards (Cuervo-Cazurra et al., 2018). This fosters a favorable innovation environment that supports risk-taking, which in turn encourages individuals to experiment with new concepts and ideas (Smith et al., 2005). These incentives allow employees to explore potential avenues to resolve prior deficiencies and help innovation recycling succeed. Considering the above arguments, we predict the following:

Hypothesis 2. Insourcing strengthens the relationship between innovation recycling and innovation ability.

3.2.2 | The moderating effects of outsourcing

The extant literature points to the value of external knowledge (e.g., Tsinopoulos et al., 2018); however, innovation recycling is not expected to align well with outsourcing. The KBV tells us that outsourcing faces several challenges specifically related to innovation recycling. In particular, innovation recycling depends mainly on experiential knowledge, which generates distinctive competitive advantage based on the noncodifiability, nonteachability, and complexity of experience (Grant, 1996). According to the KBV and TCE, this type of knowledge is better aligned with insourcing rather than outsourcing due to the differences in their levels of integration and control (Dyer, 1997; Williamson, 1981). The mentioned knowledge transfer and knowledge safeguarding issues are particularly heightened in the case of outsourcing.

Outsourcing makes innovation recycling vulnerable to the difficulties associated with safeguarding innovation recycling contracts against changing environmental conditions, as predicted by TCE (Dyer, 1997; Williamson, 1981). During outsourcing, concepts, designs, and blueprints core to innovation recycling have to be opened up to third parties (Buss & Peukert, 2015). Additionally, managers rarely have the power to create new rules when situations not specified in the contract arise (Cuervo-Cazurra et al., 2018). This incurs additional expenses or penalties related to the renegotiation, enforcement, or even cancellation of innovation contracts (Stanko & Calantone, 2011). In other words, revising an agreement with a partner subjects innovation recycling to potential intermittency or deal breakdown. Therefore, outsourcing not only increases the time to market for innovation recycling but also the costs of safeguarding the innovation against environmental uncertainties (Parmigiani, 2007), thereby reducing innovation returns. This issue is particularly relevant to SSA, where weak institutions (i.e., those with a high degree of political instability, widespread corruption, weak protection of property rights, and/or malfunctioning markets) and extensive ethnic, tribal, and linguistic variety (George et al., 2016) intensify the risks associated with opportunism.

In the case of outsourcing, limited support is provided for the communication and knowledge exchange involved in innovation recycling. Focal firms purchase solutions that R&D contractors offer at mutually agreed prices (Felin & Zenger, 2014) and then match them with innovation recycling. The value of acquired knowledge is highly uncertain as R&D contractors are generally self-selected and constrained by the network reach of the focal firms. In addition, external partners specializing in standardized technology and routinized research are likely to resell their solutions (Beneito, 2006; Huang et al., 2009) as they are paid only for their results and not their effort (Cuervo-Cazurra et al., 2018). Consequently, the use of outsourcing leads to a lack of ongoing and extensive communication between parties. Accordingly, it cannot provide customized solutions for the specific and complex needs and concerns relevant for innovation recycling.

Furthermore, the resulting exposure of innovation recycling results can increase the risk of third parties propagating similar knowledge or equivalent technology across an industry (Stanko & Olleros, 2013). This reduces the novelty value of the sensitive knowledge involved in innovation recycling (Hottenrott & Lopes-Bento, 2016), hampering firms' innovation ability. Hence, we predict the following:

Hypothesis 3. Outsourcing weakens the relationship between innovation recycling and innovation ability.

3.2.3 | The moderating effects of hybrid sourcing

The hybrid sourcing mode is based on joint innovation efforts developed with an external partner or another firm with the same parent company. The hybrid sourcing mode both encapsulates the advantages of insourcing and reduces the disadvantages of outsourcing. For instance, it enables firms to obtain the knowledge they lack within. Furthermore, it allows firms greater control of the knowledge transfer process and knowledge content. In this way, firms can avoid being kept as "prisoners" of the innovation process designed by external parties. However, despite these potentially positive effects of hybrid sourcing, several additional challenges exist.

First, hybrid sourcing does not always help to achieve better outcomes in innovation recycling, particularly when tacit knowledge is involved (Bresman et al., 2010). The nature of NPD means that it is not always easy to identify and define subproblems in the innovation process. Often, these problems cannot easily be subdivided and decomposed as they tend to be ill-structured and characterized by unknown interactions among knowledge components (Levinthal, 1997; Weigelt & Sarkar, 2012). Therefore, it will be a significant challenge to transfer and develop knowledge to solve these problems with external partners and other units within the same parent firm (Bresman et al., 2010). In short, the hybrid sourcing mode is likely to be beneficial only if activities have low interdependence, are sequential, and can be easily divided into separate subactivities with well-understood interfaces (Wheelwright & Clark, 1992). The hybrid sourcing mode thus faces the mounting pressures of having poorly defined problems to address and an ill-defined structure to use in innovation recycling.

Furthermore, converting knowledge through a hybrid mode for protected and complicated innovation recycling activities requires several complex processes to improve the innovation ability. In addition, high knowledge integration costs may occur due to the lack of a formally agreed-upon code of conduct in the exchange agreement between cooperating partners (Grimpe & Kaiser, 2010). These factors place pressure on innovation recycling by introducing additional complexities when agreeing on the key deliverables; and in terms of the knowledge sharing process; and the ownership of the intellectual property resulting from the partnership among idiosyncratic actors, knowledge sets, activities, and schedules (Tsinopoulos et al., 2018; Van de Vrande et al., 2006). Such agreements attract higher transaction costs (Williamson, 1981) and may become less effective due to low trust and minimal reciprocity (Vestal & Danneels, 2018), thereby reducing the positive impact of innovation recycling on innovation ability.

Finally, firms that adopt hybrid sourcing are likely to face increased transaction costs and risks arising from the potential opportunistic activities of partners, environmental uncertainty, and the costs associated with knowledge access, transfer, and governance (Allred & Swan, 2014; Stanko & Calantone, 2011). All of these negatively affect innovation ability. The issue of trust in SSA further intensifies the negative impact of hybrid sourcing on innovation recycling in terms of improving innovation ability. For recycling with an external partner, a firm has to share knowledge externally (e.g., information on the know–how regarding the technologies available in the firm and on the know-how regarding the characteristics of similar products that the firm has developed or is currently developing). In this case, transaction costs will rise due to the knowledge specificity and complexity that external partners may opportunistically act upon and the uncertainty and challenges in foreseeing innovation outcomes and partners' performance (Williamson, 1981). For recycling through another firm within the same parent, interfirm links and networks experience friction in knowledge transfer, communication, and coordination due to differences in internal knowledge, practices, and capabilities (Bresman et al., 2010; Tsai, 2001). The uncertainty in monitoring and evaluating units' innovation behaviors and performance also has cost implications (Williamson, 1981). Based on the above discussion, we predict the following:

> **Hypothesis 4.** Hybrid sourcing weakens the relationship between innovation recycling and innovation ability.

4 | METHODOLOGY

4.1 | Data

For the empirical analyses in this study, we used cross-sectional firm-level survey data from Tanzania, Uganda, and Zambia (from the 2013 WBES and the linked 2013 IFS) as well as from Ghana, Malawi, Namibia, South Sudan, and Sudan (from the 2014 WBES and the linked 2014 IFS). The WBES provides information on individual firm characteristics, infrastructure and services, sales and supplies, competition, finance, and performance as well as on the business environment of the considered economies (Barasa et al., 2017). It was administered through stratified random sampling to ensure it obtained a representative sample of the economy's private sector. The samples consist of firms of different sizes, industries, locations, and ownership types. The IFS focuses on product, organization, and marketing innovation as well as

TABLE 1 Measurement of constructs

Construct	Measurement
Innovation recycling	"From financial year T through T-2, did this establishment attempt to develop an innovative product or service that was abandoned or suspended before completion" (0 = "No" and 1 = "Yes").
Innovation ability	"In financial year T, what percentage of this establishment's total sales was represented by sales from the main new or significantly improved product or service?" (percentage divided by 100).
Innovation sourcing modes	"Who developed the main new or significantly improved product or service?"
Insourcing	Entirely by same firm (0 = "No" and 1 = "Yes").
Outsourcing	Entirely by another firm independent from this firm (0 = "No" and 1 = "Yes").
Hybrid sourcing	This firm in cooperation with other firms/institutions or by another firm of the same parent company (0 = "No" and 1 = "Yes").
Control variables	
Firm size	natural logarithms of employee numbers.
Legal status	0 = "if the firm is legally organized as a sole proprietorship, partnership, limited partnership or has another form" and 1 = "if the firm is organized as a corporation (shareholding company with publicly traded shares and those with nontraded or privately traded shares).
Firm age	Natural logarithm of number of years since establishment.
Internal R&D	"From financial year T through T-2, did firm conduct internal R&D?" (0 = "No" and 1 = "Yes").
Foreign ownership	Percentage of this firm is owned by private foreign individuals, companies, or organizations.
Year the main innovation was introduced	Natural logarithm of number of years since main new or significantly improved product or service was introduced.
International certification	"Does this establishment have an internationally-recognized quality certification?" (0 = "No" and 1 = "Yes").
Innovation training	"From financial year T through T-2, did this establishment provide *formal training* to any of its employees specifically for the development and/or introduction of innovative products or services and processes?" (0 = "No" and 1 = "Yes").
Degree of financial obstacles	"To what degree is access to finance an obstacle to the current operations of this establishment? "(0 = "No," 1 = "Minor," 2 = "Moderate," 3 = "Major," and 4 = "Very severe").
Degree of competitions in informal sectors obstacles	"To what degree are practices of competitors in the informal sector an obstacle to the current operations of this establishment?" (0 = "No," 1 = "Minor," 2 = "Moderate," 3 = "Major," and 4 = "Very severe").
Purchase/licensing of patents or nonpatented inventions	"From financial year T through T-2, did this establishment purchase or license any patented or nonpatented inventions, or other types of knowledge for the development of innovative products or services and processes?" (0 = "No" and 1 = "Yes").
Industry dummies	Industry dummy variable represents 18 industries.
Country dummies	Country dummy variables represents 7 countries.

innovation-related activities within firms in emerging and developing countries. It was administered to a subset of respondents randomly selected to ensure a final sample of 75% of the original WBES. The survey respondents were typically business owners and top managers. However, in some instances, they were human resource managers and company accountants who answered questions related to labor and sales, respectively. The WBES and IFS provide firm-level information for 3 years. The two datasets were merged using a unique firm identifier to generate a single dataset for analysis. Lagged variables were allowed so that causality could be tested. All observations with missing values for the variables of interest were deleted. The final sample consisted of 1076 firms from eight countries. Overall, 121 of the firms were from Ghana, 25 from Malawi, 25 from Namibia, 283 from South Sudan, 26 from Sudan, 81 from Tanzania, 222 from Uganda, and 293 from Zambia.

4.2 | Measurement of variables

Our measures were based on previous research. Table 1 provides information regarding the operationalization of different variables. The explanatory, moderation, and control variables reflect data for period T-2, and the dependent variable, which measures innovation ability, reflects the data for period T. The periods for these variables had minimal overlap, thereby alleviating simultaneity issues.

4.2.1 | Dependent variable

We used the widely applied "intensity of new product sales" to measure innovation ability, which is captured as the percentage of a firm's total sales represented by sales from the main new or significantly improved product/service. This product/service may be either new to the business or new to the market. This measure has frequently been used in prior innovation studies (Cassiman & Veugelers, 2006) and provides a direct assessment of the efficiency of R&D efforts (Yi et al., 2013).

4.2.2 | Independent variable

Innovation recycling was measured as a binary variable. A value of 1 was ascribed to a firm if, between years T-2 and T, it attempted to develop an innovative product or service that was abandoned or suspended before completion; otherwise, a value of 0 was assigned.

4.2.3 | Moderating variables

Three innovation sourcing modes (insourcing, hybrid sourcing, and outsourcing) were measured as binary variables depending on the sourcing mode adopted by a firm when developing a main new or significantly improved product or service. Main innovative products or services represented the largest proportion of sales (in value) during financial year T. Insourcing was categorized as innovation undertaken entirely by the same firm; outsourcing as innovation undertaken entirely by another independent firm; and hybrid sourcing as a joint innovation effort developed with an external partner or another firm of the same parent company.

4.2.4 | Control variables

This study controlled for firm size as previous studies found that a firm's propensity to invest in R&D is positively associated with its size (Barasa et al., 2017). Firm size was captured as a natural logarithm of employee number. We also included legal status as a dummy variable, which had a value of 1 if the firm was organized as a corporation (i.e., shareholding companies with publicly traded shares or with nontraded or privately traded shares) and a value of 0 if the firm was legally organized as a sole proprietorship, partnership, or limited partnership or if it had another form (Barasa et al., 2017). The existing research suggests that firms organized as corporations conduct more innovation activities than unincorporated ones (Ayyagari et al., 2011). By deducting the year a firm was established from the year of the survey, firm age was also computed and controlled for as a firm's age can also facilitate knowledge accumulation and experience that enhance innovation ability. Foreign ownership was defined as the percentage of ownership held in a focal firm by private foreign individuals, companies, or organizations. This was controlled for because foreign ownership of a firm can impact its ability to explore external knowledge sources (Choi et al., 2011). Ownership heterogeneity was considered essential to firm innovativeness.

The year the main innovation was introduced was used to control the impact of completed innovations from different time periods, which accounted for the largest proportion of sales (in value) in year T. Internal R&D was used as another control variable. It was based on whether a firm conducted internal R&D between T-2 and T and was associated with a firm's ability to innovate (Cassiman & Veugelers, 2006). International certification improves firm competitiveness, as it can help to differentiate its products and may also enhance or reinforce its reputation (López-Mielgo et al., 2009). Furthermore, we included a variety of innovation activities that serve as vital knowledge inputs for a firm's innovation output, such as training for innovative activities (measured according to whether a firm provided formal training to any of its employees), purchase/licensing of patents or nonpatented inventions (Wadho & Chaudhry, 2018), and the degree of financial obstacles and competition in the informal sector obstacles. A high degree of financial constraint is associated with reduced innovation effort (Howell, 2016). Informal activities, such as payments and gift-giving to government officials, comprise more than 50% of the economic output in developing economies. This could present an obstacle to legitimate commerce through developing innovation (Mathias et al., 2015).

Eighteen dummy industries were included to capture differences in innovation rates that account for innovation ability variations: (1) food and tobacco; (2) textiles, garments, and leather; (3) wood, paper, and publishing; (4) refined petroleum products; (5) chemicals; (6) plastic and rubber; (7) nonmetallic mineral products; (8) basic metals; (9) fabricated metal products; (10) machinery, machinery transportation, and electronics; (11) furniture; (12) recycling; (13) retail; (14) wholesale; (15) hotels and restaurants; (16) transport; (17) construction; and

(18) motor vehicle services. Finally, seven country dummy variables were controlled for idiosyncrasies associated with country-related effects.

4.3 | Analyses

Tobit models were estimated to account for right censoring as our dependent variable, innovation ability (Gujarati, 1995), was measured as a fraction bounded between 1 and 0 and included a nonnegligible number of 1. Unobserved heterogeneity is, at most, a minor issue in Tobit regression (Wooldridge, 2005). In addition, since the sample consisted of 1076 firms, use of the cluster option in the Tobit estimations meant that some observations were not considered independent. In essence, it controlled the correlation of residuals by clustering the standard errors at a firm level to account for the correlation between repeated observations of the same firm, thereby guaranteeing robust standard errors (Berchicci, 2013).

To empirically examine the effects of innovation recycling and innovation sourcing modes on innovation ability, five models were used to examine the hypotheses. Models 1–3 added the control and independent variables and moderating variables into the regression analyses in a sequential manner. Model 1 was predicted with only control variables included. The independent variable innovation recycling was entered into Model 2, and the moderators were added to Model 3 as control variables.

Model 4 used dummy coding to compare the moderating effect of each sourcing mode with respect to outsourcing as a reference group. Model 5 used weighted effect coding, comparing the mean innovation ability for firms adopting innovation recycling plus each sourcing mode to the mean innovation ability for all the firms adopting innovation recycling. The coding used in Model 5 was more robust, which allowed the code to be adjusted by the population weight of each sourcing mode to account for the unbalanced sample size of different sourcing modes in our data (Te Grotenhuis et al., 2017). For the coding matrix of the weighted effect coding, as a rule, the value in each cell of the matrix was weighted by the relative proportion in each group. The values in the columns of the coding matrix were weighted and summed to zero (Nieuwenhuis et al., 2017).

Within Model 5, the first comparison made was between the firms adopting innovation recycling plus insourcing and all the firms adopting innovation recycling (insourcing = 1, outsourcing $= -(n_{\text{insourcing}}/n_{\text{outsourcing}}) = -12.02$, hybrid sourcing = 0). The second comparison was between the firms adopting innovation recycling plus hybrid sourcing and all the firms adopting innovation recycling (hybrid sourcing = 1, outsourcing $= -(n_{\text{hybrid sourcing}}/n_{\text{outsourcing}}) = -3.54$, insourcing = 0). The third comparison was between the firms adopting innovation recycling plus outsourcing and those adopting innovation recycling. This comparison was omitted given that the weighted effect coding coefficient compares the moderation of each sourcing mode to all firms adopting innovation recycling instead of to a reference group. We therefore switch the reference group in the weighted effect coding to insourcing (outsourcing = 1; insourcing $= -(n_{\text{outsourcing}}/n_{\text{insourcing}}) = -0.08$; hybrid sourcing = 0) and obtain the coefficient for this comparison (Te Grotenhuis et al., 2017). A positive or negative and statistically significant coefficient for the interaction terms indicated that the mean innovation ability of firms adopting innovation recycling in conjunction with a specific kind of sourcing mode was above or below, respectively, the average level of innovation ability across all the firms adopting innovation recycling. Hence, this provided evidence of the moderating effect of the considered sourcing mode.

Both models 4 and 5 had fixed reference groups, and the results from these models were appropriate for comparing the moderating effects among different sourcing modes.

The equation for Model 5 was as follows:

$$\begin{aligned}&\text{Innovation performance}_i = \beta_0 + \beta_1 \text{Innovation recycling}_i \\ &+ \beta_2 \text{Insourcing}_i + \beta_3 \text{Hybrid sourcing}_i + \beta_4 \text{Outsourcing}_i + \beta_5 \\ &\text{Innovation recycling}_i * \text{Insourcing}_i \\ &+ \beta_6 \text{Innovation recycling}_i * \text{Hybrid sourcing}_i \\ &+ \beta_7 \text{Innovation recycling}_i * \text{Outsourcing}_i \\ &+ \beta_8 \text{Control}_i + \varepsilon_i.\end{aligned}$$

5 | RESULTS

The descriptive statistics of the sample—such as the mean, standard deviation, and the inter-correlations of all study variables—are presented in Table 2, showing that the SSA-based firms had an average of 39.38 employees. A breakdown of the sample according to the ownership structure revealed that 20.32% of the firms were held by private foreign individuals, companies, or organizations. In addition, the firms operated for an average of 13.31 years, and 23.24% of them conducted internal R&D during the 3-year survey. Overall, 80.52% of the firms introduced a main new or significantly improved product or service. Among the firms, 12.36% were involved in innovation recycling. Furthermore, 72.58% used insourcing to develop main new or significantly improved products or services, whereas 6.04% used

TABLE 2 Descriptive statistics, correlations, mean and standard deviations

	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Innovation ability	0.31	0.25	0.01	1	1															
2 Innovation recycling	0.12	0.33	0	1	0.15*	1														
3 Insourcing	0.73	0.45	0	1	0.02	0.00	1													
4 Hybrid sourcing	0.21	0.41	0	1	−0.03	−0.01	−0.85*	1												
5 Outsourcing	0.06	0.24	0	1	0.02	0.02	−0.41*	−0.13*	1											
6 Firm size (log)	2.63	1.08	0	8.29	−0.05	0.02	−0.07	0.11*	−0.07*	1										
7 Legal status	0.17	0.37	0	1	−0.03	0.04	−0.04	0.03	0.02	0.20*	1									
8 Firm age (log)	2.29	0.78	0	4.89	−0.09*	0.03	−0.05	0.13*	−0.13*	0.30*	0.03	1								
9 Internal R&D	0.23	0.42	0	1	0.04	0.16*	−0.08*	0.10*	−0.02	0.19*	0.09*	0.07*	1							
10 Foreign ownership	0.20	0.37	0	1	−0.02	−0.09*	0.01	−0.04	0.05	0.18*	0.20*	−0.13*	0.05	1						
11 Year the main innovation was introduced (log)	1.04	0.40	0	3.30	0.10*	0.08*	−0.10*	0.07*	0.07*	0.14*	0.00	0.24*	0.00	−0.03	1					
12 International certification	0.16	0.36	0	1	−0.07*	−0.02	−0.02	0.07*	−0.08*	0.36*	0.11*	0.21*	0.15*	0.12*	0.01	1				
13 Innovation training	0.28	0.45	0	1	0.09*	0.09*	−0.07*	0.10*	−0.05	0.21*	0.08*	0.12*	0.39*	0.01	0.03	0.14*	1			
14 Degree of financial obstacles	2.21	1.23	0	4	0.06*	0.08*	0.00	−0.03	0.04	−0.16*	−0.13*	−0.10*	−0.03	−0.10*	0.02	−0.11*	−0.02	1		
15 Degree of competitions in informal sectors obstacles	2.03	1.22	0	4	−0.03	0.05	0.02	−0.04	0.04	−0.07*	−0.11*	−0.02	−0.05	−0.08*	0.03	−0.02	−0.11*	0.18*	1	
16 Purchase/licensing of patents or nonpatented inventions	0.10	0.30	0	1	0.09*	0.11*	−0.03	0.02	0.02	0.11*	0.04	0.01	0.28*	0.00	0.00	0.08*	0.26*	−0.02*	0.01	1

Note: Level of statistical significance: *$p \leq 0.05$.

outsourcing, and 21.38% used hybrid sourcing. The industrial sectors exhibiting the highest percentages of innovation recycling were chemicals (37.04%); construction (27.78%); furniture (18.18%); transport (17.02%); wholesale (15.94%); food and tobacco (15.56%); machinery, machinery transportation, and electronics (15.38%); and motor vehicle services (13.89%).

Extant studies on innovation failure have largely been based on the contexts of developed countries. Generally, they have recorded similar levels of innovation abandonment between 9.2% and 16.6% (D'Este et al., 2016; Hyll & Pippel, 2016). Overall, SSA was found to exhibit a relatively high percentage of innovation recycling at 12.36%, considering innovation recycling is the next stage following innovation abandonment.

5.1 | Tobit regression

Table 3 depicts the results from the models. Model 1, which only included the control variables, suggests that formal innovation training is positively associated

TABLE 3 Tobit regressions on innovation recycling's effect on innovation ability

Variables	Model 1	Model 2	Model 3	Model 4	Model 5
Independent variable				Dummy coding	Weighted effect coding
Innovation recycling		0.05 (2.26**)	0.05 (2.20**)	0.14 (1.68*)	0.04 (2.13**)
Moderators					
Insourcing			0.12 (3.60***)	0.13 (3.72***)	0.01 (2.58***)
Hybrid sourcing			0.10 (2.74***)	0.14 (3.56***)	−0.01 (−0.50)
Outsourcing					−0.11 (−3.65***)
Interactions					
Innovation recycling * Insourcing				−0.05 (−0.57)	0.04 (2.96***)
Innovation recycling * Hybrid sourcing				−0.26 (−2.77***)	−0.15 (−4.05***)
Innovation recycling * Outsourcing					0.07 (1.13)
Control variables					
Firm size	−0.01 (−1.64*)	−0.01 (−1.57)	−0.01 (−1.64*)	−0.01 (−1.80*)	−0.01 (−1.80*)
Legal status	0.00 (−0.09)	−0.01 (−0.24)	0.00 (−0.19)	0.00 (−0.13)	0.00 (−0.13)
Firm age	0.00 (−0.36)	−0.01 (−0.39)	0.00 (−0.35)	−0.01 (−0.44)	−0.01 (−0.44)
Internal R&D	0.00 (−0.03)	−0.01 (−0.39)	−0.01 (−0.28)	0.00 (−0.21)	0.00 (−0.21)
Foreign ownership	0.03 (0.58)	0.01 (0.26)	0.01 (0.27)	0.00 (0.11)	0.00 (0.11)
Year the main innovation was introduced	0.02 (0.82)	0.02 (0.88)	0.02 (1.12)	0.02 (1.08)	0.02 (1.08)
International certification	0.00 (−0.06)	0.00 (−0.06)	0.00 (0.00)	0.00 (−0.16)	0.00 (−0.16)
Innovation training	0.05 (2.85***)	0.05 (2.86***)	0.05 (2.88***)	0.06 (3.09***)	0.06 (3.09***)
Degree of financial obstacles	0.09 (0.65)	0.00 (0.53)	0.00 (0.62)	0.00 (0.67)	0.00 (0.67)
Degree of competitions in informal sector obstacles	−0.01 (−1.02)	−0.01 (−1.17)	−0.01 (−1.01)	−0.01 (−1.11)	−0.01 (−1.11)
Purchase/licensing of patents or nonpatented inventions	0.02 (0.80)	0.02 (0.65)	0.01 (0.49)	0.01 (0.56)	0.01 (0.56)
Industry and Country dummies	Included	Included	Included	Included	Included
Wald χ^2 (*df*)	220.26 (36)	225.36 (37)	238.86 (39)	255.49(41)	255.49 (41)
Prob > χ^2	0.00	0.00	0.00	0.00	0.00
Log likelihood	4.91	7.46	14.21	22.53	22.53
Pseudo R^2	1.05	1.07	1.14	1.21	1.21
AIC	66.18	63.08	53.58	40.95	40.95
BIC	255.46	257.34	257.80	255.13	255.13

Note: Level of statistical significance: ***$p \leq 0.01$, **$p \leq 0.05$, *$p \leq 0.10$, no. of observations = 1076. The coefficients with respect to outsourcing as a reference group are omitted in Model 3 and Model 4.

with innovation ability, while firm size is negatively associated with innovation ability. It also suggests the following factors have no significant impact on innovation ability: legal status, firm age, internal R&D, foreign ownership, international certification, degree of financial obstacles and competition in the informal sectors obstacles, and purchase/licensing of patents or nonpatented inventions. Model 2 included only the predictor variables (innovation recycling) and control variables. The results confirmed H1 (path coefficient = 0.05, $p = 0.02$), suggesting that innovation recycling positively influences a firm's innovation ability. Model 2 also exhibited a larger chi-squared value than Model 1, suggesting that the addition of the main effect of innovation recycling increased the model's explanatory power.

Turning to H2–H4, Model 5 illustrated the conditional effect of the three sourcing modes on the relationship between innovation recycling and firms' innovation ability. The mean innovation ability for firms adopting innovation recycling plus insourcing was above the mean innovation ability of all firms adopting innovation recycling (path coefficient = 0.04, $p = 0.00$), corroborating H2. Accordingly, the innovation ability for firms adopting innovation recycling plus hybrid sourcing was below the mean innovation ability of all firms adopting innovation recycling (path coefficient = −0.15, $p = 0.00$). Hence, H4 was supported. At the same time, the mean innovation ability for firms adopting innovation recycling plus outsourcing was not significantly different from the mean innovation ability of all firms adopting innovation recycling (path coefficient = 0.07, $p = 0.26$). This result does not support H3.

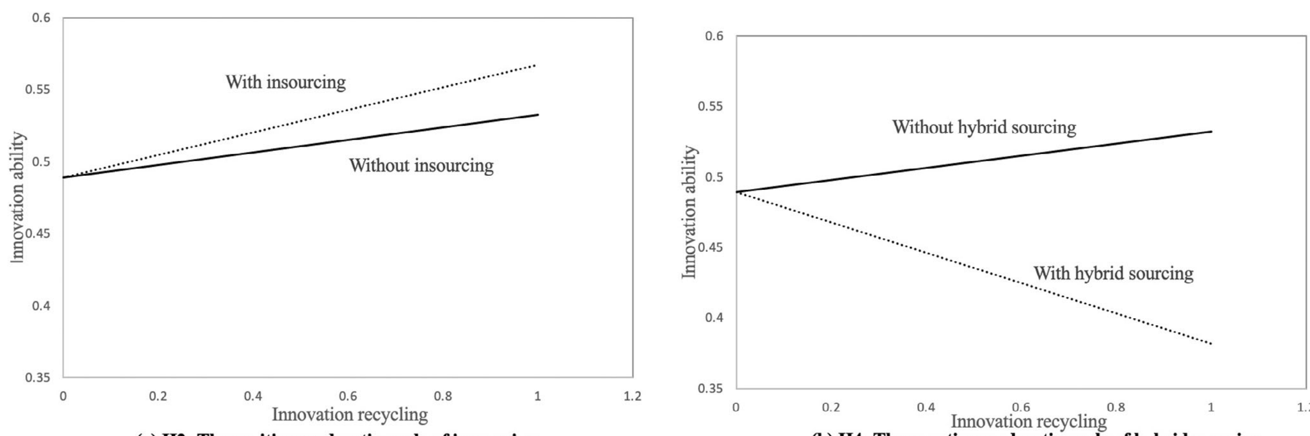
Models 4 and 5 showed consistent results. Model 4 suggested there was no significant difference (path coefficient = −0.05, $p = 0.57$) in the mean innovation ability between firms adopting innovation recycling plus insourcing and firms adopting innovation recycling plus outsourcing. It also showed that the mean innovation ability of firms adopting innovation recycling plus hybrid sourcing was below that of firms adopting innovation recycling plus outsourcing (path coefficient = −0.26, $p = 0.01$).

To better explain the moderating effects of each innovation sourcing mode, the hypothesized and supported relationships are shown in Figure 2.

5.2 | Robustness checks

Several further robustness checks were conducted. First, the same models were estimated by ordinary least squares (OLS) regression as opposed to Tobit regression, and we confirmed that the Tobit models were robust to alternative estimations. Although OLS regression does not account for the censoring of the dependent variable, unlike the Tobit estimations, it does not rely on the normality assumption. As outlined in Table 4, the OLS regression confirmed the Tobit regression results and supported H1, H2, and H4. Overall, it yielded very similar results in terms of statistical significance and the calculated coefficients.

Second, innovation recycling may be endogenous to a firm's innovation ability, such that more innovative firms may also be more likely to recycle their failed innovations, while firms that recycle failed innovations may be more innovative. Accordingly, our estimation was repeated using an instrumental variable technique to control for possible endogeneity problems with respect to innovation recycling. Our estimation was tested for potential feedback effects from the dependent variables by applying the instrumental variable Tobit model proposed by Smith and Blundell (1986). A regression of the innovation recycling on all exogenous variables and one



(a) H2: The positive moderating role of insourcing
Note: gradient of the slope with insourcing = 0.08

(b) H4: The negative moderating role of hybrid sourcing
Note: gradient of the slope with hybrid = −0.11

FIGURE 2 Moderating effects of innovation sourcing modes.

TABLE 4 Results of OLS regressions on innovation recycling's effect on innovation ability

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Independent variable				Dummy coding	Weighted effect coding
Innovation recycling		0.05 (2.16**)	0.05 (2.10**)	0.15 (1.87)	0.04 (2.03**)
Moderators					
Insourcing			0.11 (3.45***)	0.13 (3.67***)	0.01 (2.41**)
Hybrid sourcing			0.10 (2.66***)	0.14 (3.53***)	−0.01 (−0.41)
Outsourcing					−0.11 (−3.52***)
Interactions					
Innovation recycling * Insourcing				−0.07 (−0.83)	0.03 (2.69***)
Innovation recycling * Hybrid sourcing				−0.27 (−2.89***)	−0.14 (−3.89***)
Innovation recycling * Outsourcing					0.09 (1.36)
Control variables					
Firm size	−0.01 (−1.71*)	−0.01 (−1.65*)	−0.01 (−1.73*)	−0.02 (−1.87*)	−0.02 (−1.87*)
Legal status	0.00 (−0.10)	−0.01 (−0.23)	0.00 (−0.20)	0.00 (−0.13)	0.00 (−0.13)
Firm age	0.00 (−0.27)	0.00 (−0.29)	0.00 (−0.25)	0.00 (−0.35)	0.00 (−0.35)
Internal R&D	0.00 (−0.03)	−0.01 (−0.31)	0.00 (−0.20)	0.00 (−0.13)	0.00 (−0.13)
Foreign ownership	0.00 (0.08)	0.01 (0.23)	0.01 (0.24)	0.00 (0.08)	0.00 (0.08)
Year the main innovation was introduced	0.02 (0.79)	0.02 (0.84)	0.02 (1.06)	0.02 (1.04)	0.02 (1.04)
International certification	0.00 (−0.10)	0.00 (−0.09)	0.00 (−0.02)	0.00 (−0.18)	0.00 (−0.18)
Innovation training	0.05 (2.88***)	0.05 (2.89***)	0.05 (2.90***)	0.06 (3.10***)	0.06 (3.10***)
Degree of financial obstacles	0.01 (0.74)	0.00 (0.61)	0.00 (0.69)	0.01 (0.74)	0.01 (0.74)
Degree of competitions in informal sector obstacles	−0.01 (−1.06)	−0.01 (−1.19)	−0.01 (−1.04)	−0.01 (−1.13)	−0.01 (−1.13)
Purchase/licensing of patents or nonpatented inventions	0.02 (0.89)	0.02 (0.73)	0.02 (0.58)	0.02 (0.63)	0.02 (0.63)
Industry and country dummies	Included	Included	Included	Included	Included
F statistics	$F(36, 1039) = 6.33$	$F(37, 1038) = 6.46$	$F(39,1036) = 6.51$	$F(41, 1034) = 6.54$	$F(41, 1034) = 6.66$
R^2	0.18	0.19	0.20	0.21	0.21

Note: Level of statistical significance: $^{***}p \leq 0.01$, $^{**}p \leq 0.05$, $^{*}p \leq 0.10$, no. of observations = 1076. The coefficients with respect to outsourcing as a reference group are omitted in Model 3 and Model 4.

instrumental variable was conducted to obtain the residuals. The Tobit model was run as estimated above, with the residuals obtained in Step 1 included. Following this, all Tobit models shown in Table 3 were re-estimated but with the residuals from the first-stage regression.

We used average industry R&D weighted by innovation recycling as the instrumental variable because industry-level averages are uncorrelated with any unobserved firm-specific factors affecting innovation ability. Furthermore, industry R&D has a strong correlation with innovation recycling and can therefore be used to avoid weak instrument bias. The fraction of firms employing internal R&D activities weighted by the fraction of firms employing the innovation recycling strategy (excluding the focal firm) for different industries was calculated, and this detailed industry average was used as an instrument for innovation recycling. The results suggest that this instrument was highly significant and negatively related to innovation recycling (correlation coefficient $= -0.08$).

A Wald test was undertaken to determine whether the correlation between the residuals from the main equation and those from the auxiliary equation was zero, and the *p*-value for the test of the hypothesis that all the slope coefficients were jointly zero was not rejected ($\chi^2(1) = 1.68$, $p = 0.20$). There was insufficient information in the sample to reject the null hypothesis that innovation recycling is an exogenous explanatory variable. In addition, we ran Newey's (1987) minimum chi-squared estimator through the two-step function in Stata, according to which all the coefficients had the same signs as their counterparts in the maximum likelihood model. The Wald test confirmed our earlier finding of no endogeneity ($\chi^2(1) = 1.91$. $p = 0.17$). However, due to the reduction in efficiency usually involved in instrumented variable estimators, these approaches are only desirable if there is clear evidence of endogeneity. Therefore, the Tobit regression was more appropriate because it would likely have a smaller standard error.

6 | DISCUSSION AND IMPLICATIONS

6.1 | Discussion

In this paper, we investigated the role of innovation recycling, which led to several important findings. First, the results indicate that innovation recycling improves innovation ability for SSA-based firms. At the same time, this should be interpreted with caution, because this study used firms as analysis units. Due to data constraints, there is no assurance that the main new or significantly improved products or services were directly driven by recycled innovation. Generally, engaging with innovation recycling enables a firm to reflect on and learn from failed prior experiences. This resolves deficiencies in the firm, enhances the innovation strength of the firm through knowledge transfer between innovation projects (Meyers & Wilemon, 1989), and saves on NPD costs, thereby improving innovation ability.

Second, this study assessed the central role innovation sourcing mode plays regarding the impact of innovation recycling on innovation ability. The results indicate that the consequences of innovation recycling are intertwined with the innovation sourcing mode adopted by a firm for developing main new or significantly improved products or services. As the findings suggest, insourcing intensifies the positive effects of innovation recycling on innovation ability and facilitates the efficient integration of internal knowledge (Caner & Tyler, 2015). This is supported by previous studies that have argued that firms tend to amortize the sunk costs incurred during a previous innovation effort by owning and controlling intellectual property internally (Appleyard & Chesbrough, 2017; Behrens & Ernst, 2014).

Our results also indicate that adopting outsourcing does not influence the ability of firms to assimilate information from prior failures when developing innovation recycling. This should be interpreted with caution, which may be possible due to the low proportion of firms relying on these two strategies (innovation recycling and outsourcing). However, hybrid sourcing modes weaken the positive effects of innovation recycling on innovation ability. The standardized technology and routinized research offered by outsourcing (Beneito, 2006; Huang et al., 2009) are likely to be unrelated to the unique problems faced during innovation recycling. Accordingly, they do not influence the innovation recycling–innovation ability relationship. Hybrid sourcing may face the additional problem of locating and resolving interconnected sub-problems in the innovation process. Hybrid sourcing can also incur high knowledge integration costs and is subject to high uncertainty regarding other parties' adaptability and opportunistic behavior, impeding the creation of knowledge stocks inside a firm. In summary, our results imply that innovation recycling benefits from a closed innovation model rather than an open one.

6.2 | Theoretical implications

This study contributes to the literature on innovation recycling research in several respects. First, it provides support for an alternative method of firm innovation, namely, innovation recycling. We further built on this idea by taking on the KBV and expanding the analysis to include innovation recycling. In doing so, we closely examined the concept and practice of innovation recycling.

Our work thus offers new insights into the impacts of innovation recycling. Much of the innovation failure literature explores how firms learn from the experience of failure (Maslach, 2016) but does not follow up on the impact of subsequent reattempts with the same failed innovation project. Our study theorizes and empirically confirms the impact of innovation recycling on a firm's innovation ability and thus enriches the innovation literature and particularly the idea of the stage-gate system Cooper (2008). Our research also articulates that resuming suspended/failed projects can reduce uncertainty, renew knowledge, and render benefits to enhance a firm's ability to innovate.

Second, our study confirms the strategic importance of innovation sourcing in relation to implementing innovation recycling. Thus, it extends the KBV by separating different sourcing strategies to better understand their differential impacts when combined with innovation recycling, which adds to the KBV research that examines boundary decisions for experience-based learning. The most intriguing finding is the interplay between innovation recycling, innovation sourcing, and innovation ability. While innovation recycling improves innovation ability, the difficulties are associated with sourcing knowledge across, rather than within, firm boundaries.

Combining arguments from TCE, we explicated the level of control, knowledge transfer inefficiency, and opportunity risks involved in the experience-based learning process (Caner & Tyler, 2015). We found that, while insourcing compliments the development of innovation recycling, hybrid sourcing has an impairing effect. In addition, outsourcing has no impact on the probability of innovation recycling achieving greater innovation ability. Firms must have certain levels of operating experience and organizational complexity to recognize and assess other firms' experiences, which is crucial to their innovation recycling (Leoncini, 2016). The opportunity cost for further opening R&D borders is higher for firms that have accumulated firm-specific technological knowledge stock. This indicates that firms that invest in insourcing perform better than those that invest in outsourcing (Berchicci, 2013).

Our findings resonate with the work of Macher and Boerner (2012), who posit that ill-structured and difficult technological development problems—due to their uncertainty, tacit nature, and the unknown knowledge set interactions involved—require an innovation sourcing mode that offers flexibility and improvisation. Innovation recycling is inherently complex and uncertain. Insourcing is comparatively more efficient for codifying, transferring, and integrating knowledge. It responds to changing circumstances as new information is fed in and allows for adaptive, sequential, and interrelated changes (Macher & Boerner, 2012). On the other hand, hybrid sourcing is a double-edged sword. While it scans the environment in a much broader and more intensive way to obtain additional knowledge resources, it is limited in its ability to guard against knowledge appropriation. It also suffers from friction in knowledge sharing. Therefore, it is relatively inefficient in solving ill-structured problems. Developing mutual trust and establishing common information codes is also time-consuming and can make learning from failure ineffective. Some R&D collaborating firms abandon innovation projects due to cooperation failure (Lhuillery & Pfister, 2009), rather than seeing such partnerships increase the success of innovation recycling.

Using data from SSA, our study reveals how firms operating in a weak institutional environment can benefit from the use of recycling innovation projects to strengthen their innovation ability. In addition, it shows how different innovation sourcing modes impact the associated effects. This represents an important advancement in the knowledge on failed innovations, which, in the past, overemphasized advanced economies characterized by mature and stable institutional environments (Elmquist & Le Masson, 2009; Madsen & Desai, 2010; Maslach, 2016). Nevertheless, although the notion was tested within the context of SSA, our theoretical analysis using the KBV implies the effect of innovation recycling on innovation ability development may be applied to a general context. Generally, our research shows that innovation sourcing modes can influence the effect of innovation recycling. If the knowledge complexity is high, then in-house R&D may be a better way to drive a firm's innovation ability. However, with a high level of trust and a low level of uncertainty, outsourcing or hybrid sourcing can also provide benefits and compensate for their respective drawbacks. Moreover, if the market-supporting institutional mechanism is robust, outsourcing or hybrid sourcing may become generally desirable modes of knowledge sourcing.

6.3 | Practical implications

This study offers valuable managerial and policy implications. First, the findings provide the crucial insight that managers should include a periodic reflection on past innovation failures as a part of their formal innovation project management review process. Contrary to the assumption that suspended projects are sunk costs, our research demonstrates that innovation recycling, as a complementary option to new innovation, can improve a firm's innovation ability and its innovation strength.

Recycling innovation projects shelved in the past can effectively help a firm take advantage of the knowledge accumulated and create more knowledge during the process to enhance innovation ability. It can also save firm resources by shortening NPD's initial screening and evaluation processes. Innovation recycling is particularly appealing for firms located in regions that suffer from limited resources, constrained human capital supply and a higher level of uncertainty due to under-developed market-supportive institutions (Barasa et al., 2017; Julian & Ofori-dankwa, 2013), compensating for the negative impact of these factors' shortage. In short, managers are encouraged to establish a database for their suspended and/or abandoned innovation projects, carefully and regularly evaluate them, assess the knowledge involved in the innovations, and actively consider recycling them. These lead to strengthened innovation ability. In the same vein, we encourage policymakers to remove the negative stigma associated with innovation failure and provide more support to help firms conduct innovation recycling activities.

Second, managers should note that to maximize the benefit of improving their firm's innovation ability, they need to organize innovation recycling activities in house instead of sourcing them fully to or jointly with an entity outside the firm. This requires firms to develop a corporate culture that facilitates interpreting and sharing tacit experiential knowledge internally. It can be difficult to efficiently leverage the benefits of joint innovation efforts with external partners because the lower degree of control and higher risk of opportunistic behavior are not aligned with innovation recycling. Outsourcing innovation recycling projects provides no benefit in improving innovation ability as it can be difficult for a firm to remain involved in the learning process. Managers should be wary of assuming that investment in hybrid sourcing and outsourcing is a universal solution to all types of innovation.

7 | CONCLUSION AND LIMITATIONS

7.1 | Conclusion

This research aimed to enrich our understanding of innovation recycling, a widespread practice used by businesses, by uncovering its effect on firm innovation ability and investigating innovation sourcing modes as an important boundary condition. Despite the importance of this topic, it has yet to be well studied or understood. In the present study, we focused on SSA, a region with limited innovation resources, uncertain business environments, and prevailing institutional voids, which welcome innovation recycling activities among firms. Drawing on the KBV and TCE, we argued that (1) innovation recycling benefits a firm's innovation ability, and (2) the effect of innovation recycling is subject to the innovation sourcing mode. In particular, insourcing strengthens the effect, hybrid sourcing reduces it, and outsourcing exerts no impact. Our data on 1076 firms located in eight SSA countries (Ghana, Malawi, Namibia, South Sudan, Sudan, Tanzania, Uganda, and Zambia) from the WBES and IFS (2011–2014) confirmed these theorized relationships. Accordingly, this research provides a valuable contribution to the innovation recycling literature. The results indicate that to enhance their innovation ability, firms should engage in more innovation recycling and use a closed innovation model rather than an open one when doing so, particularly when faced with an environment similar to those in SSA.

7.2 | Limitations and directions for future research

Despite our contributions and the robustness of our findings, our study is not without limitations. First, to date, most empirical studies on Africa have focused on large multinational corporations. Although the inclusion of local firms in our study fosters a full grasp of the innovation activities in the region, the sample we relied on is still relatively small in relation to SSA as a whole, especially when considering that the region is rich in cultural diversity and heterogeneous with respect to lifestyle, values, beliefs, ideals, race, ethnicity, national origins, language, and religion (Seriki et al., 2010). Further studies could extend the sample to validate the results and generalize the findings. Future research might also extend the inquiry to developed countries and compare SSA with certain developed countries to provide further insights.

Second, data constraints prevented us from identifying the stages (e.g., conception or development) in which innovations were abandoned or suspended. As objectives and experience vary across different innovation stages, future studies may complement the present study by investigating how the interplay between innovation recycling at different stages and with innovation sourcing modes influences innovation ability. The stages, timing, and reasons associated with innovation abandonment and suspension can also be considered in future empirical designs to address the endogeneity in theorizing regarding the innovation recycling concept.

Third, this study used the firm as its unit of analysis. Future research might extend the analysis to the project level and introduce the number of abandoned and suspended innovation projects as a count variable to provide further insights.

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