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SME Innovativeness in a Dynamic Environment

Is there any value in combining causation and effectuation?

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SME Innovativeness in a Dynamic Environment

Is there any value in combining causation and effectuation?

Abstract

It has been suggested that, in dynamic environments, the combination of causation and effectuation will boost an SME's innovative performance, compared to a sole focus on planning. To statistically test this claim, we develop a contingency model for business planning, which considers effectuation as an internal and environmental dynamism as an external boundary condition. As expected, we find that causation positively relates to an SME's innovativeness and that this effect is amplified when combined with effectual decision-making logics. Interestingly, it turns out that this leverage effect is only present in stable environments. What is more, in dynamic environments, SMEs relying on pre-committed resources from partners appear to score lower on innovativeness than their counterparts without pre-commitments. With this finding, we provide statistical evidence that combining causal and effectual decision-making logics is beneficial for innovative performance, but that environmental dynamism acts as a barrier to fully take advantage of it.

Key words

Effectuation; Pre-commitments; Environmental dynamism; Innovative performance.

Introduction

Being innovative is a risky strategy for small businesses with limited access to resources and few network connections (Baker and Nelson 2005). To address such riskiness, much entrepreneurship research draws on bounded rationality decision models in which purposeful opportunity searching dominates (Drucker 1988). The argument is that careful planning allows companies to repeatedly engage in entrepreneurial activities, and thus be innovative (Brinckmann et al. 2010; Delmar and Shane 2003; Palmié et al. 2018).

Since Sarasvathy's (2001) seminal work on effectuation, entrepreneurship scholars started to acknowledge that entrepreneurial companies can adopt both causal and effectual decision-making logics. Causation involves planning and prediction-oriented techniques to deal with or "control" the future. Effectuation is a decision-making logic advocating flexibility, experimentation and getting pre-commitments from stakeholders to create (and thus control) the future (Sarasvathy 2001). For example, an entrepreneur collaborating with a pre-committing party *before* the actual exchange takes place, restricts its own freedom to maneuvre in exchange for uncertainty and risk reduction. As such, (s)he is able to control the future (Read, Song, and Smit 2009). While causation and effectuation are conceptually distinct, Sarasvathy (2001) argues that they can occur simultaneously, overlap, and intertwine, depending on the context of the decisions and actions taken.

The idea that causal and effectual decision-making logics interact received increased attention in academic studies. For example, Smolka et al. (2016) provide evidence of an interaction effect between causation and effectuation during company founding and Maine et al. (2015) find that innovative biotech ventures transition from adopting a pure effectuation logic to combining causation and effectuation. Berends et al. (2014) find similar results, namely that small companies adopt a combination of causation and effectuation logics during product innovation processes, and Evald and Senderovitz (2013) reveal that SMEs engaging in internal corporate venturing activities combine causation and effectuation logics. Andries et al. (2013) further develop this interaction idea, and argue that, in uncertain environments, companies concurrently focusing on causal and effectual decision-making logics might be more innovative – a statement yet to be tested empirically. To address this, we start from the argument that deliberate planning (that is, causation) enhances an established small firm's' innovative performance (Brinckmann et al. 2010). We then examine whether and how the effectual decision-making logic impacts this relationship. This is in line with, e.g. Mintzberg and Waters, who already argued in 1985 that companies can concurrently adopt deliberate and emergent strategies. Finally, we statistically examine whether and how the interaction effect between causation and effectuation is affected by environmental circumstances. Our overarching research question is thus: *In which environmental circumstances does a company's combined causal and effectual decision-making logic relate to its innovative performance?*

With this focus, we build upon recent results portraying that both causation and effectuation can enhance a firm's performance (Deligianni et al. 2017; Mthanti and Urban 2014; Smolka et al. 2016) by looking at the interaction effects between these two decision-making logics (see, e.g. Smolka et al. 2016). More importantly, we answer pleas for a focus on innovativeness in established companies (e.g. Yu et al. 2018), which incorporates the impact of environmental uncertainty (e.g. Andries et al. 2013).

Theoretical background and hypotheses development

Entrepreneurs have been defined as individuals who recognise opportunities, and subsequently exploit them by aiming at achieving pre-defined goals (Bhave 1994). Sarasvathy (2001) describes this type of decision-making logic as causation, where entrepreneurs start from a certain goal (e.g. ten per cent market share increase) and decide on developing a plan consisting of means application, such as market segmentation, to attain this goal. Accordingly, an entrepreneur can (stochastically) predict the future through planning (Wiltbank et al. 2009), so that (s)he can proactively take controlled risks. This coincides with what Mintzberg and Waters (1985) call a deliberate strategy: The company deliberately develops a goal, after which a strategy is being developed and implemented to attain this goal.

Planning allows companies to anticipate information gaps, optimise resource flows, and control goal achievement. It accelerates and guides entrepreneurial activities such as product innovation and the subsequent organisation of the company to sell the new product (Delmar and Shane 2003). Similarly, decision-making happens in a much quicker and more efficient way when business planning is in place. This, in turn, positively relates to innovation success (Salomo et al. 2007). More recently, Palmié et al. (2018) build on Brinckmann et al. (2010) to suggest that causation positively relates to innovativeness (as part of the entrepreneurial orientation construct). The argument goes that company managers can use insights from their analyses and planning efforts to specify clear innovative goals, which subsequently can be communicated to their employees. As such, the whole company pursues the same (innovative) goal, allowing for an increase in innovative performance. In line with these arguments, we posit that a causal decision-making logic is positively related to a company's innovative performance.

H1(+): A causal decision-making logic is positively related to a company's innovative performance.

According to Read and Sarasvathy (2005), the exploitation of opportunities in existing markets calls for systematic business planning, and hence causation. This however does not imply that all established companies opt for a causal decision-making logic. For example, Sarasvathy (2001) suggests that expert entrepreneurs often adopt an effectual logic. Instead of starting with a given goal, entrepreneurs reasoning in an effectual way start from a given set of means and make decisions based on their level of affordable loss, which is dependent upon the available resources (Sarasvathy 2001). The argument goes that expert entrepreneurs operating in an existing business combine strategic long-term goals with an effectual decision-making logic. In such cases, extant strategies evolve as new resources come along, alliances are developed, and multiple commitments are tied up. In strategic management literature, this relates to emergent strategies (Mintzberg and Waters 1985).

On top of the observation that expert entrepreneurs often adopt effectual decision-making logics (Read and Sarasvathy 2005), it is argued that companies strictly sticking to plans are unable to undertake the necessary changes during company development (Brinckmann et al. 2010). They refrain from undertaking risks, and are less flexible and innovative, as portrayed in studies of strategic flexibility (Barringer and Bluedorn 1999), adaptability (Dean and Thibodeaux 1994) and innovative performance (Meeus and Oerlemans 2000). Instead, an incremental strategy development approach (Brews and Hunt 1999) has been put forward to allow for increased entrepreneurial activities. The argument goes that next to planning, adopting a concurrent effectual decision-making logic might be necessary to be innovative (Andries et al. 2013). From this, we hypothesize that established SMEs adopting a combination of causation and effectuation are able to reach higher levels of innovativeness.

H2(+): Effectuation amplifies the relationship between causation and innovative performance. A company simultaneously adopting a causal and an effectual decision-making logic is more innovative than a company only opting for a causal one.

Early proponents of strategic planning advocate that it is more difficult to follow pre-defined strategic plans in uncertain environments (Mintzberg 2003) because, in such environments, entrepreneurs face unexpected contingencies (Fisher 2012). The argument goes that linear thinking and planning – which is inherently part of the causal decision-making logic – is better suited for stable environments characterized by certainty, as well as for predictable and routine circumstances (Vera and Crossan 2004). In contrast, in dynamic environments, business planning becomes ineffective because entrepreneurs face unexpected contingencies not accounted for in pre-defined plans (Fisher 2012; Mintzberg and Waters 1985; Suikki et al. 2006).

Because the effectiveness of business planning is undermined in dynamic environments (Suikki et al. 2006), sticking to original plans might hurt performance (Hmieleski and Baron 2008). We thus argue that a more dynamic environment hampers the positive effect of planning (and thus causation) on innovative performance.

H3(-): Environmental dynamism negatively moderates the relationship between causation and innovative performance.

Interestingly, Hmieleski and Baron (2008) show that deviating from original plans leads to better performance, but only in dynamic environments. In such environments, flexible processes that adapt to contingencies are needed (Fisher 2012) for more innovativeness. We posit that in a dynamic environment, the rigidity of a causal logic can be relaxed by simultaneously adopting an effectual one (Fisher 2012). In strategic management, this relates to the fact that companies simultaneously adopt deliberate and emergent strategies (Mintzberg and Waters, 1985). Indeed, Brinckmann et al. (2010) suggest adding a new concept to the planning school's reasoning: Flexibility. According to Brinckmann and colleagues, companies facing environmental uncertainty should simultaneously plan and be flexible through contingency-based reasoning. Combining causal and effectual logics becomes an imperative to be flexible, survive and stay entrepreneurial in dynamic environments. This has also been argued in strategic management literature: Both deliberate and emergent strategies are necessary for company survival (Mintzberg and Waters 1985).

We therefore posit a three-way interaction between causation, effectuation, and environmental dynamism (see Figure 1), where the synergetic effects are stronger in dynamic environments and weaker in stable environments.

H4(+): Environmental dynamism moderates the synergetic effect of a causal and an effectual decision-making logic on innovative performance. The more dynamic the *environment is, the stronger is the positive effect of a concurrent focus on causation and effectuation.*

[Insert Figure 1 about here]

Methods

Sample

The sample used in this research was collected in the context of a larger research programme that studies small business growth and innovation in Belgium (see van Witteloostuijn et al., 2015 for more information about the overall research project, the data collection process and preliminary analysis). To circumvent bias from common-method variance (Chang et al. 2010), data for this research were collected from the same group of companies at two different points in time. Data regarding the independent variables are from our 2012 questionnaire, and data for the dependent variable–innovative performance–from our 2013 questionnaire. In 2012, we received answers from 640 companies. In 2013, these 640 companies received a follow-up questionnaire. In total, 201 respondents completed the 2013 questionnaire, implying a response rate of 31.41 per cent. From these 201 companies, 162 provided valid information (listwise) on all variables used in our regression models. Of these 162 companies, one had 700 employees. Given our paper's SME focus, we left this company out. Our final sample consists of 161 SMEs with a workforce of 0.5 to 150 full-time equivalents.

Variables

Causation and effectuation

We use Chandler et al. (2011)'s scale about causation and effectuation to measure the company's decision-making logics. While Chandler et al. (2011)'s scale was developed to grasp the decision-making logics during venture creation, this research focuses on established small businesses and their entrepreneurial decision-making logics when developing new products and services. As such, we introduced our scale by asking "*Please think about the strategy you followed while developing your company's newest product / service and indicate the extent to which you agree or disagree with the following statements*".

Respondents had to answer along a five-point Likert scale, ranging from "I strongly disagree" to "I strongly agree". Typical causation items are "*We designed and planned business strategies*" and "*We had a clear and consistent vision for where we wanted to end up*". Typical effectuation items are "*We allowed the business to evolve as opportunities emerged*" and "*The product / service that we now provide is substantially different than we first imagined*". In line with Chandler et al. (2011), the exploratory factor analysis (Maximum Likelihood, with Varimax rotation) provides a six-item one-dimensional construct for causation, and multiple sub-dimensions for effectuation.

Chandler et al. (2011) built their effectuation scale with four sub-dimensions: Experimentation, affordable loss, flexibility, and pre-commitments. We find five sub-dimensions. Our factor analysis indicates that pre-commitment consists of two sub-dimensions. The first sub-dimension involves the number of pre-commitments and the frequency in which they have been used, i.e. pre-commitment *intensity*. The other sub-dimension relates to the advantages that pre-commitments offer to the company: *"Network contacts provided low cost resources*" and "*By working closely with people / organizations external to our organization we have been able to greatly expand our capabilities"*. These items were formulated by Chandler et al. (2011) at the end of their scale-development paper. They suggested that pre-commitments should not only be measured by examining the number and frequency of the company's pre-commitments, but also by a deeper understanding of the strategic advantages these pre-commitments can offer. This is not surprising, given that idea development requires in-depth interactions with a large amount of market actors, such as financers or suppliers (Klofsten 2005). We refer to this sub-dimension as pre-commitment *advantages*.

In terms of reliability, our results are in line with previous research, where Cronbach α's vary from 0.62 to 0.85 (Chandler et al. 2011; Smolka et al. 2016). Following Smolka et al. (2016), we also construct an aggregated effectuation measure that includes all items (α = 0.78). Reliability analysis on causation provides a Cronbach alpha of 0.85.

Environmental dynamism

We measure environmental dynamism with Miller's (1988) scale. We asked respondents the following questions: "*My company must change its marketing practices frequently (e.g. semi-annually)*", "*The rate at which products / services are getting obsolete in my sector is very high*", and "*The modes of production / service development change often in a major way*" with a seven-point Likert scale ranging from -3 ("I strongly disagree") to +3 ("I strongly agree"). All items load onto one factor, and reliability analysis gives a Cronbach alpha of 0.69. Our results are in line with prior research (for example, Wijbenga and Van Witteloostuijn 2007).

Innovative performance

To measure innovative performance, we use the following two items (Covin and Slevin 1989): "*In the last three years, my business has marketed very many new lines of products or services*", and "*In the last three years, changes in product or service lines have been usually quite dramatic*". Respondents were asked to rate statements on a seven-point Likert scale, ranging from -3 ("I strongly disagree") to +3 ("I strongly agree"). The two items are significantly correlated ($r = 0.92$; $p < 0.01$). As such, our innovative performance variable focuses on product and service innovation, rather than organisational and process innovation.

Control variables

We include control variables at the respondent, company and sector level. At the respondent level, we add gender and whether the respondent is the founder of the company. Although Sonfield et al. (2001) found that there are no significant gender differences in strategies of business owners, a few studies indicate that women are less prone to risk-taking than men (Johnson and Powell 1994). Because such differences might have an impact on the company's degree of innovative performance, we included "gender" as a control variable.

Second, research shows that replacing the head of a company impacts the level of entrepreneurial orientation, and thus also the company's innovativeness: When a company replaces its CEO, it tends to become more innovative and proactive, and to take more risks (Grühn et al. 2017). To account for a possible impact of the founder, we include the variable "founder" in our analyses.

Control variables at the company level include the age, size and sector of the company. Smaller companies often have less resources available, impacting the extent to which they can exploit opportunities and thus can be innovative (Stam and Elfring 2008). The same can be expected regarding the age of the company. Stam and Elfring (2008) indicate that because new companies often have access to less resources, company age might have an impact on opportunity exploitation. Finally, we include sector dummies (manufacturing and services) to control for unobserved heterogeneity at sector level. The reference sector is thus "other".

Regression analyses

We apply hierarchical multiple regression and Hayes' (2015) PROCESS macro for moderation modeling. Following Smolka et al. (2016), we execute a series of analyses with effectuation as an aggregate construct before we turn to each effectual sub-dimension. The descriptives and correlation matrix can be found in Tables 1 and 2. We report the variance inflation factor (VIF) in the result tables. We provide the result tables for effectuation as an aggregate construct (see Table 3), and for the effectual sub-dimensions providing significant two-way and / or three-way interaction effects (that is, pre-commitment intensity and pre-commitment advantages; see Tables 4 and 5). All other detailed results are available upon request.

[Insert Table 1 about here]

[Insert Table 2 about here]

[Insert Table 3 about here]

[Insert Table 4 about here]

[Insert Table 5 about here]

Results

The results show that causation is positively, consistently and significantly related to innovative performance (B = 0.346 to 0.400; p always < 0.10). We thus find strong support for Hypothesis 1. Moreover, we find a significant moderation effect of effectuation for the aggregate construct (B = 0.317 to 0.528; p = 0.023), for pre-commitment intensity (B = 0.168 to 0.389; p = 0.013 or lower) and for pre-commitment advantages (B = 0.455 to 0.470; p = 0.000 to 0.002), supporting Hypothesis 2. This synergetic effect is visualised in Figure 2 (for effectuation as an aggregate construct), Figure 3 (for pre-commitment intensity) and Figure 4 (for pre-commitment advantages), where the positive effect of causation on innovative performance is stronger when combined with effectuation.

A floodlight mediation analysis, using the Johnson-Neyman technique (Hayes 2015), provides evidence that the effect of causation on innovative performance is weak and not significant when effectuation is low, and becomes significant and stronger as the level of effectuation is higher (3.23 for effectuation as an aggregate construct; 3.03 for pre-commitment intensity and 2.67 for pre-commitment advantages).

[Insert Figure 2 about here]

[Insert Figure 3 about here]

[Insert Figure 4 about here]

We also find some support for Hypothesis 3, with consistent negative interaction effects between causation and environmental dynamism (B = -.176 to -.266; p = 0.019 to 0.109; see Figure 5). The conditional effect of causation is significant until environmental dynamism reaches -0.36. For values of environmental dynamism below -0.36, the effect is positive, but also statistically (i.e. the confidence intervals do not straddle at zero) and substantively (i.e. the marginal effect line is not flat) significant. For values of dynamism that equal or are higher than -0.36, the effect becomes statistically non-significant.

[Insert Figure 5 about here]

We do not find support for Hypothesis 4. The three-way interaction effect is not significant across the different regressions, except for pre-commitment advantages (see Table 5, Model 4). Interestingly, we find a negative three-way interaction effect (B = -0.117 to -0.200; significant p values under 0.039; see Figure 6). This means that the synergetic effect is stronger in stable environments than in dynamic ones, which contradicts our theoretical argument.

[Insert Figure 6 about here]

With a Johnson-Neyman value of 0.52 for environmental dynamism (just above neutral), we find that the synergetic effect of combining causation with pre-commitment advantages only holds in stable and neutral environments. In dynamic environments, the effect of causation on innovative performance is not significant, even when combined with high levels of pre-commitment advantages (see Table 6). A simple *t*-test confirms that the synergetic effect is not present in dynamic environments (difference of slopes between line 1 and 3 in Figure 5). Furthermore, Figure 6 suggests that, in dynamic environments, existing SMEs with high advantageous pre-commitments score lower on innovativeness.

[Insert Table 6 about here]

Finally, we find a significant and negative effect of sector on innovative performance. Surprisingly, we do not find other significant effects of control variables. For example, company age does not appear to have a significant effect on innovative performance, nor do we find a significant correlation between company age and causal or effectual decision-making logics. We find similar results for company size. Here, however, we do find that company size and pre-commitment intensity are negatively correlated: The larger the company, the less pre-commitments are pursued.

Discussion

Our results show that causation is positively related to innovative performance. Established SMEs score higher on innovativeness when they are "analyzing long-run opportunities and selecting markets that are expected to yield the best return" while "having a clear, planned and consistent vision" (see Chandler et al 2011). Thereby, it substantiates extant studies arguing that planning positively relates to innovation success.

We also find sector differences, as service companies reported lower innovative performance than companies in other sectors. Indeed, our innovative performance measure focuses on product and service innovations only, which is not the main focus of service companies. They are mostly involved in organisational innovation (see Tether and Tajar 2008). For company size, we find a significant negative correlation between size and pre-commitment intensity. This is not surprising, given the lack of resources smaller companies have, which inevitably impacts the available time they can spend on networking and setting up pre-committed agreements.

Even though our main effect (that is, causation) and control variables results are worth mentioning, our paper's added value resides in the insights it provides in the relationships between causation, effectuation and environmental dynamism, and their *joint* effects on innovative performance. Our results show that the positive relationship between causation and innovativeness is significantly moderated by both effectuation and environmental dynamism. To do this, we adopted a step-wise contingency lens.

First, we confirm that causation leads to innovative performance in a stable environment, and not in a dynamic one. Brinckmann et al. (2010) argue that the underlying reason for a positive relationship between planning and business performance might be that established SMEs face lower levels of state, effect and response uncertainty (Milliken, 1987). Our study adds to these insights, by showing that if environmental dynamism is too high, planning is no longer effective to increase innovations.

Second, we confirm that causation and effectuation can be combined for better organizational results, not only by student entrepreneurs setting up a business (see Smolka et al. 2016), but also in established SMEs. Our results show that causation positively relates to innovative performance when the company simultaneously follows an effectual decision-making logic. This is particularly the case for frequent (i.e. intense), and fruitful (i.e. advantageous) pre-commitments from external stakeholders.

The third step was adding environmental dynamism to the model. As such, we address a plea from researchers such as Andries et al. (2013), who suggested the possibility of a causation-effectuation interaction effect, with differential outcomes under different environmental circumstances. Our main argument was that thanks to the synergetic effect of a causal and an effectual decision-making logic, companies would thrive in dynamic environments. Interestingly, the synergic effect only holds in stable environments, which contradicts our hypothesis. This means that in dynamic environments, the rigidities of planning (that is, a causal logic) cannot be offset by working with strategically positioned pre-committing parties to ensure innovative performance. We find similar bootstrap results for effectuation as an aggregate construct, as well as for pre-commitment intensity.

These results suggest that because pre-commitments are closely aligned with planning (and thus a causal approach), they are unable to provide the necessary flexibility in a dynamic environment (Hmieleski and Baron 2008; Suikki et al. 2006). This might imply that because pre-commitments is a construct *shared with* causation (Chandler et al., 2011), they rather stimulate the negative effects of planning in a dynamic environment. To examine this further, we urge future research to further develop the conceptual differences between pre-commitments and causation, as well as a better understanding of the conditions under which combining decision-making logics is beneficial for established SMEs. To do so, we call for in-depth, qualitative case study research (see for instance Kaufmann 2013) offering insights into the specific organisational and environmental conditions under which a simultaneous focus on pre-commitments and causation is effective.

Conclusion

With this study, we adopt a contingency model for business planning, which considers effectuation as an internal boundary condition and environmental dynamism as an external one. The possibility of a moderating effect of environmental circumstances on the synergetic impact of causal and effectual decision-making logics has been suggested by Andries et al. (2013) but has not yet been developed in a comprehensive theoretical model, and statistical tests are limited. The current study addresses this. Our results show that following a causal decision-making logic results in higher innovativeness in stable environments, all else being equal. Adding effectuation to the equation, we find that combining causation and effectuation positively relates to innovativeness, especially in stable environments. Finally, our contingency model shows that in dynamic environments, SMEs with pre-commitments allowing them to access key resources score *lower* on innovativeness. These results urge researchers to further explore the boundary conditions for the synergetic effects of causation and effectuation on (innovative) performance in different contexts, such as established SMEs versus start-ups, dynamic versus stable environments, or emerging versus advanced economies.

Some limits must be acknowledged. First, by anchoring effectuation into the literature on strategic business planning, we contribute to (bounded) rational decision-making research. This approach tends to simplify the complexity of entrepreneurial action, notably by emphasising the role of the entrepreneur as a decision-maker. Alternatives, such as the study of entrepreneurship as a practice (Vaara and Whittington 2012) might bring a more comprehensive analysis of effectual practices. Second, we focus on a single dimension of uncertainty, namely the rate of change in terms of demand, channels, and technology. However, a high rate of change does not automatically imply prediction difficulties. Given that the notion of predictability is at the heart of the uncertainty concept (Ng 2015), we urge for the use of scales that include predictability as well. Third, we focus on SMEs, which are characterised by specific processes of innovation and diffusion (Nooteboom 1994). An examination of decision-making logics in large companies might require a different level of analysis (e.g. the team rather than the company level), as well as alignment process between the team and the corporate level. Finally, we align with extant empirical research and use subjective measures of performance, here relating to product / service innovations. Examination of objective performance would certainly add to the robustness of our findings.

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Table 1: Mean, standard deviation, minimum and maximum of variables

	N	Mean	SD	Min	Max
1. Innovative performance (IP)	161	.199	1.529	-3.00	3.00
2. Causation	161	3.486	.780	1.00	5.00
3. Dynamism	161	-.282	1.399	-3.00	3.00
4. Effectuation	161	3.190	.534	1.40	4.60
5. Experimentation	161	2.426	.994	1.00	5.00
6. Affordable loss	161	3.721	.916	1.00	5.00
7. Flexibility	161	3.828	.595	1.00	5.00
8. PC intensity	161	2.814	1.032	1.00	5.00
9. PC advantages	161	3.162	.945	1.00	5.00
10. Gender	161	NA	NA	1.00	2.00
11. Founder	161	NA	NA	1.00	2.00
12. Company age	161	23.758	20.504	1.00	114.00
13. Company size	161	13.521	23.332	.50	150.00
14. Manufacturing	161	NA	NA	.00	1.00
15. Services	161	NA	NA	.00	1.00

Variables are not mean-centered. Innovative performance (IP) and environmental dynamism (Dynamism) are measured on a seven-point Likert scale from -3 (“I strongly disagree”) to +3 (“I strongly agree”). Causation, effectuation and the effectual sub-dimensions are measured on a five-point Likert scale from 1 (“I strongly disagree”) to 5 (“I strongly agree”). For gender, there are two categories: 1 = male; 2 = female. For founder, there are two categories: 1 = yes; 2 = no. Company age is measured through the number of years passed since the company’s foundation. This ranges from 1-114 years. For company size, we used the number of full-time equivalents. The range is 0.50 to 150 FTE. Sectors are manufacturing and services. For the sector dummies: 0 = other; 1 = the sector variable.

Table 2: Bivariate correlations of all variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. IP	1.00													
2. Causation	.325**	1.00												
3. Dynamism	.285**	.342**	1.00											
4. Effectuation	.244**	.370**	.284**	1.00										
5. Experimentation	.178*	.037	.165*	.556**	1.00									
6. Affordable loss	.015	.085	.085	.568**	.082	1.00								
7. Flexibility	.179*	.219**	.193*	.496**	.018	.341**	1.00							
8. PC intensity	.210**	.338**	.243**	.708**	.280**	.193*	.199*	1.00						
9. PC advantages	.146	.417**	.159*	.603**	.120	.122	.205**	.301**	1.00					
10. Gender	.021	-.029	.033	.167*	.045	.124	.067	.176*	.070	1.00				
11. Founder	-.134	.058	-.029	.021	-.049	.008	.044	.028	.044	-.058	1.00			
12. Company age	-.141	-.081	-.059	-.057	.012	.078	-.005	-.103	-.134	-.049	.520**	1.00		
13. Company size	.035	.143	-.094	-.080	.027	.036	-.042	-.178*	-.068	-.115	.267**	.401**	1.00	
14. Manufacturing	-.032	-.139	-.209**	-.040	.008	.016	.052	-.067	-.097	-.193*	.073	.112	.059	1.00
15. Services	-.108	.031	.230**	-.026	-.093	-.015	.007	-.029	.068	.083	-.020	-.047	-.092	-.725**

* $p < 0.05$ and** $p < 0.01$; Two-tailed significance; Sample size = 161; PC = pre-commitments; IP = innovative performance.

Table 3: Hierarchical linear regression with effectuation as an aggregate construct

Outcome	Model 1	Model 2	Model 3	Model 4
Constant	1.077	1.204†	1.328†	1.368*
	(0.738)	(0.689)	(0.680)	(0.682)
	p=0.146	*p*=0.083	*p*=0.053	*p*=0.047
Control variables				
Gender	0.021	-0.013	-0.236	-0.275
	(0.449)	(0.424)	(0.420)	(0.423)
	p=0.962	*p*=0.975	*p*=0.574	*p*=0.516
Founder	-0.277	-0.390	-0.314	-0.302
	(0.298)	(0.279)	(0.276)	(0.277)
	p=0.355	*p*=0.165	*p*=0.258	*p*=0.277
Company age	-0.009	-0.006	-0.007	-0.007
	(0.007)	(0.007)	(0.007)	(0.007)
	p=0.197	*p*=0.408	*p*=0.327	*p*=0.328
Company size	0.006	0.005	0.006	0.006
	(0.006)	(0.005)	(0.005)	(0.005)
	p=0.263	*p*=0.316	*p*=0.243	*p*=0.253
Manufacturing	-0.660†	-0.415	-0.367	-0.357
	(0.388)	(0.365)	(0.356)	(0.257)
	p=0.091	*p*=0.257	*p*=0.305	*p*=0.318
Services	-0.768*	-0.769*	-0.719*	-0.730*
	(0.350)	(0.331)	(0.324)	(0.324)
	p=0.030	*p*=0.022	*p*=0.028	*p*=0.026
Direct effects				
Causation		0.373*	0.307†	0.317†
		(0.167)	(0.166)	(0.166)
		p=0.027	*p*=0.066	*p*=0.058
Effectuation		0.299	0.249	0.321
		(0.234)	(0.232)	(0.247)
		p=0.202	*p*=0.285	*p*=0.197
Dynamism		0.242**	0.286**	0.311**
		(0.089)	(0.089)	(0.093)
		p=0.007	*p*=0.002	*p*=0.001
Two-way interaction effects				
Causation*Dynamism			-0.221*	-0.242*
			(0.100)	(0.104)
			p=0.029	*p*=0.021
Causation*Effectuation			0.528*	0.396
			(0.229)	(0.278)
			p=0.023	*p*=0.157
Effectuation*Dynamism			-0.163	-0.113
			(0.152)	(0.163)
			p=0.286	*p*=0.492
Three-way interaction effect				
Causation*Dynamism*Effectuation				-0.103
				(0.122)
				p=0.403
F-statistic	1.807†	4.491***	4.421***	4.127***
Significance	0.101	0.000	0.000	0.000
R^2	0.066	0.211	0.264	0.267
Adjusted R^2	0.029	0.164	0.204	0.203
R^2 change	0.066	0.145	0.053	0.004

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$; Unstandardized coefficients; VIF always < or = to 2.298; Standard error between parentheses; Dependent variable Innovative Performance; Sample size = 161.

Table 4: Hierarchical linear regression with pre-commitment intensity

Outcome	Model 1	Model 2	Model 3	Model 4
Constant	1.077	1.176†	1.191†	1.225†
	(0.738)	(0.690)	(0.679)	(0.683)
	p=0.146	*p*=0.090	*p*=0.082	*p*=0.075
Control variables				
Gender	0.021	0.012	-0.156	-0.193
	(0.449)	(0.424)	(0.418)	(0.425)
	p=0.962	*p*=0.978	*p*=0.711	*p*=0.651
Founder	-0.277	-0.402	-0.301	-0.289
	(0.298)	(0.280)	(0.275)	(0.276)
	p=0.355	*p*=0.154	*p*=0.275	*p*=0.296
Company age	-0.009	-0.005	-0.006	-0.006
	(0.007)	(0.007)	(0.007)	(0.007)
	p=0.197	*p*=0.426	*p*=0.369	*p*=0.386
Company size	0.006	0.006	0.007	0.007
	(0.006)	(0.006)	(0.005)	(0.005)
	p=0.263	*p*=0.290	*p*=0.195	*p*=0.216
Manufacturing	-0.660†	-0.393	-0.384	-0.379
	(0.388)	(0.366)	(0.355)	(0.356)
	p=0.091	*p*=0.285	*p*=0.280	*p*=0.289
Services	-0.768*	-0.761*	-0.699*	-0.705*
	(0.350)	(0.333)	(0.325)	(0.326)
	p=0.030	*p*=0.024	*p*=0.033	*p*=0.032
Direct effects				
Causation		0.390*	0.268	0.278†
		(0.167)	(0.166)	(0.167)
		p=0.021	*p*=0.108	*p*=0.099
PC intensity		0.123	0.154	0.167
		(0.121)	(0.119)	(0.122)
		p=0.312	*p*=0.199	*p*=0.171
Dynamism		0.251**	0.295**	0.316**
		(0.088)	(0.087)	(0.095)
		p=0.005	*p*=0.001	*p*=0.001
Two-way interaction effects				
Causation*Dynamism			-0.271**	-0.280**
			(0.100)	(0.102)
			p=0.008	*p*=0.007
Causation*PC intensity			0.278*	0.250*
			(0.110)	(0.122)
			p=0.013	*p*=0.041
PC intensity*Dynamism			0.018	0.026
			(0.083)	(0.085)
			p=0.833	*p*=0.759
Three-way interaction effect				
Causation*Dynamism*PC intensity				-0.041
				(0.073)
				p=0.573
F-statistic	1.807†	4.406***	4.563***	4.217***
Significance	0.101	0.000	0.000	0.000
R^2	0.066	0.208	0.270	0.272
Adjusted R^2	0.029	0.161	0.211	0.207
R^2 change	0.066	0.142	0.062	0.002

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$; Unstandardized coefficients; VIF always < or = to 2.297; Standard error between parentheses; Dependent variable Innovative Performance ; PC intensity = Pre-commitment intensity; Sample size = 161.

Table 5: Hierarchical linear regression with pre-commitment advantages

Outcome	Model 1	Model 2	Model 3	Model 4
Constant	1.077	1.125	1.187†	1.307 *
	(0.738)	(0.693)	(0.657)	(0.652)
	p=0.146	*p*=0.106	*p*=0.073	*p*=0.047
Control variables				
Gender	0.021	0.077	-0.161	-0.239
	(0.449)	(0.420)	(0.400)	(0.398)
	p=0.962	*p*=0.855	*p*=0.689	*p*=0.549
Founder	-0.277	-0.384	-0.306	-0.314
	(0.298)	(0.282)	(0.265)	(0.263)
	p=0.355	*p*=0.175	*p*=0.251	*p*=0.233
Company age	-0.009	-0.005	-0.007	-0.007
	(0.007)	(0.007)	(0.006)	(0.006)
	p=0.197	*p*=0.434	*p*=0.261	*p*=0.286
Company size	0.006	0.005	0.006	0.006
	(0.006)	(0.005)	(0.005)	(0.005)
	p=0.263	*p*=0.377	*p*=0.239	*p*=0.243
Manufacturing	-0.660†	-0.412	-0.393	-0.383
	(0.388)	(0.366)	(0.345)	(0.341)
	p=0.091	*p*=0.263	*p*=0.257	*p*=0.264
Services	-0.768*	-0.802*	-0.745*	-0.765*
	(0.350)	(0.332)	(0.313)	(0.309)
	p=0.030	*p*=0.017	*p*=0.018	*p*=0.014
Direct effects				
Causation		0.422*	0.554**	0.546**
		(0.173)	(0.174)	(0.172)
		p=0.016	*p*=0.002	*p*=0.002
PC advantages		0.037	0.004	0.056
		(0.132)	(0.126)	(0.127)
		p=0.778	*p*=0.973	*p*=0.658
Dynamism		0.263**	0.273**	0.345***
		(0.088)	(0.083)	(0.089)
		p=0.003	*p*=0.001	*p*=0.000
Two-way interaction effects				
Causation*Dynamism			-0.148	-0.227*
			(0.092)	(0.099)
			p=0.112	*p*=0.023
Causation*PC advantages			0.462***	0.421**
			(0.126)	(0.126)
			p=0.000	*p*=0.001
PC advantages*Dynamism			-0.237**	-0.227*
			(0.088)	(0.087)
			p=0.008	*p*=0.010
Three-way interaction effect				
Causation*Dynamism*PC advantages				-0.158*
				(0.076)
				p=0.039
F-statistic	1.807†	4.273***	5.557***	5.580*
Significance	0.101	0.000	0.000	0.039
R^2	0.066	0.203	0.311	0.330
Adjusted R^2	0.029	0.155	0.255	0.271
R^2 change	0.066	0.137	0.108	0.020

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$; Unstandardized coefficients; VIF always < or = to 2.303; Standard error between parentheses; Dependent variable Innovative Performance; PC advantages = Pre-commitment advantages; Sample size = 161.

Table 6: Bootstrap results for the three-way interaction between causation, pre-commitment advantages, and dynamism

Dynamism	PCA	Causation Effect	*p*-value	LLCI	UCLI
-1.681	2.217	0.257	0.207	-0.144	0.658
-1.681	3.162	0.864***	0.000	0.451	1.277
-1.681	4.107	1.471***	0.000	0.887	2.055
-0.282	2.217	0.148	0.398	-0.198	0.495
-0.282	3.162	0.546**	0.002	0.207	0.885
-0.282	4.107	0.943***	0.000	0.472	1.414
1.117	2.217	0.040	0.869	-0.433	0.513
1.117	3.162	0.228	0.328	-0.231	0.686
1.117	4.107	0.416	0.205	-0.229	1.061

† $p < 0.10$, * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$; PCA = Pre-commitment advantages.

Figure 1: Conceptual model

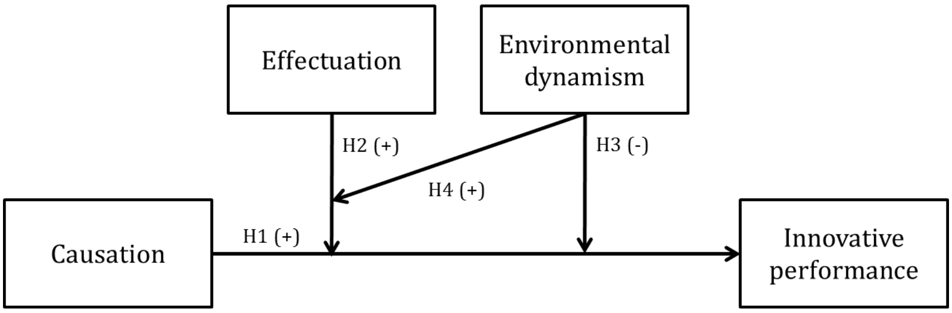

Figure 2: Two-way interaction between causation and effectuation

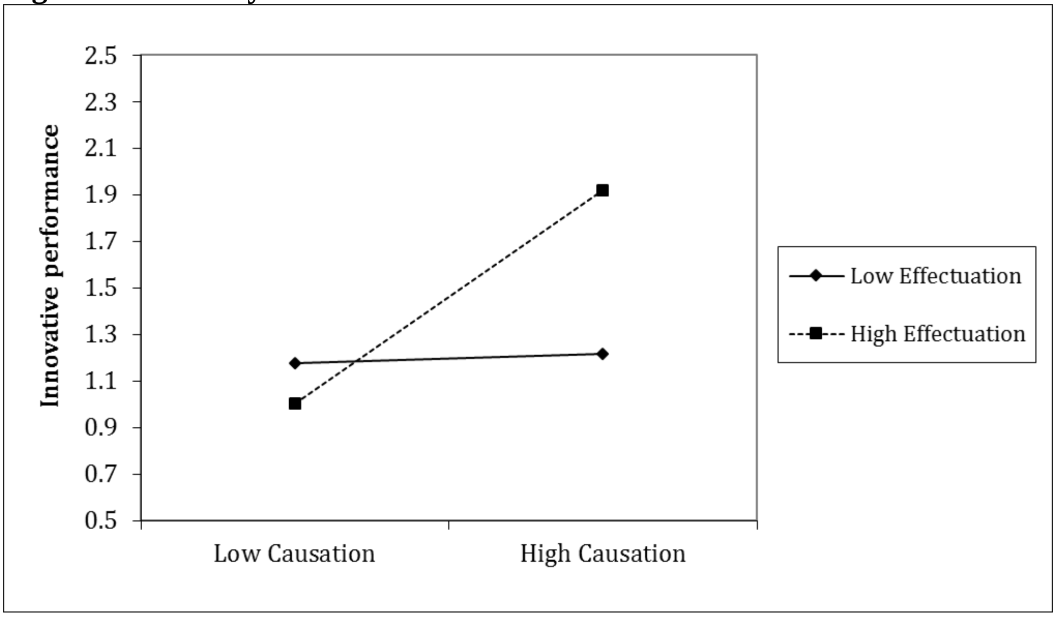

Figure 3: Two-way interaction between causation and pre-commitment intensity

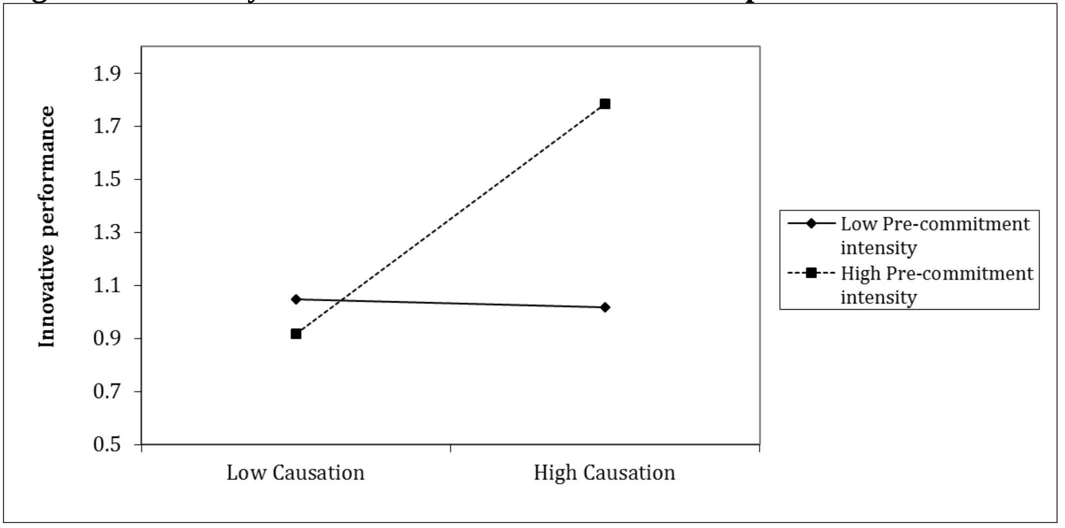

Figure 4: Two-way interaction between causation and pre-commitment advantages

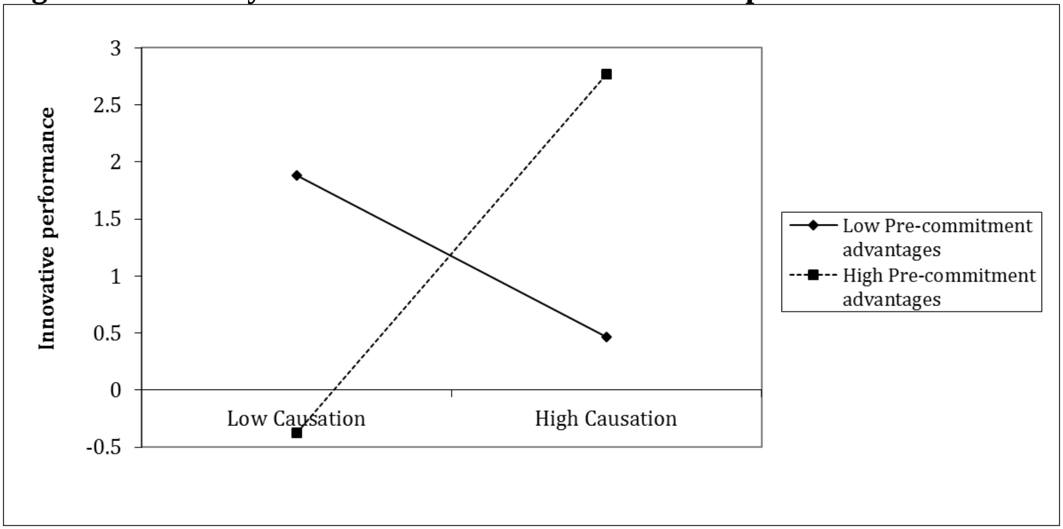

Figure 5: Two-way interaction between causation and environmental dynamism

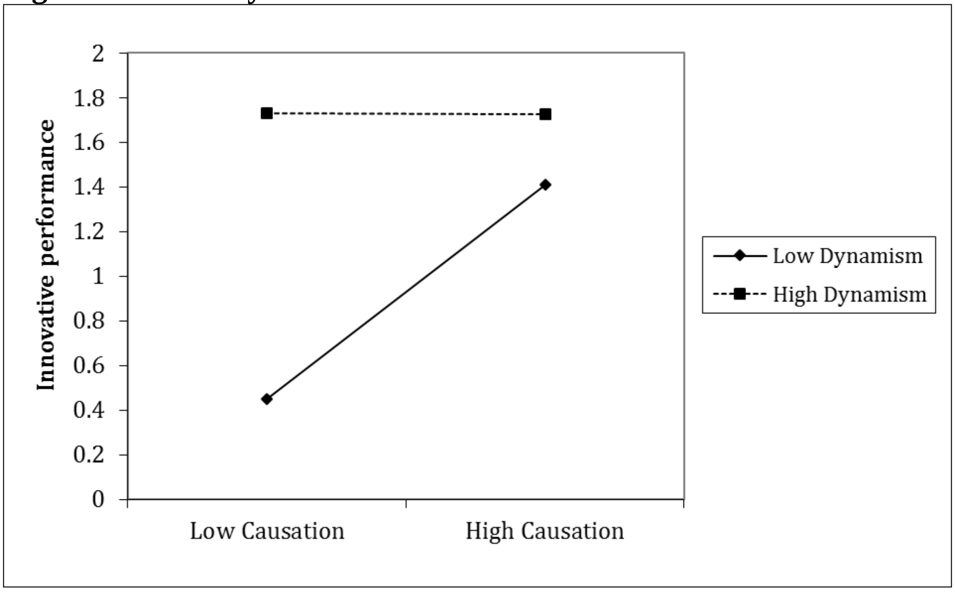

Figure 6: Three-way interaction between causation, pre-commitment advantages, and dynamism