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ABSTRACT

We examine how firms adjusted their open innovation strategy in response to the 2008 global financial crisis. While previous research has analysed the advantages, drawbacks, and methods of open innovation, less is known about how firms adjust their open innovation strategy in response to major economic shocks. Guided by theories of organisational learning and behavioural theory of the firm, we examine the impact of demand shock on firm openness to external knowledge. To test our hypotheses, we analyse a unique dataset on innovation in Swiss firms during the financial crisis. Our findings show that firms persisted with open innovation during the crisis, but the nature of the shock had a differential effect on how firms searched for external knowledge. This research contributes to a better understanding of the role of open innovation in times of crisis and provides insights into how firms adjust their innovation strategies in response to economic shocks.

KEYWORDS

strategy; financial crisis; demand shock; open innovation; external search

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1. Introduction

The collapse of Lehman Brothers in the fall of 2008 triggered a global financial crisis of historic magnitude (OECD 2009). The subsequent global recession evolved into 'one of the most virulent recessions in decades' (OECD 2009; see also World Bank 2020) and disrupted many aspects of the business environment (e.g. Duchin, Ozbas, and Sensoy 2010; Flammer and Ioannou 2021; OECD 2012). A sudden economy-wide crisis such as the financial crisis can be expected to trigger firm strategic response (Fiol and Lyles 1985) and organisational learning (Cyert and March 1963; Gavetti et al. 2012; Lampel, Shamsie, and Shapira 2009).

Firms can learn by tapping internal and external ideas, knowledge, and technology for their innovation activities (e.g. Cohen and Levinthal 1990; Katila and Ahuja 2002). One important method for identifying and utilising external knowledge is through external search (Laursen and Salter 2006). Firms use open innovation strategies to search for knowledge outside their own boundaries (Chesbrough 2003; Laursen and Salter 2006). Despite several studies that shed light on how firms learn in response to environmental changes by searching for new knowledge (e.g. Cohen and Levinthal 1990; Katila and

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Ahuja 2002; Rosenkopf and Almeida 2003), we know less about how firms search for *external* knowledge under conditions of economy-wide crisis (see Chesbrough and Garman 2009; Dahlander, Gann, and Wallin 2021, 7).

This paper develops a theoretical framework and provides new evidence about how firms adjusted their open innovation strategy as a response to the 2008 global financial crisis. The financial crisis is the context to study how one key aspect of major recessions, demand shock (economy-wide drop in demand), affects firm external search strategy. A demand shock affects how a firm organises for innovation and consequently, the external search strategy of a firm is likely to change (cf. Chesbrough and Garman 2009). While we focus on the effect of demand shock on open innovation, we also document the effect of limited access to external credit as an additional innovation constraint. This is expedient because the origin of the global recession – the collapse of the financial markets – brought on a credit crisis (known as the 'credit crunch'), and an unparalleled increase in the cost of debt financing for firms (e.g. Campello, Graham, and Harvey 2010; Duchin, Ozbas, and Sensoy 2010).

Following past work on open innovation (e.g. Garriga, von Krogh, and Spaeth 2013; Laursen and Salter 2006; Leiponen and Helfat 2010; Love, Roper, and Vahter 2013; Trantopoulos et al. 2017), we draw on theories of organisational learning and the behavioural theory of the firm to develop a theoretical framework linking demand shock to a firm's open innovation strategies. Following Laursen and Salter (2006), we distinguish between external search breadth and depth. We hypothesise that a demand shock triggers a differential effect on external search breadth (i.e. the number of external sources or search channels that firms rely upon in their innovative activities) and external search depth (i.e. the extent to which firms draw deeply from the different external sources or search channels).

We draw on a large and novel dataset on innovation in Swiss firms to examine how the global financial crisis influenced different search strategies for tapping into external knowledge sources. Particularly, we provide mechanism and evidence about the way in which firms draw external knowledge into their innovation processes when they face a demand shock. We find that firms facing a demand shock open their innovation process, but make different strategic choices about whether and how knowledge search proceeds.

Our study relates to the large body of literature on open innovation in strategic management (e.g. Bogers et al. 2017; Dahlander and Gann 2010; Dahlander, Gann, and Wallin 2021; Laursen and Salter 2006; West et al. 2014). While the link between external search and innovation performance is well-established in the literature (e.g. Laursen and Salter 2006; Leiponen and Helfat 2010; Love, Roper, and Vahter 2013; Trantopoulos et al. 2017), less is known about the underlying strategic decision-making in firms to increase (or decrease) search in external knowledge sources (Garriga, von Krogh, and Spaeth 2013). Even less is understood about how firms respond to economy-wide crises by adjusting their open innovation strategy (Chesbrough and Garman 2009; Dahlander, Gann, and Wallin 2021, 7).

This study is also related to timely work that examines how various types of economy-wide crises affect firm innovation. Several studies have focused on the impact of the 2008 global financial crisis on firm innovation investments (e.g. Archibugi, Filippetti, and Frenz 2013; Campello, Graham, and Harvey 2010; Flammer and Ioannou 2021; Giebel

and Kraft 2020; Knudsen and Lien 2014; Paunov 2012) and firm innovation output (e.g. Ahn, Mortara, and Minshall 2018; D'Agostino and Moreno 2018; Huber 2018). Another growing stream of literature focuses on the COVID-19 pandemic and firm innovation (e.g. Chesbrough 2020; Guderian et al. 2020; Radziwon et al. 2022; Soluk 2022). Scholars may take away from our study that contrary to traditional (private and closed) innovation (cf. Aghion et al. 2012; Archibugi and Filippetti 2012; Paunov 2012), open innovation was relatively impervious to the financial crisis.

2. Literature and hypotheses

2.1. Context: the financial crisis of 2008

The 2008 global financial crisis was a severe shock for most economies around the world (IMF 2010; OECD 2009): the compound GDP fell by 4.5% in industrial countries, the unemployment rate rose to an average of 9% across OECD economies, and the volume of world trade dropped by more than 40% (Alfaro and Chen 2010). During the crisis and its aftermath, firms reported a drop in demand and difficulty accessing external credit (Duchin, Ozbas, and Sensoy 2010; OECD 2012).

By now, there is broad recognition that the crisis significantly impaired firm-based innovation globally (Campello, Graham, and Harvey 2010; Archibugi and Filippetti 2012; Archibugi, Filippetti, and Frenz 2013; Filippetti and Archibugi 2011; OECD 2009, 2012; Paunov 2012; World Bank 2010). Patenting activity based on trends in PCT filings rapidly declined in 2009 compared to 2007 (OECD 2012, 28). Filippetti and Archibugi (2011) showed that the crisis had an overall negative effect on innovation investments (see also, Archibugi and Filippetti 2012; Archibugi, Filippetti, and Frenz 2013). Drawing on data from Latin America, Paunov (2012) observed that one in four firms terminated innovation projects in response to the crisis. Moreover, Campello et al's (2010) survey of 1,050 CFOs in the U.S., Europe, and Asia concluded that during the 2008 crisis, firms' constraints on external borrowing caused a 22% reduction in technology investments. Yet, did the financial crisis also weaken firms' open innovation? After all, prior work has demonstrated that faced with mounting resource constraints, firms increased their open innovation activities (Garriga, von Krogh, and Spaeth 2013).

2.2. Behavioral theory and organisation learning

Rooted in the behavioural theory of the firm, organisational learning (e.g. Cohen and Levinthal 1989; Cyert and March 1963; Huber 1991; Levinthal and March 1993) offers a comprehensive view of firm – environment interaction and predicts how a firm's use of external knowledge impacts its innovation performance (e.g. Cohen and Levinthal 1990; Laursen and Salter 2006, 2014; Trantopoulos et al. 2017).

The literature on organisational learning tend to assume that environments often change independently of firms' beliefs about them (March 1991; March and Olsen 1975), so that firms faced with the same environmental conditions react idiosyncratically (March 1991). Firms 'frame' their economic environment by harvesting and interpreting data about it. Such data could pertain to a sudden drop in demand (Bettis and Prahalad 1995) leading a firm to devise reactive strategies to adapt (Fiol and Lyles 1985). Firms that

face a sudden economy-wide crisis can be expected to adopt a strategic response and learn from internal and external sources (Cyert and March 1963; Gavetti et al. 2012; Lampel, Shamsie, and Shapira 2009; Meyer 1981). Adapted to innovation this logic implies that firms can learn from external sources and leverage this knowledge in their innovation activities.

A radical environmental change such as the financial crisis may therefore lead firms to 're-ignite' learning processes that would otherwise remain dormant (Winter 2000). Yet, re-igniting dormant learning is taxing with uncertain outcomes, since prior learning processes may also prove ineffective when the firm confronts novel environmental conditions (Elliott and MacPherson 2010). Thus, while a demand shock could trigger organisational learning (Levinthal and March 1981; Meyer 1981),[1] authors have explicitly cautioned on the fallacies of myopic firm behaviour during adaptive processes (Denrell and March 2001; March 2006), - behaviours that could reduce the anticipated benefits of 'opening up' the learning process towards the environment. The empirical question that remains is if and how the financial crisis affected the way firms tap into external knowledge sources.

2.3. External search

Firms have long tapped different external knowledge sources for their innovation activities by using a broad spectrum of knowledge sourcing mechanisms including alliances, research contracts, in-licencing, technology acquisitions, and external search. Among these mechanisms, external search is critical in open innovation (Laursen and Salter 2006). External search taps knowledge sources through informal linkages, void of contractual agreements (Laursen and Salter 2006, 2014; Mina, Bascavusoglu-Moreau, and Hughes 2014), and ranges from informal interactions with customers, suppliers, universities, consultants, or competitors, to analysing external databases or technology scouting, such as attending trade-fairs (e.g. Chesbrough 2003; Laursen and Salter 2006; Trantopoulos et al. 2017).

A large body of literature on open innovation focuses on two dimensions of external search, namely external search breadth and external search depth (Laursen and Salter 2006; see also Leiponen and Helfat 2010; Dahlander and Gann 2010; Trantopoulos et al. 2017). Search breadth captures the number of external sources or search channels on which firms rely in innovation, while external search depth captures the extent to which firms draw deeply from the different external sources or search channels (Laursen and Salter 2006).

Past work has explored how the environment may shape firms' methods of tapping external knowledge sources. For example, Pisano (1990) argues that high intensity of competition makes it beneficial for firms to opt out of R&D collaborations. Zahra (1992) found that external technology sourcing is highest for firms in hostile environments characterised by an unfavourable business climate, intense competition, and declining demand (see Zahra 1992, 192). Van de Vrande, Vanhaverbeke, and Duysters (2009)

[1]Examples of learning by the firm in response to environmental changes include identifying novel knowledge to strengthen the firm's technological base (Cohen and Levinthal 1990; Katila and Ahuja 2002; Rosenkopf and Almeida 2003), developing new capabilities (Levinthal and Myatt 1994), and forming novel responses to environmental opportunities and threats (Chattopadhyay, Glick, and Huber 2001).

found that firms facing high environmental uncertainty prefer to source technology through non-equity alliances over joint ventures. Papadopoulos et al. (2013) found that during an economic crisis, a firm's open-source software practices – a particular type of open innovation – influenced the private-collective model of innovation. More recently, Radziwon et al. (2022) showed how the COVID-19 challenges urged AirAsia airlines to leverage ecosystems for creating value through open innovation.

Yet, to the best of our knowledge, prior literature does not offer an analysis of how economy-wide crises may influence a firm's open innovation strategy, and in particular, external search. We seek to fill this important gap by examining how firms adjusted their external search strategy in response to the 2008 financial crisis.

2.4. Hypotheses

Firms that face a demand shock likely respond by seeking to adapt and learn (Lampel, Shamsie, and Shapira 2009; Winter 2000). Since sudden global recessions are rare events, they attract abnormal attention in the firm (March, Sproull, and Tamuz 1991; Rerup 2009) to information and sources of external knowledge relevant for the firm's adaptation (Gavetti and Levinthal 2000; Ocasio 1997).

A demand shock is an unexpected drop in demand triggered by economy-wide crises like the financial crisis in 2008 (Archibugi, Filippetti, and Frenz 2013; Flammer and Ioannou 2021; Paunov 2012). Applying behavioural insights, we expect a firm to favour open innovation as a reaction to a demand shock. First, tapping external knowledge sources enables the firm to conduct problemistic search (Posen et al. 2018) and transform its knowledge that may help the firm better adapt to the changing environmental conditions (Katila and Ahuja 2002, 1184; Laursen and Salter 2006; Levinthal and Myatt 1994; Powell, Koput, and Smith-Doerr 1996). Second, tapping external knowledge sources allows the firm to benefit from information about rapidly changing customer needs, markets, and technology and incorporate this into their innovation (Chesbrough 2003). Third, a demand shock causes a reduction in cash flow, which thwarts R&D investments (Aghion et al. 2012; Dixit and Pindyck 1994; Knudsen and Lien 2014; Lopez-Garcia, Montero, and Moral-Benito 2013; Schmookler 1966; Shleifer 1986; Starbuck and Hedberg 1977); a trajectory observable in the 2008 financial crisis[2] (see Archibugi, Filippetti, and Frenz 2013; Filippetti and Archibugi 2011; OECD 2009, 2012; Paunov 2012). Under such conditions, external search is an attractive alternative for reduced internal R&D investments (Chesbrough and Garman 2009; Di Minin, Frattini, and Piccaluga 2010) as it offers firms cost efficient ways to source knowledge and technology relevant for innovation (Chesbrough 2003; Zahra 1992). In other words, firms can tap external knowledge sources through search as a means to

[2]We note that scholars have also argued that a drop in demand could trigger firms to reallocate financial resources from manufacturing to internal R&D due to foregone output, suggesting a positive relationship between drop in demand and innovation investments ('counter-cyclical' pattern) (see, for example, Aghion and Saint-Paul 1998; Barlevy 2007; Lopez-Garcia, Montero, and Moral-Benito 2013). According to Knudsen and Lien (2014), the R&D-enhancing effect only predominates R&D spending cuts when the drop in demand is small. When the drop in demand is large enough, firms rather opt to cut their R&D investments ('pro-cyclical' pattern) (Knudsen and Lien 2014). Interestingly, Lopez-Garcia, Montero, and Moral-Benito (2013) find that the countercyclical pattern is reversed by the presence of credit constraints (a key aspect of the 2008 financial crisis). Both insights by Knudsen and Lien (2014), and Lopez-Garcia, Montero, and Moral-Benito (2013), are lent further credence by the demonstrated negative impact of the 2008 financial crisis on corporate innovation investments (see, for example, Archibugi, Filippetti, and Frenz 2013; Filippetti and Archibugi 2011; OECD 2009, 2012; Paunov 2012).

conserve R&D or substitute for R&D cuts without sacrificing future revenue growth through innovation (Chesbrough and Garman 2009; Helfat 1997; Kraatz and Zajac 2001; Powell, Koput, and Smith-Doerr 1996; Winter 1984).

Based on the above reasoning, firms that face a demand shock can be expected to open up their innovation process through external search. However, thus far it is not clear how a demand shock will affect the external search types (i.e. external search breadth and external search depth) in open innovation strategies. There are two reasons to expect that firms facing a demand shock would favour external search depth over external search breadth: myopic adaptation and attention allocation.

First, as we argued above, firms facing a demand shock likely respond by attempting to learn through external search and so adapt to the changing environmental conditions. However, adaptive mechanisms are myopic (Denrell and March 2001; Levinthal and March 1993). March (2006, 206) argues that within a myopic adaptation process, a firm likely opts for alternatives that 'provide benefits that are local in time or space and costs that are more distant' while 'alternatives that provide costs that are local and benefits that are more distant' are likely to be a less dominant choice. This conjecture is informative when theorising firms' likely strategic response to a demand shock through external search. A demand shock manifests high uncertainty as the firm cannot forecast when and at which levels the demand will return after the crisis. The firm must process rapidly emerging information (Stinchcombe 1990) accentuating problems of cognitive limitations and bounded rationality (Levitt and March 1988; Nelson and Winter 1982; Simon 1991; Starbuck 2009). In this manner, a demand shock reinforces 'myopic adaptation'—a preference for alternatives that reduce uncertainty, i.e. 'local' in time and 'distant' in costs rather than 'local' in costs and 'distant' in time (March 1991).

External search depth is about searching for new knowledge within or close to areas of expertise, i.e. drawing knowledge from a narrow set of external sources to 'deepen' the knowledge base of the firm (cf. Winter 1984; see also Laursen and Salter 2006; Trantopoulos et al. 2017; Lanzolla, Pesce, and Tucci 2021, 93), and is often associated with exploitation (Lanzolla, Pesce, and Tucci 2021, 93; Stanko and Henard 2017, 786). External search breadth is about searching for new knowledge outside areas of expertise, i.e. drawing distant knowledge from a wide number of sources for knowledge to broaden the knowledge base of the firm (Lanzolla, Pesce, and Tucci 2021, 93; Laursen and Salter 2006; Trantopoulos et al. 2017) and is often associated with exploration[3] (Lanzolla, Pesce, and Tucci 2021, 93; Stanko and Henard 2017, 786). Myopic adaptation arguments suggest that firms that face a demand shock are expected to draw knowledge from external sources through a search process that reduces uncertainty. Moreover, in his seminal work, March (1991, 73) argues that compared to returns from exploitation, returns from exploration are systematically less certain and more remote in time. The aforementioned line of thinking suggests that firms that face a demand shock would be more likely to favour external search depth as a strategy for opening their innovation process.

Second, an increase in the number of a firm's external knowledge sources is considered critical for increasing recombination (variety) of knowledge for innovation and

[3]Scanning a wide number of external knowledge sources is subject to considerable uncertainty as it is ex ante difficult for firms to know which source will be most beneficial prior to engaging in the relationship (Laursen and Salter 2006). Also, the reliability of such distant knowledge might be lower (Katila and Ahuja 2002).

eventually fostering an increase in innovation performance (e.g. Laursen 2012; Leiponen and Helfat 2010). However, there are limits to such benefits as an external search strategy involves attention allocation across an increasing number of external sources (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010) and firms have limited attention capacity (Cyert and March 1963; Ocasio 1997; Simon 1947, 1991). Importantly, cognitive limitations, bounded rationality, and limited attention will be accentuated when a firm faces a demand shock during a global recession (Levitt and March, 1988; Simon 1991; Starbuck 2009). In light of these accentuated cognitive limitations, firms that face a demand shock can be expected to limit their attention to broad external search and opt to open up through searching external sources that are key to their internal innovation process (Chesbrough 2003; Greve 2008; Laursen and Salter 2006; Ocasio 1997). In other words, we expect firms to decrease the overall number of external sources that they rely upon in their innovative activities and increase the number of external sources that they draw upon more deeply. To summarise, we offer the following hypotheses:

Hypothesis 1 (H1): A demand shock negatively affects external search breadth.

Hypothesis 2 (H2): A demand shock positively affects external search depth.

3. Data and methods

3.1. Data

Our data is drawn from the 2011 Swiss Innovation Survey, which covers Swiss firms' innovation activities in 2008–2011.[4] The Swiss Innovation Survey parallels the Eurostat Community Innovation Survey (CIS) and is administered by the Swiss Economic Institute (KOF) on behalf of the State Secretary on of Economic Affairs. The survey is based on the KOF enterprise panel, which is a stratified random sample from the Swiss business census on firms with more than five employees, spanning small private firms, but also large public firms. The survey has a comprehensive coverage of all relevant industries (29) in the manufacturing, construction, and service sector.[5] Responses were received from 2,363 firms (a 35.9% response rate). Despite the partly self-reported nature of the questionnaire, various features of CISs have made them a standard inventory of innovation studies in strategic management (e.g. Grimpe and Sofka 2009; Laursen and Salter 2006, 2014; Leiponen and Helfat 2010; Trantopoulos et al. 2017). For example, in order to avoid common method bias (Podsakoff et al. 2003), the Swiss questionnaire contains different response types (quantitative questions, binary qualitative questions, questions based on a four- or five-point Likert scale), and the questions related to our dependent and independent variables are spatially separated. Moreover, the complexity of the questionnaire quite frequently requires that more than one person within a firm

[4]We use proprietary, confidential data that can only be accessed in a secure technological environment. ETH Zurich, KOF Swiss Economic Institute, which hosts the data, offers the possibility to access the raw data in their data centre. All researchers have free access to this data centre and can run our code to replicate the data. For more information, please visit: https://kof.ethz.ch/en/data/kof-micro-data-centre.html

[5]For example, industries include chemicals, pharmaceuticals, basic metals machinery & equipment, electrical equipment, electronics, vehicles, energy, wholesale, retail, banking, telecommunication, real estate, technical and commercial services, and personal services.

provides the data and information; e.g. R&D related information stems from the R&D department, while questions related to the overall firm performance come from the accounting department. In addition, the questionnaires rely on mail versus telephone interviews to minimise interpretability shortcomings, and have been applied internationally to confirm validity among contexts.[6]

We supplemented the 2011 Swiss Innovation Survey with data from the 2013 Swiss Innovation Survey which is also based on the KOF enterprise panel. The 2013 survey included a special set of questions to capture the impact of the crisis on the Swiss economy.[7] Response types included Likert-scaling and qualitative (yes/no) answers. The crisis-related section was part of the official Swiss Innovation Survey, guaranteeing the statistical quality of the sample and responses (responses were received from 2034 firms, corresponding to a 32.7% response rate). Since both surveys are based on the KOF enterprise panel, we can merge them without losing too many observations.

Our combined dataset contains information on: (i) the innovation activities of Swiss firms during the period of the economic downturn, and (ii) the impact of the global financial crisis on Swiss firms. The two surveys were conducted independently, which avoids a common response bias. The final econometric estimations comprise between 1,217 and 1,219 unique firm-level observations, depending on the specifications of the econometric models.

3.2. Measures

3.2.1. Dependent variables

We conceptualise the different strategies for tapping external knowledge (external search breadth, external search depth) as follows: The Swiss Innovation Survey lists 14 potential sources of external knowledge relevant for innovation.[8] Responding firms characterised the importance of each source using a Likert scale (from 1='no usage' to 4='high usage'). Following relevant literature (e.g. Garriga, von Krogh, and Spaeth 2013; Grimpe and Sofka 2009; Laursen and Salter 2006; Trantopoulos et al. 2017), we operationalised *external search breadth* as the count of different external sources that a focal firm taps for its innovation activities.[9] In a similar manner, we constructed *external search depth* by first coding each source as a binary, with 1 corresponding to high degree of usage (firm response 4), and 0 otherwise. Next, we added all the binaries so that the resulting variable reflects the count of different external sources that a firm uses intensively for its innovation activities. Both measures reflect the openness of a firm's external search strategies and have been extensively used in open innovation studies drawing upon Community Innovation Surveys (e.g. Garriga, von Krogh, and Spaeth 2013; Laursen and Salter 2006,

[6]For a detailed description of CISs, see for example Laursen and Salter (2014).

[7]The survey asked for 'Effects of the financial and economic crisis that occurred in 2008'. More concretely we use the following survey question: 'How important were the following factors for the problems in your company during the crisis?' Listed factors included 'exchange rates', 'drop in demand', 'lower credit limits from banks' for the own company. The companies responded to these question on a 4 point scale ranging from 1="no importance" to 4='high importance'.

[8]These range from customers, suppliers, competitors, and consultants to public research institutes, universities, technology transfer offices, scientific publications, technology fairs, and external databases.

[9]The set of items has a high degree of inter-item reliability (Cronbach's alpha coefficient = 0.87).

2014; Leiponen and Helfat 2010; Love, Roper, and Vahter 2013; Trantopoulos et al. 2017; West et al. 2014).

3.2.2. Explanatory variables

We operationalised demand shock to the focal firm using the survey question, 'How important were the following factors for the problems in your company during the crisis?' Ten different factors (in the form of survey items) are included, to which firms responded using a four-point Likert scale (1='no importance' to 4='high importance'). We used one survey item, namely 'drop in demand,' to proxy the *demand shock*. In line with our theoretical development, this survey item captures the firm's perception of the intensity of the demand shock. We constructed our explanatory variable by coding it as a binary, with a value of 1 when the focal firm's response indicated moderate or high importance (firm response 3 or 4), and 0 otherwise.

We also included a number of control variables. Most importantly, we control for other types of shocks that a company potentially faced. First, we refer to the survey item 'lower credit limits from banks' due to the crisis. From this question, we construct a binary variable *financial shock* that takes the value 1 if the company indicated a medium to high impact.[10] Second, we control for the exposure of a company to the exchange rate shock. For Swiss companies, the Euro area is the most important export region. On average, companies generate about 30% of their turnover with exports (see Table 1). As a result of the global financial crisis, the Swiss franc suddenly appreciated strongly against the euro, hitting companies exporting to the euro area particularly hard (Kaiser et al. 2018). To differentiate this exchange rate shock from the demand shock, we control for it with a binary variable *exchange rate shock*. It receives the value 1 if a company has indicated that it was negatively affected to a medium to high degree (value 3 or 4 on the 4-point scale) by the appreciation of the Swiss franc.

Recent work on open innovation has indicated that the search for knowledge is affected by the abundance of external knowledge in a U-shaped manner, and by constraints on resource application (Garriga, von Krogh, and Spaeth 2013). Thus, we included in our model specification, first, a variable that captures the *abundance of external knowledge* constructed as the firms' assessment (1='very low' to 5='very high') of the technological potential of knowledge in the external environment, together with its square term (see also Garriga, von Krogh, and Spaeth 2013). Second, we included a variable that captures the focal firm's *constraints* on innovation.[11] Third, we included the variable *R&D intensity* and *employees skills* measured by the share of employees with a higher degree[12] (Bolli, Renold, and Woerter 2018) to control for the focal firm's absorptive capacity (Cohen and Levinthal 1990; Zobel 2017), computed as R&D investments divided by total

[10]Firms responded on a four-point scale ranging from 1 'no importance' to 4 'high importance'. The values 3 or 4 indicate a medium to high impact.

[11]We constructed this variable as follows: The Innovation survey lists 16 items that may be obstacles to innovation, including costs, lack of human personnel or technological capabilities, and regulatory issues. Following Garriga, von Krogh, and Spaeth (2013) we constructed constraints as an aggregate variable that captures the total number of obstacles for innovation faced by the focal firm (Cronbach's alpha coefficient = 0.93).

[12]Higher education (advanced education) entails workers with professional tertiary education (ISCED97 4), incl. university of applied sciences (ISCED 5b) and to workers with conventional university tertiary education (ISCED97 5a and 6).

Table 1. Descriptive statistics.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1)	External search breadth	1																
(2)	External search depth	0.12	1															
(3)	Demand shock	0.05	0.05	1														
(4)	Exchange rate shock	0.12	0.08	0.26	1													
(5)	Financial shock	−0.04	0.03	0.05	0.03	1												
(6)	Knowledge abundance	0.39	0.23	0.00	0.08	0.03	1											
(7)	Knowledge abundance sq	0.34	0.26	0.00	0.06	0.03	0.98	1										
(8)	Constraints	0.43	0.05	0.09	0.11	0.05	0.17	0.15	1									
(9)	R&D	0.15	0.09	0.06	0.18	0.05	0.28	0.27	0.11	1								
(10)	R&D intensity	0.07	0.06	0.00	0.08	−0.01	0.20	0.22	0.03	0.30	1							
(11)	Exports	0.14	0.08	0.13	0.36	0.01	0.19	0.19	0.05	0.40	0.27	1						
(12)	Age	0.08	0.00	0.00	0.05	0.00	−0.05	−0.05	0.04	0.01	−0.06	−0.03	1					
(13)	Size	0.22	0.08	−0.02	0.14	−0.04	0.20	0.19	0.09	0.19	0.10	0.22	0.27	1				
(14)	Price competition	0.10	0.08	0.06	0.09	0.02	0.08	0.07	0.09	0.05	−0.06	0.04	0.07	0.10	1			
(15)	Employees Skills	0.09	0.13	0.01	0.09	−0.06	0.22	0.23	0.01	0.11	0.22	0.22	−0.10	0.08	−0.06	1		
(16)	Innovation support	0.12	0.07	−0.04	0.09	0.08	0.18	0.17	0.13	0.33	0.28	0.24	0.06	0.18	0.00	0.10	1	
(17)	No. competitors	0.07	−0.03	0.03	−0.01	−0.08	0.06	0.06	−0.02	0.10	0.05	0.11	0.05	0.09	−0.09	−0.02	0.11	1
	Mean	0.73	0.07	0.60	0.68	0.05	2.71	8.57	9.82	0.41	0.01	28.51	59.86	4.27	4.00	23.76	0.07	0.27
	SD	0.24	0.13	.	.	.	1.10	6.18	5.47	.	0.06	35.23	40.56	1.46	0.99	21.00	.	.
	Min	0	0	0	0	0	1	1	0	0	0	0	2	0	1	0	0	0
	Max	1	0.78	1	1	1	5	25	16	1	1.01	100	231	10.59	5	100	1	1

sales.[13] We also used a binary variable to control for whether the focal firm *exports*, a critical aspect of innovation in a crisis context (Brancati et al. 2018), since exporting firms where primarily affected by the crisis in the case of Switzerland, not at least by the revaluation of the Swiss currency (Kaiser et al. 2018). We further controlled for *age* and *size* of the focal firm; the latter measured by the log of the number of employees (Cohen 2010). We also control for the competitive environment of a company. It is likely that the intensity of price competition and the number of principal competitors have an impact on companies' open innovation activities (Geilinger, Woerter, and von Krogh 2020) and also on how severely companies are affected by the economic crisis (Arvanitis and Woerter 2014). We measure price competition on a five-point scale ranging from 1 (no price competition) to 5 (strong price competition), and the number of main competitors is assigned a value of 1 if a company is exposed to between 1 and 5 principal competitors in its main sales market worldwide, and 0 if the company is exposed to 6 or more principal competitors (Arvanitis and Woerter 2015; Geilinger, Woerter, and von Krogh 2020). Innovation promotion has the potential to mitigate a company's exposure, as it strengthens its financial base and, in the case of Switzerland, also promotes openness to innovation. In fact, the most important measure of innovation promotion in Switzerland focuses on the promotion of research collaborations. Moreover, Arvanitis and Woerter (2014) show that research collaborations are related to the cyclical behaviour of companies and can therefore be linked to both the extent to which they are affected and the openness of innovation behaviour. We measure innovation support through a binary variable. It receives the value 1 if the company has received innovation funding and 0 otherwise. Finally, we control for the 7 larger regions in Switzerland (NUTS 2 regions) and we used 29 industry dummies to reduce unobserved heterogeneity in terms of industry-specific and regional-specific open innovation behaviour. The latter control variables are also related to the possibilities of finding cooperation partners in the region.

3.3. Econometric model

Our dependent variables are non-negative counts, which suggests using a count data model (negative binomial or Poisson model) that takes into account over-dispersion. However, our dependent variables are restricted on the lower and the upper bounds. In such a case, the suggested count data models might lead to spurious estimates. Instead, Papke and Wooldridge (1996) and Wooldridge (2002) suggest the so-called 'fractional logit regression.' This transforms the dependent count variable y in the following way: $(y - a)/(b - a)$, where a and b are the lower and upper bounds of the dependent variable, respectively. This results in a variable that is restricted to the interval $[0, 1]$. Usually one could log-transform the dependent variable and estimate an ordinary least squares (OLS) model. However, since the distribution plot of our dependent variables

[13] As we inflated the R&D intensity variable by adding a zero value for all firms without R&D activities, it is necessary to correct for this inflation by adding the binary R&D variable. Excluding firms without R&D activities from the analysis would bias our sample, as it would restrict it to only R&D-intensive firms.

shows observations on the lower and upper bounds, such a transformation would cause serious estimation problems (see Papke and Wooldridge 1996). Estimating $E[y|x]$ as a logistic function can solve this problem, where $E[y|x] = \exp(xb)/[1 + \exp(xb)]$. This model ensures that the predicted values for y are between 0 and 1 and that the effect of any $x$on $E[y|x]$ diminishes as $xb \to \infty$ (for further characteristics of the model, see Wooldridge 2002, 662).

We use this fractional logit estimator to estimate the following equation:

$$Openness_{it} = a + \beta demand\,shock_{it-1} + yX_{it-1} + e_{it} \quad (1)$$

where $Openness \in (external\,search\,breadth, external\,search\,depth)$

X stands for the control variables described above, which include controls for the exchange rate shock and the financial shock.[14]

3.4. Endogeneity

Similar to Laursen and Salter (2014) one can argue that the decision for deep and broad search in external knowledge sources might be jointly taken by the firm. Thus, the residuals of the single equations on the decision to search are significantly correlated. Thus, additional estimations were performed controlling on the right-hand side of the equation for the search depth in search breadth equation and for the search breadth in search depth equation. Hence, we consider that both decisions might be related. The results are presented in Appendix Tables A1 and A2. It shows that the decisions for search breadth and depth are indeed not independent of each other. We see a significant and positive relationship between the two search variables. However, this result does not affect the relationship between the type of shock and the company's search behaviour, which is important for this study. In the search depth equation, however, we see that the measure of the relationship with demand shock becomes somewhat weaker. The difference with the main equation is minor; the coefficient of the demand shock decreases from 0.283 (main equation) to 0.249 and the standard error remains very similar 0.171 and 0.172, respectively. This insight is important to studies that investigate the determinants of external search. Hence, the estimation of the fractional logit regression in our main analysis presents consistent results; they are unlikely to be affected by the potential simultaneity of the external search decisions.

Other endogeneity issues relate to reverse causality and/or omitted variables. Although we used lagged values of the variables, endogeneity issues, such as reverse causality, can still be problematic unless there is little or no serial autocorrelation of the error term and endogeneity risks are low (see Bellemare, Masaki, and Pepinsky 2017). While we cannot test based on the available data the extent of serial autocorrelation, we can assume that endogeneity threats due to omitted variables are low given our comprehensive control vector (see also discussion about omitted variable in the next paragraph). Estimation techniques such as dynamic panel

[14] In an extended estimation model, we add interaction terms between the demand shock and the exchange rate shock. The relationship between exchange rate turbulence and the demand shock may be particularly important – as the Swiss economy is strongly export-oriented – when we explore the relationship between the demand shock and openness. Specifically we estimate the following equation:
$Openness_{it} = a + \beta_1 demand\,shock_{it-1} + \beta_2 exchange\,rate\,shock_{it-1} + \beta_3 exchange\,rate\,shock_{it-1} * demand\,shock_{it-1}$-
$+yQ_{it-1} + e_{it}$.

estimators, which could effectively address reverse causality, cannot be applied due to limited data availability (see Leszczensky and Wolbring 2022).

Omitted variables could still be a problem and would require instrumental variable regression. Given the complexity of the estimation procedure, including the interaction terms, it is difficult to find valid and strong instruments. The use of weak instruments is not recommended as this could severely bias the results without necessarily solving the endogeneity problem (Hahn and Hausman 2003; Murray 2006). Therefore, we refrain from instrumental variable estimations in this paper. However, to mitigate the omitted variable bias we utilise an extensive control vector. We control not only for the simultaneity of the open innovation decision (see above), but also for the use of resources and the skills of employees (R&D, R&D intensity, employment skills), the competitive environment (price competition, number of principal competitors), the funding environment (innovation support), innovation constraints, the knowledge environment (abundance of knowledge), the international orientation of the company (export) and key company characteristics such as company size and the age of a company. We also control for other shocks that may have occurred in the context of the global financial crisis. Thus, we believe we have accounted for the most significant factors that could cause a correlation between the demand shock variable and the error term. Since we ultimately cannot completely rule out endogeneity issues, we acknowledge this limitation and leave it to future studies to address this issue in greater detail, for instance, in the form of an experimental (natural) study design.

4. Results

Table 1 presents descriptive statistics and pair-wise correlations of the variables. Export status is positively correlated with R&D activities and R&D has a stronger than average positive correlation with knowledge abundance. The latter clearly indicates the need for R&D to exploit commonly available knowledge. Similarly, R&D correlates positively with innovation promotion. As expected, there is a notable correlation between the exchange rate shock and a company's export activities. Importantly, none of the correlation coefficients are high enough to cause concern about multicollinearity.

The results of the estimations for external search breadth and depth are presented in Tables 2 and 3, respectively. The coefficient of *demand shock* is positive but insignificant for *external search breadth* (see Table 2).[15] The coefficient of *demand shock* is positive and highly significant ($p < 0.01$) for *external search depth* (see Table 3), indicating that if a company is affected by the demand shock it increases its search depth by 33.7%-points.[16] In sum, these results do not support H1 but lend support to H2, which stated that *demand shock* positively affects *external search depth*.

The estimation of search breadth (Table 2) shows another interesting result; there is a significant and negative relationship between the *financial shock* and the breadth of

[15]Since the exchange rate shock could influence the relationship between the demand shock and the open innovation method, we control for the latter. It turns out that its influence is minimal. The coefficient of the demand shock in the external search breadth equation decreases marginally from 0.026 to 0.019 and remains insignificant (see Table 2, Column 2). The interaction terms between demand shock and exchange rate shock also show no significant effects (see Table 2, Column 3). Thus, the influence of the exchange rate shock does not play a role in the external search breadth equation.

[16]Since we do not observe a strictly causal relationship, we do not want to give too much emphasis to the economic effects. For the calculation of the marginal effects see, for instance, Wedderburn (1974).

Table 2. Main estimations search breadth.

	External search breadth	External search breadth	External search breadth
Demand shock	0.026	0.019	
	(0.085)	(0.087)	
Exchange rate shock		0.043	
		(0.098)	
Demand shock = 0 and Exchange rate shock = 1			0.122
			(0.134)
Demand shock = 1 and Exchange rate shock = 0			0.115
			(0.146)
Demand shock = 1 and Exchange rate shock = 1			0.086
			(0.121)
Financial shock	−0.408**	−0.410**	−0.416**
	(0.186)	(0.186)	(0.187)
Knowledge abundance	0.941***	0.934***	0.930***
	(0.170)	(0.171)	(0.171)
Knowledge abundance squared	−0.111***	−0.110***	−0.109***
	(0.030)	(0.030)	(0.030)
Constraints	0.085***	0.085***	0.085***
	(0.008)	(0.008)	(0.008)
R&D	0.061	0.058	0.056
	(0.099)	(0.100)	(0.100)
R&D intensity	−0.390	−0.382	−0.432
	(0.787)	(0.787)	(0.788)
Exports	0.002	0.002	0.002
	(0.001)	(0.002)	(0.002)
Age	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Size	0.120***	0.119***	0.119***
	(0.031)	(0.031)	(0.031)
Price competition	−0.022	−0.023	−0.021
	(0.042)	(0.042)	(0.042)
Employees skills	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)
Innovation support	0.091	0.090	0.093
	(0.170)	(0.170)	(0.171)
No. competitors	0.144	0.146	0.143
	(0.092)	(0.092)	(0.092)
Constant	−1.604***	−1.591***	−1.637***
	(0.351)	(0.351)	(0.356)
Regional fixed effects	yes	yes	yes
Industry (2-digit) fixed effects	yes	yes	yes
N	856	856	856
Rmse	1.302	1.303	1.306

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; fractional logit estimations.

external search. This means that when faced with sudden problems in getting access to credit, companies tend to rely on fewer external knowledge sources (search breadth). They significantly streamline their portfolio of knowledge sources. However, as we see in the estimates of external search depth (Table 3), they do not deepen the relationships with the remaining knowledge sources; the coefficient of the financial shock variable is negative and insignificant.[17]

[17]Introducing the exchange rate shock into the external search depth equation only marginally reduces the coefficient of the demand shock variable from 0.337 to 0.282; the relationship between demand shock and external search depth remains significant (see Table 3, Column 2). A more differentiated examination based on the interaction terms (see Table 3, Column 3) shows that companies that are only exposed to the exchange rate shock have a somewhat greater search depth (coefficient: 0.750) than companies that are only exposed to the demand shock (coefficient: 0.595). The search depth is even higher for companies that are exposed to both a demand shock and an exchange rate shock (coefficient: 0.867). The differences in the effect on the search depth are not statistically significant.

Table 3. Main estimations search depth.

	External search depth	External search depth	External search depth
Demand shock	0.337**	0.283*	
	(0.166)	(0.171)	
Exchange rate shock		0.473**	
		(0.194)	
Demand shock = 0 and Exchange rate shock = 1			0.750***
			(0.267)
Demand shock = 1 and Exchange rate shock = 0			0.595**
			(0.290)
Demand shock = 1 and Exchange rate shock = 1			0.867***
			(0.240)
Financial shock	−0.253	−0.200	−0.177
	(0.364)	(0.367)	(0.371)
Knowledge abundance	−0.599*	−0.625*	−0.632*
	(0.333)	(0.337)	(0.340)
Knowledge abundundance squared	0.176***	0.183***	0.186***
	(0.059)	(0.060)	(0.060)
Constraints	−0.006	−0.008	−0.007
	(0.015)	(0.015)	(0.015)
R&D	0.335*	0.367*	0.351*
	(0.195)	(0.197)	(0.198)
R&D intensity	−1.129	−0.896	−0.908
	(1.539)	(1.554)	(1.566)
Exports	0.001	−0.001	−0.001
	(0.003)	(0.003)	(0.003)
Age	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)
Size	0.096	0.071	0.058
	(0.061)	(0.061)	(0.062)
Price competition	0.229***	0.237***	0.253***
	(0.082)	(0.083)	(0.084)
Employees skills	0.005	0.005	0.004
	(0.005)	(0.005)	(0.005)
Innovation support	0.327	0.321	0.293
	(0.333)	(0.336)	(0.339)
No. competitors	−0.572***	−0.535***	−0.530***
	(0.180)	(0.182)	(0.184)
Constant	−5.461***	−5.535***	−5.701***
	(0.686)	(0.694)	(0.707)
Regional fixed effects	yes	yes	yes
Industry (2-digit) fixed effects	yes	yes	yes
N	856	856	856
Rmse	4.984	5.077	5.156

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; fractional logit estimations.

We controlled for a number of factors. The *abundance of external knowledge* (technological potential) is significant and non-linearly related with the dependent variables. *Constraints* and *Size* are significant and positively related with *external search breadth*. Other controls in the search breadth estimations are insignificant. The *abundance of external knowledge* is also significantly and non-linearly related to external search depth. *Constraints* do not show any significant relationship and *R&D* and *price competition* are positively related with external search depth, while the *number of competitors* shows a negative relationship. The latter indicates that in markets with less than 6 principal competitors (oligopolistic markets) deep search is less common compared to markets with more competitors. Moreover, the industry fixed effects (2-digit level) are jointly significant.

5. Discussion and conclusion

This study investigates the response of firms to demand shock during the 2008 global financial crisis in terms of their open innovation strategies. In contrast to previous studies that highlighted the negative impact of the crisis on closed innovation, we reveal the persistence of open innovation during this period. By theorising and offering empirical evidence, we explore the relationship between demand shock and external search strategies. Our findings reveal that firms adapted to the crisis by tapping external knowledge sources for innovation, selectively opening their innovation process in terms of external search depth while maintaining insignificant effects on external search breadth. This suggests that deep use of key external knowledge sources was preferred to safeguard firms' innovative competitiveness during the financial crisis. As Laursen and Salter (2006) argue, drawing knowledge intensively from a set of external sources (deep search) requires extensive effort and time to build up an understanding of their norms, habits, and routines. Our results highlight the importance of maintaining deep relational links with external knowledge sources, as disruption of these links could lead to difficulty rebuilding them after the crisis. Overall, our research contributes to a better understanding of the adaptive mechanisms employed by firms during demand shocks and provides insights for future studies on open innovation strategies.

Our study provides empirical evidence that firms relied on open innovation during the financial crisis, dispelling concerns that open innovation may only serve as a justification for R&D cuts. As such, managers should observe that open innovation, especially a strategy of deep external search, is often adopted by firms in times of economy-wide crises. This observation suggests that supplementing or substituting closed internal innovation with open innovation methods may be advantageous under various conditions. Therefore, managers are advised to gain a thorough understanding of how open innovation can assist their firms in responding to unexpected environmental changes. Moreover, policy makers should take note that while innovation activities generally decline during and after a crisis, firms do not appear to reduce open innovation efforts in such circumstances. Given that financial crises are frequently occurring phenomena and will likely persist in the future (Reinhart and Rogoff 2009), policies that reinforce open innovation during and after a financial crisis may be highly effective.

This study is not devoid of certain limitations, which ought to be acknowledged. Firstly, endogeneity issues associated with the target variables have been identified and already discussed. Moreover, the study may be subject to 'survival bias', as businesses experiencing severe difficulties may have departed from the market, resulting in the loss of vital information that may influence the presented findings. Resolving this shortcoming would require substantial effort, such as identifying the entities that have exited the market and requesting their participation in the survey. However, convincing them to cooperate would be an arduous undertaking. Addressing this matter and estimating the potential bias would necessitate a separate investigation, beyond the scope of this present study.

The present study opens up promising avenues for future research. Our findings indicate that companies preferred external search depth over breadth as a response to the financial crisis. However, an important inquiry is whether this strategy was eventually profitable and sustained when normal times returned. Furthermore,

additional empirical evidence is required to understand the underlying theoretical mechanisms governing the reliance of firms on open innovation during crises. While our study focused on the impact of the 2008 financial crisis on external search, we anticipate that it encourages future research on the association between open innovation and other economy-wide crises, such as the COVID-19 pandemic. Ascertaining the role of open innovation in such complex crises poses a significant challenge, but we hope that our study inspires future research to pursue this direction.

Disclosure statement

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References

Aghion, P., P. Askenazy, N. Berman, G. Cette, and L. Eymard. 2012. "Credit Constraints and the Cyclicality of R&D Investment: Evidence from France." *Journal of the European Economic Association* 10 (5): 1001–1024. https://doi.org/10.1111/j.1542-4774.2012.01093.x.

Aghion, P., and G. Saint-Paul. 1998. "Virtues of Bad Times: Interaction Between Productivity Growth and Economic Fluctuations." *Macroeconomic Dynamics* 2 (3): 322–344. https://doi.org/10.1017/S1365100598008025.

Ahn, J., L. Mortara, and T. Minshall. 2018. "Dynamic Capabilities and Economic Crises: Has Openness Enhanced a Firm's Performance in an Economic Downturn?" *Industrial and Corporate Change* 27 (1): 49–63. https://doi.org/10.1093/icc/dtx048.

Alfaro, L., and M. Chen 2010. Surviving the Global Financial Crisis: Foreign Direct Investment and Establishment Performance. *Harvard Business School BGIE Unit Working Paper No. 10-110.*

Archibugi, D., and A. Filippetti. 2012. *Innovation and Economic Crisis: Lessons and Prospects from the Economic Downturn*. New York: Routledge. https://doi.org/10.4324/9780203804513.

Archibugi, D., A. Filippetti, and M. Frenz. 2013. "Economic Crisis and Innovation: Is Destruction Prevailing Over Accumulation?" *Research Policy* 42 (2): 303–314. https://doi.org/10.1016/j.respol.2012.07.002 .

Arvanitis, S., and M. Woerter. 2014. "Firm Characteristics and the Cyclicality of R&D Investments." *Industrial and Corporate Change* 23 (5): 1141–1169. https://doi.org/10.1093/icc/dtt013.

Arvanitis, S., and M. Woerter. 2015. "Exploration or Exploitation of Knowledge from Universities: Does It Make a Difference?" *Economics of Innovation & New Technology* 24 (6): 596–623. https://doi.org/10.1080/10438599.2014.973294 .

Barlevy, G. 2007. "On the Cyclicality of Research and Development." *The American Economic Review* 97 (4): 1131–1164.

Bellemare, M. F., T. Masaki, and T. B. Pepinsky. 2017. "Lagged Explanatory Variables and the Estimation of Causal Effect." *The Journal of Politics* 79 (3): 949–963. https://doi.org/10.1086/690946.

Bettis, R. A., and C. K. Prahalad. 1995. "The Dominant Logic: Retrospective and Extension." *Strategic Management Journal* 16 (1): 5–14. https://doi.org/10.1002/smj.4250160104.

Bogers, M., A. Zobel, A. Afuah, E. Almirall, S. Brunswicker, L. Dahlander, L. Frederiksen 2017. "The Open Innovation Research Landscape: Established Perspectives and Emerging Themes Across Different Levels of Analysis." *Industry and Innovation* 24 (1): 8–40. https://doi.org/10.1080/13662716.2016.1240068.

Bolli, T., U. Renold, and M. Woerter. 2018. "Vertical Educational Diversity and Innovation Performance." *Economics of Innovation & New Technology* 27 (2): 107–131. https://doi.org/10.1080/10438599.2017.1314075.

Brancati, R., E. Marrocu, M. Romagnoli, and S. Usai. 2018. "Innovation Activities and Learning Processes in the Crisis: Evidence from Italian Export in Manufacturing and Services." *Industrial and Corporate Change* 27 (1): 107–130. https://doi.org/10.1093/icc/dtx022.

Campello, M., J. Graham, and C. Harvey. 2010. "The Real Effects of Financial Constraints: Evidence from a Financial Crisis." *Journal of Financial Economics* 97 (3): 470–487. https://doi.org/10.1016/j.jfineco.2010.02.009 .

Chattopadhyay, P., W. Glick, and G. Huber. 2001. "Organizational Action in Response to Threats and Opportunities." *The Academy of Management Journal* 44 (5): 937–955. https://doi.org/10.2307/3069439 .

Chesbrough, H. 2003. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.

Chesbrough, H. W. 2020. "To Recover Faster from Covid-19, Open Up: Managerial Implications from an Open Innovation Perspective." *Industrial Marketing Management* 88:410–413. https://doi.org/10.1016/j.indmarman.2020.04.010.

Chesbrough, H. W., and A. R. Garman. 2009. "How Open Innovation Can Help You Cope in Lean Times." *Harvard Business Review* 87 (12): 68–76, 128.

Cohen, W. M. 2010. "Fifty Years of Empirical Studies of Innovative Activity and Performance" In *Handbook of the Economics of Innovation*, edited by I. I. A. U. Rosenberg and I. I. U. H. Hall, 129–213. Vol. 1.https://doi.org/10.1016/S0169-7218(10)01004-X.

Cohen, W. M., and D. A. Levinthal. 1989. "Innovation and Learning: The Two Faces of R & D." *The Economic Journal* 99 (397): 569–596. https://doi.org/10.2307/2233763.

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective of Learning and Innovation." *Administrative Science Quarterly* 35 (1): 128–152. https://doi.org/10.2307/2393553.

Cyert, R. M., and J. G. March. 1963. A Behavioral Theory of the firm. *Englewood Cliffs*. New Jersey: Prentice-Hall.

D'Agostino, L. M., and R. Moreno. 2018. "Exploration During Turbulent Times: An Analysis of the Relation Between Cooperation in Innovation Activities and Radical Innovation Performance During the Economic Crisis." *Industrial and Corporate Change* 27 (2): 387–412. https://doi.org/10.1093/icc/dtx035 .

Dahlander, L., and D. Gann. 2010. "How Open is Innovation?" *Research Policy* 39 (6): 699–709. https://doi.org/10.1016/j.respol.2010.01.013 .

Dahlander, L., D. Gann, and M. Wallin. 2021. "How Open is Innovation? A Retrospective and Ideas Forward." *Research Policy* 50 (4): 104218. https://doi.org/10.1016/j.respol.2021.104218.

Denrell, J., and J. G. March. 2001. "Adaptation as Information Restriction: The Hot Stove Effect." *Organization Science* 12 (5): 523–538. https://doi.org/10.1287/orsc.12.5.523.10092.

Di Minin, A., F. Frattini, and A. Piccaluga. 2010. "Fiat: Open Innovation in a Downturn (1993–2003)." *California Management Review* 52 (3): 132–159. https://doi.org/10.1525/cmr.2010.52.3.132.

Dixit, A. K., and R. S. Pindyck. 1994. *Investment Under Uncertainty*. Princeton, NJ: Princeton University Press. https://doi.org/10.1515/9781400830176.

Duchin, R., O. Ozbas, and B. Sensoy. 2010. "Costly External Finance, Corporate Investment, and the Subprime Mortgage Credit Crisis." *Journal of Financial Economics* 97 (3): 418–435. https://doi.org/10.1016/j.jfineco.2009.12.008 .

Elliott, D., and A. MacPherson. 2010. "Policy and Practice: Recursive Learning from Crisis." *Group & Organization Management* 35 (5): 572–605. https://doi.org/10.1177/1059601110383406.

Filippetti, A., and D. Archibugi. 2011. "Innovation in Times of Crisis: National Systems of Innovation, Structure, and Demand." *Research Policy* 40 (2): 179–192. https://doi.org/10.1016/j.respol.2010.09.001.

Fiol, C. M., and M. A. Lyles. 1985. "Organizational Learning." *The Academy of Management Review* 10 (4): 803–813. https://doi.org/10.2307/258048.

Flammer, C., and I. Ioannou. 2021. "Strategic Management During the Financial Crisis: How Firms Adjust Their Strategic Investments in Response to Credit Market Disruptions." *Strategic Management Journal* 42 (7): 1275–1298. https://doi.org/10.1002/smj.3265.

Garriga, H., G. von Krogh, and S. Spaeth. 2013. "How Constraints and Knowledge Impact Open Innovation." *Strategic Management Journal* 36 (9): 1134–1144. https://doi.org/10.1002/smj.2049.

Gavetti, G., H. R. Greve, D. A. Levinthal, and W. Ocasio. 2012. "The Behavioral Theory of the Firm: Assessment and Prospects." *The Academy of Management Annals* 6 (1): 1–40. https://doi.org/10.5465/19416520.2012.656841 .

Gavetti, G., and D. Levinthal. 2000. "Looking Forward and Looking Back- Ward: Cognitive and Experiential Search." *Administrative Science Quarterly* 45 (1): 113–137. https://doi.org/10.2307/2666981 .

Geilinger, N., M. Woerter, and G. von Krogh. 2020. "The Division of Innovative Labour: When Does Customer Codevelopment Contribute to Firm Innovation Performance?" *Technology Analysis and Strategic Management* 32 (6): 653–665. https://doi.org/10.1080/09537325.2019.1692133.

Giebel, M., and K. Kraft. 2020. "Bank Credit Supply and Firm Innovation Behavior in the Financial Crisis." *Journal of Banking & Finance* 121:105961. https://doi.org/10.1016/j.jbankfin.2020.105961.

Greve, H. R. 2008. "A Behavioral Theory of Firm Growth: Sequential Attention to Size and Performance Goals." *Academy of Management Journal* 51 (3): 476–494. https://doi.org/10.5465/amj.2008.32625975.

Grimpe, C., and W. Sofka. 2009. "Search Patterns and Absorptive Capacity: Low- and High-Technology Sectors in European Countries." *Research Policy* 38 (3): 495–506. https://doi.org/10.1016/j.respol.2008.10.006 .

Guderian, C. C., P. M. Bican, F. J. Riar, and S. Chattopadhyay. 2020. "Innovation Management in Crisis: Patent Analytics as a Response to the COVID-19 Pandemic." *R&D Management* 51 (2): 223–239. https://doi.org/10.1111/radm.12447.

Hahn, J., and J. Hausman. 2003. "Weak Instruments: Diagnosis and Cures in Empirical Econometrics." *American Economic Review* 93 (2): 118–125. https://doi.org/10.1257/000282803321946912.

Helfat, C. E. 1997. "Know-How and Asset Complementarity and Dynamic Capability Accumulation: The Case of R&D." *Strategic Management Journal* 18 (5): 339–360. https://doi.org/10.1002/(SICI)1097-0266(199705)18:5<339:AID-SMJ883>3.0.CO;2-7 .

Huber, G. P. 1991. "Organizational Learning: The Contributing Processes and the Literatures." *Organization Science* 2 (1): 88–115. https://doi.org/10.1287/orsc.2.1.88.

Huber, K. 2018. "Disentangling the Effects of a Banking Crisis: Evidence from German Firms and Counties." *American Economic Review* 108 (3): 868–898. https://doi.org/10.1257/aer.20161534 .

IMF (International Monetary Fund). 2010. *World Economic Outlook*. Washington. https://www.imf.org/en/Publications/WEO/Issues/2016/12/31/World-Economic-Outlook-October-2010-Recovery-Risk-and-Rebalancing-23542 .

Kaiser, B., M. Siegenthaler, A. Spescha, and M. Woerter. 2018. "The Impact of Real Exchange Rates on Swiss Firms: Innovation, Investments, Productivity, and Business Demography." *KOF-Studies* 109. *April, Zürich*. https://doi.org/10.3929/ethz-b-000262860.

Katila, R., and G. Ahuja. 2002. "Something Old, Something New: A Longitudinal Study of Search Behavior and New Product Introduction." *Academy of Management Journal* 45 (6): 1183–1194. https://doi.org/10.2307/3069433 .

Knudsen, E., and L. Lien. 2014. "*Investments in Recessions*." In *Finance and Strategy (Advances in Strategic Management*, 3–36. Vol. *31*. Bingley: Emerald Group Publishing Limited.

Kraatz, M. S., and E. J. Zajac. 2001. "How Organizational Resources Affect Strategic Change and Performance in Turbulent Environments: Theory and Evidence." *Organization Science* 12 (5): 632–657. https://doi.org/10.1287/orsc.12.5.632.10088.

Lampel, J., J. Shamsie, and Z. Shapira. 2009. "Experiencing the Improbable: Rare Events and Organizational Learning." *Organization Science* 20 (5): 835–845. https://doi.org/10.1287/orsc.1090.0479.

Lanzolla, G., D. Pesce, and C. L. Tucci. 2021. "The Digital Transformation of Search and Recombination in the Innovation Function: Tensions and an Integrative Framework." *Journal of Product Innovation Management* 38 (1): 90–113. https://doi.org/10.1111/jpim.12546.

Laursen, K. 2012. "Keep Searching and You'll Find: What Do We Know About Variety Creation Through firms' Search Activities for Innovation?" *Industrial and Corporate Change* 21 (5): 1181–1220. https://doi.org/10.1093/icc/dts025.

Laursen, K., and A. Salter. 2006. "Open for Innovation: The Role of Openness in Explaining Innovative Performance Among UK Manufacturing Firms." *Strategic Management Journal* 27 (2): 131–150. https://doi.org/10.1002/smj.507 .

Laursen, K., and A. Salter. 2014. "The Paradox of Openness: Appropriability, External Search and Innovation Collaboration." *Research Policy* 43 (5): 867–878. https://doi.org/10.1016/j.respol.2013.10.004.

Leiponen, A., and C. E. Helfat. 2010. "Innovation Opportunities, Knowledge Sources, and the Benefits of Breadth." *Strategic Management Journal* 31 (2): 224–236. https://doi.org/10.1002/smj.807 .

Leszczensky, L., and T. Wolbring. 2022. "How to Deal with Reverse Causality Using Panel Data? Recommendations for Researchers Based on a Simulation Study." *Sociological Methods and Research* 51 (2): 837–865. https://doi.org/10.1177/0049124119882473.

Levinthal, D. A., and J. G. March. 1993. "The Myopia of Learning." *Strategic Management Journal* 14 (S2): 95–112. Winter Special Issue. https://doi.org/10.1002/smj.4250141009.

Levinthal, D., and J. G. March. 1981. "A Model of Adaptive Organizational Search." *Journal of Economic Behavior & Organization* 2 (4): 307–333. https://doi.org/10.1016/0167-26818190012-3.

Levinthal, D., and J. Myatt. 1994. "Co-Evolution of Capabilities and Industry: The Evolution of Mutual Fund Processing." *Strategic Management Journal* 15 (S1): 45–62. https://doi.org/10.1002/smj.4250150905.

Levitt, B., and J. March. 1988. "Organizational Learning." *Annual Review of Sociology* 14 (1): 319–338. https://doi.org/10.1146/annurev.so.14.080188.001535.

Lopez-Garcia, P., J. M. Montero, and E. Moral-Benito. 2013. "Business Cycles and Investment in Productivity-Enhancing Activities: Evidence from Spanish Firms." *Industry and Innovation* 20 (7): 611–636. https://doi.org/10.1080/13662716.2013.849456.

Love, J. H., S. Roper, and P. Vahter. 2013. "Learning from Openness: The Dynamics of Breadth in External Innovation Linkages." *Strategic Management Journal* 35 (11): 1703–1716. https://doi.org/10.1002/smj.2170.

March, J. G. 1991. "Exploration and Exploitation in Organizational Learning." *Organization Science* 2 (1): 71–87. https://doi.org/10.1287/orsc.2.1.71.

March, J. G. 2006. "Rationality, Foolishness, and Adaptive Intelligence." *Strategic Management Journal* 27 (3): 201–214. https://doi.org/10.1002/smj.515.

March, J. G., and J. P. Olsen. 1975. "The Uncertainty of the Past: Organizational Learning Under Ambiguity." *European Journal of Political Research* 3 (2): 147–171. https://doi.org/10.1111/j.1475-6765.1975.tb00521.x.

March, J. G., L. S. Sproull, and M. Tamuz. 1991. "Learning from Samples of One or Fewer." *Organization Science* 2 (1): 1–13. https://doi.org/10.1287/orsc.2.1.1.

Meyer, A. 1981. "Reacting to Surprises: Hospital Strategy, Structure and Ideology." *Health Care Management Review* 6 (4): 25–32. https://doi.org/10.1097/00004010-198100640-00005.

Mina, A., E. Bascavusoglu-Moreau, and A. Hughes. 2014. "Open Service Innovation and the Firm's Search for External Knowledge." *Research Policy* 43 (5): 853–866. https://doi.org/10.1016/j.respol.2013.07.004 .

Murray, M. P. 2006. "Avoiding Invalid Instruments and Coping with Weak Instruments." *Journal of Economic Perspectives* 20 (4): 111–132. https://doi.org/10.1257/jep.20.4.111 .

Nelson, R. R., and S. G. Winter. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Ocasio. 1997. "Towards an Attention-Based View of the Firm." *Strategic Management Journal* 18:187–206. Special Issue.

OECD (Organization for Economic Cooperation and Development). 2009. *Policy Responses to the Economic Crisis: Investing in Innovation for Long-Term Growth*. Paris: OECD.

OECD (Organization for Economic Cooperation and Development). 2012. Science Technology and Industry Outlook. *Innovation in the Crisis and Beyond*. Paris: OECD.

Papadopoulos, T., T. Stamati, M. Nikolaidou, and D. Anagnostopoulos. 2013. "From Open Source to Open Innovation Practices: A Case in the Greek Context in Light of the Debt Crisis."

Technological Forecasting and Social Change 80 (6): 1232–1246. https://doi.org/10.1016/j.techfore.2012.10.030.
Papke, L. E., and J. M. Wooldridge. 1996. "Econometric Methods for Fractional Response Variables with an Application to 401(k) Plan Participation Rates." *Journal of Applied Econometrics* 11 (6): 619–632. https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<619:AID-JAE418>3.0.CO;2-1.
Paunov, C. 2012. "The Global Crisis and firms' Investments in Innovation." *Research Policy* 41 (1): 24–35. https://doi.org/10.1016/j.respol.2011.07.007 .
Pisano, G. P. 1990. "The R&D Boundaries of the Firm: An Empirical Analysis." *Administrative Science Quarterly* 35 (1): 153–176. https://doi.org/10.2307/2393554.
Podsakoff, P. M., S. B. MacKenzie, J.-Y. Lee, and N. P. Podsakoff. 2003. "Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies." *Journal of Applied Psychology* 88 (5): 879–903. https://doi.org/10.1037/0021-9010.88.5.879.
Posen, H. E., T. Keil, S. Kim, and F. D. Meissner. 2018. "Renewing Research on Problemistic Search—A Review and Research Agenda." *Academy of Management Annals* 12 (1): 208–251. https://doi.org/10.5465/annals.2016.0018 .
Powell, W. W., K. W. Koput, and L. Smith-Doerr. 1996. "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." *Administrative Science Quarterly* 41 (1): 116–145. https://doi.org/10.2307/2393988 .
Radziwon, A., M. L. Bogers, H. Chesbrough, and T. Minssen. 2022. "Ecosystem Effectuation: Creating New Value Through Open Innovation During a Pandemic." *R&D Management* 52 (2): 376–390. https://doi.org/10.1111/radm.12512.
Reinhart, C. M., and K. S. Rogoff. 2009. *This Time is Different: Eight Centuries of Financial Folly*. Princeton University Press.
Rerup, C. 2009. "Attentional Triangulation: Learning from Unexpected Rare Crises." *Organization Science* 20 (5): 876–893. https://doi.org/10.1287/orsc.1090.0467.
Rosenkopf, L., and P. Almeida. 2003. "Overcoming Local Search Through Alliances and Mobility." *Management Science* 49 (6): 751–766. https://doi.org/10.1287/mnsc.49.6.751.16026.
Schmookler, J. 1966. *Invention and Economic Growth*. Cambridge, MA: Harvard University Press.
Shleifer, A. 1986. "Implementation Cycles." *Journal of Political Economy* 94 (6): 1163–1190. https://doi.org/10.1086/261428.
Simon, H. A. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. Chicago: MacMillan.
Simon, H. A. 1991. "Bounded Rationality and Organizational Learning." *Organization Science* 2 (1): 125–134. https://doi.org/10.1287/orsc.2.1.125.
Soluk, J. 2022. "Organisations' Resources and External Shocks: Exploring Digital Innovation in Family Firms." *Industry and Innovation* 29 (6): 792–824. https://doi.org/10.1080/13662716.2022.2065971.
Stanko, M., and D. Henard. 2017. "Toward a Better Understanding of Crowdfunding, Openness and the Consequences for Innovation." *Research Policy* 46 (4): 784–798. https://doi.org/10.1016/j.respol.2017.02.003 .
Starbuck, W. H. 2009. "Perspective—Cognitive Reactions to Rare Events: Perceptions, Uncertainty, and Learning." *Organization Science* 20 (5): 925–937. https://doi.org/10.1287/orsc.1090.0440.
Starbuck, W. H., and B. Hedberg 1977. Saving an Organization from a Stagnating Environment. *Strategy + Structure = Performance*. 249–258.
Stinchcombe, A. L. 1990. *Information and Organizations*. Berkeley, CA: University of California Press.
Trantopoulos, K., G. von Krogh, M. Wallin, and M. Woerter. 2017. "External Knowledge and Information Technology: Implications for Process Innovation Performance." *MIS Quarterly* 41 (1): 287–300. https://doi.org/10.25300/MISQ/2017/41.1.15.
Van de Vrande, V., W. Vanhaverbeke, and G. Duysters. 2009. "External Technology Sourcing: The Effect of Uncertainty on Governance Mode Choice." *Journal of Business Venturing* 24 (1): 62–80. https://doi.org/10.1016/j.jbusvent.2007.10.001.

Wedderburn, R. M. W. 1974. "Quasi-Likelihood Functions, Generalized Linear Models, and the Gauss-Newton Method." *Biometrika* 61 (3): 439–447. https://doi.org/10.1093/biomet/61.3.439.
West, J., A. Salter, W. Vanhaverbeke, and H. Chesbrough. 2014. "Open Innovation: The Next Decade." *Research Policy* 43 (5): 805–811. https://doi.org/10.1016/j.respol.2014.03.001 .
Winter, S. G. 1984. "Schumpeterian Competition in Alternative Technological Regimes." *Journal of Economic Behavior & Organization* 5 (3–4): 287–320. https://doi.org/10.1016/0167-26818490004-0.
Winter, S. G. 2000. "The Satisficing Principle in Capability Learning." *Strategic Management Journal* 21 (10–11): 981–996. https://doi.org/10.1002/1097-0266(200010/11)21:10/11<981:AID-SMJ125>3.0.CO;2-4 .
Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: TheMIT Press.
World Bank. 2010. *How are FIrm in Eastern and Central Europe Reacting to the FInancial Crisis?*. Enterprises Note No. 8. New York: World Bank Group.
World Bank. 2020. Global Recessions Policy Research Working Paper 9172. Washington: World Bank.
Zahra, S. A. 1992. "Technology Strategy and Financial Performance: Examining the Moderating Role of the Firm's Competitive Environment." *Journal of Business Venturing* 11 (3): 189–219. https://doi.org/10.1016/0883-9026(96)00001-8 .
Zobel, A. K. 2017. "Benefiting from Open Innovation: A Multidimensional Model of Absorptive Capacity." *Journal of Product Innovation Management* 34 (3): 269–288. https://doi.org/10.1111/jpim.12361.

Appendix

Table A1. Independence of external search breadth from search depth.

	External search breadth	External search breadth	External search breadth
External search depth	0.560*	0.554*	0.548*
	(0.329)	(0.329)	(0.330)
Demand shock	0.022	0.016	
	(0.085)	(0.087)	
Exchange rate shock		0.033	
		(0.098)	
Demand shock = 0 and Exchange rate shock = 1			0.109
			(0.135)
Demand shock = 1 and Exchange rate shock = 0			0.109
			(0.146)
Demand shock = 1 and Exchange rate shock = 1			0.074
			(0.121)
Financial shock	−0.417**	−0.418**	−0.424**
	(0.186)	(0.186)	(0.187)
Knowledge abundance	0.987***	0.981***	0.976***
	(0.173)	(0.173)	(0.173)
Knowledge abundance squared	−0.122***	−0.121***	−0.120***
	(0.031)	(0.031)	(0.031)
Constraints	0.085***	0.085***	0.084***
	(0.008)	(0.008)	(0.008)
R&D	0.048	0.046	0.044
	(0.100)	(0.100)	(0.100)
R&D intensity	−0.315	−0.310	−0.358
	(0.788)	(0.789)	(0.790)
Exports	0.002	0.002	0.002
	(0.001)	(0.002)	(0.002)
Age	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)
Size	0.119***	0.118***	0.118***
	(0.031)	(0.031)	(0.031)
Price competition	−0.026	−0.027	−0.026
	(0.042)	(0.042)	(0.042)
Employees Skills	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)
Innovation support	0.093	0.092	0.095
	(0.171)	(0.171)	(0.171)
No. competitors	0.151	0.152	0.149
	(0.092)	(0.092)	(0.093)
Constant	−1.624***	−1.614***	−1.657***
	(0.351)	(0.352)	(0.356)
Regional fixed effects	yes	yes	yes
Industry (2-digit) fixed effects	yes	yes	yes
N	856	856	856
Rmse	1.305	1.306	1.309

Notes: *p < 0.1; **p < 0.05; ***p < 0.01; Multivariate regression estimation.

Table A2. Independence of external search depth from search breadth.

	External search depth	External search depth	External search depth
External search breadth	1.284***	1.382***	1.554***
	(0.402)	(0.403)	(0.412)
Demand shock	0.360**	0.249	
	(0.168)	(0.172)	
Exchange rate shock		0.537***	
		(0.195)	
Demand shock=0 and Exchange rate shock=1			0.796***
			(0.272)
Demand shock=1 and Exchange rate shock=0			0.591**
			(0.296)
Demand shock=1 and Exchange rate shock=1			0.898***
			(0.245)
Financial shock	−0.260	−0.160	−0.091
	(0.369)	(0.370)	(0.379)
Knowledge abundance	−0.798**	−0.770**	−0.801**
	(0.349)	(0.351)	(0.358)
Knowledge abundance squared	0.199***	0.197***	0.201***
	(0.061)	(0.061)	(0.063)
Constraints	−0.017	−0.021	−0.023
	(0.016)	(0.016)	(0.017)
R&D	0.401**	0.438**	0.409**
	(0.197)	(0.198)	(0.202)
R&D intensity	−1.058	−0.872	−0.969
	(1.557)	(1.562)	(1.596)
Exports	0.001	−0.001	−0.001
	(0.003)	(0.003)	(0.003)
Age	0.004	0.002	0.002
	(0.002)	(0.002)	(0.002)
Size	0.077	0.068	0.042
	(0.062)	(0.062)	(0.064)
Price competition	0.217***	0.227***	0.273***
	(0.083)	(0.083)	(0.085)
Employees Skills	0.004	0.004	0.004
	(0.005)	(0.005)	(0.005)
Innovation support	0.269	0.233	0.242
	(0.337)	(0.338)	(0.345)
No. competitors	−0.578***	−0.447**	−0.450**
	(0.183)	(0.183)	(0.187)
Constant	−5.693***	−5.970***	−6.289***
	(0.697)	(0.700)	(0.723)
Regional fixed effects	yes	yes	yes
Industry (2-digit) fixed effects	yes	yes	yes
N	856	856	856
Rmse	5.096	5.132	5.354

Notes: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$; fractional logit estimations.