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Antecedents and Determinants of High-tech SMEs' Commercialisation Enablers: Opening the Black Box of Open Innovation Practices

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Antecedents and determinants of high-tech SMEs' commercialisation enablers: opening the black box of open innovation practices

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ABSTRACT

Innovation activities have become globalised and open in ways that were unimaginable 20 years ago. These changes have brought new insight into research on innovation activities and specific innovation practices in organisations, including that previous research largely ignored small and medium-sized enterprises (SMEs). This paper tests a variance-based structural equation model (SEM) for selected antecedents and determinants of commercialisation enablers on a sample of 105 SMEs from Slovenia – a small, open, post-transition economy with a dominant SME sector. The main contribution of the paper lies in testing how two specific open innovation practices (open innovation information exchange and open innovation collaboration) impact the commercialisation enablers of high-tech SMEs through their innovation activities (antecedent) and their innovativeness (determinant). Both open innovation practices show statistically significant effect on high-tech SMEs' innovativeness, thus supporting the idea that both collaboration and information exchange lead to more innovativeness in high-tech SMEs. They also show a high impact of internal (organisational) factors on innovation activities of and a high impact of innovativeness on the commercialisation enablers of high-tech SMEs.

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1. Introduction

Innovation activities have become globalised and open in ways unimaginable 20 years ago (Wooldridge, 2010). These changes have brought new insight into research on innovation activities and specific innovation practices in organisations. In particular, the concept of open innovation[1] has attracted much interest from both managers and academia (Huizingh, 2011). However, in today's highly competitive world innovativeness should be seen as necessary, but insufficient for organisational performance and long-term success (Hult, Hurley, & Knight, 2004; Tsai & Yang, 2013). This is because today 'successful innovation is typically

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defined at the firm level using indicators such as market shares, productivity, or profitability' which are all commercially based (Palmberg, 2006, p. 1253). Such a perspective calls for a better understanding of the internal organisational link between innovativeness and commercialisation of innovation in organisations (Černe, Jaklič, & Škerlavaj, 2013), particularly within small and medium-sized enterprises (SMEs). This is central for understanding the open innovation paradigm and has yet to be empirically tested.

Existing empirical research on open innovation has been scant, although many examples are analysed in Carlsson, Corvello, Duarte, & Sarkar (2011). They initially used existing data sources like the European Community Innovation Survey (CIS) survey (Ebersberger, Herstad et al., 2011; Mention, 2011) or global indicators that were not designed to measure open innovation (De Backer, López-Bassols et al., 2008). They later included specific quantitative studies, but often focused on certain industries (Harison and Koski, 2010), countries (Lazzarotti, Manzini et al., 2010) or institutions (Spithoven, Clarysse et al., 2010). Some quantitative studies focused on SMEs and discovered that open innovation is a logical step for them. Consequently, they are collaborating with external partners more frequently than large companies (van De Vrande, de Jong et al., 2009). However, the overview of the existing empirical research on open innovation activities shows a general lack of research testing the suggested links between specific innovation activities and their results. Among the missing analyses is the role that specific open innovation practices play in fostering the link between innovation activities, innovativeness and commercialisation of innovation in organisations.

We have introduced the concept of commercialisation enablers as a set of activities which companies use in order to align themselves more closely to market needs and help the results of their innovation reach the market (Datta, 2011; Oberg & Tsung-Ying Shih, 2014). Such a concept has been developed fairly recently and has been previously employed in the analysis of commercialisation of publicly developed innovation (Berggren, 2013). Similar to market orientation, this concept is not trying to measure commercialisation through its results (such as revenue or profitability), but rather as an influence force facilitating innovation to 'cross the chasm' to the market (Moore, 1991). It aims to 'encourage people to do more market value research and commercialize their products in global market' (Nagaretham, 2012, p. 160).

In our research, we operationalise and test commercialisation enablers through specific firm activities and organisational changes which facilitate commercialisation of innovation; where partnership-based behaviour in particular plays an important role (Schoeman, Baxter, Goffin, & Micheli, 2012). As shown in Table 2 below, we have used four specific variables to measure a company's internal restructuring and external realignment in order to benefit more from its innovativeness. Among them, business model innovation has been the focus of much attention in the open innovation literature recently (Chesbrough, 2006).

Despite the almost panacean status of open innovation, particularly within the innovation management literature (Chesbrough, 2003; Gassmann, 2006; van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009), significant theoretical and empirical gaps still remain in our understanding of open innovation. With regards to theoretical gaps, intellectual property issues (especially trading), spatial and network aspects of organisation of research and development (R&D) teams, and management research on the operational and implementation aspects of open innovation in organisations are just some of the key areas where more research is needed. Filling this gap will facilitate the consistency of open innovation theory, since there is currently no holistic model of open innovation which

would identify all the determinants of the innovation process, test the limits to the opening up of organisations following the open innovation paradigm or help us understand the underlying cause-and-effect mechanisms of open innovation practices (Gassmann, Enkel, & Chesbrough, 2010).

In terms of empirical gaps van de Vrande et al. (2009, p. 423) point to open innovation research focusing mostly on: 'large, high-tech multinational enterprises (MNE) drawing on in-depth interviews and case studies' (Chesbrough, 2003; Kirschbaum, 2005). Thus, van de Vrande et al. (2009), as well as Gassmann et al. (2010) explicitly recognise SMEs and their management of open innovation as one of the biggest empirical gaps related to the open innovation literature. This is despite the acknowledged importance of SMEs as key innovation players in most economies (van de Vrande et al., 2009; cf. Chesbrough, 2003). Even the authors who have recognised the empirical gap related to open innovation in SMEs have not been able to answer *how* SMEs implement and manage specific open innovation practices, as well as position themselves within relevant innovation networks. Furthermore, there are only a handful of empirical studies targeting the implementation of open innovation activities specifically in SMEs (van de Vrande et al., 2009). Further, all of these studies focus either on Western developed economies like the Netherlands (e.g. van de Vrande et al., 2009), or Asia – especially South Korea (Lee, Park, Yoon, & Park, 2010). Thus, apart from Radas and Božić's (2009) paper on the antecedents of SME innovativeness in Croatia, little is known about SME innovativeness, let alone SME open innovation in other transition or post-transition economies – like Eastern Europe – in which SMEs usually constitute a much larger share of the economy (Morec & Rašković, 2011) and face more constraining external and institutional obstacles to innovation (Radas & Božić, 2009).

Building on the specifics of high-tech SMEs in transition economies (Radas & Božić, 2009), the characteristics of the open innovation philosophy (Chesbrough, 2003), and on the crucial role of successful commercialisation of innovation for the survival of SMEs (Lee et al., 2010; Palmberg, 2006), this paper tests an integrated variance-based structural equation model (SEM) of antecedents and determinants of commercialisation enablers among Slovenian high-tech SMEs. It integrates the traditional internal–external determinants' perspective of high-tech SME innovativeness (e.g. Radas & Božić, 2009) with a focus on the role of specific open innovation practices in high-tech SMEs (van de Vrande, 2009) in trying to provide answers to two research questions, namely:

1. What are the specific antecedents and determinants of high-tech SMEs' commercialisation enablers?
2. How do two specific open innovation practices (open innovation information exchange and open innovation collaboration) impact on high-tech SMEs' commercialisation enablers through their innovation activities (antecedent) and innovativeness (determinant)?

In addition to integrating Radas and Božić's (2009) work on the internal and external antecedents of SME innovativeness with the work by van de Verde et al. (2009) on the application of specific open innovation practices within high-tech SMEs, the second important theoretical contribution of our paper is testing the impact of innovation activities of high-tech SMEs (antecedent) and their innovativeness (determinant) on commercialisation and its enablers in high-tech SMEs, thus staying true to Chesbrough's (2003) understanding of commercialisation being an integral consequence of open innovation. A single company

is rarely capable of generating successful diffusion in the commercialisation of an innovation; success often requires cooperation between individual actors and organisations, and support from stakeholders (Aarikka-Stenroos, Sandberg et al., 2014). Commercialisation as a result of open innovation systems and within innovation networks has been previously shown to result from cooperation and the building of social capital, knowledge variables and financial resources that have great influence on the success of these complex adaptive systems (Purchase, Olaru et al., 2014). We aim to look into the open innovation process leading to successful commercialisation.

This paper contributes to a better understanding of specific processes and activities that high-tech SMEs leverage through their open innovation processes in order to commercialise their innovations. Furthermore, our results also open the black box of high-tech SMEs' open innovation processes, which is particularly valuable for the SME innovation management literature. While the empirical contribution of our research should be seen in its survey-based dataset of high-tech SMEs from an East European post-transition economy, the methodological contribution of our research should be viewed in its move away from traditional interview- and/or case-based data (van de Vrande et al., 2009). Additionally, the employment of SEM may be more suitable for the testing of complex and multi-item latent constructs (e.g. innovativeness) which have so far at best been reduced to single variables in simplified regression models with unrealistic (methodological) assumptions. Lastly, we discuss the implications of our findings for development of more effective policy toward high-tech SMEs.

2. Theoretical framework

SMEs tend to focus on later stages of innovation, especially the commercialisation stage (Chesbrough, Vanhaverbeke, & West, 2006). Lee et al. (2010), for example, call for a special model of explaining innovation activities of SMEs, which would emphasise the role of intermediaries and their role in both innovation and commercialisation activities of SMEs. Parida, Westerberg, and Frishammar (2012) have on the other hand constructed a model showing how different open innovation practices lead to different innovation performance results in SMEs, where again the commercialisation of innovation activities has been more strongly emphasised (compared to large enterprises). Despite recent attempts to better understand the context- and contingent-specific characteristics of high-tech SMEs' innovation activities and their commercialisation outcomes, there is still a general lack of research on the effects open innovation has on commercialisation activities in SMEs, even though it is recognised as particularly important for them. This is surprising, since commercialisation of innovation has been an integral consequence of the open innovation concept from the very beginning (Chesbrough, 2003).

Our conceptual model in Figure 1 outlines six underlying research hypotheses (H1–H6). Commercialisation enablers of high-tech SMEs represent the key endogenous latent construct of the model which is in turn driven by the antecedent-determinant relationship between high-tech SMEs' innovation activities (antecedent) and their innovativeness (determinant). The reason for not focusing explicitly on innovation performance – as it is usually the case in research on high-tech SMEs (Hult et al., 2004; Radas & Božić, 2009) – but rather on commercialisation enablers stems from the fact that van de Vrande et al. (2009) have shown on a sample of Dutch SMEs that high-tech SMEs' primary motivation

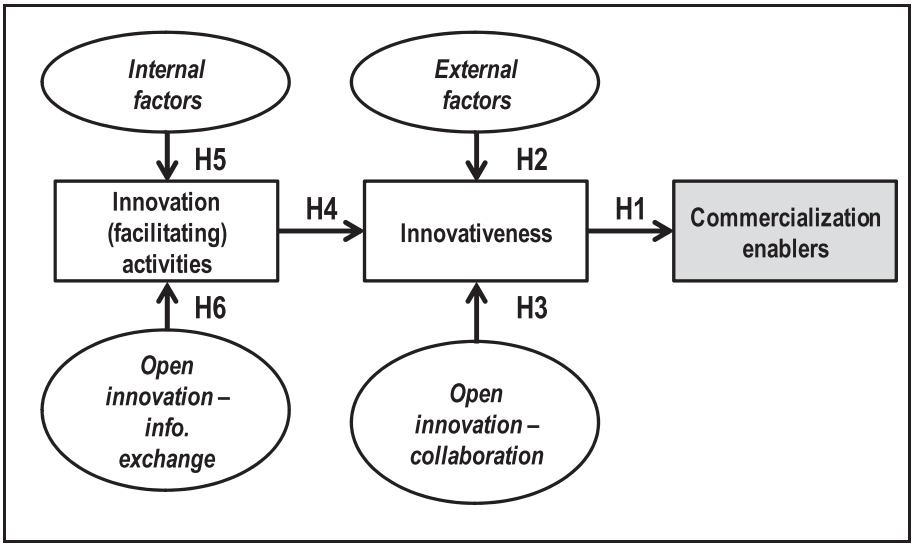

Figure 1. Proposed conceptual model of the antecedents and determinants of commercialisation enablers of high-tech SMEs. Source: Authors' conceptualisation based on relevant literature review (see also Table 2).

behind (open) innovation is much more commercially oriented, compared to other types of high-tech enterprises. Lee et al. (2010) have also supported such a view by showing how commercialisation of innovations is the overwhelming performance criterion for Korean high-tech SMEs. On the other hand, Aarikka-Stenroos and Sandberg (2012) have more recently also pointed to a clear research gap related to the role of open innovation networks and their explicit impact on innovation commercialisation activities, as part of business performance in high-tech enterprises in general.

Our conceptual model was developed by integrating the work by Radas and Božić (2009) on the antecedents of SMEs' innovativeness with the work by Rhee, Park, and Lee (2010) on the drivers of innovativeness and performance in high-tech SMEs and Chesbrough's (2003) open innovation model. According to this model, any enterprise strives to combine internal and external R&D and innovation processes through buying, outsourcing and/or licensing various types of innovations, processes and/or know-how, as well as coupling them with external information and diverse collaborative behaviour in order to push its innovation to the market through various types of commercialisation enablers by better optimising its resources and leveraging various types of internal and external competitive capabilities (Chesbrough, 2003).

While some authors define innovation commercialisation solely and narrowly through its market success (Nerkar & Shane, 2007), we conceptualised commercialisation enablers of high-tech SMEs more broadly through high-tech SMEs' self-perceived organisational changes that are implemented to achieve success for their innovations in the market (see Table 1 for a more detailed overview of construct operationalisation). This approach is similar to the four so-called 'inside-out' open innovation activities aiming to connect a given enterprise across its boundaries in order to reach and succeed in the market (Chesbrough, 2003).

Table 1. Sample characteristics.

Structure by size		Sector breakdown		Demographics	
Micro enterprises (5–10 employees)	59.6%	Knowledge-intensive services (KIS)	74.7%	Median age	18 years
Small enterprises (10–50 employees)	25.3%	High-tech manufacturing	25.3%	Median number of employees	17 employees
Medium-sized enterprises (50–250 employees)	15.2%			Median gross added value per employee	34.821 EUR

Source: High-tech SME survey, 2012 ($n = 105$).

Research hypotheses

In our model the relationship between innovativeness and commercialisation enablers of high-tech SMEs is grounded in the literature on the positive relationship between innovativeness and business performance through the competitive advantage-building nature of innovation (Damanpour, 1991; Porter, 1990). In this regard, the positive impact of innovativeness on business performance has been described both in the mainstream organisational literature as 'generally known to be true' (Hult et al., 2004, p. 431), as well as more specifically in the literature related to high-tech SMEs (Rhee et al., 2010). In our case, we have replaced business performance with commercialisation enablers, based on the increased importance of such reorganisation in achieving business performance among high-tech SMEs (van de Vrande et al., 2009), as well as based on the so-called chain-linked model of innovation (Kline & Rosenberg, 1986; Palmberg, 2006). In this model, the final (fifth) stage of the model in effect corresponds to successful development of commercialisation enablers and is also strongly dependent on the type of innovation (this also has implications for research hypothesis H3). Finally, and particularly relevant to high-tech SMEs, the impact of innovativeness on commercialisation is believed to be especially strong because of the role of entrepreneurial orientation (Slater & Narver, 1995), which Hult et al. (2004) have emphasised in analysing the impact of innovativeness on business outcomes among high-tech SMEs. However, even though entrepreneurial orientation in high-tech SMEs can facilitate commercialisation, this is not certain without commercialisation enablers. They improve the chances for successful commercialisation by influencing changes in the firm's activities and organisation. Supporting this hypothesis is also recent evidence by Parida et al. (2012), who were able to show a clear positive link between specific open innovation policies (e.g. technology sourcing, technology scouting) on innovation performance of high-tech SMEs, including commercialisation.

Research hypothesis 1: *Innovativeness will have a positive impact on commercialisation enablers in high-tech SMEs.*

In our model, innovativeness of high-tech SMEs is believed to be determined by three constructs, namely external factors (H2), open innovation based on collaboration (H3) and the actual innovation activities of high-tech SMEs (H4). While Radas and Božić (2009) adopted the classification of external factors based on Keizer, Dijkstra, and Halman's (2002) three groups of external factors – namely, the supporting institutional environment, linkages to other firms and linkages with other knowledge centres – we wanted to more clearly distinguish the open innovation aspects of such external factors from the institutional and support environment factors (which we simply call external factors in our model). This is

because previous empirical research on the role of institutional and support environment factors has shown this to be a particularly relevant issue for Slovenia (as a post-transition society) and an inhibitor of its high-tech SMEs (Rašković, Pustovrh, & Jaklič, 2012; Rašković, Pustovrh, Jaklič, & Makovec Brenčič, 2011). In the case of both H2 and H3, Radas and Božić (2009), in addition to for example van der Meer, Trommelen, Vleggaar, and Vriezen (1996) and Birchall, Chanaron, and Soderquist (1996), have shown that differences in both the institutional and support environments, as well as the implementation of collaborative behaviour (particularly across industries and with universities) have a positive impact on the level of firm innovativeness.

Research hypothesis 2: *External factors will have a positive impact on the innovativeness of high-tech SMEs.*

Innovation collaboration is another standard open innovation practice, defined already by Gassmann and Enkel (2004) as a coupled innovation activity. Due to its dual nature in both influencing internal innovation activities and providing a path for the flow of internal knowledge to partners outside the boundaries of the firm, we expect these factors to influence the overall innovativeness of the firm, including not only its internal innovation activities but also other external factors. This is also in line with the literature summarised by Keizer et al. (2002), which shows that collaboration is joined by other external factors in its influence on innovation efforts. Lastly, the link between external collaboration and innovativeness is also clearly emphasised in Chesbrough's (2003) first stage of the open innovation process.

Research hypothesis 3: *Open innovation collaboration will have a positive impact on the innovativeness of high-tech SMEs.*

With regard to hypothesis 4, we explicitly differentiate between innovation activities of the firm that are, by definition, internal, and innovativeness, defined as the capacity to introduce some new process, product, or idea to the market (Garcia & Calantone, 2002). The connection between observed innovation activities and innovativeness (willingness and capacity to innovate) is not straightforward. Both concepts can be influenced by the organisational culture of the company and some existing research (e.g. Han, Kim et al., 1998) suggests that firm culture affects firm activities. Thus, innovativeness can also affect innovation activities (a firm with high innovativeness conducts more innovation activities). At the same time, innovation activities lead to more innovativeness. Causality between the two concepts can run both ways.

In our sample, the average age of the companies exceeded 16 years, thus allowing us to assume that they have already developed their innovation activities and that they will have positive impacts on innovativeness.

Accordingly, in our model internal factors influence innovation activities while external factors supplement firm's innovation activities in influencing innovativeness of the firm. This distinction was also influenced by Lee et al. (2010, p. 294), who observed that SMEs tend to be 'less active than large firms in most innovation activities'. Such an observation clearly delineates the need to specifically study the level and types of various innovation activities in terms of their impact on high-tech SMEs' innovativeness and subsequent performance. According to Lee et al. (2010), this is related to their different market positions (e.g. high-tech SMEs usually cater to individual large customers mainly through product customisation), as well as the fact that SMEs are in a completely different position to seize external

environment opportunities (Radas & Božić, 2009). Additionally, the discussion on the ambiguity of the innovativeness concept in the innovation literature (Garcia & Calantone, 2002) also supports the distinction between innovation activities on the one hand and firm innovativeness on the other.

Research hypothesis 4: *Innovation activities will have a positive impact on the innovativeness of high-tech SMEs.*

With regard to the fourth hypothesis it is also important to note that innovation activities measured in this way are internal (inside the boundaries of the firm) but nevertheless fit into the open innovation framework as they are influenced by external knowledge. In this way, they hold similarities to measuring the absorptive capacity of the firm. Our innovation activities construct thus represents the internal part of the innovation process in the firm and combines with other factors to influence innovativeness of the firm.

The fifth hypothesis corresponds to the relationship between internal factors and high-tech SMEs' innovation activities. This hypothesis again draws on work by Radas and Božić (2009; cf. Keizer et al., 2002) and reflects the so-called resource-based view of the firm (Wernerfelt, 1984), where firms' competitive advantage is derived through the process of 'channelling resources into the development of new products, processes' (Hult et al., 2004, p. 431).

Research hypothesis 5: *Internal factors will have a positive impact on the innovation activities of high-tech SMEs.*

The fifth hypothesis is grounded in abundant empirical research which, besides the importance of internal funds and R&D investment (Oerlemans, Meeus, & Boekema, 1998), also emphasises the positive influence of myriad other internal factors on the innovation activities of high-tech enterprises – for example, top management support and appropriate leadership (e.g. LeBlanc, Nash, Gallagher, Gonda, & Kakizaki, 1997; Hoffman, Parejo, Bessant, & Perren, 1998), strategic management (e.g. Carrier, 1994) and project management (e.g. van der Meer et al., 1996), human capital (e.g. Hoffman et al., 1998; LeBlanc et al., 1997), as well as specific technology supporting policies (e.g. Oerlemans et al., 1998).

The last hypothesis is perhaps most intuitive of the six, since it relates to the positive relationship between openly exchanged information beyond the organisational boundaries and high-tech SMEs' innovation activities. It relates to the standard outside-in open innovation practice of using different knowledge sources in the external environment (Laursen & Salter, 2006). While it is consistent with the so-called resource-based view of the firm – by treating information as a key resource for innovation activities – it clearly emphasises the importance of external knowledge and information sharing as the cornerstone idea of the open innovation philosophy (Ye & Kankanhalli, 2013).

Research hypothesis 6: *Open innovation information exchange will have a positive impact on the innovation activities of high-tech SMEs.*

3. Data and methodology

3.1. Data

Our dataset includes a sample of 105 high-tech SMEs[2] from both manufacturing and service industries that employed at least five people. We focused only on high-tech enterprises

with at least five employees, assuming that enterprises with fewer than five employees were generally too small to engage in *systematic* and comprehensive innovation activities (Arvanitis & Hollenstein, 1998). Overall, we estimated the whole population of Slovenian high-tech SMEs to count 108 high-tech manufacturing and 2156 SMEs related to knowledge-intensive services (KIS). This was taken from the 2011 Slovenian business register and estimated based on Eurostat's (2009) identification of specific high-tech manufacturing and knowledge-intensive service sectors, as well as the recommendations from Organisation for Economic Co-operation and Development's (OECD) Oslo manual (OECD, 2005). This is the dominant and most widely accepted approach to high-tech enterprise identification today.

Data collection took place between September and October of 2011 through a web-based survey accompanied by telephone reminders and follow-ups. Our respondents were managers responsible for innovation activities within their enterprise. 'The questionnaire items that we've used are presented in the Appendix'. The response rate among high-tech manufacturing enterprises was 23.1% (mainly due to intensive telephone follow-ups), while the response rate among KIS enterprises was 3.4%. This low response rate is in our opinion mainly due to a much larger population of KIS enterprises, as well as the limitations of a sectorial identification of high-tech service enterprises, where not all SMEs engaged within a specific KIS sector are actually high-tech enterprises. However, as most data were collected via personal interviews, we believe that the responses gathered are representative of the actual high-tech companies in the sample (those that have large shares of R&D investments) and that the low response rate reflects the inclusion of non-R&D intensive companies in the high-tech industries, thus making them unsuitable for our survey questions. Additionally, the same survey (but with additional questions) was also conducted in two previous years on the same sample of companies, yielding comparable results. Therefore we believe that non-response bias is not a serious concern and that our sample is representative of high-tech companies in Slovenia. Table 1 summarises key descriptive statistics pertaining to our sample needed for the interpretation of our results.

3.2. Operationalisation of constructs

Based on the presented conceptual model in Figure 1, Table 2 provides a summary of our construct operationalisation. All constructs were measured as multi-item reflective latent constructs with seven-point Likert-type scales (1 = lowest possible value and 7 = highest possible value). The only exception was the construct of open innovation collaboration which was measured in a nominal way with the respondents choosing between not collaborating or collaborating with five different types of partners (see Table 2) just domestically, in the EU, in ex-Yugoslavia, in the US, or in other regions. In this regard we not only measured various types of collaboration, but also their geographical breadth. This aspect is particularly relevant given Slovenia's small export economy status and strong geographical concentration of its exports.

3.3. Methodology

Given the latent nature of our analysed constructs (e.g. innovativeness), as well as their reflective multi-item nature, we employed structural equation modelling to test our conceptual model from Figure 1 and to assess the importance of specific antecedents and determinants

Table 2. Construct operationalisation.

Construct	Operationalisation (item descriptions)	References
INTERNAL FACTORS	• Strategic focus and explicitness of company strategy • Top management support • Existence of an independent innovation strategy • Availability of internal R&D activities including finances • Organisational structure of the company (e.g. innovation project teams) • Internal availability of human resources • Internal system of employee motivation • Innovation output controlling system • Internal culture of innovation and creativity • Time for experimentation, innovation and creativity • Connection between marketing and R&D functions	Adopted from the work of Keizer et al. (2002), Radas and Božić (2009)
EXTERNAL FACTORS	• Availability of human resources on the labour market • Infrastructure • Availability of technology and materials	Adopted from Keizer et al. (2002), Radas and Božić (2009)
OPEN INNOVATION – INFORMATION EXCHANGE	• Technology transfer offices • Entrepreneurship incubators • Research partners • Conference and business fair visits • Scientific publications	Similar to Laursen and Salter (2006)
OPEN INNOVATION – COLLABORATION	• Collaboration with suppliers of equipment, spare parts and/or software • Collaboration with customers • Collaboration with consultants, commercial labs, private R&D institutions • Collaboration with universities or high schools	Similar to Antikainen, Mäkipää, and Ahonen (2010), Gassmann and Enkel (2004), Lee et al. (2010)
INNOVATION FACILITATING ACTIVITIES	• Perceived support for product and process innovation • External R&D usage for internal innovation • Presentation of external knowledge to internal R&D personnel • Establishment of special departments for individual innovations • Changes to the organisational structure of the company to boost innovation	Adopted from Lee et al. (2010)
INNOVATIVENESS	• Support for technical innovations based on research findings • Following and measuring R&D activities and outcomes • Capability to implement fast changes in design, product, service, process • Capability for technological changes in processes based on market demands • Capability of technological changes in products and services based on market demands • Focus on new product development • Focus on new service development	Adapted from Hult et al. (2004), Hurley and Hult (1998), Rhee et al. (2010)
COMMERCIALISATION ENABLERS	• Connections with existing external partners • Development of new business models • Acquiring new business models from another company • Finding new external strategic partner	Adapted from Rhee et al. (2010), Chesbrough (2003)

Source: Authors' conceptualisation based on relevant literature review.

of commercialisation enablers of high-tech SMEs in Slovenia. SEM is employed as a gold standard methodology in managerial research (Babin, Hair, & Bowles, 2008) because it enables the simultaneous assessment of 'latent variables at the observation level (outer or measurement model) and … relationships between latent variables on the theoretical level (inner or structural model)' (Hair, Sarstedt, Ringle, & Mena, 2012, pp. 414–415).

Within SEM we decided to employ a variance-based partial least squares (PLS) modelling approach rather than the traditional covariance-based ordinary least squares (OLS) modelling approach. Several factors influenced our choice of PLS SEM: our survey-based variables were not distributed normally; our model testing is exploratory in nature; our sample size is limited; the model is fairly complex (given the sample size); and our focus is to estimate the predictive power of our model. In all these cases, PLS SEM has been recommended over OLS SEM, despite its lack of fit statistics and global optimisation criteria (Hair et al., 2012; Hensler, Ringle, & Sinkovics, 2009). Our PLS SEM was tested using smartPLS 2.0 (Ringle, Wende, & Will, 2005).

4. Results

4.1. Descriptive statistics

Table 3 displays the correlation matrix between the measured latent constructs in our SEM from Figure 1, further accompanied by basic descriptive statistics, and the corresponding reliability and validity statistics. As we can see from the simple mean scores related to our constructs in Table 3, the mean score for innovativeness is 5.14 on a seven-point ordinal scale – quite high within our sample of Slovenian high-tech SMEs. This is followed by a moderately high level of internally available factors to support innovation activities within our high-tech enterprises (4.78). On the other hand, an extremely low mean score of just 1.22 indicates a virtually non-existent employment of open innovation collaboration practices, which is closely followed by a lack of another open innovation practice – using open innovation information sources (mean score of 2.37). All of this indicates (on average) a very limited employment of two specific open innovation practices – namely, open innovation collaboration and open innovation information sources – among our sampled Slovenian high-tech SMEs.

Looking at the corresponding internal reliability statistics, we can see that composite reliability (CR) is sufficiently high in all cases, well above the minimum 0.7 value outlined by Hair, Black, Babin, and Anderson (2010). The same also holds for convergent validity, where the average variance extracted (AVE) is above the 0.5 value in all cases (Fornell & Larcker, 1981).

Table 3. Construct correlation matrix and descriptive statistics with reliability and validity analysis.

Construct/statistic	Mean	SD	CR	AVE	1	2	3	4	5	6	7
1-Commercialisation activities	2.41	1.54	0.87	0.62	***0.79***						
2-External factors	3.77	1.24	0.81	0.59	*0.10*	***0.77***					
3-Innovation activities	2.47	1.28	0.81	0.52	*0.43*	*0.22*	***0.72***				
4-Innovativeness	5.14	1.29	0.91	0.60	*0.34*	*0.38*	*0.47*	***0.78***			
5-Internal factors	4.78	1.33	0.95	0.63	*0.35*	*0.38*	*0.34*	*0.47*	***0.79***		
6-Open innovation – collaboration	1.22	0.80	0.82	0.54	*0.17*	*0.19*	*0.27*	*0.34*	*0.32*	***0.73***	
7-Open innovation – info. exchange	2.37	1.32	0.89	0.61	*0.55*	*0.00*	*0.33*	*0.09*	*0.20*	*0.17*	***0.78***

Notes: Mean = simple average, SD = standard deviation, CR = composite reliability, AVE = average variance extracted.
Source: High-tech SME survey, 2012 (n = 105).

Table 4. SEM results with corresponding path coefficients and significance levels*.

Path (research hypothesis)	Path coeff.	R^2	t-value (based on bootstrapping)	Df**	p (2-tailed level)
Internal factors → Innovation activities	0.82	**0.17**	2.97	499	0.003
Open innovation information exchange→ Innovation activities	0.32		1.91	499	**0.057****
External factors → Innovativeness	0.11	**0.33**	2.80	499	0.005
Innovation activities → Innovativeness	0.21		4.33	499	0.000
Open innovation collaboration → Innovativeness	0.17		2.31	499	0.021
Innovativeness → Commercialisation enablers	0.68	**0.12**	4.43	499	0.000

*Path coefficient significance levels based on bootstrapping (500 samples).
**Df = Degrees of freedom; determined as the number of bootstrapping samples minus 1 (Sosik, Kahai, & Piovoso, 2009).
***Hypothesis 6 suggests a positive test (one-tail test), so it is supported by the current result even at this level.
Source: High-tech SME survey, 2012 (n = 105).

Lastly, the square roots of AVE on the diagonal are sufficiently higher than any single pair-wise Pearson's correlation coefficient, which satisfies the criteria for sufficient discriminant validity (Chin, 2010). All pair-wise Pearson's correlation coefficients between any of our analysed constructs are low to moderate, with the highest pair-wise Pearson's correlation coefficient being $\beta = 0.55$ between commercialisation enablers and open innovation information sources.

4.2. SEM results

Having established the appropriate reliability and validity of our modelled constructs, Table 4 presents the results of the PLS SEM testing of our conceptual model from Figure 1.

As we can see from the PLS SEM results in Table 4, all six hypothesised path coefficients are statistically significant. Generally speaking, we can observe that internal factors have a highly positive ($\gamma = 0.82$) and significant ($p = 0.003$) impact on the level of innovation activities within our sample. This is contrary to the impact of open innovation information exchange on innovation activities where this impact is positive, but barely significant ($\gamma = 0.32$; $p > 0.057$).

With regard to the determinants of innovativeness, high-tech SMEs' innovation activities have a high positive impact on their innovativeness ($\beta = 0.21$; $p = 0.000$), followed by open innovation collaboration ($\gamma = 0.17$; $p = 0.021$) and external factors ($\gamma = 0.11$; $p = 0.005$). In turn, the high-tech SMEs' degree of innovativeness also significantly positively determines their commercialisation enablers ($\beta = 0.68$; $p = 0.000$) which supports existing theory on the link between innovativeness and commercially based business performance (Palmberg, 2006). In terms of the predictive power of our PLS SEM, the antecedents and determinants of commercialisation enablers explain some 12% of our dependent reflective latent construct of commercialisation enablers within Slovenian high-tech SMEs, which compares favourably to traditional econometric studies and reflects the complex nature of commercialisation enablers within high-tech SMEs anywhere.

4.3. Control variables

High-tech companies in our sample were actually quite diverse, spanning different industries (ICT, pharmaceuticals, knowledge-intensive services) and quite varied in size (between

Table 5. Impact of selected control variables in our SEM.

Path (research hypothesis)	Path coeff.	R^2 change	t-value (based on bootstrapping)	Df*	p (2-tailed level)
Industry → Commercialisation enablers	0.150	**0.026**	0.901	499	**0.368**
Size → Commercialisation enablers	−0.184		0.974	499	**0.331**

*Determined as the number of bootstrapping samples minus 1 (Sosik et al., 2009).
Source: High-tech SME survey, 2012 (n = 105); own calculations in smartPLS using Bootstrapping (based on 500 samples).

5 and 249 employees). Based on the literature review, it was reasonable to assume that significant differences in the effects of innovation activities on innovativeness and on commercialisation enablers could occur (e.g. Stahlbrost, 2013). We have therefore tested two specific control variables – namely industry type (manufacturing or knowledge-intensive services) and enterprise size (small or medium-sized). Both were included in the model as formative single-item dummy constructs. Table 5 presents the results of testing the impact of industry type and enterprise size on commercialisation enablers of our high-tech SMEs. As we can see, neither industry type or enterprise size seem to have a significant impact on commercialisation enablers (R^2 change of 0.026) of Slovenian high-tech SMEs, which in turn provides an additional robustness check for our model.

5. Discussion and implications of the results

5.1. Theoretical implications

The results show that we have constructed a working model of the antecedents and determinants of commercialisation enablers of high-tech SMEs. Our SEM results in particular confirm that there is a strong and positive link between innovativeness and commercialisation enablers in high-tech SMEs. First, related to the theory of the firm, our results show a much higher impact of internal factors on innovation activities of high-tech SMEs vis-à-vis the impact of external factors on high-tech SMEs' innovativeness. This is consistent with the resource-based view of the firm and the pecking order theory of the firm where SMEs seem to be first and foremost limited by a lack of internal resources (Morec & Rašković, 2011), but then constrained also by external and institutional factors (Radas & Božić, 2009). Alternatively, it can also result from apparently relatively closed innovation systems of the companies in our sample that are being 'forced-open' by their embrace of open innovation activities that in turn enable them to commercialise their innovations.

Secondly, looking at the impact of the two modelled open innovation practices, only open innovation collaboration has a positive and statistically significant impact ($\gamma = 0.17$, $p = 0.021$) on high-tech SMEs' innovativeness and can be thus seen as an antecedent to commercialisation enablers of high-tech SMEs. This shows that high-tech SMEs that engage in broader types of open collaboration display higher levels of innovativeness which also leads to a higher commercialisation propensity. This seems to be consistent with the so-called collaborative paradigm but in addition shows the explicit mechanism through innovativeness.

On the other hand, the primary motivation behind embracing open innovation in high-tech SMEs is the focus on inside-out, commercially oriented activities (Rhee et al., 2010; van De Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009). A lack of a significant

impact of open innovation information exchange on innovation activities of high-tech SMEs in Slovenia may indicate the reactive and market-oriented, rather than proactive and market-constructing nature of Slovenian high-tech SMEs. Prior empirical evidence by Rašković et al. (2012) seems to support this perspective.

5.2. Implications for policy-making

The open innovation paradigm is putting more emphasis on the market transactions in the innovation activities – 'opening' innovation activities that previously belonged to closed organisations and non-market transactions. Emphasising market transactions of technology, ideas, and all resources, companies need to increase their innovation success. The market exchange of these non-material assets is the crucial reason why open innovation demands strong intellectual property rights and protection of intellectual property (IP). However, the paradigm shift in conducting innovation activities does not mean that the markets for innovation function well. In fact, open innovation strongly supports government intervention in order to achieve better allocation of resources for innovation and to improve linkages between actors. Justification of government intervention in the corporate innovation activities is based on the market failure argument. In the world of perfect competition, the market's innate coordination mechanisms would allocate goods and services efficiently. They would reach the Pareto optimum (Arrow & Debreu, 1954). However, as the perfect competition requirements are not fulfilled in the real world, the resulting allocation of resources is not optimal (Greenwald & Stiglitz, 1986). Knowledge has characteristics of a public good as it spills over from creator to other actors who are only limited by their own capabilities in utilising it. This results in the so-called appropriation problem for the creator of the knowledge. Innovating companies cannot fully appropriate the returns of their innovation and hence, in the absence of appropriation mechanisms, will under-invest in knowledge and knowledge-creating processes (Arrow, 1962). These classic arguments for government intervention apply to all innovation policy including open innovation policy.

Open innovation theory does not contradict these insights and firmly supports the notion that government intervention in supporting innovation activities is justified. In fact, the open innovation theory suggests another line of reasoning to support government intervention. It argues that linkages between actors serve as channels for knowledge diffusion and recombination and therefore increases the value of knowledge that is created. Lack of linkages and networking across organisational boundaries represents a system failure, as do lock-ins to specific collaboration partners, sources of ideas, and information or excessive overall 'closure' of the learning processes (Herstad, Bloch, Ebersberger, & van de Velde, 2010). These failures need to be tackled in a similar way as market failures – with policy intervention which creates first and foremost a pragmatic enabling environment (Klein Woolthuis, Lankhuizen, & Gilsing, 2005).

In order to help develop high-tech industries, policy-makers should help innovative high-tech companies to collaborate with other companies and science and technology (S&T) institutions in order to boost their innovation capabilities as well as commercialisation activities. They should actively support SMEs' innovation and collaboration (linkages) in order to support their development. Some studies even see lack of government support as one of the major hurdles for their innovation (Tsangari & Vrontis, 2012). Our findings support public policy measures aimed at embracing open innovation practices in SMEs as it has

the potential to help them grow. For high-tech SMEs, openness can lead to innovativeness and better commercialisation.

Unfortunately, the support to the companies in our sample seems to have been focused on innovation activities itself and not commercialisation enablers. The nature of collaboration between different partners has different effects on the commercialisation enablers. Lately, new expectations have challenged the 'Ivory Tower', a common metaphor for isolated academic research disconnected from practical use (Etzkowitz & Leydesdorff, 2000) and are aiming to develop universities and public research organisations as 'engines of innovation' (Berggren, 2013). With such developments, relations that high-tech SMEs establish with S&T institutions can become critical also for commercialisation enablers in such companies.

Additionally, the nature of national innovation policy limits collaboration and even information exchange to a national context. Others have found that national-level tools are still the most immediate form of intervention into innovation behaviour (Herstad et al., 2010). However, in the newly globalised world, limiting public support to the national context can redirect information exchange and linkages to within national borders, thus 'closing' government support for open innovation.

National innovation policy in the context of a small open transition economy is especially useful as national innovation policies have been forced to take into account the drawbacks of a small domestic market (for products, services, IP and human resources). But it should be focused on commercialisation and on open collaboration across national boundaries. In fact, it should aim to attract innovative ecosystems and innovation networks to locate their international hubs in particular countries and to facilitate embedding in foreign innovation networks. In that way, they should aim to connect regional and national innovation systems.

Slovenia was among the first EU transition economies to develop a specific national innovation strategy and to invest heavily in innovation policy (MVZT, M. za visoko šolstvo znanost in tehnologijo, 2011). This has resulted in its improved standing according to the Innovation Union Scoreboard, where it advanced from 'innovation follower' to 'innovation challenger' (EU, 2012). Additionally, 99% of all companies in Slovenia are SMEs and a large share of those are innovative (Rašković, Pustovrh, Jaklič, & Brenčič, 2011). As such, it represents a case study for other transition economies in the EU. Unfortunately, the innovation policy and significant monetary support did not force the companies to focus on commercialisation enabling. Even worse, it did not facilitate their international collaboration. Instead, the support is focused on collaboration inside national borders. In this way, a lot of money has been spent on innovation with relatively few results in the form of commercial success.

We suggest that relatively small changes to the way national innovation policy is implemented could have significant effects on the commercialisation activities of the companies. At the same time, it could actually decrease the amount of public funds needed to support an effective innovation economy.

6. Limitations and future research

The first set of research limitations is connected to the size and characteristics of our sample of high-tech SMEs. With regard to the former, one has to take into account the smallness of Slovenia's SME sector in general and the limited number of high-tech SMEs in particular, especially high-tech manufacturing SMEs. With regard to the latter, a small response rate,

related to high-tech KIS SMEs, may also be connected to the limitations of using Eurostat and OECD criteria for the identification of high-tech SMEs (sectorial affiliation). Following their guidelines, high-tech SMEs were chosen based on their alleged and inherent innovativeness of belonging to a particular 'high-tech' sector. However, the definition of high technology is troubling (Eurostat, 2009) and excludes enterprises which belong to other sectors, but could still be very innovative. It would make sense to find a better definition of innovative SMEs and focus on their commercialisation activities, even if they are not high-tech. However, we did not pursue this option in order not to lose the international comparability of our results. We strongly believe that future research should explore an alternative approach and try to identify SMEs across every sector which can be considered high-tech vis-à-vis an average sectorial benchmark (e.g. mean added value per employee or percentage of workforce with a scientific or advanced degree).

The second set of our research limitations may be seen in testing only two specific open innovation practices. Despite including two of the most fundamental open innovation practices that we believe to be crucial to SMEs in particular, namely information exchange and external collaboration, other practices and activities should also be considered in the future. For example, more research should be conducted on the effects of other open innovation activities like licensing, spin-offs and joint ventures, as well as buying IP in terms of high-tech SMEs' commercialisation activities. The results in Table 4 show that internal factors and information exchange account for 17% of the variation of innovation activities and that innovativeness explains 12% of the variation of commercialisation enablers. These values are low, suggesting that more important antecedents and determinants are absent from this study, even though these results support the research hypotheses. More research is needed to identify them.

The third set of our research limitations is connected to the way we have operationalised specific constructs in our model. In this regard, we have to once again point out that we have taken a very broad and self-reported approach to measuring the commercialisation activities of our high-tech SMEs; however, we believe such an approach is appropriate for SMEs as it realistically measures their commercialisation 'mindset' and propensity. Using more elaborative and quantitative criteria for the commercialisation of innovation did not work when applied to Slovenian high-tech SMEs in the past. It would have been interesting to empirically test other determinants of commercialisation enablers, namely, the one related to the relationships established with the networks of science and technology institutions, concerning the effects on joint (cooperative) versus separate (competitive) commercialisation initiatives. Unfortunately, the design of the survey did not allow us to empirically test these relations, but we would like to add them to the future surveys, thus allowing us to further expand our conceptual model.

Additionally, we cannot directly draw causal conclusions because the data gathered are cross-sectional. We believe that our research has opened a black box of innovativeness in high-tech SMEs. The results of this study provide the foundation to form and test specific causal relationships. Other research designs such as quasi-experimental or longitudinal studies should be conducted in the future to test the relationships posited here in a causal context.

Lastly, our data was gathered using a single respondent approach, which was deemed better than using a number of less informed respondents (Kalmi & Sweins, 2010). This is in spite of the fact that single respondents can introduce single respondent bias. However,

one also has to note that in high-tech SMEs it is quite normal for a single person to direct the company's innovation activities (mean size within our sample was just 17 employees). We specifically targeted the person within the organisation with these responsibilities as the respondent to the questionnaire. Regardless of this, we have employed the so-called Harman's single-factor test for common method bias effects, which did not indicate common method variance (the first factor explained less than 25% of the variance of the original items).

7. Conclusion

With a growing body of knowledge on open innovation, more specific research questions and topics are coming into focus. Open innovation in SMEs is one such topic. How SMEs can utilise existing internal innovation and take it to the market (inside-out) is one example of a narrow research area within this concept. This is a research topic that is often described as commercialisation. High-tech SMEs are more research oriented than other companies by definition and thus more suitable for the research of commercialisation of innovation. However, this has not been the target of much empirical research due to the lack of empirical data. In this study, we have built upon a survey among high-tech companies in Slovenia to obtain empirical evidence on the open innovation practices that they use to support growth by improving their innovativeness and commercialisation.

The main contribution of this research lies in testing how two specific open innovation practices impact on the commercialisation enablers of high-tech small and medium-sized enterprises through their innovation activities and innovativeness. Acknowledging some limitations of our research, we were still able to develop a working SEM of antecedents and determinants of commercialisation enablers of high-tech SMEs which integrated both the traditional internal–external determinants' perspective of high-tech SME innovativeness (e.g. Radas & Božić, 2009) with a focus on the role of specific open innovation practices in high-tech SMEs (van de Vrande, 2009). The results show that such enterprises which engage in broader types of open collaboration display higher levels of innovativeness which also leads to a greater propensity for commercialisation, hopefully leading to their faster growth.

The construction of a working model of the antecedents of commercialisation enablers of high-tech SMEs has clear implications for managers of such companies. It confirms that there is a strong and positive link between innovativeness and commercialisation enablers in high-tech SMEs. The results also show that high-tech SMEs which engage in broader types of open collaboration display higher levels of innovativeness which also leads to a higher commercialisation propensity. The lesson for them is clear: managers of high-tech SMEs can see their companies benefit from applying open innovation activities.

In providing answers to our two opening research questions we can say that in addition to internal and external factors, open innovation collaboration and information exchange – as specific open innovation practices – are significant antecedents to commercialisation enablers of high-tech SMEs which are in the case of our data strongly determined by high-tech SMEs innovativeness. This shows that commercialisation is not just directly connected to open innovation, but outlines a clear mechanism of action (impact through innovativeness).

Notes

1. We use Chesbrough's definition of open innovation which he defines as: 'the use of purposive inflows and outflows of knowledge to accelerate internal innovation and to expand the markets for external use of innovation, respectively' (Chesbrough et al., 2006, p. 1).
2. We employed the OECD definition of SMEs, where small enterprises are those employing up to 50 employees, and medium-sized enterprises are those employing from 51 to 250 employees.

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Appendix. Questionnaire items measuring individual constructs.

Construct	Question in the questionnaire
Internal factors	Please estimate the availability of the following internal factors supporting high-tech SMEs in Slovenia on a seven-point scale (1 = very bad availability, 7 = very good availability): • Strategic focus and explicitness of company strategy • Active top management support (through assets, activities etc.) • Existence of an independent innovation strategy • Availability of internal R&D activities including finances • Organisational structure of the company (e.g. innovation project teams) • Internal availability of human resources • Internal system of employee motivation • Innovation output controlling system • Establishment of internal organisational culture of innovation and creativity • Time for experimentation, innovation and creativity • Connection between marketing and R&D functions
External factors	Please estimate the availability of the following external factors supporting high-tech SMEs in Slovenia on a seven-point scale (1 = very bad availability, 7 = very good availability): • Availability of human resources on the labour market • Infrastructure • Availability of technology and materials
Open innovation – information exchange	Please state the sources of information that have lead you to innovations in the seven-point scale (1 = never, 2 = very rarely, in less than 10% of cases,7 = very often, in more than 80% of cases): • Technology transfer offices • Entrepreneurship incubators • Research partners • Conference and business fair visits • Scientific publications
Open innovation – collaboration	Please state your innovation collaboration with other companies. Do you collaborate with the following partners in the field of innovation (please tick the box in front of the partners that you collaborate with in innovation): • Collaboration with suppliers of equipment, spare parts and/or software • Collaboration with customers of your products or services • Collaboration with consultants, commercial labs, private R&D institutions • Collaboration with universities or high schools The first option was that the companies do not collaboratively innovate with these partner groups. The second option was that they do innovate collaboratively with partners in Slovenia. The second option was that they do innovate collaboratively with partners in the EU. The second option was that they do innovate collaboratively with partners in ex-Yugoslavia. The second option was that they do innovate collaboratively with partners in the USA. The second option was that they do innovate collaboratively with partners in other countries.*(Multiple option choice was allowed).*

Continued

Appendix. (*Continued*)

Construct	Question in the questionnaire
Innovation facilitating activities	Which innovation activities did you use in the past three years in your company? Use the seven-point scale (1 = never, 2 = very rarely, in less than 10% of cases, 7 = very often, in more than 80% of cases): • Perceived support for product and process innovation • External R&D usage for internal innovation • Presentation of external knowledge to internal R&D personnel • Establishment of special departments for individual innovations • Changes to the organisational structure of the company to boost innovation
Innovativeness	Please estimate the 'soft' and 'hard' aspects of innovativeness on a seven-point scale (1 = I disagree, 7 = I agree): • Support for technical innovations based on research findings • Following and measuring R&D activities and outcomes • Capability to implement fast changes in design of product, service, process • Capability for technological changes in processes based on market demands • Capability of technological changes in products and services based on market demands • Focus on new product development • Focus on new service development
Commercialisation enablers	How often did you use the following activities in the past three years to support the commercialisation of innovation? Use the seven-point scale (1 = never, 2 = very rarely, in less than 10% of cases, 7 = very often, in more than 80% of cases): • Connections with existing external partners (e.g. suppliers) • Development of new business models • Acquiring new business models from another company • Finding new external strategic partner

Source: Authors' calculations.