Improvisation and innovation in teams: the jazz effect

Article

Accepted Version

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Abstract

While numerous models examine the linkages between improvisation and innovation, the factors that moderate this relationship at the team level are unknown. Consequently, this study builds on principles and insights from the jazz jam session framework used by jazz musicians and regression analysis to examine the nature of the improvisation process and consider how it affects innovation. By using unbalanced panel data on 2,749 teams containing between 2 and 8 employees in the United Kingdom during 2002-2016, this study demonstrates that the success of the improvisation process relies on both internal and external factors conducive to innovation. Subsequently, conclusions drawn may help entrepreneurs and team managers think differently about the role improvisation plays in the innovation activity. As a result of which, important practical implications are drawn for team managers and entrepreneurs intending to cultivate a willingness to improvise in teams and nurture collaborative relationships with external partners for innovation.

Keywords: innovation; jazz jam session; improvisation; performance; strategy; teams

1. Introduction

A standard model prevalent within management literature suggests that the innovation process is mechanistic, in that innovative activity is the predictable output from knowledge inputs such as research and development (R&D) and human capital (Godin, 2006; Balconi, Brusoni and Orsenigo, 2010). By contrast, one alternative view suggests that innovation is not driven solely by innovation inputs, and any differences in innovative success are down to improvisation in teams and organizations (Miner, Bassoff and Moorman, 2001; Baker and Nelson, 2005; Vera and Crosson, 2004; Hmieleski and Corbett, 2008; Vera et al., 2016). Because improvisation is critical to an organization's learning and innovation (Hmieleski and Corbett, 2006; 2008; Hadida, Tarvainen and Rose, 2015), a substantial body of research has sought to identify how the improvisation process takes place (Cunha et al., 2003, 2006; Suarez and Montes, 2019; Balachandra, 2019). For example, Hmieleski and Corbett (2008) explored the effects of improvisational behavior on venture performance, Baker et al. (2003) studied the role of competencies and skills in the improvisation process, and Vera et al. (2016) examined the

moderating role of “minimal structures” (goal clarity combined with autonomy) as a contextual factor supporting effective improvisation. While the improvisational process is central to innovation activity in firms (Balachandra, 2019) and teams (Vera and Crosson, 2005), improvisation as a process has been used by jazz musicians to create new music for over a century within the ‘jazz jam’ session setting. Practicing improvisation is a complex process that helps musicians to overcome self-consciousness, develop competencies, establish mentoring systems, exercise leadership and collaboration, along with developing community support Herzig and Baker 2014; Belitski and Herzig, 2018)

According to the jazz jam session framework to create new music, it is not the ability to improvise alone that matters as described in the improvisation literature, but rather the context of the improvisation process and within team interactions. Management research is focused on the use of indicators and measurements to predict innovation activity, with a primary focus on the organizational context and how firms respond to a changing environment, while there is a paucity of knowledge on how team improvisation along with other team-specific attributes can i) explain innovation and ii) examine factors that moderate the relationship between improvisation and innovation. This study extends the model used for more than a hundred years by jazz musicians to management science literature, adding to substantial research of Kamoche and Cunha (2003), Kamoche, Pina, Cuhna and Da Cunha (2003), Cunha et al. (2003), Vera and Crosson (2005) on team improvisation and innovation.

Despite the fact, jazz jamming has been studied extensively in entrepreneurship and organisation science literature (Barrett, 2012; Hatch 1999, Weick 2002, Diasio, 2016, Kamoche and Kunha, 2003), the existing literature on how the jazz jam session setting can be used as a

process of improvisation in teams is underresearched (Aldrich and Martinez, 2001; Liu et al., 2018; Visscher et al., 2018).

Team creativity and performance are often attributed to a team's ability to improvise and the interactions with external stakeholders who enhance the team's willingness to take risks to innovate (Moorman and Miner, 1998a; Hargadon and Bechky, 2006). However, there is no consensus on how improvisation - performance effects are shaped and moderated.

The extant literature has been remarkably silent about the role of improvisation in moderating the relationship between team-specific factors, external factors, and innovation. Research has generally focused on the context where the R&D team members work (Vera et al., 2016), on knowledge resources such as organizational memory or expertise (Brown and Eisenhardt, 1998; Moorman & Miner, 1998a, 1998b), or the individual-level training effects for improvisation (Vera and Crossan, 2005), often resulting in mixed evidence (Flach, 2014).

This study aims to bridge the gap in management literature by applying the jazz jam session model (JJSM) framework to team innovation. Firstly by advancing our understanding of interactions within and outside teams. Secondly, by examining factors that moderate the relationship between the improvisation process and innovation (Vera and Crossan, 2004, 2005; Suarez and Montes, 2019). The JJSM framework could be helpful as a tool to further study the team innovation process and to investigate the moderators, which shape improvisation-performance effects (Barrett, 1998; Diasio, 2016; Vera et al. 2016). We define team improvisation as a multipurpose collective capability (Eisenhardt and Martin, 2000; Miner et al. 2001; Helfat and Winter, 2011) of teams (Miner et al., 2001; Akgun et al., 2007).

To test our research hypothesis, we rely on unbalanced panel data of 3,589 observations and 2,749 firms between 2 and 8 employees in the UK during 2002-2016, drawing on calls for empirical

research of team improvisation (Vera and Crossan, 2004, 2005; Vera et al., 2016; Suarez and Montes, 2019).

The remainder of this study is organised as follows: the review of literature, our next section, introduces the theoretical framework, building on the extant management and innovation literature. Section 3 explains our analysis methodology, while section 4 presents the major results and performs robustness checks. Section 5 discusses the findings and concludes.

2. Literature review

2.1. Improvisation and the jazz jam session model

Drawing on Winter's (2003) view of a capability as a high-level routine and consistent with Moorman and Miner (1998a, 1998b) and Miner et al.'s (2001), improvisation is not embodied in individuals, but rather, collective and team level characteristics may endorse individuals to co-create new ideas using improvisation (Miner et al., 2001).

Management scholars typically define the improvisation process as the spontaneous composition and execution of novel action (Moorman and Miner, 1998a; Hmieleski and Corbett, 2006, 2008) as well as capacity for problem-solving and finding solutions in a crisis (Diasio, 2016, Kamoche and Kunha 2003). Other scholars also argue that improvisation includes preparation taken ahead of time that enables greater flexibility (Conforto et al., 2016).

An individual can engage in the improvisation process in teams at any given moment to generate novel combinations of resource and market opportunities. For example, Eisenhardt and Tabrizi (1995) concluded that a hands-on improvisational approach to new product development to be more effective than a rational approach, which contrasts with the economic theory of rational behavior.

Improvisation is an action-based approach and an integral component of the improvisatory process exercised by jazz musicians (Berliner, 1994; Barrett, 2012) which is observed during a jazz jam session. The JJSM focuses on the improvisational and collaborative behavior of individuals playing together as a team (Weick, 1995, 2002; Humphreys et al., 2012) and how jazz musicians collaborate and develop collaborative capabilities with the common goal (Herzig and Baker, 2014).

The JJSM framework consists of seven factors: practicing improvisation and overcoming self-consciousness, skills and competence in the field, establishing mentoring systems, establishing democracy and collaboration, leadership, community support and the continuous evaluation system. As a result, the JJSM framework explains which factors facilitate new music creation with improvisation at the heart of it, linking the improvisation process to team outcomes, further outlined in figure 1, which also differentiates between internal and external factors that affect improvisation during a jazz jam session.

Figure 1 about here

2.2. Hypotheses formulation

Prior research in management and organization science has advanced our understanding of the role of team improvisation in innovation and change (Miner et al., 2001; Akgun et al., 2007; Vera et al., 2016; Liu et al., 2018). It is widely accepted, for example, that a firm's internal resources, leadership and role models and environmental support (Vera et al., 2016) can facilitate the innovation in teams through the stimulation of improvisation practices.

Team improvisation involves new solutions which are not fully planned in advance by each team members or altogether, while improvisation can also draw on related prior structures such as

knowledge and plans of a team to create a novel action or process (Hadida et al., 2015; Cunha et al., 2016). Cunha's et al. (2016) definition of improvisation incorporates three important conceptual pillars: firstly, that there is a convergence of design and performance; secondly, the creation of some degree of novel action (innovation); and thirdly, a design created through enactment (planning). Similarly, Vera and Crossan (2005) emphasize that effective improvisation requires readiness and training. Furthermore, Vera and Crossan (2005) discuss the role of innovative training in enhancing the incidence and effectiveness of improvisation. These findings debunk the misconception that willingness to improvise is a character trait and support improvisational training in entrepreneurship education. Improvisation exercises can be used to hone skills in the areas of business strategy, the context, organizational members and the organizational culture, and can be learnt via specific training for innovation.

Research on the improvisation process demonstrates that the process is neither inherently good or bad (Vera and Crosson, 2004, 2005; Hmieleski and Corbett, 2008); rather, it facilitates new ideas and may lead to a novel product creation. We hypothesize:

H1: Improvisation is positively associated with innovation.

The relationship between improvisation and innovation is moderated by other team specific and external factors. Cunha et al. (2003) posits that knowledge stock is important for improvisation, as it requires novel resources and unorthodox skills (Liu et al., 2018; Flor et al., 2018). In the same way jazz musicians may spend hours practicing their instruments, transcribing solos, and learning the language of jazz (Berliner, 1994), teams invest in training for innovation which plays an enormous role in improvisation (Vera and Crossan, 2005). The

discipline required to learn new skills and craft and the determination of musicians to do so exemplifies improvisation and results in more innovation (Herzig, 2020).

Vera and Crosson (2005) found that the greater the team's expertise (domain- and task-relevant), the more positive is the relationship between team improvisation and innovation. Innovators with high levels of knowledge and skills might identify the potential benefits and challenges of combining strategic resources quickly and capitalize on the potential synergies of investment in knowledge, and vice versa. This logic is captured by the following hypothesis:

H2a: Knowledge in the field is positively associated with innovation.

H2b: Knowledge of the field moderates the relationship between team improvisation and innovation.

Teams learn through active collaboration and from role models. Experienced jazz musicians share their knowledge through mentorship on and off the bandstand through a modeling approach (Herzig, 2020). Evidence for effective learning through mentorship is documented by Simonton (1984), who found successful artists generally had many mentors of different types.

In the search for new knowledge, managers learn directly through team work and indirectly (e.g., observing others, collaboration with external partners and knowledge spillovers). Team members interact with each other and with external partners (teams, organisations) to develop the ability to create a shared understanding of new knowledge, search for new experiences of working together, and develop their ability to gather and transfer knowledge and relevant experience (Vera et al., 2016). While actively learning from collaborators (Junni, Sarala, Tarba and Weber, 2015; Audretsch, Belitski and Caiazza, 2021), a mentor is instead an internal actor (Moon, 2014) that enables to share relevant to team knowledge and has full access to information and profile of team members. Mentorship in this

sense allows teams to quickly introduce mentor's knowledge and experience into intra-team interactions, learning from someone more competent and whom they trust, which enhances their capability of risk-taking and develops the confidence in experimentation.

Team knowledge sourcing within an enterprise group can serve as a role model for a team, simultaneously increasing the level of improvisation and innovation effort. Due to the technological and cognitive proximity of the innovation within a group, the learning methods will strengthen the improvisation-innovation effect. The reduction of such collaboration will therefore reduce innovation effort (Hmieleski and Corbett, 2008). We hypothesize:

H3a: Mentoring and role models are positively associated with innovation.

H3b: Mentoring and role models moderate the relationship between team improvisation and innovation.

Team improvisation is not just "a function of having the "right" expertise on the team" (Vera and Crosson, 2005: 206), but must be coordinated within the team and the collaboration in teams must be managed effectively (Faraj and Sproull, 2000). The process of performing jazz music as a collaborative team requires a true democratic setting and give-and-take leadership. In the jam session setting, each musician contributes equally to improvisation aiming to create new music (Herzig and Baker, 2014). Mutual acceptance of the "democracy and collaboration" principle facilitates improvisation, making the process of innovation equally important and accessible to every team member. Related to this argument, Lewin, Massini and Peeters (2011) argued that practicing democracy and collaboration in teams is conducive to taking risks as well as it improves the form of interactions within a team, allowing exchange of new ideas leading to innovation. Suppressing delegation and teamwork impedes democratic participatory leadership and weakens the improvisation innovation link. Democratic participatory leadership requires

establishing business structures or practices which create new ways of organizing work responsibilities to enable improvisation through open decision-making and participative leadership (Shepherd and Cardon, 2009). We hypothesize:

H4a: Democracy and collaboration is positively associated with innovation.

H4b: Democracy and collaboration in teams moderates the relationship between team improvisation and innovation.

Kamoche et al. (2003) suggested that improvisation was unlikely to take place in teams where there is a power disparity, as this could lead to role imposition. For innovation in teams, a leadership shapes business strategy and managerial practices that include all new and significantly improved forms of organisation, business structures or practices (Hitt et al., 2001; Skaggs and Youndt, 2004; O'Toole and Meier, 2009). Therefore, team leadership aims to raise internal efficiency via business re-engineering, knowledge management, people management and other.

Team leadership significantly increases the chances of new ideas creation (O'Toole and Meier, 2009) if diversity is embraced by leadership (Cumming and Leung, 2021). Literature suggests, that leaders manage people by motivating and engaging them in improvisation process and collaboration with external partners (Barker and Mone, 1998). Leaders improve forms of organisation, business structures or practices for team members to deploy resources for innovation (Salancik and Meindl, 1984; Castrogiovanni, Baliga and Kidwell, 1992). Leaders will support and manage staff to reduce their fear of experimentation and facilitate their improvisation, resulting in a stronger link between improvisation and innovation and vice versa (Cacciotti and Hayton, 2015). We hypothesize:

H5a: Team leadership is positively associated with innovation.

H5b: Team leadership moderates the relationship between team improvisation and innovation.

For jazz musicians, an environment where they perform rejuvenates and motivates them known as a community support (Herzig and Baker, 2014). For innovation in teams, this means that team members interact with external partners on new ideas and discuss them with the community. These interactions are often referred as collaboration breadth - the range of external sources of new knowledge and channels for innovation (Laursen and Salter, 2006). A diversity of collaboration partners crates a variety of new non-trivial solutions (Cumming and Leung, 2021) enabling further team improvisation for innovation (Argote and Miron-Spektor, 2011). If knowledge breadth is low there is little knowledge diversity to choose from to improvise, limiting new solutions and innovation. If knowledge breadth is high, then improvisation-innovation effects will benefit from the complexity and combinations of new knowledge (Baker et al., 2003; Magni et al., 2013). Kobarg et al. (2019) also argued that the breadth of knowledge collaboration may determine the level of risk. An increase in knowledge breadth leads to sharing a cost of experimentation and improvisation, reduce time from idea to innovation, and increases innovation. We hypothesize:

H6a: Community support is positively associated with innovation.

H6b: Community support moderates the relationship between team improvisation and innovation.

Consequently, teams that want to become more innovative need to learn to be attentive and alert to environmental cues (Vera and Crossan, 2005), paying close attention to signals from their external partners - customers, suppliers, consultants and other stakeholders (Kobarg et al., 2019; Audretsch and Belitski, 2020a).

External evaluation systems usually represent a system of signals and responses from external partners and knowledge collaborators, to track team's learning progress. When evaluation systems are low - we expect the reflection on improvisation will be limited and firm performance stiffened. An increase in the intensity of collaboration leads to an increase in external knowledge sourcing, practices and further improvisation and innovation. An increase in evaluation systems and intensity of collaboration results in knowledge becoming more observable and open (common knowledge). Evaluation systems furthers an exchange of relevant information in real-time via networks, in addition to the establishment of effective feedback, assessment and evaluation of new ideas, which rewards risk-taking behavior and improvisation. Evaluation systems include customers and clients, consultants and partner research institutions who are willing to exchange knowledge and co-create new ideas. While evaluation systems facilitate innovation, high level of evaluation systems will reduce team's ability to innovate. Why? The cost of the knowledge depth of collaboration is an oversaturation with knowledge, which can send conflicting signals to team managers, affecting the speed and(or) their decision-making, raising the complexity, transaction and operational costs (Roper et al. 2017; Audretsch and Belitski, 2020a). These costs of collaboration will limit team's ability to indefinitely benefit from evaluation systems and further use of knowledge for innovation. As evaluation system increase one may expect a) less innovation resulting in an inverted U-shaped effect and b) weaker relationship between improvisation and innovation.

H7a: There is an inverted U-shaped relationship between evaluation systems and innovation.

H7b: Evaluation systems moderate the relationship between team improvisation and innovation.

Figure 2 provides a conceptual model for our hypothesis.

Figure 2 about here

3. **Data and method**

3.1. Data and sample

To test our research hypotheses we used seven cross-sectional surveys from two datasets: the Business Registry (BSD) and the UK Innovation Survey (UKIS) during 2002-2016. Firstly, we collected and matched six consecutive UKIS waves conducted by the Office of National Statistics (ONS): UKIS 4 2002-04, UKIS 5 2004-06, UKIS 6 2006-08, UKIS 7 2008-10, UKIS 8 2010-12 and UKIS 9 2012-14 and UKIS10 2014-16. Secondly, we used BSD data for the years 2002, 2004, 2006, 2008, 2010, 2012 and 2014. The data was matched to the correspondent UKIS survey. Firm age and ownership, employment, industry, firm size and firm location were matched from BSD. The match was possible due to a unique identifier – a firm (at a reporting unit level and enterprise-level).

Taken together, the non-missing sample results in 3,589 observations, and 2,749 firms with only a fraction of firms have been observed for two periods and more. The following criteria were applied to select the firms. First, we only selected micro firms between 2 -8 FTEs drawing on management literature (Kamoche and Cunha, 2003; Kamoche et al. 2003). Secondly, firms that are subsidiaries were excluded. The data in the sample embraces a wide spectrum of industries, regions and time periods and is illustrated in Table 1.

Table 1 about here

3.2. Variables

Dependent variable.

Our dependent variable is innovation, which is calculated as a percentage of total turnover over the last three years from goods and services that are new to the market. It varies between zero and one hundred percent. The average share of new to market products in our sample is 3.98

percent of sales for all firms in a sampler and 12.75 percent for innovators of new products (services). De Leeuw et al. (2014) interpreted 'new products to the market' as an indicator of product innovation. Operationalizing innovation variable is consistent with innovation studies in related contexts (Laursen and Salter, *2014;* Roper et al. 2017; Kobarg et al. 2019; Audretsch and Belitski, 2020b).

Explanatory variables.

We draw on Crossan et al. (1999) and Vera et al. (2016) as we operationalize improvisation with investment in internal or external training for personnel specifically for the development and/or introduction of innovations. Innovative training enhances team's ability to create new knowledge by combining prior skills and experiences and building new one innovation– related, balancing between exploration and exploitation (Vera and Crossan, 2005).

We operationalise team knowledge of the field by using a share of employees holding bachelor and master's degrees in science and engineering as a legal proof of formal specialised education (Kobarg et al. 2019).

Mentorship is operationalized as the intensity of collaboration with another local units or consultants within the enterprise group. Mentoring is internal as it indicates the intensity of collaboration on innovation between the focal firm and other units within an enterprise group (Ahuja, 2000; Schilling and Phelps, 2007; Argote and Miron-Spektor, 2011).

Democracy and collaboration factor is operationalized with a binary variable that equals one if a team has introduced new methods of organizing work responsibilities and decision making based on democratization and collaboration– teamwork, decentralization, decentralization, integration, integration of departments, zero otherwise. Democratization and collaboration in teams increases personal trust among team members that reinforces their decision-making and responsibilities (Crossan, 1998).

Leadership is a binary variable equals one if over the last 3 years, a business has made major changes in new business practices for organising procedures (e.g. supply chain management, business re-engineering, knowledge management, lean production, quality management, people management, etc.), zero otherwise. The measure may still have limitations and its quite broad, however this is an internal measure of leadership representing how people are managed. This measure demonstrates the extent to which someone (e.g. firm -manager, founder, CEO) takes a leading role in people and resource management.

We operationalised community support as a knowledge collaboration breath (Kobarg et al. 2019). It is measured by the number of external partner types for a team to collaborate. Variety of knowledge sources facilitates the effect of team improvisation on innovation (Alves et al, 2018).

Finally, to operationalize evaluation systems as an average value of the collaboration depth with suppliers, customers and clients, consultants and R&D labs and universities and other high educational institutions (a value varies from zero - no collaboration to 3 – the high extent of collaboration) (Salge et al., 2013).

Control variables.

Our control variables include a binary variable export as a proxy of firm internationalisation which equals one if a firm has revenues from markets outside the country (Belderbos et al., 2015) and zero otherwise. We controlled for firm size using the logarithm of employment (2 to 8 employees). Firm size is expected to influence the team's ability to engage in innovation. Firm age is measured as a logarithm of firm age since the establishment that may change teams propensity to innovate (Coad, Segarra and Teruel, 2016). Younger firms are more likely to use external knowledge and invest less in internal R&D for innovation (Asimakopoulos et al., 2020). We control for a foreign ownership which is a binary variable that takes the value 1 if a firm is

foreign-owned and zero otherwise. We control for process innovation which is a binary variable equals one if the firm has introduced any new or significantly improved processes for producing or supplying goods or services and zero otherwise (Salge et al., 2013). We controlled for a firm survival, as a binary variable which equals one if a firm has survived until 2018, zero otherwise including the case of acquisition (Audretsch et al. 2021).

Further, we included industry (2-digit) dummies (mining and agriculture as reference category) time period (wave) dummies (2002-2004 as a reference year) and regional dummies for 128 regions in the UK (York city as a reference category). For the full list of variables used in this study, please refer to Table 2. The correlation between variables is illustrated in Table 3.

Table 2 about here

Table 3 about here

3.3. Method

Innovation production function

We estimate the innovation production function using Tobit regression with a dependent variable y_{it} (innovation) and m_{it} (improvisation intensity):

$$y_{it} = \beta_0 + \beta_1 m_{it} + \beta_2 r_{it} + \beta_3 m_{it} * r_{it} + \beta_4 z_{it} + \lambda_t + \tau_s + a_j + u_{it} \quad (1)$$

We can also call it structural equation to emphasize that we are interested in β_1 which is the size of the effect of improvisation on innovation and β_3 which is a vector of interaction coefficients related to our H2-H7. Vector r_{it} indicate six additional team and external factors that may directly and indirectly affect innovation; z_{it} is a vector of exogenous control variables not correlated with u_{it}, while m_{it} is likely to be correlated with u_{it} (Wooldridge, 2009: 517), where and u_{it} is an error term. λ_t, τ_s are time and industry fixed effects, a_j is region (borough) fixed effects where firm is located. We use

a multivariate Tobit regression model when predicting innovation performance as our dependent variable is left-censored.

4. Results

4.1. Improvisation and innovation

We present our results in two sections. First, we discuss the results for hypotheses 1-7. Second, we perform the robustness check to deal with two important issues. First, we apply the IV Tobit method to deal with potential endogeneity between improvisation and innovation. Second, we introduce a different model, where we assume that each factors of the JJSM leads to a greater improvisation and then to innovation, with improvisation intensity as a mediator in the JJSM – innovation relationship.

Table 4 presents the Tobit estimation suggesting that all elements except the democracy element of JJSM directly contribute to innovation (spec. 2-4, Table 4).

Table 4 about here

The results in Table 4 (spec. 2-4) support H1, as one unit increase in improvisation intensity increases innovation between 6.64 (β=6.64, $p<0.01$) and 10.56 per cent (β=10.56, $p<0.05$). Given an average innovation sale for firms in our sample is 532,205 British pounds (GBP) a year, an increase in improvisation intensity by 1 percent will result in on average 35,338 GBP (532,205*0.0664) additional sales of new products (spec. 3, Table 4). Our findings extends what we know from prior research of Hmieleski and Ensley (2004), Hmieleski and Corbett (2006, 2008) who found that startups led by entrepreneurs with a greater improvisational effort outperformed their counterparts. His study demonstrated controlling for firm age that both young and mature teams who improvise are equally likely to product and service innovation. Our strudy

does not treat improvisation as a binary outcome, as we demonstrate that innovation changes as a response to a different extent of team's improvisation effort.

Our H2a is supported as an increase in a share of employees with BSc and MSc degrees by 1 percent is associated with 0.18-0.23 percent higher innovation (spec. 2-3, Table 4). An increase in the role of mentoring by 1 percent is associated with an increase in innovation by 7.28-8.54 percent, supporting H3a (spec. 2-3, Table 4). Our H4a is not supported as the coefficients of democracy and collaboration are insignificant (spec. 2-3, Table 4). H5a is supported as the presence of internal leadership is associated with on average 4.10-7.19 percent increase in innovation (spec. 2-3, Table 4). An increase in collaboration breadth by one partner is associated with an additional 7.17-9.39 percent innovation supporting H6a (spec. 2-3, Table 4). Finally, our H7a is supported as we demonstrate an inverted U-shaped relationship between knowledge depth as a proxy for evaluation systems and innovation. The infliction point is 1.93 which means that teams with a medium intensity of knowledge collaboration have the highest level of innovation, while those with lower and greater intensity are associated with lower innovation activity. Our finding further advances what we know from Kobarg et al. (2019) and Audretsch and Belitski (2020b) who researched the limits to external knowledge collaboration as we were able to explain it further and apply it for innovation in teams.

As the beta coefficients in Table 4 (specifications 1-4) provide averaged results of model estimation and are limited in capturing non-linear effects associated with factors that may moderate the relationship between improvisation and innovation. In order to test our H2b-H7b we calculated six post-estimated predictive margins for each interaction variable, drawing on Williams (2012), using the estimated results (specification 4, Table 4). To build the predictive margins we employed six interactions of improvisation with binary and continuous variables. Continuous variables such as

knowledge in the field (competences), mentoring, community support and evaluation systems were standardised.

Figure 3 about here

Our H2b is supported as knowledge in the field (a share of employees with science and technology degrees) positively moderates improvisation-innovation effects ($\beta=0.11$, $p<0.05$) (specification 4, Table 4). Figure 3A illustrates that an increase in knowledge in the field (above the mean) has a greater effect on innovation as improvisation increases, furthering what we know from Vera and Crosson (2005) about the non-linearity between team improvisation and innovation.

Our H3b is not supported. The interaction coefficient between mentoring as a collaboration within an enterprise group and improvisation is insignificant (specification 4, Table 4). Figure 3B shows overlapping confidence intervals, when improvisation intensity is high, while different effects when improvisation is low. This results demonstrates that teams with high level of improvisation will achieve similar innovation performance at different levels of mentoring. It also demonstrates that low improvisation levels and high mentoring is still associated with higher innovation.

We do not find support for H4b which states that democracy and collaboration is a moderator of improvisation-innovation effects (Lewin et al. 2011) (spec. 4, Table 4 and Figure 3C). While prior research demonstrated that creating more inclusive democratic environment (Shamir and Melnik, 2002) makes teams to improvise and innovate more, we do not find the support for this thesis using innovation data. Our H5b is supported as an interaction coefficient between leadership and improvisation is positive and significant ($\beta = 3.45$, $p < 0.05$), while the direct effect of leadership on innovation is also positive and statistically significant ($\beta = 5.31$, $p <$

0.05) (specification 4, Table 4). This finding demonstrates that an increase in improvisation propensity by 1 per cent given strong team leadership is associated with an additional increase in innovation by 8.76 percent (3.45+5.31). Figure 3D illustrates this findings and adds to prior research on leadership (Mueller and Barker, 1997).

Teams with weak leadership will experience lower improvisation-innovation effects, which is consistent with literature that examines employee performance (Datta et al., 2010) and innovation (Dougherty and Bowman, 1995).

We find that community supported measured as collaboration breadth does not moderate improvisation-innovation effects, not supporting H6b. Figure 3E also illustrates that teams with a greater number of partner types are on average more innovative.

Our H7b is not supported – the evaluation systems, measured as collaboration depth does not moderate the improvisation-innovation effects (spec. 4, Table 4). Figure 3F demonstrates overlapping confidence intervals , while we also find that more developed evaluation systems are more likely to increase innovation.

4.2.Robustness check

4.2.1. Resolving the endogeneity problem

While estimating model (1) there could be an endogeneity issue related to team's decision to improvise. A team decides whether to invest in improvisation or not. Highly innovative teams may invest more in training and intangibles to sustain their innovation. This can crate endogeneity in the relationship between improvisation and innovation (Wooldridge, 2009).

First stage estimation

The first stage concerns with the decision of investing in innovative training to enhance improvisation activity or not and the extent of this investment. We instrument m_{it} (improvisation

intensity) with two exclusion restrictions (exogenous instrumental variables- IVs) if ϱ_1 (intra-industry R&D spillover) and ϱ_2 (inter-industry R&D spillover), that do not appear in (1) and are uncorrelated with the error u_i.

Intra-industry knowledge spillover is calculated as a ratio of R&D expenditure in £000s (by 2 digit SIC) within sector where a firm is located and in a region where firm is located (nominator) to a total R&D expenditure in 2 digit SIC (excluding firm's expenditure) in a country (denominator) weighted by the degree of input-output sales within the sector. Inter-industry knowledge spillover is calculated as a ratio of R&D expenditure in £000s (by 2 digit SIC) in sectors outside a sector where a focal firm is located and in a region where firm is located (nominator) to a total R&D expenditure in 2 digit SIC in a country by all outside sectors (denominator). Input-output matrix was used to weight inter-industry sales in intermediate products as the size of the spillover is different between and within industries.

Both spillovers are associated with team's decision on further investment in training for innovation, given the availability of external knowledge, however an investment in internal R&D by other firms within and between industries is unlikely to affect team innovation behavior. In the reduced form of equation in Table A1 (Appendix A) is estimated as:

$$m_{it} = \pi_0 + \beta_i x_{it} + \pi_1 \varrho_1 + \pi_2 \varrho_2 + v_{it} \qquad (2)$$

where $E(v_{it}) = 0$, $cov(\varrho_{1t}, v_{it}) = 0$, $cov(\varrho_{2t}, v_{it}) = 0$. For this IV not to be perfectly correlated with ϱ_{1t} we need $\pi_2 \neq 0$ and not to be perfectly correlated with ϱ_{2t} we need $\pi_1 \neq 0$. The identification requires that $\pi_1 \neq 0$ and $\pi_2 \neq 0$ or both (Wooldridge, 2009: 523).

We included several control variables which are not part of equation (1) such as R&D intensity and knowledge appropriability (Kobarg et al. 2019), which is measured drawing on the role of intellectual property protection for decision on investment in innovative training (Hall and

Sena, 2017). Table A1 in Appendix illustrates the first stage estimation and provides post-estimation test (chi2) of a joint significance of chosen instruments. The first condition being satisfied with the coefficients of the chosen instruments and significant and positively associated with endogenous variable m_i ceteris paribus.

We perform an additional robustness check for the quality of the found instruments. Firstly, we saved u_{it} from equation (1) to provide the evidence of the second condition for IVs to hold: ϱ_1 and ϱ_2 to be uncorrelated with u_i corr(ϱ_{it},u_{it}) = 0, any linear combination is also uncorrelated with u_{it} (Wooldridge, 2009). Secondly, we estimated equation (3), where the dependent variable is u_i from equation (1) regressed on the chosen IVs (ϱ_{1t}, ϱ_{2t}):

$$u_{it} = \beta_0 + \rho_1\varrho_{1t} + \rho_2\varrho_{2t} + \lambda_t + \tau_s + \psi_j\epsilon_{it} \quad (3)$$

where u_{it} is error from equation (1). Variables λ_t, τ_s are control for region and year fixed effects and ϵ_{it} is an error term. Coefficients ρ_1 and ρ_2 were not statistically significant and we conclude that corr(ϱ_i,u_{it}) = 0, thus ρ_1 and ρ_2 are valid instruments for improvisation.

Second stage estimation

Table 4 (specifications 5-8) reports the second-stage IV Tobit estimation with $\widehat{m_{it}}$ and x_{it} as explanatory variables. Now instead of m_{it} we use the predicted values of improvisation intensity $\widehat{m_{it}}$ in equation (1). We compare the significance and size of coefficients from equation (1) for m_{it} between specifications 2-4 and specifications 6-8 in Table 4. While the overall results are consistent between two models , there are following differences we found. Firstly, the interaction coefficient of evaluation systems and improvisation intensity is positive and significant demonstrating that an increase of evaluation systems moderates improvisation and contributes positively to innovation (β=2.56, p<0.01). Secondly, the direct effect of team improvisation on innovation has increased from

6.64-10.56% (spec. 2-4, Table 4) to 33.35-35.80% (spec. 6-8, Table 4). Finally, we found that democracy negatively moderates improvisation-innovation link in teams (spec. 8, Table 4).

4.2.2. Team improvisation as a mediator between the jazz jam session elements and innovation.

In addition to team characteristics, the effectiveness of improvisation and innovation is subject to various contextual factors (Vera et al., 2016). These contextual factors nurture an improvisation culture which results in greater innovation effort. In teams, creating a business environment that nurtures improvisational culture can be an incredibly useful way to leverage the improvisation process and spur innovation activity (Baum and Locke, 2004; Cunha et al., 2006; Visscher et al., 2018). AS part of the robustness check of our conceptual model, we tested an alternative model where in the first stage we used team attributes and external environment (six elements of the JJSM) to predict team improvisation. In the second stage, improvisation to explain team innovation.

Estimating a model, where team improvisation is not a moderator but a mediator in the relationship between JJSM elements and team innovation enables to compare the results of the conceptual model (Figure 2) estimated in (1) with the alternative model.

The first stage concerns the decision on investing in innovative training to enhance team improvisation. We instrument m_{it} with six elements of the JJSM related we used as explanatory variables to test our H2a-H7a. We included several control variables such as firm age and employment, as well as year and regional fixed effects decision on investment in innovative training (Hall and Sena, 2017) (see Table A2 in Appendix).

Table A2 demonstrates that all factors of the JJSM model but community support (β=0.057, $p>0.05$) are positively associated with team improvisation. We perform an additional robustness

check for the quality of the instruments assuming corr(ϱ_{it},u_{it}) = 0 (Wooldridge, 2009) and found that instruments are correlated with u_{it} in equation 1. The JJSM elements are directly related to team innovation again supporting H2a–H7a.

Table 4 (specification 9) reports the second-stage IV Tobit estimation where improvisation $\widehat{m_{it}}$ is a mediator between explanatory variables representing JJSM framework and team innovation. Now instead of m_{it} we use the predicted values of improvisation intensity $\widehat{m_{it}}$ from stage 1. The main outcome of the second stage estimation across two different models (specifications 2-4 and spec. 9, Table 4) is that the relationship between team improvisation and innovation remains statistically significant and positive ($\beta = 38.10$, $p < 0.01$) (spec. 9, Table 4). The goodness of fit of the model where improvisation is used as a mediator is lower (spec. 9, Table 4) compared to a model where JJSM elements moderate improvisation -innovation link (spec. 1-4 and spec. 5-8, Table 4). The result of robustness check demonstrated that equation (1) and our conceptual model in Figure 2 better predict the relationship between team improvisation and innovation.

5. Discussion and Conclusion

This study examined the relationship between improvisation and team innovation by integrating the jazz jam session model into management science research. Two main findings of this study emerge. Firstly, the improvisation-innovation main effect is positive and statistically significant across all model specifications and estimation methods. Secondly, the magnitude of the improvisation-innovation effect is contingent on the positive influencing effects of four out of seven predicted moderators – elements of the JJSM. Our results support the view that the improvisation process follows the team improvisation and interactions principles. The jazz jam session setting helps team members to master this skill (e.g., “mentoring,” “community support,” “competencies,” and “evaluation systems”). This is applicable in startups and can be learned and effectively applied by

organizational teams at different stages of firm growth. We extend what we know from prior research (Meyer et al., 1998; Vera and Crosson, 2005; Belitski and Herzig, 2018; Suarez and Montes, 2019). We concluded that the lack of strong support for democracy and collaboration (Cunha et al., 2016) for innovation could be associated with the specific characteristics of the team. Regarding the negative effect on leadership, we consider that improvisation is unlikely in teams where power disparities exist. Managers who aim at market leadership and the first-mover advantage purposefully speed up innovation and converge the improvisation process to introduce innovation to the market quickly while choosing speed over creativity.

In our robustness check section, comparisons between factual and predicted values of improvisation intensity showed the effects of training in innovation are consistent when controlling for endogeneity. In addition, the effect of the innovative training was stronger for the contextual factors (Vera and Crossan 2004, Vera et al., 2016) related to building new relationships with external partners and employing new methods of external engagement, creating an effective system of collective improvisation (Moorman and Miner 1998a, 1998b; Cunha et al., 2003, 2016).

Theoretical implications

This study builds upon prior research on the role of improvisation in innovation in the following important ways. Firstly, we contribute to the works of Vera and Crosson (2004, 2005) who argued that the spontaneity of improvisation tends to be overemphasised. We use regression analysis to conceptualise and examine the effect of investment on innovative training as a mechanism for enhancing the effectiveness of improvisation and improvisation intensity for innovation performance. This study, consequently, moves beyond the organizational settings of

Vera and Crosson (2005) and Vera et al. (2016) to demonstrate which other intra-team and external factors could moderate the relationship between improvisation intensity and innovation.

Secondly, there is a general assumption that improvisation always leads to positive performance (Baker and Nelson, 2005; Hmieleski and Corbett, 2006, 2008; Balachandra, 2019). This study clarifies the conceptual confusion about improvisation by employing the JJSM framework and laying out the various aspects of the improvisation process required for an effective link between improvisation and innovation. In our JJSM framework, we delineate how the improvisational jazz principle of "taking risks" links to other team interactions and external stakeholders (e.g., suppliers, customers, consultants, universities, alliances, other partnerships) to develop new products to market.

Thirdly, comparing two estimation methods showed that the relationships are similar, and our results are robust. Our findings are consistent with the literature on collective improvisation regarding innovation performance and improvisation that examines contextual factors (Belitski and Herzig, 2018; Balachandra, 2019). In view of this, our study also advances the literature on the role of heterogeneous mechanisms within and outside the team that moderate improvisation for innovation.

Finally, this study discusses the critical role of improvisation in the management literature as a legitimate and recommended choice when team managers face uncertainty and risk (Crossan and Sorrenti 1997; Crossan et al., 1999, 2005). In doing so, this study defines and conceptualizes new elements of the improvisation process such as "mentoring," "team competencies," "community support," and "evaluation systems," with the effect between improvisation and innovation both linear and curvilinear.

Managerial implications

The findings from our research have several significant implications for practitioners. Firstly, when drawing on Herzig and Baker (2014), the JJSM framework used in this study can explain how

the new piece of music (innovation) reflects the most novel combination of resources that contribute to the improvisation process. Therefore, when considering jazz musicians who work together to improvise a new piece of music, we can, in fact, conceptualise teams within organisations improvising together, substantially transforming the often-limited available resources for maximum impact as a result (Weick, 1995; Herzig and Baker, 2014). Secondly, the JJSM framework helps practitioners, particularly those who manage people, think differently about how improvisation processes for innovation, team collective capabilities and environmental context contribute to innovation's impact within an organisation. Thirdly, managers could use the JJSM as a framework to co-create new products and services together with external partners by pooling their resources. Consequently, managers who apply the seven-factor model can shape the improvisation process, accounting for interdependences intra-team and external partners to achieve more innovative and effective results improvising.

Limitations and Future research

Despite its theoretical developments and novel findings, this paper has a number of limitations. Firstly, due to the anonymous nature of the UK Innovation survey, no additional sources for information on external partners could be added to the database, which could have been used to supplement the data. Secondly, although this study focuses on innovation as the major outcome, innovation is in fact a heterogeneous phenomenon and may require a combination of various mechanisms of improvisation. Thirdly, for several firms the data was cross-sectional. There will be firm types and industries for which the JJSM may not be applicable.

Further research is needed to understand the alternative methods which could be used to examine the link between improvisation and innovation. We hope that researchers and team

managers will be able to further investigate the black box of the improvisation process by integrating and testing a variety of improvisational models that come from music and theatre, as well as experimental and applied research, to advance the theory and practice of innovation. We are interested in one particular aspect of organizational learning and the improvisation process: business model reconfiguration and the time effect of switching between different business models, industries, and markets by employing the improvisation process in teams.

Subsequent empirical research should use more sophisticated longitudinal data to unpack the black box of the improvisation process across different contexts. Future research may focus on improvisation techniques that indirectly benefit innovation, for example, by opportunity selection and encouraging leaders to accumulate experience and implement them quickly. More research is needed to identify the types of resources and leadership models conducive to improvisation.

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Table 1: Sample distribution by industry and survey year

Industry	N. of obs.	%, total firms
Mining and Quarrying	30	0.84
Manufacturing basic	132	3.68
High-tech manufacturing	535	14.91
Electricity, gas and water supply	21	0.59

Construction	453	12.62
Wholesale, retail trade	675	18.81
Transport, storage	256	7.13
Hotels & restaurants	200	5.57
Information and communication techs.	205	5.71
Financial intermediation	122	3.40
Real estate and business activities	469	13.07
Public admin, defense	348	9.70
Education	61	1.70
Other community, social activities	82	2.28
Survey year	**N. of obs.**	**%, total firms**
2002-04	880	24.52
2004-06	652	18.17
2006-08	548	15.27
2008-10	555	15.46
2010-12	454	12.65
2012-14	273	7.61
2014-16	302	8.41
UK Region	**N. of obs.**	**%, total firms**
North East England	314	8.75
North West England	230	6.41
Yorkshire and the Humber	385	10.73
East Midlands	343	9.56
West Midlands	328	9.14
Eastern England	295	8.22
London	144	4.01
South East England	417	11.62
South West England	309	8.61
Wales	291	8.11
Scotland	82	2.28
Northern Ireland	454	12.65
Total	**3,589**	**(100)**

Source: Office for National Statistics (2017). *UK Innovation Survey, 1994-2016: Secure Access*. [data collection]. *6th Edition.* UK Data Service. SN: 6699, http://doi.org/10.5255/UKDA-SN-6699-6 hereinafter named UKIS – UK Innovation Survey (2002-2016).
Office for National Statistics. (2017). *Business Structure Database, 1997-2017: Secure Access*. [data collection]. *9th Edition.* UK Data Service. SN: 6697, http://doi.org/10.5255/UKDA-SN-6697-9 , hereinafter named BSD - Business Register (2002-2016).
Business Strategy and Practices Include all new and significantly improved forms of organisation, business structures or practices aimed at raising internal efficiency or the effectiveness of approaching markets and customers.

Table 2: Summary statistics

Variable (Source)	Description	Sample size 3,589 obs.			
		Mean	St. Dev.	Min	Max
Innovation (UKIS)	*Dependent variable:* percentage of business's total sales from goods and services that were new to a market, %	3.98	13.79	0.00	100.00
Improvisation intensity (UKIS)	The amount of expenditure on training for innovative activities (000s), to total sales (000s pound sterling). Internal or external	0.18	0.39	0.00	1.36

	training for your personnel specifically for the development and/or introduction of innovations				
Improvisation intensity predicted (UKIS)	Predicted value of imitation intensity (first stage as part of robustness check)	-0.30	0.33	-1.08	1.64
Knowledge in the field (UKIS)	The proportion of employees that hold a degree or higher qualification in science and engineering at BA / BSc, MA / PhD, PGCE levels	5.84	16.55	0.00	85.00
Mentoring (UKIS)	Important to business's innovation activities (from zero – not important and not used to 1- low, 2- medium and 3 highly importance) was collaboration with another local unit or consultant within the enterprise group	1.20	1.22	0.00	3.00
Democracy (UKIS)	Binary variable =1 if enterprise has introduced new methods of organizing work responsibilities and decision making in a team (i.e. first use of a new system of employee responsibilities, teamwork, decentralization, integration or de-integration of departments), zero otherwise	0.17	0.35	0.00	1.00
Leadership (UKIS)	Business strategy and managerial practices that include all new and significantly improved forms of organisation, business structures or practices aimed at raising internal efficiency (e.g. supply chain management, business re-engineering, knowledge management, lean production, quality management, people management, etc)=1, zero otherwise	0.15	0.35	0.00	1.00
Community support (UKIS)	Number of partner types with whom firm collaborates on innovation (collaboration breadth) including suppliers, customers and clients, consultants and R&D labs, competitors, universities and government. The number varies from zero= no external collaboration partners to a maximum of 6 partner types.	0.19	0.53	0.00	6.00
Evaluation systems (UKIS)	An average value of the collaboration depth with suppliers, customers and clients, consultants and R&D labs and universities and other high educational institutions (from zero = none to 3 – high extent of collaboration).	0.85	0.76	1.00	3.00
Age (BSD)	Age of a firm (years since the establishment), in logarithms	2.48	0.80	0.00	3.68
Employment (BSD)	Number of full-time employees, in logarithms	3.15	1.15	0.69	8.13
Exporter (BSD)	Binary variable = 1 if enterprise is an exporter, zero otherwise.	0.22	0.41	0.00	1.00
Survival (BSD)	Binary variable=1 if a firm survived as an independent unit until year 2017, 0 otherwise	0.65	0.47	0.00	1.00
Foreign (BSD)	Binary variable = 1 if enterprise has a foreign owner, zero otherwise	0.21	0.40	0.00	1.00
Process Innovation (UKIS)	Binary variable = 1, if a firm introduced significantly improved processes for producing / supplying goods (services), zero otherwise	0.19	0.39	0.00	1.00
Variables used to predict the improvisation intensity					
Age (BSD)	Age of a firm (years since the establishment), in logarithms	2.48	0.80	0.00	3.68
Employment (BSD)	Number of full-time employees, in logarithms	3.15	1.15	0.69	8.13
Intra-industry R&D spillover	Intra-industry knowledge spillover by 2 digit SIC and 128 UK boroughs calculated using R&D expenditure in £000s within firm sector at 2 digit SIC (excluding firm's expenditure) in the borough where a firm is located.	0.07	0.14	0.00	0.95
Inter-industry R&D spillover	Inter-industry knowledge spillover by 2 digit SIC and 128 UK boroughs calculated using R&D expenditure in £000s outside firm sector at 2 digit SIC level in the borough where a firm is located.	0.06	0.08	0.01	0.48

R&D intensity	The amount of expenditure in internal Research and Development (000s), to total sales (000s pound sterling)	0.01	0.05	0.00	0.66
Appropriability (UKIS)	Sum of scores of the effectiveness of the following methods for protecting new products and processes: secrecy, complexity of goods and services, lead time advantages, patenting, design, copyright, trademarks, lead, complexity, secrecy (rescaled between zero and one).	0.05	0.12	0.00	1.00

Source: BSD - Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).
Note: several values were "suppressed" as they may potentially identify a firm as part of the Office of National Statistics (ONS) UK data clearance procedure and disclosure control (UK data service team, ONS).

Table 3 Correlation matrix.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Innovation	1													
2	Improvisation intensity	0.24*	1												
3	Improvisation intensity predicted	0.35*	0.40*	1											
4	Knowledge in the field	0.27*	0.23*	0.36*	1										
5	Mentoring	0.28*	0.35*	0.40*	0.24*	1									
6	Democracy	0.15*	0.21*	0.14*	0.12*	0.31*	1								
7	Leadership	0.21*	0.23*	0.23*	0.16*	0.33*	0.42*	1							
8	Community support	0.34*	0.23*	0.24*	0.23*	0.32*	0.27*	0.28*	1						
9	Evaluation systems	0.27*	0.37*	0.43*	0.25*	0.61*	0.31*	0.32*	0.39*	1					
10	Age	-0.15*	-0.21*	-0.41*	-0.12*	-0.16*	-0.07*	-0.11*	-0.08*	-0.14*	1				
11	Employment	-0.01	-0.07*	-0.06*	-0.07*	-0.03*	0.03	-0.08	-0.09	-0.07*	0.02*	1			
12	Exporter	0.18*	0.11*	0.24*	0.23*	0.25*	0.15*	0.18*	0.19*	0.24*	-0.03*	0.01	1		
13	Survival	-0.01	-0.01	-0.05*	0.06	0.04*	0.03*	0.02	0.02	0.05*	0.13*	-0.11*	0.07*	1	
14	Foreign	-0.05*	-0.08*	-0.03*	-0.03	-0.09*	-0.08*	-0.06*	-0.04*	-0.10*	0.15*	0.29*	0.05*	-0.07*	1
15	Process Innovation	0.23*	0.29*	0.26*	0.16*	0.39*	0.25*	0.31*	0.29*	0.17*	-0.11*	0.01*	0.15*	0.02	-0.03*

Note: Significance level * $p<0.05$.
Source: BSD - Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).

Table 4: Tobit estimation results. DV: Innovation

Model	Improvisation intensity				Improvisation intensity (predicted)				Improvis. intensity as mediator
Method	Tobit				Second stage estimation (Tobit) using predicted team improvisation				
Specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Improvisation (H1)	27.05*** (2.30)	8.95*** (2.15)	6.64*** (2.18)	10.56* (5.39)	58.99*** (3.21)	34.83*** (3.56)	35.80*** (4.06)	33.35*** (11.12)	38.10*** (2.68)
Knowledge in the field (H2a)		0.23*** (0.04)	0.18*** (0.04)	0.18*** (0.06)		0.10*** (0.04)	0.08** (0.04)	0.10*** (0.04)	
Mentoring (H3a)		8.54*** (1.13)	7.28*** (1.14)	8.15*** (1.32)		7.37*** (1.17)	6.40*** (1.12)	4.90*** (1.43)	
Democracy (H4a)		2.67 (2.59)	2.57 (2.56)	1.90 (3.38)		4.32* (2.49)	3.74* (2.05)	0.17 (2.24)	
Leadership (H5a)		7.19*** (2.43)	4.10* (2.14)	5.31* (3.01)		6.22*** (2.37)	3.65* (2.08)	5.21*** (2.28)	
Community support (H6a)		9.39*** (1.54)	7.98*** (1.53)	7.17*** (2.02)		8.59*** (1.49)	7.20*** (1.50)	6.83*** (1.38)	
Evaluation systems (H7a)		23.73*** (4.87)	20.91** (4.85)	20.17*** (5.04)		23.89*** (4.75)	21.76** (4.77)	23.22*** (5.12)	
Evaluation systems squared (H7a)		-5.87** (1.17)	-5.19** (1.59)	-5.27** (1.14)		-6.64*** (1.17)	-6.02* (1.74)	-6.80** (1.75)	
Age			-2.65** (1.19)	-2.38*** (1.00)			2.24 (1.36)	0.14 (1.31)	1.95 (1.33)
Employment			0.83 (1.33)	0.99 (1.32)			1.43 (1.29)	1.47 (1.27)	1.52 (1.31)
Exporter			9.14*** (2.17)	9.24*** (2.09)			5.73*** (2.17)	6.11*** (1.05)	10.81*** (2.17)
Survival			-3.57 (2.79)	-2.01 (2.13)			-3.88 (2.00)	-3.55 (2.02)	-2.25 (2.17)
Foreign			-2.55 (2.82)	-2.41 (2.83)			-3.76 (2.76)	-3.63 (2.45)	-1.48 (2.80)
Process Innovation			11.35** (2.21)	11.39*** (2.57)			12.15*** (2.40)	11.30*** (1.94)	13.42*** (2.21)
Improvisation x Knowledge in the field (H2b)				0.11** (0.05)				0.14* (0.05)	
Improvisation x Mentoring (H3b)				-3.58 (2.49)				-3.52 (3.60)	
Improvisation x Democracy (H4b)				1.33 (4.08)				-15.05** (5.65)	
Improvisation x Leadership (H5b)				3.45* (2.04)				7.60* (4.15)	
Improvisation x Community support (H6b)				1.57 (2.57)				3.85 (3.00)	
Improvisation x Evaluation systems (H7b)				2.53 (4.15)				2.26 (5.27)	
Constant	-52.46** (4.08)	-75.12** (4.72)	-63.28** (6.77)	-63.72*** (6.80)	-26.98*** (3.32)	-59.42*** (4.58)	-62.10*** (6.56)	-53.39*** (6.45)	-40.43*** (6.11)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,589	3,589	3,589	3,589	3,589	3,589	3,589	3,589	3,589
Chi2	694.28	2514.20	2535.20	2549.50	827.18	2551.28	2575.8	2598.5	1010.9

Left-censored	2951	2951	2951	2951	2951	2951	2951	2951	2951
Log-likelihood	-3977.2	-3067.5	-3057.2	-3050.7	-3727.5	-2865.7	-2853.4	-2842.1	-3535.25
Pseudo R2	0.09	0.29	0.30	0.30	0.10	0.31	0.31	0.32	0.13

Note: Standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1.
Reference year: CIS4 2005. Reference category region North-East England. Reference category industry: mining and quarrying.
Source: Authors using Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).

Figure 1: The concept of the Jazz jam session model

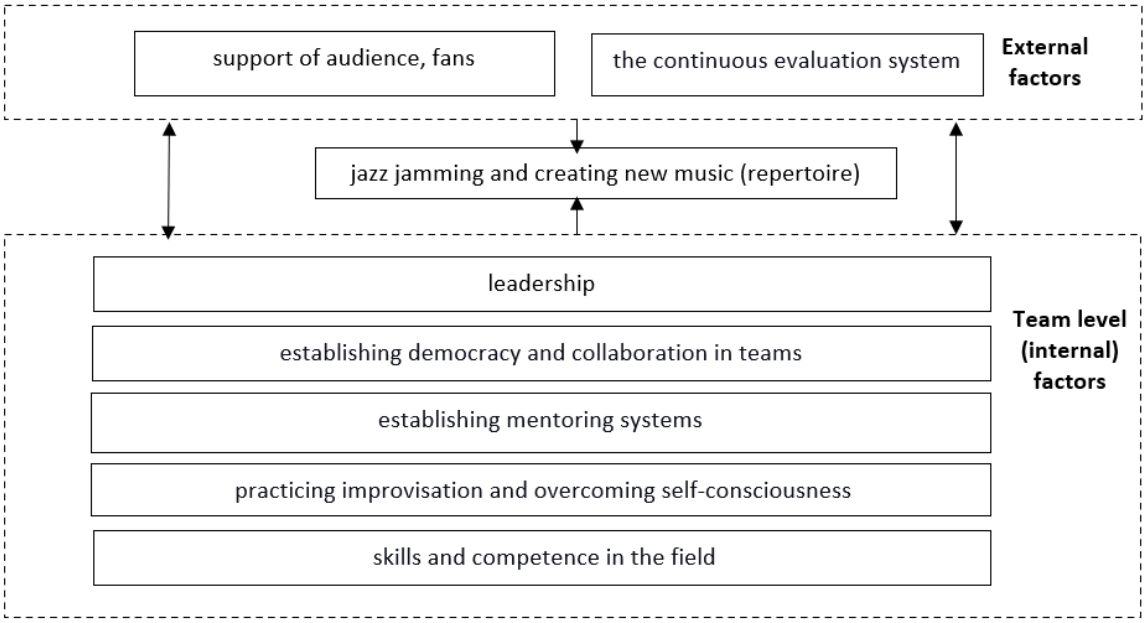


Figure 2: Conceptual model of JJSM of innovation

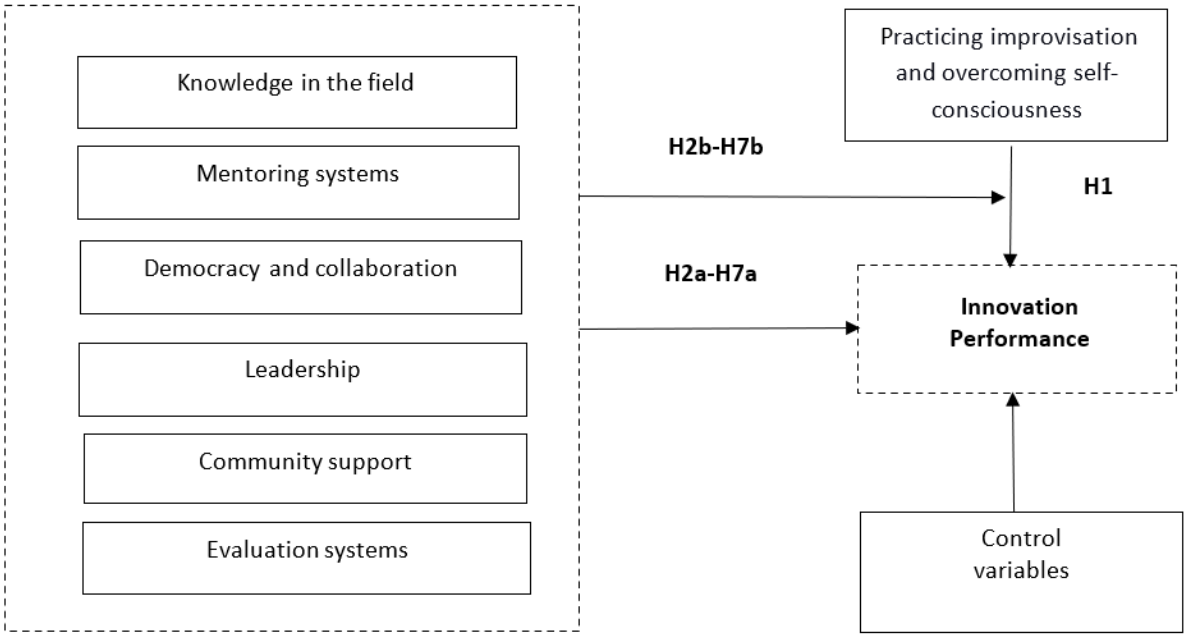
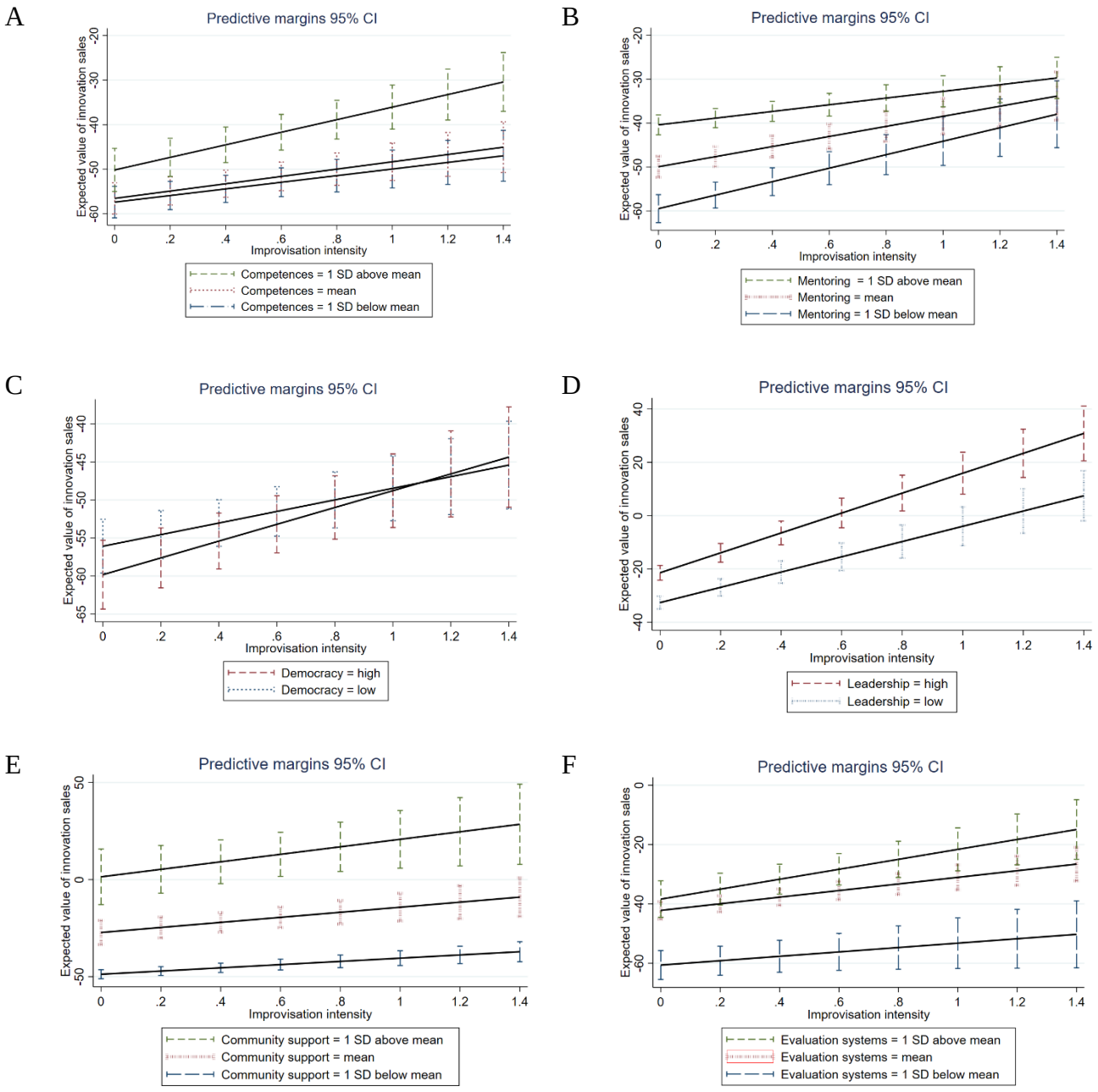


Figure 3: Predictive margins of team innovation within the jazz jam session model



Source: Authors using Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).

Appendix A

Table A1: First stage Tobit regression used for constructing the predicted values of improvisation

Variables	Improvisation intensity		
	dx/dy	SE	p-values
Age (log)	-0.11	0.01	0.00
Employment	-0.01	0.00	0.03
Intra-industry R&D spillover	-0.10	0.04	0.02
Inter-industry R&D spillover	-0.08	0.04	0.06
R&D intensity	2.43	0.11	0.00
Appropriability	1.02	0.04	0.00
Year and region fixed effects	Yes		
Number of obs. Likelihood ratio test Wald chi2 Prob > Chi2 Pseudo-R2	3,589 -2411.15 0.00 0.08		

Note: Standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1. Both models include year controls, which are jointly significant.
Source: Authors using Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).

Table A2: First stage Tobit regression for team improvisation in the mediation approach to JJSM

Variables	Improvisation intensity		
	dx/dy	SE	p-values
Age (log)	-0.144	0.020	0.00
Employment	-0.079	0.022	0.00
Knowledge in the field	0.004	0.001	0.00
Mentoring	0.126	0.018	0.00
Democracy	0.231	0.045	0.00
Leadership	0.128	0.044	0.01
Community support	0.057	0.029	0.05
Evaluation systems	0.847	0.080	0.00
Evaluation systems squared	-0.202	0.029	0.00
Year and region fixed effects	Yes		
Number of obs. Likelihood ratio test Wald chi2 Prob > Chi2 Pseudo-R2	3,589 -2343.78 0.00 0.22		

Note: Standard errors in parentheses. Significance level *** p<0.01, ** p<0.05, * p<0.1. Both models include year controls, which are jointly significant.
Source: Authors using Business Register (2002-2016) and UKIS - UK Innovation Survey (2002-2016).