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CREATIVITY, INNOVATION EFFECTIVENESS AND PRODUCTIVE EFFICIENCY IN THE UNITED KINGDOM

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ABSTRACT

Purpose
Creativity is often referred to as a seedbed of innovation. As such it holds the key to better performance and the competitiveness of firms. To better understand how creativity influences birth and commercialization of innovations and productive efficiency of firms the paper investigates how hiring of employees with different creative skills impacts innovation process and productivity. The purpose of the paper is to determine the role of creativity in innovation behaviour and productive efficiency of firms.

Design/Methodology/Approach
Theoretical framework of the paper rests on pillars of evolutionary, Schumpeterian and endogenous growth literature contributions to the economics of innovation. The multi-stage analytical framework is applied to examine contribution of creativity to the decision of firms to innovate, investment in innovation activities, commercialization of innovations and firm efficiency. The econometric techniques of generalised tobit and simultaneous equations framework are applied to confidential data from the United Kingdom Innovation Survey in 2010-2012 period.

Findings
The investigation broadens our understanding of factors and forces that shape innovation process and improve productive efficiency of firms. It provides empirical evidence on an impact of the effectiveness of innovation process on the productivity of firms. The results reveal that creative skills contribute to the generation of novel ideas and investment in R&D but the ability to meet customer requirements draws from other organizational skills such as marketing or organizational innovations. Differences are revealed among economic sectors with respect to the forces driving the innovation process.

Practical implications
The results provide implications to managers regarding the management of innovation process. First, the study reveals how creative potential of employees can be optimally exploited in different stages of innovation process. Second, the research highlights number of other factors relevant in this process from the utilization of information, subsidies and the general management of human resources. Finally, the result suggest that sectoral heterogeneity should be taken into account in management of innovation activities of individual firms.

Research limitations/implications
Further research will be needed to investigate cross-country differences in management of creativity and its contribution to the innovation process and productivity. The limited availability of data on creativity and innovation activities of firms presents the most important

limitation in this sense. The framework set by this paper can serve as direction for further investigations.

Originality/Value

While the impact of creativity on innovation has been addressed previously, this paper is one of first attempts to examine the linkages between management of creativity, effectiveness of innovation process and productive efficiency of firms within a single framework. One of reasons for this is the fact that it relies on the confidential dataset of firms not easily accessible to researchers.

Keywords: *Creativity, Innovation, Effectiveness, Performance*

1. Introduction

Ever since the birth of economics scholars have sought to explain why some firms perform better than others. Empirical research traced origins of superior performance of some firms over others to their innovation activities (Hall et al., 2010). The quest for factors moulding innovation within psychology and sociology notes pivotal role in the birth of innovations to the creative efforts of individuals (Amabile, 2000; Miron, Erez and Naveh, 2004). Within economics, Schumpeter (1942) was first to formalise the relationship between creativity and innovations. In his view, the creative efforts of individuals are the principal driving wheel behind the birth of new economic structures and the destruction of existing ones. Subsequent theoretical contributions such as endogenous growth theory (Aghion and Howitt, 1992) and resource–based view (Kogut and Zander, 1994) have further expanded our knowledge about the link between creativity and innovations. However, the link between creativity and innovations is still far from understood.

The impact of innovations on various aspects of firm performance has been exhaustively investigated but the same cannot be said about the research on factors moulding the innovation process. What is common to existing research is the prevailing failure to acknowledge the complexity and interrelatedness of different stages of innovation process from the decision of firms to innovate, over their thinking about the amount of investment in research and development (R&D), the successful commercialization of innovations and finally the translation of successful innovations into better performance or efficiency of firms. Few empirical studies have attempted to establish a coherent framework that connects all of the above stages of innovation process (Loof and Hesmati, 2006; Griffith et al, 2006; Halpern and Murakozy, 2012; Hashi and Stojcic, 2013) and little or no attention within this body of work has been given to the creativity. To this end, there is the need to shed further light on the relationship between creative efforts of individuals, innovation process and efficiency of firms.

Creative pool of enterprises commonly involves creative individuals in different professions. At each of its stages, innovation process requires different set of skills and thinking. Managerial ability to employ right combination of creative skills at each innovation stage distinguishes successful innovators from the rest of firms. Conventional analyses focus on the relationship between individual stages of innovation process and creativity. As such they observe only part of the phenomenon and fail to acknowledge the entirety of these linkages. The whole picture of the relationship between creativity and innovation process requires a more complex approach that takes into account interdependencies between different stages of innovation process and the contribution of creativity to each of these stages.

Over recent decades two contributions have been put forward that, when brought together, can provide a new perspective for empirical studying of the relationship between creativity and innovations. Recently offered dynamic componential framework of creativity (Amabile and Pratt, 2016) conceptualises sequential nature of innovation process and elaborates on the role of individual creativity and individual and organizational enabling factors in this process. Such framework is conceptually close to already mentioned multi-stage model of innovation behaviour originally developed by Crepon et al. (1993) and later applied by several authors. Together, the two can be applied to explore the role of individual creativity in the whole process of innovation development from idea generation to its implementation.

With the above in mind the objective of this paper is to explore how creativity influences birth and commercialization of innovations and productive efficiency of firms in one of the world's leading economies, the United Kingdom. The paper investigates how hiring of employees with different creative skills impacts innovation process and productivity. The most significant contribution of paper

is its multi-dimensional approach to the role of creativity in innovation process. It relies on recently put forward dynamic component model of individual creativity and organizational innovation (Amabile and Pratt, 2016) that allows for cyclical and recursive nature of innovation process and models contribution of creativity to different stages of innovation development as well as learning feedback loops that emerge from previous innovation activities.

The investigation broadens our understanding of factors and forces that shape innovation process and improve productive efficiency of firms. It provides empirical evidence on an impact of the effectiveness of innovation process on the productivity of firms. The results reveal that creative skills contribute to the generation of novel ideas and investment in R&D but the ability to meet customer requirements draws from other organizational skills such as marketing or organizational innovations. Our findings reveal differences among economic sectors with respect to the forces driving the innovation process.

To address the above issues the data is extracted from the 2010-2012 UK Innovation Survey, a confidential dataset with limited availability to researchers that can be accessed only through secure servers of the UK Office for National Statistics. This dataset contains information on innovation activities, creative skills and performance of firms. The methodological approach of paper is adherent to the multi-stage innovation research (Crepon et al., 1998; Hashi and Stojcic, 2013) which analyses different stages of the innovation process from the decision of firms to innovate, to their decision on innovation expenditure, the relationship between innovation input and innovation output and finally the impact of innovation output on firm productivity. The advantage of such approach is the ability to assess contributions of different factors to each stage of the innovation process while taking into account the potential interrelatedness between these stages and the potential endogeneity of individual variables. As such it can provide valuable recommendations to managers of innovative firms.

The multi-stage approach to the innovation process has been applied previously in analyses of firm innovation behaviour but, to the best of our knowledge, there has been no such attempt to assess the role of creativity in different stages of the innovation process within this framework. The ability to assess the contribution of creativity to an entire innovation process within single framework and from there to the productive efficiency of firms presents additional valuable contribution of this paper to the existing body of knowledge. The paper is structured as follows. Next section provides an overview of existing research on the relationship between creativity, innovation effectiveness and productive efficiency. The characteristics of methodology and dataset are discussed in section three. The model of investigation is presented in section four and it is followed with discussion of results in section five. Finally, section six concludes.

2. Creativity, innovation effectiveness and productive efficiency

The success of modern firms increasingly depends on their ability to innovate. Over recent years many studies have pointed to creativity as a principal driver of innovation, profitability, market share and survival of firms (Amabile, 2000; Miron, Erez and Naveh, 2004; Andari et al. 2007; Huggins and Clifton 2011; Cooke and De Propris 2011). The general message coming from this literature is that innovation process starts from a creative idea whose concept has market potential, has received funding and has overcome some of the obstacles such as technology challenges and competitive pressures. These ideas are conceived through brainstorming activities of creative individuals or teams managed in a way that enhances their creative potential. Hence, no innovation is possible without the creative processes as the latter is often an initial invention or deep insight in some of several stages of innovation (Yusuf, 2009). From there it follows that creativity is a multi-dimensional concept that encompasses individual, team, organizational and multi-level perspective (Anderson et al., 2014).

Over the years, many scholars have attempted to draw a distinction between creativity and innovation. A common starting point in such efforts is the depiction of innovation as sequential process. In this process creativity enters as initial stage of intra-individual cognitive and inter-individual social efforts that result in a generation of novel and useful ideas (Amabile et al., 1996). However, such simplistic view cannot encompass the complexity of innovation and properly explain the role of creativity in its development. From its birth to commercialization the path of innovations is rarely linear. It often includes reiterative steps, exploration of new avenues and rethinking of original ideas. From within and outside of organization creative inputs flow into various stages of this cyclical and recursive process (Van de Ven et al., 1989; Paulus, 2002, Amabile and Pratt, 2016). It follows from there that contribution of creativity is not limited to an initial stage but extends over entire innovation process. Most empirical studies, however, fail to acknowledge complexity of the creativity-innovation construct and treat creativity as an initial stage of innovation process.

Recent empirical evidence from several studies suggests that the speed, frequency and magnitude of innovations are increasingly dependent on creativity of individuals both within and outside of organizations (Baldwin and von Hippel, 2011; Conaldi et al., 2012; Tonellato, 2014; Mascia et al, 2015). Along the same path theoretical advances on the creativity and its link with innovations have over past decades centered their efforts around understanding of traits and enablers of individual creative potential. In one set of explanations the focus is on traits of creative individuals. Another line of thinking is concerned with inter-personal, organizational and environmental factors that can lead to harnessing of individual creativity and brought together for the benefits of an entire organization and success of innovation process. Although these two lines evolved to the point where they form distinctive research streams they share the common central point of search for ways to form and extract the individual creative potential within organizations.

Individual creativity arises from combination of traits such as personality (Feist, 1999), expertise (Weisberg, 1999) and intellectual capabilities (Sternberg, 1995). It requires support of relational and social capital embodied in collaborative networks inside organizations (Björk & Magnusson, 2009). It is enhanced in dynamic environments characterized by unconventional ways of doing things, challenging authority, creating conflict, competition and taking risks (Baron and Tang, 2011). Flexible and decentralized organizational culture is considered to be supportive of creative action and innovativeness as it enables better flow of information that in turn facilitates teamwork and dissemination of ideas (Meyer, 1982; Nonaka, 1994; Garvin, 1993). Such organizational setting is, however incongruent with conformity principles ruling many modern organizations. It follows from there that creation of creative climate poses challenge on modern organizations of how to create a creative environment in which employees are motivated to engage in creative activities but at the same time to meet organizational rules and standards.

Apart from the above, individual creativity should be placed also in social and cultural context. Social contexts and cultural values shape the relationship between individuals' values and beliefs, their creativity and attitudes towards managerial and organizational incentives (Erez and Nouri, 2010; Zhou and Su, 2010). A culture that is tolerant to risk is also more tolerant to innovations making individuals more ambitious to search for creative ideas (Yusuf, 2009). Florida (2002) asserts that the creative class is especially attracted to places that are characterized by a tolerant urban climate that is open to new ideas and to newcomers. This diversity then serves as an inspiration to the creative thinking process (Andersen and Lorenzen, 2005).

All of the above discussions on creativity have been grouped together in a theoretical setup known as componential model (Anderson et al., 2014) that identifies individual creativity as core of creative process that can be enhanced through elements of organizational culture and managerial practices. Componential theory of creativity assumes three necessary ingredients for creative process to take

place defined as basic resources, individual creative thinking and drivers. The former two are relatively straight forward while latter has been subject of much discussion in the literature. Several scholars have argued that intrinsic motivation is likely to result in high creativity and therefore should provide opportunities by assigning employees to jobs that are challenging and complex in nature (Hackman and Oldham, 1980). Although the literature suggests that intrinsic motivation enhances creativity, some organizations rely on extrinsic rewards such as monetary incentives or recognition (Frese et al. 1999; Van Dijk and Van den Ende, 2002).

More recently Amabile and Pratt (2016) have put forward an extension known as dynamic componential model that attempts to encompass theoretical contributions on the relationship between creativity and innovation during past two and half decades and to offer comprehensive theoretical link between these two constructs. The model first establishes the traits of innovation and creative processes before it brings them together in a joint framework. As such it forms more realistic portray of the link between these two concepts than any of previous theoretical advances.

Under dynamic componential framework, innovation and creative processes emerge as analogous sequences of five stages whose paths intersect at some points. Innovation process in such framework begins with decision to innovate and advances through stages of investment in innovations, implementation and commercialization of original ideas. The successful completion of all these stages requires adequate work environment that includes motivation to innovate and skills in innovation management as well as availability of relevant financial, human, physical, intellectual, creative and other resources that can aid innovation process. Creativity develops in such framework through stages that involve preparation, generation and validation of ideas and assessment of achieved outcome. Analogous to innovation process, the generation of creative ideas is facilitated through three sets of individual components defined as intrinsic and extrinsic motivational factors, relevant skills and creativity-relevant processes (Amabile and Pratt, 2016).

The value added of dynamic componential lies in its setup of innovation and creative processes. Both types of enabling factors, work environment and individual components enter model in multiplicative terms. From there it follows that neither process can succeed if one of enabling factors is absent. Moreover, unlike previous models of individual creativity and organizational innovation, the dynamic componential framework does not assume termination of either process with success or failure outcomes. Instead it allows for learning and feedback loop towards new cycle of innovation. These features make it closer to cyclical and recursive nature of innovation process than any of its theoretical predecessors. Finally, like many of its predecessors dynamic componential framework assigns central role to creativity in idea generation stage of innovation process. However, it also allows for impact of individual creativity on other stages of innovation process. As outlined earlier, in their efforts to enhance innovation process organizations rely on all available and relevant resources in the task domain that can aid successful outcome of innovation process. Within these resources individuals with expertise, skills and interest in creative work have relevant role in any stage of innovation process.

Recent empirical findings on individual creativity and organizational innovation have been somewhat ambiguous. It seems that creative individuals make greater impact on product innovations and modifications of existing products than on process innovations (Lee and Drever, 2012). Evidence from several European Union member states adds to these also impact on production efficiency (Marrocu and Paci (2012). A recent study by Lee and Rodriguez-Pose (2013) examined the interrelationship between creative occupations and innovation in urban and rural environment. Results indicate that creative occupations are important factor in development of entirely new and learned innovations in both urban and rural locations. Among empirical studies on individual creativity and innovation, Yoshida et al. (2014) investigated how different leadership styles affect employee creativity and team innovation activities. Their results reveal relationship between leadership styles and innovation

success. The importance of leadership for creativity of employees has also been confirmed by Eisenbeis and Boerner (2013). Their findings suggest that transformational leadership has positive effect on the creativity of employees while the dependency of employees on their managers results in opposite.

Work of some authors suggests that translation of individual creativity into organizational innovation requires integration of knowledge, creative skills and expertise from several disciplines. The bridge from creative idea to successful innovation can not be crossed if all relevant perspectives such as financial, organizational, marketing or others are not taken into account. Litchfield et al. (2015) develop a model in which relationship between individual creativity and organizational innovation is moderated through combination of individual components defined as ability of perspective-taking and creative environment within the organization or team. Their findings are in line with predictions of dynamic componential framework on multiplicative moderating effects of enabling factors on link between individual creativity and organizational innovation as the two exercise moderating effect only jointly. In a similar vein, Pratoom and Savatsomboon (2012) observe mediating effect of organizational culture and self-leadership on introduction of new products and processes through individual creativity. Finally, along same line of thinking, Cekmecelioglu and Gunsel (2013) report the positive impact of individual creativity and organizational climate on successful market adoption of firm's innovations.

Other empirical studies taking organizational behavior approach found mixed results. Baron and Tang (2011) using survey data on 99 entrepreneurs in five South-eastern states of the United States and employing hierarchical regression analysis tested interrelationship between entrepreneur's positive affect and creativity and firm innovation moderated by environmental dynamism. The results indicate that both the relationship between positive affect and creativity, and the relationship between creativity and innovation, are moderated by environmental dynamism and are stronger in highly dynamic environment. Similarly, Sohn and Jung (2010) investigated the determinants of creativity by genetic abilities of employees or by the external environment and the effects of creativity on firm performance in South Korea. They used Structural Equations Modelling to investigate direct, indirect and total effects of factors influencing innovation process and creativity in a company and determine the degree of influence of innovative performance and creativity on each factor. They found that Korean companies are in general interested in creativity, however its impact on innovation is insignificant. Zdunczyk and Blenkinsopp (2007) adopted Martins and Terblanche's (2003) theoretical framework to explore which organizational factors influence creativity and innovation among Polish managers. The findings suggest that strategy, organizational structure and employee's behaviour are less supportive of creativity and innovation in domestic firms compared to foreign owned firms.

Summing it all up, it can be concluded that theoretical advances on relationship between creativity and innovation have reached the stage where it is widely acknowledged that innovation develops through phases in all of which creative inputs can be made. While being complex and shaped with organizational culture, innovation and creativity management practices as well as team environment organizational creativity at its core depends on creativity of its individuals. Existing body of knowledge suggests that successful translation of individual creativity into innovations requires complementary support of all enabling factors. This process, however, is not uni-directional but rather cyclical and recursive as organizations learn from their past creative efforts and innovation experiences. These findings enable us to put forward research questions of our investigation.

In building of research questions we start from theoretical premises put so far particularly nexus of evolutionary and Schumpeterian propositions mentioned in the Introduction and dynamic componential framework elaborated in this section. The former in coherence with endogenous growth models and more recent management theories such as resource-based view suggests that new products

and processes enable firms to differentiate from their rivals and achieve superior performance results. *As its first research question our investigation thus aims to investigate what is the impact of innovation activities on productive efficiency of firms.*

The discussion from this section assigns pivotal role in innovation process to individual creativity. Under premises of dynamic componential framework creative efforts of employees influence different stages of innovation process. Enterprises that harvest creativity are those that create such organizational climate which yields original and novel ideas that can be transformed into commercially successful goods and services. In this process, the decisive role belongs to creative employees who are able to identify problems and figure out new organizational solutions combine ideas and knowledge in new innovative ways. Hence, hiring of such employees and their management are of decisive importance for success of innovation efforts. *From there a second research question emerges that wishes to examine whether and in what way creative employees influence innovation activities of firms.*

The creativity is a complex concept. It emerges across range of talents and skills all of which are important for the success of innovation process. Firms aiming to secure success of their innovation activities must seek not only creative employees but more importantly those employees that can bring creative difference in key areas for firm performance. As outlined throughout this section, challenge for management of innovative organizations consists of the ability to recruit creative personnel and to combine creative resources in order to maximise their potential. *The third research question of the paper will explore, thus, whether employees with creative skills of different kinds are equally important for all stages of innovation process.*

Finally, creativity does not influence only innovation activities but also firm performance. The relationship between creativity and firm performance is indirect and takes place through innovations as transmission channel. From there it follows that the firm performance such as productive efficiency will be higher among those firms that are more successful in harvesting creativity for innovations. From there, *the final research question of the paper will examine whether creativity influences productive efficiency of firms indirectly through its impact on the innovation process.*

3. Model and methodology of investigation

Our theoretical framework asserts that innovations do not emerge instantaneously. They develop through process that consists of several stages. Broadly speaking these can be divided in three categories as the decision to innovate or the birth of idea about innovation, the investment in R&D activities or the input in innovation process and finally transformation of previously mentioned ideas and investment into commercially viable goods and services. In theory, these three stages are related but empirical research failed to acknowledge this link in many cases. However, building on foundations of Crepon et al. (1998) several studies have adopted empirical strategy that connects previously mentioned stages of innovation process and then pours innovation output into firm performance (Loof and Hesmati, 2006; Griffith et al, 2006; Halpern and Murakozy, 2012; Hashi and Stojcic, 2013). Even though none of these studies deals with the role of creativity in the innovation process they provide a framework under which the contribution of creativity can be examined.

To assess the contribution of creativity to the innovation process, a model is applied that portrays innovation process through four stages. First two stages of the model observe the determinants of the decision of firm to innovate and its decision on the amount of research and development expenditure. The unobserved decisions of firm to innovate g_i^* and to allocate certain amount of investment in innovation k_i^* are portrayed with their observable counterparts g_i and k_i from where the first two stages of the model can be defined as follows:

$$g_i = \beta_0 x_i^0 + u_i^0 \quad (1)$$

$g_i = 1$, if $g_i^* > 0$, otherwise $g_i = 0$

and

$$k_i | g_i > 0 = \beta_1 x_i^1 + u_i^1 \quad (2)$$

$k_i = k_i$ if $k_i^* > 0$, otherwise $k_i = 0$

The impact of different determinants on the decision of firms to innovate and on their actual level of expenditure on innovation is assessed through the set of independent variables x_i^0, x_i^1 and their corresponding parameters β_0, β_1.

The third stage of model is concerned with the effectiveness of innovation process defined as the success in commercialization of innovations. It is expressed through:

$$t_i = a_k k_i + \beta_2 x_i^2 + u_i^2 \quad (3)$$

In equation (3) the observed innovation effectiveness t_i is specified as function of research and development efforts k_i estimated in equation (2) and set of explanatory variables x_i^2 among which the inverse Mills' ratio is included as a control for selection bias. The productive efficiency of firms enters (3) also to control for potential feedback effect. The final stage of innovation process deals with the impact of innovation effectiveness on productive efficiency of firm. This relationship is modelled as:

$$q_i = \alpha_t t_i + \beta_3 x_i^3 + u_i^3 \quad (4)$$

with q_i indicating the firm's productive efficiency, t_i representing estimates of innovation effectiveness from Equation 3, x_i^3 being vectors of independent variables.

In all four equations it is assumed that disturbances u_i are randomly distributed and not correlated with explanatory variables. However, it is assumed that these error terms are semi-correlated with each other through the unobserved heterogeneity stemming from managerial characteristics, financial factors or market conditions. To allow for such correlation, the first two equations are estimated in a framework of generalised tobit model. Our model may also be prone to potential endogeneity of some of the explanatory variables. The R&D expenditure enters equation (2) as dependent variable but appears on the right hand side of the equation (3). Similarly, innovation effectiveness, the dependent variable of equation (3) is among regressors of equation (4). This problem is taken into account through the estimation in a simultaneous equations framework of three-stage least squares where potentially endogenous variables are being controlled for with proper instrumentation. The contribution of creativity to innovation activities and productive efficiency is modelled through a set of variables that enter first three stages of the model. From there it follows that the impact of creativity on firm performance is modelled indirectly through its impact on the innovation process.

4. Data and variables

The investigation is based on the data of the 2010-2012 UK Innovation Survey undertaken by Office for National Statistics, the main source of information on the innovation activities of firms in the United Kingdom. This survey corresponds to similar Community Innovation Surveys undertaken biannually across European Union member states and survey questionnaire is developed by Eurostat.

Typically, Community Innovation Survey questionnaires consist of set of standard questions that repeat through every survey round and set of questions on specific topic that change in each round of survey. The 2010-2012 round included set of questions on hiring of employees with creative skills which made available this research. The dataset contains information on innovation activities of nationally representative sample of firms with 10 or more employees across all major sectors of economic activity. The sample was stratified with respect to business size, sector and region of the surveyed firm.

The survey was distributed to 28.365 firms of which 14.487 firms responded which constitutes response rate of 51.1%. The dataset is not publicly available and can only be accessed through special secure access arrangement with UK Data Service. The access is provided under terms that no information that can potentially lead to identification of surveyed firms can be taken out. This means that no descriptive statistics can be provided as well. Among surveyed firms, there are also those that did not provide all required information and as such cannot be used in analysis. After adjustment for these firms, the sample covers 13683 firms of which about one third (4482) have invested in some form of innovations over analysed period and about 17% (2258) have successfully commercialized their innovation efforts.

Our modelling strategy aims to meet several objectives. First it aims to assess determinants of innovation effectiveness and productive efficiency. Second, it aims to investigate factors moulding different stages of the innovation process. Third, it aims to explore the role of creativity in different stages of this process, and fourth it aims to assess the differences in innovation process and related importance of creativity within individual economic sectors. The multi-stage model has been developed to meet these objectives that consists of four equations corresponding to the decision to innovate, decision to invest in innovation, innovation output equation and productivity equation. All model variables have been developed on the basis of answers provided by respondents and in line with theoretical framework of the paper.

The dependent variables of the four stages of the model are defined as follows: The dependent variable of equation (1) defines firm as innovative if it reported a positive amount of innovation expenditure of any kind. In the equation (2), the left-hand side variable (R&D expenditure) is the natural logarithm of total innovation investment, regardless of its source over 2010-2012. period. The effectiveness of innovation process is modelled in the third stage. Schmidt and Finnigan (1992) defined effectiveness as the ability of organization to meet requirements of customers. Following this definition, a dependent variable of third stage is defined as the natural logarithm of the proportion of sales attributable to new products. An increase of this measure would signal better ability of firm to recognize needs of its customers.[1] Finally, following Kling (2006), the productive efficiency of firm in the equation (4) is measured with labour productivity, the ratio of turnover to total employment of firms in 2012.

Our primary interest lies in the modelling of *creativity*. As explained earlier, in 2010-2012 round of survey participating firms were asked whether in three years prior to the survey they hired employees with creative skills in areas of graphic arts, design of objects, multimedia and web design, software development, engineering, applied sciences and mathematics and statistics. From there, three categorical variables were constructed that take value of one if firm hired employees with creative skills in some of the following areas. First variable takes value of one if firm hires individuals with creative skills in areas of graphic arts and design (*Graphic and design creative skills*). The second

[1] Innovation effectiveness and innovation output are similar but not exactly the same. If innovation output is measured as, for example, number of new products, the two are not the same as the number does not indicate success of the products with customers. However, when the output is measured as the proportion of sales arising from new products (as in this paper), the two concepts are the same.

variable controls for firms that hire employees with creative skills in the area of information technologies such as multimedia and software development (*IT creative skills*). Finally, the third variable controls for the contribution of creative skills in applied and technical sciences (such as engineering and mathematics) to the innovation process (*Applied and technical sciences creative skills*). It is likely, however, that all sorts of creative skills will not exercise same weight in all sectors of economic activity. To control for such sectoral effects, the model also includes two sets of variables controlling for sector specific creativity effects in manufacturing and service sectors (interaction terms indicating creative skills in the two sectors). All creativity-related variables enter equations (1) – (3). It is thus assumed that the impact of creativity on productive efficiency takes place through innovation effectiveness channel.

Among controlling variables that enter all four equations model includes measure of *firm size* (the natural logarithm of a number of employees) and categorical variable for firms that sell their products on international market (*exporting*). These two variables control for factors such as economies of scale, business experience, learning by exporting and international demand and competition factors. Across all equations model also includes categorical variable for firms that hire at least 50% of staff with tertiary education (*academic degree*) as a proxy for the quality of human capital. In survey questionnaire firms were asked also about factors hampering their innovation activities divided in three groups as *cost factors, knowledge and market factors*. The former two enter model as categorical variables in first two equations while the latter one enters only first equation. The reason for this is the fact that respondents were asked about importance of market factors solely in context of the decision to innovate while other two variables were constructed on the basis of answers on questions aiming on an entire innovation process.

The determinants of the decision to innovate (1) and the decision on amount of investment in R&D (2) include also dummy variables for firms that introduced *organisational and marketing innovations*, a dummy variable for *ongoing and abandoned innovations* and two categorical variables for *manufacturing and service sectors*. Equation (2) also includes two categorical variables controlling for firms that received *national and EU subsidies* for the development of innovations. The innovation effectiveness is specified as function of, R&D expenditure from the second stage, the inverse Mills ratio from the first stage; controls for EU and national subsidies. The model also includes in this stage controls for firms that had ongoing or abandoned innovation activities (reflecting potential experience) and for firms that cooperated with actors from their environment (firms, universities, professional institutions, etc) on the development of innovations. There are four variables for *sources of information* on innovation including internal sources, market sources, institutional sources and other sources. Finally, the productive efficiency is specified as a function of, innovation effectiveness from the third stage; organisational and marketing innovations, and previously abandoned or ongoing innovations.

5. Discussion of results

The results of investigation are presented in Tables 1 and 2 where Equations 1 to 4 refer to the four stages of the innovation process discussed in the previous section. For expositional convenience, the variables are grouped by their characteristics and their role in answering of research questions. Our starting point is the question on the impact of innovations on the productive efficiency. Model diagnostics (LR test) reveal existence of relationship between first and second stage of innovation process (the decision to innovate and decision on innovation investment). Moreover, the impact of innovation expenditure from the second stage on innovation effectiveness (innovation output) in the third stage is also positive. Finally, a positive impact of innovation output on firm productivity is confirmed as well. Together these findings suggest that innovations have beneficial effect on productive efficiency of firms and thus answer our first question.

(Table 1 about here)

The findings on the role of creativity in innovation process offer interesting story. It appears that creative skills are relevant in early stages of innovation process (decision to innovate and invest in R&D) while the implementation of innovations (the effectiveness of innovation process) requires stronger conformity and meeting of rules and standards which may be incompatible with creativity. From there it follows that organisations that do not hire individuals with creative skills are more effective in developing products that meet requirements of their customers. However, it is possible that our results reflect the inability of managers to exploit the full potential of individuals with creative skills in this advanced stage of the innovation process (transformation of innovation inputs into innovation output). Regarding sectoral differences in management of creativity, we observe positive impact of creative skills in information technology in both services and manufacturing sectors as well as positive impact of creative skills in applied and technical sciences on the decision to innovate in the manufacturing sector and on the decision on innovation expenditure in the service sector. However, the impact on the innovation output stage is largely negative or insignificant which is consistent with our previous findings.

(Table 2 about here)

Among factors constraining innovation we obtain positive sign in first equation on all three variables. Such finding is consistent with earlier literature (e.g. Hashi and Stojcic, 2013) and can be taken as a sign that constraining factors motivate firms to search for new ways of survival including innovations in order to differentiate themselves from their rivals. There is also evidence that organisational and marketing innovations such as changes in supply chain management, business re-engineering, improvements in the knowledge and quality of management, introduction of new systems of employee responsibilities, team work, decentralization, training of employees as well as new methods of organising external relations and the implementation of changes to marketing concepts or strategies are beneficial for the firm's innovation activities. The model also includes, in second and third stage, two variables controlling for access of firms to national and EU subsidies for innovation. Reported findings suggest that firms receiving subsidies spend more on innovation but are less effective in the commercialization of innovations. These findings question the validity of existing innovation subsidy schemes.

Previous experience in innovation activities is beneficial for both decision to innovate and transformation of innovation inputs into outputs. Similarly, cooperation with subjects from external environment such as rivals, suppliers and distributors, consultants, professional and scientific institutions as well as universities and research institutes has beneficial effect on innovation output stage. Our model also includes four variables controlling for sources of information on innovation activities, internal sources, market, institutional and other sources. The positive impact of these sources on innovation expenditure and the negative impact on innovation output stage is further signal of suboptimal use of available resources in innovation process. Finally, we obtain positive coefficient on the variable controlling for the quality of human capital in firm, a categorical variable taking value of one if firm employs more than 50% of employees with tertiary education in first two stages but negative coefficient in the third stage. Such finding may be signal that managers within these firms fail to exploit the full potential of their human capital, consistent with our already reported findings on the management of individuals with creative skills.

Finally, significant coefficients are obtained on nearly all variables controlling for manufacturing and service industry suggesting the presence of industrial heterogeneity in innovation process. In all four stages we observe the positive and statistically significant impact of firm size. This signals that

economies of scale and other drivers of efficiency associated with larger firms motivate them to engage in innovation, spend more in this process and be more successful in the commercialization of their innovation efforts. The evidence suggests that exporting firms are more likely to engage in innovation than their non-exporting counterparts; they spend more on innovation and are more productive but they are less successful in transforming innovation inputs into innovation output. On the basis of these findings it can be concluded that these firms base their competitiveness on non-innovative products despite investing strong efforts in innovation activities.

6. Conclusions

Over past years, significant efforts have been invested in understanding innovation activities and the process of innovation. The interest in this matter stems from the beneficial impact of innovative efforts on firm performance and competitiveness. The existing research in this area has pointed to a number of factors that facilitate the innovation process. However, within the vast amount of literature produced on this topic, the relationship between creativity and innovation has been relatively unexplored. This is particularly surprising as the importance of creativity for innovation has been recognised in the academic literature for several decades. With this in mind the objective of this research was to explore the impact of creativity on different stages of the innovation process among firms in advanced European economy. The paper uses a dataset not publicly available to researchers, containing information on innovation activities, performance and creative efforts of firms for its empirical investigation.

The findings from our research provide support to the long line of investigation suggesting that there is a positive relationship between the decision of firms to innovate, their innovation expenditure, innovation output and productivity. These findings suggest that the effectiveness of the innovation process, i.e. the ability of firms to meet requirements of their customers has positive effect on productive efficiency. Similar positive effects can be associated with firm size and R&D process. Most importantly, there is evidence of the impact of creativity on all stages of innovation process. Our findings in this respect are in line with recently put forward dynamic componential model (Amabile and Pratt, 2016). To this end, investigation established that innovation process develops through several stages before it eventually translates into higher productive efficiency of firms. Evidence was also found in favour of feedback loops introduced in dynamic componential framework and mentioned in section two. Our findings are in line with predictions that previous innovation experience facilitates generation of novel and useful ideas but also helps in translation of these ideas into successful innovations.

Through all stages of innovation process effects of enabling work environment elements and external characteristics are found. Our results have also confirmed the relationship between individual creativity and all stages of innovation process. The effects are positive in initial stages of innovation process, as predicted by much of existing literature but opposite holds when it comes to the commercialization of innovation efforts (innovation effectiveness). This finding can be attributed to the inability of managers to optimally exploit the creative potential of their staff in all stages of the innovation process but. It seems plausible if one looks at a number of other reported findings such as the utilization of sources of information in the innovation process, the use of subsidies, exporting and the use of staff with tertiary education. However, in line with arguments of Litchfield et al. (2015) the negative effect of creative individuals on innovation effectiveness can be associated with their propensity towards perspective-taking. The inability to consider organisational, financial and other aspects of innovation development all of which are relevant at such advanced stage can lead to conflict and even result in negative effect of creative individuals on innovation success.

Above findings have important implications for managers. They reveal that creative skills of employees are not equally important in all stages of innovation process. Thus, organizational structure should be organized in a way that enables optimal exploitation of the creative potential. In management of innovation process, one should take into account also sectoral heterogeneity as our evidence reveals. Our research also has implications for policy makers. On the one hand, findings on use of subsidies question the effectiveness of existing subsidy schemes in the field of innovations. On the other hand, while some of our findings can be associated with managerial inability to optimally exploit potential of their organizations they may also be associated with wider weaknesses in the structure of particular policies. This primarily refers to findings on the use of staff with formal tertiary education. A likely explanation for our finding is mismatch between acquired knowledge of employees and skills required by enterprise.

While contributing to a relatively unexplored area of the relationship between creativity and innovation, the present research has several limitations. First, it is undertaken on the sample of firms from only one country. Second, it focuses on only one period in time due to the nature of data (three-yearly Community Innovation Surveys). Third, it does not take into account many other factors related to the innovation process such as financial factors. However, perhaps the most important drawback of the research is its inability to address all aspects of creativity. Hiring employees with creative skills presents only the first step in developing the innovation potential of firms. The ability of talented individuals to generate novel ideas depends also on the ability of their managers to create favourable climate and to employ proper methods to stimulate creativity. Unfortunately, dataset for the UK does not provide information on such managerial activities and this issue remains to be addressed by subsequent research. Together, these limitations of our work can be considered as guidance for future research.

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Table 1: Results of estimation – innovation process and creative skills of employees

Variables/ Equations	**1**	**2**	**3**	**4**
Innovation process				
Innovation input	-	-	4.98***	-
Innovation output	-	-	-	0.26**
Inverse Mills ratio	-	-	0.03	-
Creative skills of employees				
Graphics & Design creative skills	0.32***	0.13**	-0.58***	-
IT creative skills	0.34***	0.20**	-0.99***	-
Applied and technical sciences creative skills	0.31***	0.46***	-2.19***	-
Graphics and design creative skills in manufacturing	0.03	-0.18	0.66***	-
IT creative skills in manufacturing	0.21*	-0.004	0.15	-
Applied and technical sciences creative skills in manufacturing	0.18*	0.13	-0.57***	-
Graphics and design creative skills in services	-0.20*	0.23	-1.04***	-
IT creative skills in services	0.23**	0.02	-0.15	-
Applied and technical sciences creative skills in services	-0.07	0.45***	-2.14***	-
Number of observations	13683	4482	2258	2258
LR test	0.35***	-	-	-

Table 2: Results of estimation – control variables

Variables/ Equations	**1**	**2**	**3**	**4**
Factors hampering innovation				
Cost factors hampering innovation	0.39***	0.02	-	-
Knowledge factors hampering innovation	0.19***	-0.06	-	-
Market factors hampering innovation	0.10***	-	-	-
Subsidies				
EU subsidies	-	0.81***	-3.81***	-
National subsidies	-	0.52***	-2.58***	-
Sources of information on innovation				
Sources of information on innovation – internal	-	0.32***	-1.41***	-
Sources of information on innovation – market	-	0.22*	-1.13***	-
Sources of information on innovation - institutions	-	0.40***	-1.91***	-
Sources of information on innovation - others	-	0.11*	-0.45***	-
Human capital quality				
Academic degree	0.13*	0.57***	-2.74***	-0.10
Previous innovation experience and cooperation				
Ongoing and abandoned innovations	1.35***	-	0.09*	-0.04
Cooperation in the development of innovations	-	-	0.14**	-
Organizational and marketing innovations				
Organisational innovations	1.54***	0.06	-	-0.12*
Marketing innovations	1.40***	0.04	-	-0.06
Other				
Firm size	-0.02*	-0.43***	2.04***	0.06***
Exporting	0.45***	0.80***	-3.93***	0.48***
Manufacturing	0.05	0.60***	-2.92***	-0.06
Services	-0.11**	-0.03	0.28***	-0.40***
Constant term	-1.77**	0.07	2.14***	3.51***
Number of observations	13683	4482	2258	2258
LR test	0.35***	-	-	-

Source: Own calculation

***,** and * note statistical significance at 1%, 5% and 10% level of significance respectively.