

UNIVERSITY OF PARDUBICE
FACULTY OF ECONOMICS AND ADMINISTRATION

**INFLUENCE OF SELECTED DETERMINANTS OF THE KNOWLEDGE
PRODUCTION FUNCTION ON INNOVATION PERFORMANCE IN REGION**

Dissertation

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In Pardubice on June 26, 2025

Emmanuel Ebo Arthur by own hand

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DEDICATION

I wish to dedicate this research dissertation to my wife Ms. Georgina Gyan and kids- Fiifi Nhyira Arthur and Lois Ewura Efua Arthur.

ANNOTATION

Global production of knowledge is essential for innovation. To remain competitive and profitable, firms must improve their innovation performance continuously. Knowledge is a crucial driver of innovation, and universities, firms, and governments engage in various activities to manage, share, and transfer knowledge effectively. Knowledge-production function comprises several knowledge-based determinants. Although determinants of knowledge production function have significantly contributed to promoting innovation performance in the EU, few studies have examined the context they influence the relationship. This study addresses the gap in current literature by (i) examining the direct influence of knowledge-based determinants (knowledge management, knowledge networks and knowledge diffusion) on innovation performance among moderate and emerging EU countries and (ii) assess the context in which factors in the business environment moderates the relationship. Furthermore, this study proposes the best practices and strategies used by firms in moderate and emerging innovative EU countries to enhance firm innovation performance.

KEYWORDS

Knowledge Management, Knowledge Networks, Knowledge Diffusion, Innovation Performance, Production Function, Marginal Effects Approach.

NÁZEV

Vliv vybraných determinantů znalostní produkční funkce na inovační výkonnost regionu

ANOTACE

Globální produkce znalostí je pro inovace zásadní. Aby firmy zůstaly konkurenceschopné a ziskové, musí neustále zlepšovat svou inovační výkonnost. Znalosti jsou klíčovým motorem inovací a univerzity, firmy a vlády se zapojují do různých aktivit, aby znalosti efektivně spravovaly, sdílely a přenášely. Znalostní produkční funkce zahrnuje několik determinantů založených na znalostech. Ačkoli determinanty znalostní produkční funkce významně přispěly k podpoře inovační výkonnosti v EU, jen málo studií zkoumalo kontext, ve kterém dochází k utváření tohoto vztahu. Tato disertační práce řeší mezeru v současné literatuře (i) zkoumáním přímého vlivu determinant založených na znalostech (řízení znalostí, znalostní sítě a šíření znalostí) na inovační výkonnost v specifickém souboru zemích EU (dle stupně rozvoje) a (ii) posouzením kontextu, v němž faktory v podnikatelském prostředí tento vztah moderují. Studie dále navrhuje osvědčené postupy a strategie používané firmami v zemích EU ke zlepšení inovační výkonnosti firem.

KLÍČOVÁ SLOVA

Řízení znalostí, Znalostní sítě, šíření znalostí, inovační výkonnost, produkční funkce, přístup mezních efektů

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LIST OF ABBREVIATIONS

EU	European Union
KPF	Knowledge Production Function
CIS	Community Innovation Survey
KM	Knowledge Management
KN	Knowledge Network
RIS	Regional Innovation System
IVPROBIT	Instrumental Variable Probit Regression
FDI	Foreign Direct Investment
VIF	Variance Inflation Factor
IPRs	Intellectual Property Rights
KIBS	Knowledge Intensive Business Services
HR	Human Resource
WBES	World Bank Enterprise Survey

INTRODUCTION

The production function is a critical economic and mathematical concept that demonstrates the connection between the inputs and outputs of a production process. Mathematically, a simple production function can be expressed as $Q = f(K, L)$, where Q represents the maximum output, K and L represent capital and labour inputs, respectively, and f denotes the function. Raw materials, technology, labour, and capital are input factors, while goods and services are output factors. Understanding the relationship between input and output factors is essential because it reveals the most effective combinations of labour, capital, raw materials, and technology in production. Output is a function input factor in the production function ecosystem. This makes the output a dependent variable and the input factor independent. The production function can also be considered the maximum output achieved through a mix of input factors, usually labour and capital. Companies aim to maximize profits by using their resources efficiently, and therefore, they substitute and combine input factors in ways that allow them to reach a specific output target. The graphical representation of the production function in Figure 1 illustrates how labour and capital interact to produce a given output (Q).

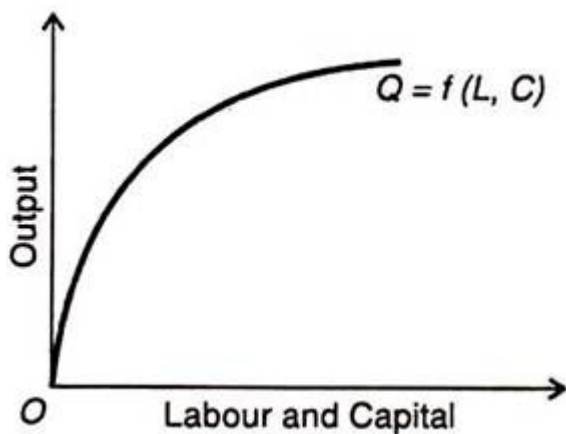


Figure 1: Graphical presentation of the production function

The present text depicts a graphical representation of the short-run functional relationship between output and one input, i.e., labour and capital, with the Y-axis representing output and the X-axis representing labour. The curve begins at the origin, with zero labour, and as more labour is employed, output increases, but eventually, the curve bends downwards in a concave manner, signifying a diminishing marginal

product of labour. This concept applies to various areas, including resource allocation, policy evaluation, and cost analysis, where firms utilize the production function to determine the most efficient means of combining inputs and allocating resources to produce high-quality goods and services. Moreover, knowledge of the production function aids in assessing the impact of policy changes and policy combinations on output. In a cost analysis, the production function helps to reduce costs through an effective and efficient combination of inputs for better output. The production function is linked to several economic theories, including Keynesian economics, neoclassical economics, supply and demand theory, and endogenous growth theories. John M. Keynes is considered the father of Keynesian economic theory, which assumes that the market lacks the capacity to restore equilibrium naturally and requires government intervention. It emphasizes the influence of aggregate demand on outputs, the use of factor inputs, and technology in economic development. The Keynesian theory reflects the concept of the production function, as it illustrates how factor inputs and technology impact output. Factors such as labour, capital, and technology are crucial in the production process of achieving high-quality goods and services. According to neoclassical economic theory, the production function models the relationship between these inputs and their outputs. Neoclassical economists, as proposed by Marshall, believe that individuals make rational decisions to maximize utility, firms strive to maximize profits, and people base their choices on available information. **The production function assumes that firms aim to maximize profits by combining inputs efficiently to produce optimal outputs.** However, as more inputs are added to production, diminishing returns set in, causing output to increase at a diminishing rate and eventually decrease, to restore equilibrium and increase output in the long run, fixed inputs should be expanded. This enhances the understanding of resource allocation and productivity growth as indicated by the production function. Demand and supply theories are fundamental concepts in economics. Demand theory examines how consumers purchase goods at different price levels. Although the production function does not directly influence demand, it indirectly affects demand through supply. Supply theory determines the quantity of output that a firm can produce given the available inputs and their efficient combination. Fewer and less efficient inputs lead to a decrease in output. Similarly, consumer demand determines the price and quantity of a firm's output. In cases of high demand, firms may adjust their production functions by increasing their input combinations to boost output. Another economic theory related to the production function is endogenous growth theory. Endogenous growth theory posits that Economic growth is primarily driven by internal processes and systems, which are

enhanced by a country's human capital, technological advancements, and efficient means of production. Improving productivity requires investment in innovation and human capital. The connection between endogenous growth theory and the production function is evident in the input factors such as innovation, new knowledge, and human capital within the economic system. Endogenous growth theory combines these internal inputs to boost productivity. This study builds on existing research on the production function, specifically on the selected determinants of the knowledge production function and their impact on innovation performance in the European Union.

This study is significant in theory and practice. It provides insight into how knowledge creation and dissemination drive firm and regional innovation necessary for economic growth and competitiveness. Disparities at the firm and regional levels are linked to differences in determinants and resources. Understanding how the determinants of knowledge production function promote innovation helps policymakers design and implement tailored and inclusive growth policies that fit firms and regions for economic growth and competitiveness. This helps to reduce inequalities and regional disparities. Knowledge production in the current knowledge economy involves collaborations and networks of multiple actors such as government, universities and industry. Examining the impact of selected determinants of knowledge production function on innovation helps comprehend how collaborative networks and spin-offs help in knowledge sharing and diffusion, leading to innovation. This makes firms and economies more resilient and competitive in the innovation ecosystem. Theoretically, the study helps understand the role of external and internal determinants of knowledge production function in the innovation creation process. Thus, firms and economies can leverage knowledge-based determinants within and outside their scope to create innovation. This is linked to the axioms of endogenous and exogenous growth theories. Exogenous growth theory supports growing a firm or an economy from external determinants such as capital and labour. In contrast, endogenous growth theory supports reliance on internal determinants such as human capital, research and development, and technological innovation. The study extends the literature on growth theories by emphasizing the value of determinants such as labour, capital, human capital, R&D and technological innovation in innovation and economic growth. The findings from this dissertation study are relevant and significant to academia and practical policy formulation and implementation.

The dissertation is organized as follows: chapter one provides the theoretical framework of the dissertation, chapter two examines literature on innovation performance, knowledge production function

and its selected determinants, chapter three explores the dissertation gap, aim and objectives, chapter four presents the methods and materials, and chapter five covers the results of the dissertation. Chapter six is the discussion and chapter seven presents the conclusion of the study.

1. THEORETICAL FRAMEWORK OF THE STUDY

Innovation is a vital driver of economic growth, competitiveness, and technological progress, and the knowledge production function plays a significant role in fostering these processes. Examining the effects of the determinants of the knowledge production function on innovation necessitates the use of multidisciplinary theoretical frameworks from economics, innovation studies, and organizational studies. Regional economics broadly categorizes factors that drive long-term economic growth based on exogenous and endogenous growth theories. These theories have also paved the way for more advanced models based on the assumptions and options of exogenous and endogenous growth theories. This study explains the exogenous and endogenous growth theories and their related models. Again, the study treats other theories whose principles align with knowledge production function and innovation performance nexus. The following section discusses the theories in detail.

1.1 Exogenous Growth Theory

The exogenous growth model asserts that long-term economic growth is influenced by external factors such as technological progress. The Solow-Swan model is the most popular exogenous growth model (Abreu, 2021). It identifies capital and labour as the external factors that drive economic growth and explains capital accumulation, labour, or population growth as the function of economic growth. It assumes that capital accumulation can experience diminishing returns (Atangana & Goufo, 2022). Capital accumulation is investing in physical assets such as machinery and infrastructure. The diminishing returns of capital mean that, as more and more capital is added to the production process, additional output decreases over time. Due to diminishing returns associated with capital, it cannot produce additional output in the long run. Hence, there is steady state growth and constant returns to scale in production. Another distinctive axiom of exogenous growth theory is technological progress. Technological advances enhance capital and labour productivity, leading to sustainable economic growth. However, the exogenous growth theory does not explain the drivers of technological progress. Technological progress is assumed to occur at a constant, unidentified rate, independent of economic activities like R&D. Exogenous growth theory is beset with limitations such as unexplained technological progress and non-inclusion of human capital and R&D as drivers of economic growth. Exogenous growth theory treated technological

progress as an external unexplained force driving economic growth. It stated that, in addition to labour and capital driving economic growth, another unidentified factor drives economic growth. Exogenous growth theory does not explain how the unidentified factors arise and influence economic activities and policies. In recent times, no economy can achieve innovation and economic growth without human capital (education, skills) and R&D. Exogenous growth theory does not include these important factors that drive innovation and economic growth. This study connects with exogenous growth theory because it gives extensive insight into how capital and labour contribute to regional innovation and knowledge creation. **In the context of external factors, the exogenous growth theory explains that firms' and economies' innovations are influenced by technology transfers, labour mobility, foreign direct investments and imports of high-tech products from more advanced regions. This implies that an economy or firm open to the external world attracts new knowledge to enhance innovation and economic growth. Having established the meaning and axioms of exogenous growth theory, the following sections explore theories propounded under the principles of exogenous growth theory.**

Technological Diffusion Model

The technological diffusion model aligns with the exogenous theory (Novales et al., 2021). It is the process of spreading new technologies from the place of invention or innovation to other firms, countries, or regions. The model shows why and how firms and countries adopt technology and the factors influencing the adoption rate. The technological diffusion model explains that technology adoption is a process in stages (Kim, 2020). First is the innovation stage. At the innovation stage, the new technology is introduced and tested. This stage attracts few users referred to as early adopters because the new technology is not well known in the market, and potential users are skeptical about its efficacy. The second stage is referred to as the adoption stage. At this stage, the success of the new technology becomes prominent, and as new firms, countries, or regions observe it, they adopt its usage. This accelerates the diffusion rate of using the new technology. The final stage is referred to as the saturation stage. After some time, the diffusion process of technology slows down because it does not attract new users at the saturation point. Thus, most potential users have already adopted and used it. Novales et al. (2021) identified cost and benefit, knowledge and skills, availability of infrastructure, institutional policies and openness to trade and foreign direct investments as factors influencing technological diffusion. These elements influence the speed and efficiency of new technologies adopted and implemented across various economies. For example,

businesses and economies opt for new technology with consideration of the cost-benefit analysis if the expected benefits exceed the expenses. This is particularly evident in moderate and emerging innovative economies, where the high cost of training new employees or acquiring new equipment can hinder the spread of technology adoption. In addition, the capacity of firms and economies to embrace and implement new knowledge relies on the skill level and expertise of the workforce. Consequently, skilled and knowledgeable workers can swiftly grasp and implement new technologies, enhancing technology diffusion.

Regarding infrastructure, advanced transportation and information and communication technologies enable firms and economies to access and integrate new technologies efficiently. Institutional policies, such as tax incentives for R&D and subsidies for technology adoption, can enhance the spread of knowledge and technology, and bureaucratic barriers may impede the adoption of new technologies. Finally, openness to trade and foreign direct investment (FDI) attract advanced technologies to economies. FDI introduces new technologies into an economy, fostering the spread of knowledge and technology and encouraging local innovation. For instance, China's technological progress is primarily driven by multinational corporations, which stimulate knowledge spillover and technology adoption (Wang et al., 2021).

The technological diffusion model is relevant to this study because it highlights how firms, countries, and regions absorb and use new knowledge created elsewhere. It connects with the knowledge production function's process of promoting innovation by absorbing external knowledge and technologies. Again, the technological diffusion model helps to understand how the determinants of the knowledge diffusion model, such as firm collaboration, R&D investments, and high-tech exports, facilitate knowledge diffusion through new knowledge and technology across firms, countries, and regions. **Following the shortcomings of the exogenous growth theory, the endogenous growth theory was proposed, and the next section further examines it.**

1.2 Endogenous Growth Theory

In response to the limitations of exogenous growth theory, Paul Romer and Robert Lucas propounded the endogenous growth theory in the 20th century. Their stance was that the economy drives economic growth. Endogenous growth theory suggests that internal factors in an economy or system spur change, growth, and development in the long run (Howitt, 2020). **This is a shift from the traditional Solow-Swan model, which focuses on exogenous factors such as labour**

and capital, to endogenous factors such as human capital, research and development, and technological innovation. Endogenous growth theory asserts that investment in human capital, technological innovation and R&D increases returns to scale. This contradicts the exogenous growth theory that assumes that more factors input in exogenous elements leads to diminishing returns to physical capital (Chandra & Chandra, 2022). The endogenous growth theory measures growth by output per person and is determined by the rate of technological progress. Thus, the tenets of endogenous growth theory include knowledge and public good, spillover effects across firms and regions, and increasing returns to scale impacting sustainable economic growth due to investments in R&D, human capital and R&D.

Endogenous growth theory serves as a crucial framework for examining the relationships between the determinants of the knowledge production function and innovation. **It is relevant to this study because it provides insight into how economies grow and develop through internally generated knowledge from the determinants of knowledge production function.** Again, it explains that innovation and economic growth do not occur randomly. Instead, economies and firms grow and develop when there is a deliberate and conscious investment in human capital and R&D.

Endogenous growth was proposed to address the three main shortcomings of exogenous growth theory (Chandra & Chandra, 2022). The first is the exogenous growth theory, which assumes that technological progress occurs without economic decisions and considerations of R&D and innovation. These are critical factors for economic growth and should not be treated as external factors. It does not include any means by which models for firms and governments influence technological advancement through R&D, investment in education, and policy incentives. Thus, the Solow model only explains growth in relation to capital accumulation and labour. The endogenous growth theory resolves this shortfall in the exogenous growth theory. Endogenous growth theory assumes that economic growth is the result of technological progress, which is the result of investments in human capital, innovation, and R&D. For instance, endogenous growth theory assumes that Silicon Valley's innovation ecosystem is the result of intentional and purposive investments. Second, while exogenous growth theory assumes diminishing capital returns, endogenous growth theory addresses this setback by adopting model factors, such as human capital development, that can sustain long-term increasing returns for economic development. According

to Romer (1994), unlike physical capital, human capital, in the form of education, skills, and knowledge, does not diminish. The more educated, skilled, and knowledgeable a country's workforce is the higher its productivity and development. This also explains the variations and divergence in economic development among countries. Finally, exogenous growth theory assumes policy irrelevance in that government policies cannot sustain economic growth beyond a natural steady state. This is a drawback of the theory, and it is addressed by the endogenous growth theory that strong institutions and better policies supporting education, intellectual property rights, and incentives promote economic growth. For instance, good institutions and better policies in developing countries can lead to economic growth, whereas weak institutions and poor policies in developing countries are likely to retard economic growth. **To further elaborate on the endogenous growth theory, the study explores other theories that align with its principles in the next section.**

1.2.1 AK Model

Endogenous growth theories have gone through several evolutions. According to Howitt (2020), the autonomous technological progress and capital (AK theory) is the first version of the endogenous growth theory. Proposed by Frankel in 1962 (Liu et al., 2023), the AK model states that the aggregate production function shows a constant marginal product of capital (Barbosa, 2024). AK theory proposes that economic growth is a function of both physical and human capital and that there is a constant return to scale. The reason is that human capital and knowledge are necessary components of capital. This is because as the state or firm accumulates more capital, it positively affects intellectual capital, leading to technological progress, offsetting the possibility of diminishing marginal product. Based on the same premise, Lucas in 1988 extended the AK model, focusing on human rather than physical capital (Zhu, 2021). He stated that human capital and technological knowledge were the same. Human capital is the stock of individuals' skills, knowledge, and experiences in an organization or a country. Skilled individuals and experienced individuals have the capacity and are potentially efficient in absorbing and applying knowledge. Their experiences offer them the best practices, methods, and equipment for assimilating and applying new knowledge. In addition, skilled individuals are also efficient in creating novel ideas and developing practical applications and technologies through research to solve problems. For instance, the skills possessed by individuals in academia in conducting quality research produce research findings that could be applied to industry practices to improve innovative offers by firms

and countries. The impact of high levels of human capital is directly linked to innovation. A country with high levels of human capital can adopt foreign technologies efficiently to create innovation. Again, higher levels of patenting, start-up businesses, and product and process development are sustained by quality human capital development. Broström et al (2021) assert that countries with strong university systems create more knowledge through innovations and inventions rippling into economic growth. Human capital promotes knowledge spillovers. When skilled, experienced and trained individuals move between firms, regions or countries, they move with knowledge, ideas and the technological know-how that benefits firms and countries that engage or host them. Thus, countries and firms that attract high-quality human capital tend to experience faster rates of innovation. The movement and concentration of human capital creates a hub for innovation because there is a spill-over and cross-pollination of ideas between firms and countries where human capital is buzzing. For instance, Silicon Valley is the hub of tech companies in the United States. It therefore attracts individuals from all over the world with high skills and experience in the tech industry. It is consequently argued that Silicon Valley experiences faster and higher levels of innovation compared to other places in the USA without the concentration of human capital. The impact of human capital on economic growth is also well-documented and explored in extensive literature. Economic growth is endogenously driven by investment in human capital, innovation and knowledge rather than capital accumulation. Higher innovation through human capital improves productivity, leading to higher income per capita and sustained economic growth. Countries and firms that invest in human capital development through training workshops, seminars, and educational experience innovate, improve productivity and sustain growth. It is also essential to emphasize the fact that several mechanisms can potentially weaken or enhance the impact of human capital on innovation and economic growth. Zhang and Li (2023) identify. Institutional factors such as good governance, legal protection, and innovation-friendly policies and mechanisms can improve or weaken human capital's impact on innovation. They also stated that human capital requires complementary infrastructure such as quality labs, internet access, and finance to effectively translate knowledge into innovation with economic growth as the rippling effect. This raises the fact that, as much as human capital is critical in developing innovation, as advocated by the AK model, it is essential to consider the interacting factors that could improve or weaken the relationship.

AK theory states that sustained economic growth is possible through continuous human capital and knowledge investment. The knowledge production function provides a framework through which R&D and human capital create innovation and enhance economic growth without diminishing returns. The next model, closely linked to the endogenous growth theory, is the Schumpeterian innovation model

1.2.2 Schumpeterian Innovation Model

Joseph Schumpeter's Schumpeterian theory of innovation presents a dynamic perspective on innovation's development through entrepreneurship and creative destruction. This theory highlights entrepreneurs' crucial role in connecting knowledge production and innovation (Majeed et al., 2025). By leveraging new knowledge obtained from higher education, research and development, and spillovers, entrepreneurs create novel products or services to capture new markets. At the core of Schumpeterian theory is creative destruction, which emphasizes entrepreneurs' role in introducing radical innovations to capture new markets. Such innovation is novel to the firm and the market and results from substantial advancements in knowledge. Creative destruction processes lead to substantial changes in innovation, replacing outdated technologies and practices.

It is essential to note that endogenous growth theory and the Schumpeterian theory of innovation identify human capital, research and development, and entrepreneurship as determinants of the knowledge production function that drives innovation. **Furthermore, the following section discusses other theories relevant to the study but not directly linked to exogenous and endogenous growth theories.**

1.3 Other Theories

1.3.1 Open Innovation Model

The theory of open innovation, introduced by Henry Chesbrough in 2003, challenges the traditional model of closed innovation, in which firms rely on their internal resources to innovate and do not consider external influences. Thus, according to this theory, superior innovation performance does not lie solely in the activities of internal, vertically integrated R&D labs, but instead requires co-location within vice-disintegrated innovation networks that link firms to suppliers, customers, universities, research labs, consultants and start-ups (Audretsch et al., 2023). **Thus, open innovation encourages firms to collaborate with external partners to co-create new technologies, products and services (Bartello et al., 2024).** As such, the model is based on the

idea that valuable knowledge and resources exist inside and outside the firm. Using external knowledge can significantly accelerate innovation and thus improve a firm's competitive advantage (Prokop et al., 2021).

In the framework of open innovation theory, two fundamental processes—outbound and inbound open innovation—form the core mechanisms through which firms manage the flow of knowledge and innovation across organizational boundaries (Jesus & Jugend, 2023). Outbound open innovation focuses on disseminating ideas and innovations and distributing innovative products to customers. In contrast, inbound open innovation focuses on the innovation process and emphasizes acquiring and using knowledge from external sources. The strategic intent of inbound innovation is to integrate external insights into the company's R&D processes, which can lead to more sophisticated, market-responsive innovations. These two processes are not mutually exclusive but somewhat interdependent, often working to create a dynamic flow of knowledge into and out of the organization that ultimately drives innovation performance and competitive advantage.

1.3.2 Absorptive Capacity Model

Cohen and Levinthal developed the absorptive capacity theory in the 1990s. **This theory focuses on an organization's ability to recognize, assimilate, and apply external knowledge.** The absorptive capacity theory presents a contingent approach for organizations to leverage external knowledge to enhance innovation capabilities. This requires retraining the existing workforce in modern ways of doing things, as the practical application of external knowledge is coupled with the existing knowledge base. Institutions with high absorptive capacity are better equipped to apply external knowledge effectively in their operations and use it to develop new goods, processes, and services (Müller et al., 2021). This makes continuous learning and knowledge-sharing critical components of the innovation ecosystem. **The next model looks at the contingency model, which shows the mechanisms through which the determinants of knowledge production function influence innovation.**

1.3.3 Contingency Model

Firms possess open systems susceptible to environmental conditions (Victor, 2020). External activities have the potential to influence firms' operations, and the impact of firm activities on performance is also relevant. Consequently, the effectiveness of a firm's knowledge development activities is contingent upon its environmental context. Contingency theory provides a better

explanation for this scenario. The impact of the determinants of the knowledge production function on innovation is contingent upon the environmental context. Internal and external factors in the environment affect the determinants of the knowledge production function on innovation. Organizational culture, as an internal factor, can influence the determinants of the knowledge production function on innovation. Contingency theory posits that an organization's structure, leadership principles, and resource allocation should align with its knowledge production goals for maximum impact on innovation performance. The structure of an organization is a significant determinant of knowledge flow. A highly bureaucratic organizational structure hinders the ease of knowledge transfer and sharing. Firms that allocate more resources to R&D investments and train their human resources on leadership and current issues in innovation tend to create and effectively manage new knowledge for innovation. Externally, government policies, regulatory body activities, and competition could also influence the impact of determinants of the knowledge production function and innovation. Government effectiveness encompasses the perception of the quality of public services and the credibility associated with the government's commitment and implementation of public policies. This concept is believed to promote social and economic growth, as well as the well-being of the population (Halaskova, 2023). **A government's dedication to formulating and implementing sound economic and environmental policies is thought to foster economic growth.** Public institutions are directly involved in working with stakeholders to ensure the effectiveness of policies formulated. These institutions must be adequately resourced and empowered to deliver high-quality services. If state institutions are under-resourced, they are rendered ineffective and struggle to work with formulated policies, which could hamper the determinants of the knowledge production function in innovation. Current studies utilize government effectiveness as an institutional quality indicator to assess its impact on economic growth. Zhao et al. (2021) employ government effectiveness as an explanatory variable to examine the impact of institutional reforms on economic growth and investments in developing countries.

Competition is another environmental factor that could impact the knowledge-based activities of a firm on innovation, and it is contingent. Goel et al. (2022) argue that informal competition undermines firm performance. This is due to price cuts and profit margins, unfair competitive advantage, quality perception, and brand reputation. Informal competitors operate without adhering to rules and regulations or evading taxes, which leads to a distorted competitive landscape and disadvantages formal businesses. This reduction in growth, performance prospects, and

sustainability in the long term negatively impacts formal businesses. **Having established the foundational theories that support the study, the following section examines the determinants of the knowledge production function.**

1.4 Overview of Production Function

In economics, production functions are typically classified into short-term and long-term categories. **In the short run, a firm's production is limited by at least one fixed factor, such as machinery or buildings.** Consequently, the firm cannot adjust its input levels to meet an increase in demand. Therefore, only the variable input causes the ratio of the factors to change. When the quantity of labour is increased, production increases, and when it is reduced, production decreases. This phenomenon is commonly observed in manufacturing firms. In the long run, all factors of production are variable. The law of returns to scale explains the long-term production function, which states that an increase in output results from an increase in input, even at optimal production capacity. Félix et al. (2024) identified three types of production functions: linear, Cobb-Douglas, and Leontief. These functions depend on the inputs of labour and capital for output levels but differ in the extent of capital-labour **substitution**. These differences are evident in the isoquant curves. The linear production function, also known as Constant Elasticity Substitution (CES), demonstrates a constant rate of output change in response to input changes. The Cobb-Douglas production function exhibits limited substitutability but not perfect substitution. In contrast, the Leontief production function uses inputs in fixed proportions and cannot be substituted. **The following section critically assesses current studies on the production function.**

1.5 Scholarly Studies on the Production Function Concept

Meireles (2023) examined the reliance on capital and labour as determinants of the classical knowledge production function. **They introduced university research and commercial R&D as determinants of the function and their impact on innovation.** The authors assert that university research is empirically valuable for knowledge spillover in the context of regional knowledge production function. Their model posits that the quality of knowledge generated from university research and commercial R&D within the regional knowledge production function depends on several indicators related to the institutional and management environment. This suggests that the determinants of the knowledge production function are not absolute but subject to external influences, which can consequently affect the relationship between the determinants of the function

and innovation performance. Another production function study worth noting is Malikov et al. (2024), which examined the structural identification of production functions. The authors focused on Olley and Pake's (OP) and Levinsohn and Petrin's (LP) models from the production function perspective. **They recognized that endogeneity issues arise when determining the determinants of a production function.** Several production function researchers have employed instrumental variables (IV) and fixed effect (FE) estimations to find a sustainable solution to this problem. Estimation necessitates identifying variables that correlate with observed input variables but do not correlate with the error term. FE estimation assumes that unobserved variables remain constant over time. In addressing the determinants of the production function, the OP and LP models utilize observed determinants to "control" for unobserved productivity shocks, resulting in collinearity issues. Malokov et al. (2024) introduced an "intermediate input proxy" into the production function to enhance the model's robustness to serially correlated, unobservable variables. The input of the intermediate input proxy projects, such as labour in the production function, has dynamic effects on the output variable. This approach was based on strict assumptions of homogeneity. In other studies, Malikov et al. (2023) confronted endogeneity issues when utilizing intangible determinants, such as tacit knowledge and managerial quality, in the production function model. These factors are typically unobserved yet must be controlled since they tend to correlate with input usage.

In their research on the production function, they advocated for a shift towards multidimensional factor productivity with a substantial reliance on Hicks-neutral technical change. Hicks-neutral technical change is grounded in the premise that any modification in the determinants of the production function should not impact critical determinants like labour and capital. The impact of technological shifts on labour productivity is an issue that has been studied extensively by prior research. When determining the determinants of the production function, it is crucial to exercise caution and consider potential endogeneity and collinearity issues, as using non-tangible determinants like tacit knowledge can introduce technicalities and challenges that may result in an unbiased impact on firm innovation. Despite these limitations, the production function concept has been widely used to benefit firms and industries.

One of the main criticisms of the production function is how capital is used as an input and how natural resources are omitted as an input factor. The British economist Joan Violet Robinson criticized the production function theory for misleading economists with the idea of

factor proportions and incorrectly measuring capital. She also referred to the production function theory as a "Powerful instrument of miseducation." Despite these criticisms, the production function concept remains widely used in economics. Another criticism of the production function comes from the works of two American economists, Robert Merton Solow and Joseph Eugene Stiglitz. The Solow-Stiglitz model attempts to develop a more realistic production function by including natural resources, specifically energy, as an input factor. Thus, according to the Solow-Stiglitz model, the new production function is expressed as:

$$Q = f(K, L, E) \tag{1}$$

where

K the inputs of capital
L labour, and
E energy
Q output.

However, some critics, including the Romanian mathematician, statistician, and economist Nicholas Georgescu-Roegen, have argued that the Solow-Stiglitz model fails to consider the laws of thermodynamics that affect energy. According to Georgescu-Roegen, energy input is influenced by time, while labour and capital depend on energy for optimal output. For instance, electricity is crucial for machines and labour at any stage of the production process, and power outages can significantly reduce their maximum output. **Despite the shortcomings, the production function and its determinants remain valuable tools** for economic research and their roles in promoting innovation and economic growth are discussed in the following section.

1.6 Role of Production Function

The function of production in the innovation process can be examined from three perspectives: resource allocation efficiency, resource substitution efficiency (Félix et al., 2024), and institutional collaboration efficiency. Innovation requires human and financial resources that are limited in supply; however, optimal utilization of these resources in the innovation process results in improved innovation. Funds from the government, private, and international sources must be appropriately allocated. The production function enhances the optimal allocation of scarce resources and promotes demand-driven innovation. Consumer preferences influence innovation activities that should in firms. The production function helps to

effectively allocate resources, including labour, capital, and raw materials in the production process. The principle of substitutability promotes optimal resource combination in the right amount to enhance innovation within a firm. The production function comprises various determinants, and their optimal blending can improve innovation performance while reducing resource waste. Yuan and Wang (2019) identify the production function as one of three methods for estimating knowledge spillovers in promoting innovation alongside case studies and patent counts.

Furthermore, institutional collaboration leads to knowledge sharing and efficient resource utilization. The production function also facilitates collaboration decisions with public research institutions, universities, and firms. This is influenced by common interests, funding, capacity, and institutional or public regulations. The production function offers the most effective means of blending available resources for maximum output. The principle of the production function enables firms to make informed decisions on resource substitution and combination to improve innovation.

Expanding upon the arguments of the production function, the study examines the state of “Knowledge” in the production function model in the following section.

2. PRODUCTION FUNCTION TO KNOWLEDGE PRODUCTION FUNCTION

The production function is the concept that describes the quantitative relationship between the input and output. Output depends on inputs, so the output is usually called the dependent variable, while the input factor(s) is called independent variables. In modern economics, the unique characteristics of knowledge have become pivotal in innovation, economic growth and competitiveness. However, the traditional production function depends on physical inputs such as labour and capital for economic growth, excluding the role of knowledge and technological advancement as drivers of economic growth. Hence, Griliches introduced the knowledge production function in 1979 (Colther & Doussoulin, 2024). It is an extension of the Cobb-Douglas production function that uses capital and labour as the primary input factors, with elasticity and constant factors as parameters. **The transition from traditional production function (with tangible inputs such as labour and capital) to knowledge production function (with intangible inputs such as knowledge and technological advancements)** helps to capture the role of R&D, human capital, knowledge networks and collaborations in creating new knowledge for innovation outputs. It also helps to understand how intangible inputs drive long-term economic growth and sustainable innovation. This helps to design knowledge-based policies to drive economic growth in increasingly knowledge-driven economies. Griliches' works in economics have focused on technological change and the roles of R&D and patents in the diffusion of knowledge. KPF extends the determinants of the production function by including "Knowledge" as one of the determinants. It is expressed as

$$Q = f(x_1, x_2, x_3, + \text{Knowledge}) \quad (2)$$

where

Q denotes innovation,

x_1, x_2, x_3 denote non-knowledge-based determinants and

'Knowledge' represents knowledge-based determinants.

The knowledge production function is the relationship between technological knowledge and R&D investment (Link & Scott, 2020). Its purpose is to assess the impact of R&D and knowledge spillovers on production growth. By implication, a change in productivity results from variations

in input factors, namely, R&D capital or investment and knowledge spillover. Therefore, productivity growth is a function of R&D investment and knowledge spillover. The KPF concept has been employed in various studies across multiple disciplines, making it possible to evaluate the economic benefits of knowledge in the modern economy both theoretically and empirically. In addition to its use in understanding the impact of R&D investment and knowledge spillover on productivity, it also helps to estimate the rate of return on R&D and comprehend the factors determining the intensity of innovation activities across industries and economies at various spatial scales, as noted by Verba (2022). The KPF approach promotes the examination of R&D's influence on patents, with the Griliches framework of the KPF positing that new knowledge arises from R&D and is cumulative. Also, KPF can be viewed as R&D expenditure from previous periods, as asserted by (Teslenko et al., 2021). Knowledge stock is the sum of prior and current R&D investments; thus, new knowledge is grounded in the existing stock of 'old' knowledge. The KPF is prominently featured in endogenous growth theory, which posits that economic growth is mainly the result of internal factors while also asserting that investments in human capital, innovation, and knowledge are necessary to attain economic growth.

The neoclassical economic perspective posits that external, uncontrollable factors drive economic growth. However, the Endogenous Growth Theory (EGT) suggests that the growth of all other economic variables depends on knowledge growth. Consequently, productivity improvement is closely linked to accelerated innovation and investment in human capital. To this end, the EGT advocates for increased government and private sector investments in research and development and intellectual property rights to foster innovation initiatives and incentivize individuals and firms to be creative. The Kaldor-Pasinetti Framework also recognizes capital and labour as the primary input factors for innovation in output (Baranzini & Mirante, 2021). The potential of capital and labour can be harnessed by producing new knowledge derived from R&D investments. Improved capital and labour in the KPF led to economic growth. Understanding the theoretical foundations of the KPF requires an appreciation of the nexus between EGT and KPF. Not only do they emphasize the significance of R&D investments in achieving innovation and economic growth, but they also highlight the role of knowledge as a crucial catalyst for these outcomes. Verba (2022) asserts that the standard encountered in the EGT is the Romer-Jones knowledge production function in the form:

$$\dot{A} = \delta L_A^\zeta A^{\phi} \quad (3)$$

where

(A)	knowledge flow,
A	knowledge stock,
L_A	labour employed in the R&D sector,
ζ	a parameter measuring the rate of return of knowledge from R&D labour,
δ	the productivity of knowledge discovery, and
ϕ	the intertemporal spillover parameter.

Romer-Jones KPF states that economic improvement is due to technological advancement, and technological changes are endogenous. However, Griliches and Romer-Jones KPF describe two different processes of knowledge formation. While Griliches refers to the knowledge formation process as a research effort proxied with R&D expenditure, Romer-Jones similarly explains the process as a research effort but proxied with the quantity of labour employed in the R&D sector, which broadly incorporates labour and physical capital. **Building on the previous discussions, the study considers “Knowledge” as a factor of production in the following section.**

2.1 Knowledge as the Fifth Factor of Production

From a traditional economic perspective, the factors of production are typically considered to be land, labour, and capital, which are combined to produce goods and services. **However, knowledge has been recognized as the fifth factor of production**, alongside land, labour, capital, and entrepreneurs (Robertson et al., 2021). Including knowledge as a factor of production has significant implications for the value of labour and enterprise. New businesses can now succeed without relying heavily on human resources. For example, information stored on a computer can generate valuable information, such as details of a new production or distribution process. Knowledge, as a factor of production, is essential for learning, understanding, and decision-making in the business environment (Foroudi et al., 2021). It can be defined as the facts, information, meaning, or awareness that an individual acquires through experience or learning. Therefore, employees of firms need to not only learn new ideas and ways of doing things but also unlearn outdated practices. It is important to note that learning, understanding, and decision-making are interrelated in the context of new knowledge. A firm's knowledge-based view (KBV)

posits that knowledge, as one of the most valuable strategic resources for a firm's progress, can be created through interfirm knowledge sharing (Foroudi et al., 2021). As a result, inter-firm cooperation can enhance knowledge-sharing, leading to increased competitiveness and success for both parties involved.

However, sharing knowledge can be both intricate and arduous simultaneously. **The failure rate regarding knowledge sharing through inter-firm collaboration typically falls between 40% and 70%** (Luvison & de Man, 2015). This can be attributed to various factors such as mistrust, lack of common objectives, and loyalty to the cooperation pact before inter-firm collaboration. The inter-firm collaboration aims to exchange ideas on current market trends, find solutions to existing challenges, and develop new products or services based on customer specifications. It has been proposed that knowledge can be considered either a residual production factor or an individual production factor (Alshanty & Emeagwali, 2019). As a residual production factor, knowledge is believed to be present in other factors of production, such as labour and capital.

To effectively operate in the business environment, labour must acquire knowledge through training or the transfer of labour from one firm to another. On the other hand, capital development depends on acquiring new knowledge. Knowledge can be divided into two categories: explicit and tacit (Kucharska, 2021). In the past, knowledge was typically passed down from one generation to the next through various forms of face-to-face narration, conscious teaching, learning, and observation. Knowledge conveyed through narrative forms is often recorded and preserved for future generations. **According to Kucharska (2021), tacit knowledge refers to information not explicitly expressed in words or images and derived from personal experience.**

In contrast, explicit knowledge refers to information that can be easily communicated, written down, and shared between individuals (Cao et al., 2022). Companies cannot harness and utilize tacit knowledge for innovation, making it crucial for current human resource managers to convert it into explicit knowledge through knowledge sharing. Successful managers can acquire and manage tacit knowledge to enhance innovation. **Firms need to convert tacit knowledge into explicit knowledge to benefit from it through innovation.** Research has shown that approximately 90% of knowledge is stored and synthesized in people's minds (Nguyen, 2021). In a corporate context, it is widely acknowledged that tacit knowledge is acquired, disseminated, and shared through various means, such as knowledge fairs, instruction, learning communities, study missions, tours, advisory boards, job rotation, anecdotes, and myths. Given the critical role of tacit

knowledge in promoting innovation, knowledge management has emerged as a crucial issue for businesses in the contemporary era. This is mainly due to inadequate employee motivation, ineffective leadership styles, and inadequate organizational cultures. Canonico (2020) recommended utilizing the Nonaka and Takeuchi model to manage tacit knowledge effectively for the benefit of the organization. The Nonaka and Takeuchi model is a dynamic spiral model that integrates knowledge within an organization to facilitate knowledge sharing and transfer tacit knowledge to explicit knowledge via Socialization, Externalization, Combination, and Internalization (SECI).

Table 1. Comparison between tacit knowledge and explicit knowledge

Basis for comparison	Tacit Knowledge	Explicit Knowledge
Nature	Subjective, cognitive and experiential.	Objective, logical and technical
Codification	Not codified	Codified
Transfer	Difficult to transfer.	Easy to transfer
Means of Acquisition	Hands-on experience, in-depth analysis, observation, fact-finding	Logical deduction and hands-on experience
Recording and storing	It is in the heads of people and cannot be recorded and stored physically	It can be recorded and stored in physical or electronic form

Source: Author's own

The model defines socialization as sharing knowledge through face-to-face interactions with superiors, subordinates, and colleagues. Externalization refers to converting tacit knowledge into explicit knowledge, the foundation for new knowledge. Combination involves successfully incorporating new knowledge into an organization's existing knowledge system, while internalization refers to embedding new knowledge as the spiral process begins. Companies must invest in new knowledge and human resources to effectively utilize knowledge for innovation and profitability. This is because knowledge is not an end but a means to produce new goods and services. Therefore, entrepreneurs, stakeholders, and shareholders must prioritize investments in knowledge to promote innovation. **The subsequent section discusses the taxonomy of the knowledge production function.**

2.2 Taxonomy of Determinants of Knowledge Production Function

The determinants of the production function for innovation performance vary, according to various scholars. The taxonomies of these determinants are based on several factors, including institutional, political, social, environmental, technological, and economic disciplines. **This study identifies the economic determinants (Li et al., 2022), environmental determinants (Damanpour, 2020), socio-political determinants (Ege & Ege, 2019), and knowledge-based determinants (Ishaq et al., 2024) determinants as taxonomy of the knowledge production function.** According to Pavitt's taxonomy of the production function, economic factors are recognized as the critical determinants of the production function towards innovation performance (Camino-Mogro et al., 2023). The classification is based on sources and technological potential, with firms grouped into four categories: supplier-dominated, intensive-scale specialized suppliers, and science-based firms. Li et al. (2022) argues that the economic determinants of the production function towards innovation performance are influenced by market structures, profit, foreign direct investment (FDI), unemployment, and imports. Drawing on prior scholarship on innovation performance and the production function, they identified research institutions, universities, training and development, innovation policies and regulations, and public funding of R&D as socio-political elements in the taxonomy of the production function. **Another aspect of the production function debate is the role of environmental factors.** In terms of environmental determinants, any element of the business environment that has the potential to impact innovation is considered environmentally related. Damanpour (2020) states that such elements include competition, concentration and appropriate environmental conditions. Competition can be formal or informal, local or global, and the level of competition a firm face determines its level of innovativeness. Schumpeter argued that innovation thrives in areas with a concentration of firms, as firms can share ideas and collaborate more within their local jurisdiction. Higher concentrated, localized firms tend to be more innovative than dispersed firms (Damanpour, 2020). Appropriability conditions relate to the ability of innovative firms to obtain value for their innovative activities.

In an environment where inventions or innovative products can be easily imitated, firms do not receive the necessary returns on their innovations, which does not motivate them to innovate. **The second group of determinants is the knowledge-based determinants.** These factors promote knowledge creation, transfer, sharing, and usage, as knowledge is the foundation of innovation. These factors include R&D stock, R&D investment, R&D employment, ICT use and penetration,

Intellectual Property Rights (IPR), FDI, and big data. Despite the categorization of determinants of the production function, the factors often overlap and transcend from one category to another. For example, FDI is an economic and knowledge-based factor, and regulations can be environmental and socio-political. This study focuses on the influence of knowledge-based determinants on innovation.

Table 2. Categorization of determinants of production function

Groups	Determinants
Economic	Market structures, profit, Foreign Direct Investment (FDI), labour market conditions, unemployment and imports.
Socio-political	Research institutions, Universities, training and innovation policies and regulations.
Environmental	Climate, sustainability, and geographical location.
Knowledge-based	Human capital, scientific collaborations, R&D stock, R&D employment, ICT use and penetration, Intellectual Property Rights (IPR), knowledge diffusion and big data

Source: Author's own

is the level of investment in innovation activities. This is seen in the R&D intensity of firms. Innovation impacts the economic and social effects of innovation in an economy or firm. This is evident in productivity, profitability and environmental sustainability. While open innovation involves factors such as accessibility to open-source software, innovation outputs are the number of patents, publications and new or improved products introduced by firms. This study employed innovation performance as the dependent variable and proxied it with product and process innovations. **The definition and measurement of dependent variables were based on the 2018 Edition of the Oslo Manual.** Other scientific studies have used product and process innovations to measure innovation performance (Rammer et al., 2022). Product innovation is a new or improved product that differs significantly from a firm's previous product and primarily encompasses physical goods, services, or digital products. Process innovation (PI) is distinct from product innovation. A firm is a process innovator if it has introduced a new process or improved an existing process in areas such as logistics, communication, marketing, organization, and administration in the preceding three-year period, significantly different from the existing process. Examining how elements, such as firm collaboration, influence these innovations is essential. **The explanatory variables are discussed in the following section.**

2.3 Independent Variables

In assessing innovation performance among moderate and emerging EU countries, the study considered determinants that promote knowledge management and knowledge networks at the firm level and determinants that promote knowledge diffusion at the country level. **The following sections critically examine specific explanatory variables of the study.**

2.3.1 Firm Channels of Information

Firm's channels of information refer to the formal and informal sources firms rely on to acquire, process and disseminate new knowledge for innovation, competitive advantage and strategic decision-making (Cohen & Levinthal, 1990; Blind et al., 2022). Prior studies on firm channels of information have focused on the use of R&D (Arora et al., 2021), licensing acquisition (Pandey et al., 2022) and professional networks (Thomas et al., 2021) as channels of new knowledge for firm innovation. This study uses standard documents as a proxy for firm channels of information. While standard industry documents are viewed as an explicit knowledge source for firm innovation (Arthur & Vanicek, 2024), they have rarely been used by current studies. Standard industry documents as a channel of information contain established guidelines, safety regulations, performance benchmarks, the industry's best practices, and patent information, which can be valuable knowledge channels for new knowledge towards firm innovation development. Information from standard industry documents is technical, reliable and valid for innovation practice (Arthur & Vanicek, 2024). Thus, the study examines the impact of firm channels of information, such as standard documents, on product innovation in emerging EU markets. Standard industry documents are used as a proxy due the fact that they are under explored in current studies as firm source of information. Also, firms could access and use with ease. Firms in the merging market might not be financially viable to access other well-known information channels such as R&D and licensing. Therefore, it will be interesting to examine standard documents as a firm's channel of information and how they influence product innovation in the EU's moderate and emerging markets. **This leads to the formulation of hypothesis H1a.**

2.3.2 Knowledge-Based Human Resource Practices

On the other hand, through knowledge-based human resource practices, firms can effectively manage information or new knowledge for innovation. The human factor is essential for knowledge acquisition and sharing. Armstrong and Taylor (2023) refer to human resource practices as

activities and strategies that are consciously managed to develop and use labour skills. This study adopts cross-functional groups and planned job rotations as proxies for human resource practices. These two proxies are used because they are understudied in current literature, and both help in intra-firm knowledge sharing (Le, 2024). Planned job rotation is where employees are systematically moved across different roles and departments (De Clercq, 2023). On the other hand, cross-functional groups bring employees from varied backgrounds to collaborate (Le & Mohiuddin, 2024). These knowledge-based human resource practices enhance knowledge sharing, creativity and problem-solving for firm innovation. Thus, the link between knowledge-based human resource practices and innovation is valid in extant literature. However, less is seen about knowledge-based human resource practices (cross-functional groups and planned job rotation) and innovation nexus, particularly in merging countries. The gap in existing studies on assessing external knowledge sources, such as channels of firm information, and internal knowledge-based factors, **such as human resource practices in connection with firm innovation motivate us to formulate the hypothesis H1b.**

2.3.3 Technical Knowledge Intensive Business Services

Knowledge-intensive business Services (KIBS) have emerged as crucial actors in innovation ecosystems, especially in product innovation development (Davies, 2018). KIBS are demand-led, knowledge-intensive business services that design, provide, and implement state-of-the-art value-adding solutions that meet client-specific requirements (Hall & Williams, 2019). This shift from material goods to value-added goods implies that knowledge is not only the focus of innovation, but it should also be focused on how it is allocated and how it is used, which becomes essential to strengthen competitive advantage, and for the transition from traditional economies of the industrial type to economies of knowledge (Ericson, Johansson & Nergård, 2015). They are characterized by their ability to generate new technologies and enhance existing ones, directly contributing to product innovation in client firms (Figueiredo et al., 2017). Studies have shown that T-KIBS contribute to product innovation in moderate and emerging countries by facilitating the development of new technologies and processes (Vaillant et al., 2021; Bomm et al., 2023). Others argue that enhancing firms' absorptive capacity enables them to assimilate and apply external knowledge (Flor et al., 2018; Horvat et al., 2019). Zieba (2021) argued that T-KIBS is a co-creator in innovation processes, particularly high-tech industries. For example, IT consulting firms (a subset of T-KIBS) have been instrumental in helping companies integrate digital technologies into

their product development processes, leading to innovative products, such as smart devices and IoT-enabled solutions (Cabigiosu, 2019). **This suggests that T-KIBS significantly impacts product innovation by providing technical expertise and fostering technological advancement. Thus, formulating hypothesis H2a.**

2.3.4 Professional Knowledge Intensive Business Services

Professional Knowledge-Intensive Business Services (P-KIBS) focus on strategic, managerial, professional bodies and regulatory aspects of innovation. They provide firms with insights into market trends, customer preferences, and regulatory compliance, which are essential for successful product innovation (Bumberová & Milichovský, 2019). Although they may not directly develop new technologies, they facilitate innovation by enhancing organizational capabilities and improving decision-making processes (Chichkanov, 2021). P-KIBS contributes to product innovation by offering strategic advice on market positioning and competitive differentiation (Krupskaya & Pina, 2022). Horner (2019) argued that ensuring compliance with regulatory standards is particularly important in highly regulated industries, such as pharmaceuticals and finance. Hence, it facilitates organizational change and innovation management, enabling firms to adapt to dynamic market conditions. For instance, management consulting firms (a subset of P-KIBS) help design innovation strategies that align with market demands, leading to the development of customer-centric products (Pham, 2017). This indicates that P-KIBS play a significant role in shaping product innovation's strategic and managerial dimensions (Dinu et al., 2023). Consequently, the literature highlights the distinct yet complementary roles of T-KIBS and P-KIBS in fostering product innovation. While T-KIBS provides the technical expertise and technological capabilities necessary for developing innovative products, P-KIBS offers the strategic and regulatory insights required to ensure market success and compliance (Zbucnea et al., 2024). Both types of KIBS contribute to firms' innovation capabilities by providing valuable external resources **and enhancing their dynamic capabilities (Janssen et al., 2018). Based on the literature, hypothesis H2b is formulated.**

2.3.5 Social and Political Globalization

Innovation contributes to regional economic growth and competitiveness (Edeh & Prévot, 2024; Mewes & Broekel, 2022). Knowledge is the bedrock of innovation (Holl et al., 2023). The rate at which knowledge is shared is a major determinant of regional innovation. In an era of globalization,

the interconnectedness and cooperation among countries catalyzes knowledge sharing and knowledge diffusion. There are several reasons for bilateral or multilateral collaborations between countries. The reasons range from economic, political, social and environmental. **Niazi (2025) and Tang (2022) identify social globalization and political globalization as underexplored factors that connect countries globally for social and political reasons to spur knowledge diffusion and innovation.** The interest in this study is partly to examine how social and political globalization in moderate and merging innovative EU countries influences regional innovation performance (Patent applications). Social globalization refers to the information flow, personal contacts and cultural proximity (Ahmed, 2024; Hsu et al., 2023) between countries. This is evidenced in indicators such as international telecom traffic, the degree of tourism, the number of foreign populations in a country, trade in newspapers, internet users, and foreign restaurants, such as McDonalds. Ahmed (2024) asserts that the indicators of social globalization promote knowledge diffusion. Thus, the rate of knowledge circulation between emerging countries will be high if they engage in activities that enhance social globalization. It must be emphasized that countries decide which to collaborate socially based on proximity, mutual interest and benefits (Sjöholm, 2024). This implies that countries with mutual interest in development and innovation are likelier to engage in personal contacts, information flows and cultural activities. Also, countries collaborate for political purposes, referred to as political globalization.

Rehman et al. (2024) refer to political globalization as the number of embassies and high commissions in a country, the number of international organizations to which a country is a member, and the number of treaties signed between two or more countries. Political globalization enhances knowledge sharing and diffusion. Countries that engage in political globalization learn new things and practices from each other for innovation. Factors hindering a country's involvement in political globalization include ideological differences and non-democratic governance. Like social globalization, countries are more likely to politically engage in bilateral or multilateral agreements with countries with similar interests and benefits. Notwithstanding the potential benefits of social and political globalization, **Sjöholm (2024) asserts that EU economies are becoming more inward-looking and more hesitant towards globalization.** Again, current studies confirm that countries engage in economic globalization more than social and political globalization (Hurtado et al., 2024). This presents an interesting case to examine how social and political globalization enhances regional innovation performance, particularly among moderate

and emerging innovative EU countries catching up in innovation activities. **This presents an in-depth insight into the role of social and political globalization in regional innovation performance (Patent application)**, which has been unstudied per extant literature. It will also give a policy direction to emerging EU countries to exploit the benefits of globalization beyond economic purposes. **The study therefore hypothesizes H3a and H3b.**

2.3.6 Moderation Role of Competition Intensity.

Competition intensity refers to the number of competitors in a firm's business environment (Handoyo et al., 2023). It explains the level of market rivalry that firms experience. In a highly competitive business environment, firms are expected to constantly innovate by diversifying their offers to remain competitive. Firms' channels of innovation and product innovation nexus could be influenced by the competition that firms face in the business environment. Firms tend to search and use the most viable or multiple knowledge sources to strengthen their internal information and improve their innovation capabilities in a highly competitive business environment. In this situation, firms increase the tendency for open innovation and collaboration to acquire new knowledge to survive the intense competition. Huang (2023) asserts that in a highly competitive environment, firms could copy competitors instead of leveraging their own information channel for new knowledge. While firms in emerging markets have limited financial and technological resources they are expected to optimize and enrich their information channels to keep them in business. Thus, competition intensity can weaken or strengthen the channels of firm information and innovation nexus depending on the market conditions.

On the other hand, Harr et al. (2022) argues that the effectiveness of human resource practices in knowledge management for firm innovation development is contingent on the market conditions. Competition intensity is a critical market condition that determines firm innovation activities. Human resource practices such as planned job rotation and cross-functional groups help generate and share ideas and knowledge across the firm's various departments. They ensure that employees' diverse skills are shared and collaborated effectively to generate new ideas for innovation. In a highly competitive business environment, firms develop HR strategies to boost their employees' skills, knowledge, and competencies to adapt to the changing technologies and demands. Also, in a highly competitive business environment, firms may lose their ace employees to competitors through poaching. To remain competitive, employees must be abreast of current industry happenings to stay in business (Al-Khatib & Al-Ghanem, 2022). This makes firms adopt strategic

knowledge-based human resource practices such as planned job rotation and cross-functional groups to keep their employees abreast of new industry practices and avoid information asymmetry or knowledge loss when employees leave the firm to join a competitor. This implies that firms facing more competition should invest in their employees to retain and attract top talents and improve their know-how for innovation development. Testing how competition intensity interacts with HR practices and product innovation linkages would be interesting to firms in emerging markets. **To examine these linkages in moderate and emerging EU countries, the study hypothesizes H1c and H1d.**

2.3.7 Moderation Role of Competition Intensity and Regulatory Quality

Technical Knowledge-Intensive Business Services (T-KIBS) are widely recognized as key enablers of product innovation, providing firms with access to specialized technical expertise, R&D capabilities, and advanced technologies (Carrillo-Carrillo & Alcalde-Heras, 2020). However, the extent to which T-KIBS contributes to product innovation is not uniform, as it is influenced by external contextual factors such as regulatory quality and competition intensity (Miles, Belousova & Chichkanov, 2019). Regulatory quality refers to the effectiveness of government policies and regulations in creating a stable and supportive environment for innovation (Zhu et al., 2024), whereas competition intensity reflects the degree of rivalry among firms in a market (Grant, 1991; Anning-Dorson et al., 2017). Therefore, regulatory quality is vital for creating an environment conducive to innovation. Brousseau et al. (2010) contended that effective regulations ensure contract enforceability, reduce bureaucratic barriers, and promote fair competition. High-quality regulations support T-KIBS by protecting intellectual property rights and providing a stable legal framework that encourages investment in R&D activities facilitated by these services (Pinto et al., 2015). Savic et al. (2020) affirmed that clear and consistent regulations reduce the risks associated with innovation activities, encouraging firms to invest in R&D and collaborate with T-KIBS. Supportive regulatory frameworks are found to be ardent promoters of public-private partnerships and knowledge-sharing networks, enhancing the diffusion of technical knowledge (Siemiatycki, 2013). Conversely, weak institutional conditions may impede innovation efforts, as firms spend more time navigating complex regulatory systems than focusing on research (Sun et al., 2021). For instance, in the European Union (EU), stringent regulatory standards in industries such as pharmaceuticals and automobiles have driven firms to collaborate with T-KIBS to develop compliant and innovative products (Peck, 2017). This suggests that regulatory quality enhances

KIBS ability to contribute to product innovation by providing a stable and supportive institutional framework.

Competition intensity is another key factor moderating the relationship between T-KIBS and product innovation. **In highly competitive markets, firms must continuously innovate to maintain their market positions (Chichkanov, 2021).** This creates a strong demand for specialized services provided by T-KIBS, and as firms seek to access cutting-edge technologies, they rely on T-KIBS for advanced technical expertise to differentiate their products and gain a competitive edge (Haakonsson et al, 2020). Li (2017) and Carrillo-Carrillo & Alcalde-Heras (2020) contend that intense competition drives firms to shorten their product development cycles and respond quickly to market changes, increasing their reliance on T-KIBS and leveraging T-KIBS to complement their internal capabilities and overcome resource limitations. For instance, intense competition in the IT and telecommunications sectors has led firms to rely heavily on T-KIBS for software development, system integration, and digital transformation, resulting in rapid product innovation (Hu et al., 2014). This finding suggests that competition intensity amplifies the impact of T-KIBS on product innovation by increasing firms' reliance on external technical expertise. The interaction between regulatory quality and competition intensity further amplifies their individual effects on the relationship between T-KIBS and product innovation (Content et al., 2022). Well-designed regulations facilitate fair market conditions in which competitive pressures encourage firms to engage with T-KIBS more effectively (Hinrichs-Rahlwes, 2013). Conversely, poor regulation can lead to monopolistic practices or excessive compliance costs that hinder competitiveness and access to the innovative technologies provided by T-KIBS (Peck, 2017). **Drawing on the literature above,** it is evident that the business environment plays a crucial role in shaping the impact of T-KIBS on product innovation. **Based on this, hypothesis H2c and H2d are proposed.**

2.3.8 Moderation Role of Civil Liberties Index

In this section, the study finds that higher regional innovation performance in moderate and emerging innovative EU countries may not depend only on social and political globalization, but more importantly, on the civil liberties index. Civil liberties index refers to freedom of expression, associational and individual rights, the rule of law and personal autonomy. (Filippaios et al. 2019). Scholars recognize civil liberties as a key contributor to innovation and economic growth.

Innovation is costly and risky; hence, the friendly characteristics of a country's business environment play a significant role (Galiński et al., 2024). Thus, national stability and a good quality of institutional framework are preconditions for an innovative performance (Avom & Kamguia, 2025). This is supported by the institutional theory that high-quality regulatory and institutional performance creates and shapes innovative activities in a country (Pucheta-Martínez & Gallego-Álvarez, 2024). The preceding arguments suggest that the concept of civil liberties in the form of guaranteeing human and organizational rights, the rule of law, freedom of speech and personal autonomy has gained considerable attention in current literature. Civil liberties determine the number of foreign investors and tourists and the amount of knowledge that circulates or enters a country. The country's decision to have bilateral agreements is influenced by the level of human and organizational rights established (Ahmed et al., 2024; Alvarado et al., 2023). This is important because tourists and investors consider safety in the environment. Similarly, there is a positive link between the laws of a country and the level of innovative activities. Investors and innovators require value for their efforts. To compensate them adequately, a legal institution embedded in civil liberties should effectively protect investors' inventions and innovations. The study argues that the relationship between social and political globalization can be strengthened or weakened depending on a country's level of civil liberties. **This is a novelty because current studies mostly use civil liberties as an explanatory variable and examine the impact on the environment and sustainability.** The study departs from the assertion by introducing civil liberties as a moderator contingent factor in the social and political globalization and regional innovation nexus. Therefore, the study expects social and political globalization to improve regional innovation performance in the context of civil liberties. **In line with the preceding arguments, the study proposed hypotheses H3c, H3d and H3e.**

2.4 Control Variables

The study controlled for firm characteristics when firm-level data was used for the analysis and country characteristics when country-level data was used. At the firm level, firm age and size were controlled, while at the country level, factors such as GDP per capita, R&D expenditure per GDP, trade openness, and trade freedom were controlled. Controlling these variables is due to their influence on the innovation performance of firms and countries. Hence, if not controlled, they will interfere with the relationship between determinants of knowledge production function and innovation performance, leading to biases in the results.

2.4.1 Firm Characteristics

The study controlled for firm age (Chatterjee et al., 2022). Firm age is a recognized firm-level characteristic internal to firms that positively correlates with firm size (Pellegrino & Piva, 2020) and may influence firm innovation performance. Firm age was categorized into four groups based on the year of establishment. The value one was assigned to firms established in 2016 or later, 2 for those established from 2014 to 2015, 3 for those established from 2010 to 2013, and 4 for those established in 2009 or before. Firm size can influence innovation activity. Large firms and corporations are known to possess more significant resources and more stable financial capacity to engage in R&D for new knowledge and innovation (Bachmann et al., 2021). Firm size is measured by the number of employees. This study includes medium (50-249) and micro (10-49) firms. Variations in size can influence a firm's innovation performance. Consequently, firm size was controlled, with one for micro and two for medium firms.

2.4.2 Country and Year-Fixed Effects Characteristics

The study also controlled GDP per capita, trade openness and trade freedom (Hausken & Moxnes, 2019) sourced from the World Bank, R&D expenditure per GDP sourced from the United Nations database, measured in percentage (Tajaddini & Gholipour, 2021) and patent applications (Jin et al., 2022) sourced from WIPO and measured in the number of applications. Per the extant literature reviewed, these variables impact innovation performance. **Hence, controlling these variables helps to give the true impact of inward FDI and globalization on innovation performance.** In addition, study creates a country-level control variable (Prokop *et al.*, 2023). Countries were grouped into two according to the innovation performance based on the European Commission's innovation scoreboard criteria. It classifies countries into four, namely innovation leaders (Denmark, Sweden, Finland, Netherlands and Belgium), strong innovators (Austria, Germany, Luxembourg, Ireland, Cyprus and France), moderate innovators (Estonia, Slovenia, Czechia, Italy, Spain, Malta, Portugal, Lithuania, Greece and Hungary) and emerging innovators (Croatia, Slovakia, Poland, Latvia, Bulgaria and Romania). Following the studies of Prokop *et al.* (2023), the two groups will be innovation performers comprising innovation leaders and strong innovators, while the eco-innovation catch-up will comprise moderate innovators and emerging innovators. **The section after this discusses the current studies on the determinants of the knowledge production function.**

2.5 Current Studies on Determinants of Knowledge Production Function

Determinants of the knowledge production function require periodic assessment. This helps show the real-time impact and effectiveness of firm innovation. Prior literature has adopted different variables to measure the determinants of KPF in innovation-coupled models used to analyze the impact of the determinants of KPF on firms' innovation performance. Some of the determinants include the training of human resources (Cozzarin & Percival, 2021), IPR regimes (Ljungwall & Wang, 2022), human and physical capital accumulation and knowledge dynamics R&D (Verba, 2022), ICT revolution and evaluation of research–use of citation counts (Link & Scott, 2021), and Foreign Direct Investments-FDI (Jungmittag & Welfens, 2020). The models used in the analysis were mainly quantitatively related and regression biased. The table below summarizes the current research variables used in measuring the determinants of KPF and innovation, with the associated models for the analysis. Existing studies on knowledge production functions have identified several determinants. These include FDI acquisition (Garcia-Vega et al., 2019), R&D expenditure (Kijek & Kijek, 2019), and structure of human capital (Teslenko et al., 2021). Based on extant literature, this study classifies the selected determinants of the knowledge production function into knowledge management, knowledge networks, and knowledge diffusion.

2.6 Limitations of the Knowledge Production Function

Although the knowledge production function has been explored in several studies, it has limitations. Griliches identified the previous R&D knowledge as a determinant of knowledge production function. However, Jha and Basu (2025) posits that obtaining accurate and reliable information on past R&D is challenging and is coupled with inaccuracies. The information on R&D investments made a long time ago is scarce. Several businesses have lost track of R&D information, which could adversely affect the constant term of the knowledge production function. Such situations lead to misrepresentation and misspecification of the input variable. Romer-Jones KPF excludes the full spectrum of efforts committed to discovering knowledge. Embedded in the functional equation, the variation in output comes only from labour, excluding the physical capital used in R&D. Another shortcoming of Romer-Jones KPF is that it does not consider accumulation in knowledge creation. It includes only current labour efforts in knowledge production. R&D research indicates that knowledge discovery is subject to lags, valuing the contribution of prior knowledge to knowledge creation and innovation. However, current labour efforts are as important as previous ones in knowledge production. **In short, while Griliches' approach to KPF**

acknowledges the contributions of knowledge accumulation, Romer-Jones's KPF does not include knowledge in knowledge production. The following section examines the innovation concept.

Table 3. Determinants of production function per current literature

Author	Determinants KPF	Determinants of Innovation	Model used
Ljungwall & Wang (2022)	IPR regimes	Patenting performance and innovation efficiency	Fixed effects spatial regression
Verba (2022)	Human and physical capital accumulation & knowledge Dynamics R&D	Innovation growth	FE, RE regression & GLS
Vadia & Blankart (2021)	Public funding	Cardiovascular device innovation	OLS, exploratory spatial data analysis
Li & Ljungwall (2021)	Knowledge management, Knowledge stock & R&D personnel	General patent application & invention patent application	FE negative binomial regression
Cozzarin & Percival (2021)	Training	New and improved innovation process and product innovation	2-stage least squares method
Proenca & Glorias (2021)	Spatial spillovers externalities	Innovation	2-step pseudo-maximum likelihood estimator or spatial autoregression PPML
Link & Scott (2021)	Research capital stock & research labour services	New scientific publications & technological change	Generalized Autoregressive conditional heteroskedasticity (GARCH)
Link & Scott (2020)	ICT revolution & evaluation of research (use of citation counts)	Invention disclosures (a measure of scientific knowledge)	Solow KPF
Link & Scott (2020)	Federal R&D capital per unit of scientific personnel	Scientific publications per unit of scientific personnel	Solow method of functional decomposition
Jungmittag & Welfens (2020)	FDI	Innovation dynamics	Pooled OLS, KPF
Duarte, Goncalves, Chein, Taveira (2020)	Total academic and administrative personnel & investments in scientific research	Number of publications and patents	Negative Binomial
Kijek & Kijek (2019)	R&D expenditure	Patent applications	EGT & spatial model

Source: Author's own

2.7 The Innovation Concept

Even though there is no widely accepted definition for innovation, most definitions include new ideas, knowledge, products, processes, and markets. Applying new knowledge to improve processes, products, and services leads to innovation. According to Lacquement and Chevalier, (2024), innovation is distinct and recognized in three forms. Innovation as an outcome explains what output is sought, including product, process, marketing, business model, supply chain, and organizational innovation. Innovation as a process is manifested in how innovations should be organized so that outcomes become a reality.

2.8 Innovation Performance

Innovation has become an increasingly significant concept in social sciences and technological advancement. However, providing a clear and concise definition of innovation is a challenge. Generally, innovation performance can be understood as the effectiveness of an organization, institution, country, or region in generating, implementing, and adapting new ideas, products, services, or processes to contribute to economic growth, development, competitiveness, and profitability. Innovation refers to the introduction of a new or improved product, service, or process (Stoneman, 2022). It involves new ideas or inventive activity that may be considered an addition to the stock of knowledge. Innovation could be radical or incremental. Radical innovation is when a firm introduces a new product or service to the firm and the market. On the other hand, an incremental product is where the firm improves on an existing product or service that is not new to the firm but new to the market. Innovation also features the improved or new process of producing a product or service. The process through which products or services are created could also be enhanced through innovation. This makes the production process faster, efficient and reliable. Several metrics have been used for innovation studies. They include a new or improved product or service, a new or improved process (OECD, Oslo manual 2018), patent applications, patent counts, patent citations (Acosta, 2022) and high-tech exports (Navarro Zapata et al., 2024). This study measures innovation performance from the perspective of innovation outputs. Innovation outputs, as used here, refer to the outcome of any knowledge-related activity undertaken by the firm or country involved in the study. The metrics for innovation performance for this study include product innovation and patent applications. These metrics have been chosen because they have been used in existing literature as effective measures of innovation performance for firm and country-level analysis. According to Siriram (2022), innovation serves as a mechanism that allows

firms to adapt to changing environments and remain competitive. This process is driven by knowledge that creates novelty, utility, and value. According to Wilson et al. (2023), innovation performance can be divided into two dimensions: innovation input and output. Innovation inputs refer to the resources invested in innovation activities, such as human capital, physical and virtual IT infrastructure, research and development (R&D) expenditures, policies, and institutional frameworks—the more effective the innovation input, the better the innovation output.

Innovation output measures the results of innovation input and includes new or improved products, services, processes, patents, and technological advancements. Positive innovation output can increase market share, revenue, profitability, and enhanced competitive positioning.

Another critical dimension of innovation performance is innovation capacity. This refers to an entity's ability to effectively generate and apply new knowledge. Acquiring new knowledge is beneficial only when there is an adequate capacity to apply it effectively, leading to improved innovation performance. A high innovation capacity is a better predictor of successful innovation performance, as stated by Kastelli et al. (2024). Innovation dissemination refers to the expedient and efficient way businesses, organizations, and nations embrace and adapt to novel innovations. The broader the reach of innovation within a firm or economy, the more substantial the economic and social advantages for the populace. **The following section evaluates proxies for innovation performance in current studies.**

2.9 Factors that Influence Innovation Performance

Several studies have investigated the factors affecting innovation from various perspectives. The effects of these factors on innovation can differ significantly across sectors and economies, with economic strength playing a vital role. Cozzarin and Percival (2021) identified training and human capital development factors that influence innovation and found that training and human capital development in Canadian firms enhanced new process innovation. A skilled and knowledgeable workforce, attracting and retaining experienced employees, and a talented workforce are critical for innovation performance. Institutional support is another crucial factor for innovation performance. Innovation thrives in economies where government policies protect and support intellectual property rights. Innovation thrives in environments with strong institutions. In China, regions with more robust IPR protection exhibit better innovation performance (Ljungwall & Wang, 2022). In the EU, investment in R&D in the form of public funding is considered an

influential determinant of innovation performance. Other studies have identified knowledge stock (Li & Ljungwall, 2021), spatial spillover externalities (Proenca & Glorias, 2021), ICT (Kijek & Kijek, 2019b), and Foreign Direct Investment (FDI) acquisition (Garcia-Vega, 2019) as critical knowledge-based factors influencing innovation performance. A key consideration among these determinants is that they are knowledge-based and influence the creation of new knowledge during the innovation process. **The study further examines the factors that influence regional differences in innovation performance.**

2.9.1 Regional Disparities in Innovation Performance

Innovation disparities across regions and countries pose a significant challenge on a global scale, contributing to economic and social inequality. Regional disparities in knowledge production may exacerbate this issue. Addressing innovation disparities is essential to foster balanced regional development and maximize the potential for innovation to improve lives. Access to funding plays a crucial role in the development of innovation. In regions where firms can access venture capital, government grants, and other sources of funds with relative ease, startups and innovation-driven firms can be better supported. In contrast, regions lacking access to funding face obstacles in supporting innovative firms. In essence, regions that invest in R&D projects are more likely to promote innovation. The availability of skilled human capital is another significant determinant of regional innovation capacity. Regions with strong educational institutions that promote science, technology, engineering, and mathematics tend to train a workforce capable of driving innovation. On the other hand, regions lacking such educational institutions cannot build a skilled labour force that can promote innovation. Moreover, labour migrations in the form of brain drain can also affect losing regions, as regions with better job opportunities tend to attract a highly skilled and experienced workforce that can steer regional innovation.

Institutional policies and the level of regulatory compliance in a region also influence innovation disparities. Regions with effective institutions that promote intellectual property rights and favourable policies for startups tend to promote entrepreneurship and innovation more effectively than regions that lack such policies. Firm clustering can also promote local buzz and knowledge spillovers. Regions with firm agglomerations serve as innovation hubs, as firms within such regions can share knowledge, undertake joint projects, and enjoy economies of scale. A well-known example is Silicon Valley in the USA. **Having reviewed the literature and concepts of the study, the next section explores the research gap and aims.**

2.9.2 Collaboration and Networks

Collaboration and networks refer to partnerships between and among firms to share knowledge, ideas, and expertise. The decision of firms within a region to innovate is based on shared common interests and proximity. Existing studies confirm that regions advance innovation performance when they collaborate and network with partners such as customers, suppliers, competitors, and research organizations (Tóth et al., 2021). Suppliers comprehensively know the critical materials and resources for new products and services. Hence, collaboration with suppliers allows firms to gain valuable information and insights that aid in creating innovative solutions and product development. Supplier collaboration and innovation are positively associated.

Contrary to studies on Irish and Dutch manufacturing firms, supplier collaboration has a negative and insignificant impact on product innovation (Lapido et al., 2022). The triple helix concept is pivotal in studying collaboration and networks for innovation. The triple helix concept is an interaction between the university, industry, and government. This concept was made famous by Etzkowitz and Leydesdorff in 1995 (Fidanoski et al., 2022). Collaboration and networks are seen in this concept as government funding research activities at universities and research **findings being commercialized as spin-offs to the industry to apply new knowledge to improve products and services**. Achieving UN SDGs requires education institutions, governments, NGOs, and individuals to commit to collaboration and networks and adopt triple helices to promote sustainable innovation (Zhou & Etzkowitz, 2021). This establishes that the determinants of KPF promote knowledge sharing through collaboration and networks to enhance innovation performance.

2.9.3 Institutional Factors

The determinants of KPF do not operate in utopia. The institutional framework embodies and manages these determinants through policy and regulation. Factors such as intellectual property rights, government policies on innovation, and regulatory frameworks (such as the rule-of-law and by-laws) influence the determinants of knowledge production function in the innovation ecosystem. Innovation and invention are costly and time-consuming. The originators of new knowledge must be protected to be adequately rewarded and motivated. Institutional policies should create an appropriate avenue for the commercialization of innovations. Regulatory agencies should ensure that property rights are strictly enforced. It is worth noting that policies and regulations play a vital role in collaboration and networks. Existing policies and regulations also

promote human capital training and development. Prior studies assert that the evolution of regional institutions has created fertile ecosystems that enhance innovation capacity (Mosconi & D'Ingiullo, 2023). Thus, institutions function as catalysts for firms' abilities to create, transform, and effectively combine the determinants of KPF to enhance regional innovation performance. Recent literature emphasizes that the unique characteristics of regional institutions can be explained as vital determinants of regional disparities and innovation gaps (Mosconi & D'Ingiullo, 2023; Rodríguez-Pose, 2013). **Institutional frameworks are not just regulatory bodies and policies but strategic assets that help achieve competitive advantage and allow for the resilience of firms and regions to environmental changes.** Strong institutions in the form of voice and accountability, government effectiveness, control of corruption, upholding the rule of law, and a high regulatory quality index propel the determinants of KPF to shape the capacity of regions to innovate.

2.9.4 Knowledge Spillovers

Knowledge spillovers occur when knowledge created in an organization spread to others, potentially spurring innovation or productivity and leading to benefits for others. The spread of knowledge can be intentional or unintentional. Labour mobility is a means of knowledge spillover. Labour is embedded in tacit knowledge. Labour movement across firms or countries indicates that tacit knowledge is transferred. This is in the form of the skills and experiences of employees. Publications and conferences also aid knowledge spillovers. The presentation of academic papers and reports from industry and the dissemination of research findings serve as a wheel for spreading knowledge towards innovation. Some studies argue that incremental improvements in a firm's product, process, production methods, technologies, and organizational structure require less radical knowledge, which can be achieved through knowledge spillovers within and between firms (Audretsch & Belitski, 2022). **Firms that lack the required funds to invest in R&D usually find knowledge spillover to lower the cost of new knowledge acquisition through R&D expenditure.** The extant literature argues that reducing R&D and increasing knowledge spillovers positively affect firms' innovation incentives (Holl et al., 2023). This implies that when knowledge spillovers are low, firms that cannot invest in R&D cannot innovate because of the increased cost of accessing knowledge spillovers. Other mechanisms of knowledge spillover include reverse engineering, informal exchanges, and formal collaborations.

2.9.5 Research and Development Expenditure

R&D expenditures are the mainstay of innovation. This is the investment made by the government, firms, and private institutions in the R&D of new products, services, processes, and technologies. Current studies indicate a strong association between research and development (R&D) and innovation. In the US, all other things being equal, every 10% increase in R&D expenditure leads to a 20% improvement in innovation (Pegkas et al., 2019). Firms that seek to create radical innovations focus on R&D expenditure. R&D expenditure is intricately linked to economic growth. Innovations created by R&D leave new industries, markets, and job opportunities. It is also established in the extant literature that subsidies on R&D investment extend beyond firm innovation to physical capital production. Physical capital production creates long-run economic growth due to the motivation to create new and varied products. Thus, R&D investment, besides enhancing innovation, also creates a rippling effect in different sectors of the economy. Tung and Hoang (2024) confirmed that the limitations placed on economic growth due to resource scarcity can be alleviated through R&D investments. The impact of R&D investments on economic growth is significant in middle- and upper-income countries compared to lower-income countries.

Narrowing it to the firm level, R&D expenditure enhances profitability in two ways (Tajaddini & Gholipour, 2021). **First, it helps firms create advanced technologies at a lower cost.** Through R&D investment and advanced technology, firms become efficient, producing increasingly high-quality goods and services with limited resources. **The second is increased sales due to introducing a new or improved product or service.** Policy formulators and decision-makers should focus on R&D investment because of its impact on innovation and economic development. The graph below indicates R&D expenditure by sector in the EU from 2012-2022.

Gross domestic expenditure on R&D by sector, EU, 2012-2022
(%, relative to GDP)

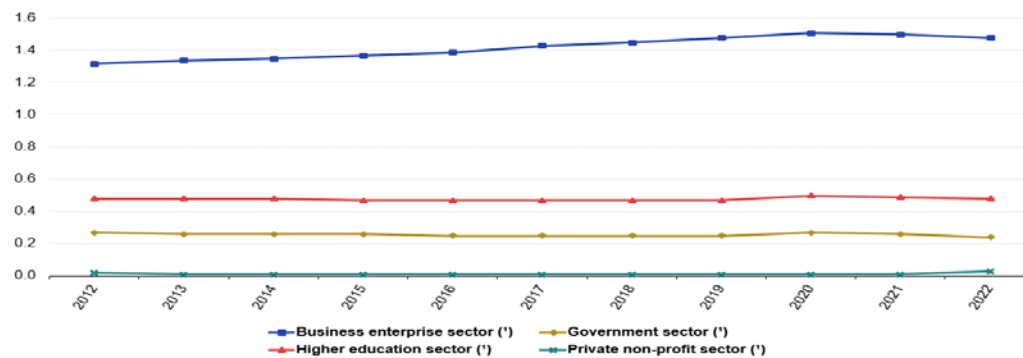


Figure 2: R&D expenditure per GDP in the EU

Source: European Commission (2024)

2.9.6 Human Capital

Human capital is pivotal in creating, managing, and disseminating knowledge in innovation literature. It explains individuals' skills, experiences, and capabilities that drive and sustain innovative activities in an organization or economy. A firm's human capital is an intangible resource that can produce a competitive advantage. The knowledge-based view (KBV) asserts that firms with creative and skilled employees are rich in new ideas and knowledge (Sun et al., 2020). This creates both incremental and radical innovation capability. The stock of highly educated workers is one of the main proxies for measuring human capital. When employees have the required skills and experience, a firm's absorptive capacity is high. This enables easy assimilation of new ideas and knowledge. Therefore, human capital development should be deliberate and conscious.

Since knowledge is tacit and resides in individuals' minds, employees need insight into effectively synthesizing and combining the acquired knowledge to create innovation (You et al., 2021). **A critical fundamental aspect of innovation is the number of knowledge components employees can manage simultaneously.** To achieve this, employees require skill development, training, and education. Employees must connect internally and externally with various knowledge components to effectively apply them. Firms should be ready to spend money on the professional development of their employees to push their innovation frontiers.

3. RESEARCH GAP AND AIM

3.1 Research Gap

In the field of innovation and knowledge production function (KPF), previous studies have identified various determinants of KPF that contribute to innovation. Many of these studies have acknowledged the importance of knowledge and its related factors in innovation settings (Verba, 2022; Link, 2021). Knowledge outcomes have a substantial impact on the profitability of firms, their competitiveness in the marketplace, and economic growth. **Despite the increasing attention given to knowledge creation, dissemination and application, not much studies is seen on knowledge management variables (such as channels of information and KM HR practices), knowledge network variables (such as knowledge intensive business services) and knowledge diffusion variables (such as social and political globalization.** These proxies for knowledge-based determinants were chosen because they offer valuable insights into innovation performance but have received limited attention in the literature on the knowledge-production function. For instance, the existing literature on knowledge management has not adequately explored how the human resource factor and information channels contribute to innovation performance in moderate and emerging European Union countries.

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3.1.1 Research Gap for Objective 1

Knowledge management refers to the creation, organization, storage, retrieval sharing, and using knowledge to improve firm performance (Usman et al., 2019). Knowledge management comprises how firms manage external knowledge sources and internal knowledge sharing (Usman et al., 2019; Li, 2020). Current literature posits that effectively managing external sources of knowledge and internal knowledge sharing is critical to innovation development. Firm innovation is a human

issue (Kianto et al., 2017). Hence, since human beings develop and implement new knowledge, effective human resource practices are critical for firm performance. Thus, the mechanisms of new knowledge entering a firm cannot be under-emphasized. Knowledge sources determine the quality and sophistication of new knowledge acquired by a firm. Akhmadi and Tsakalerou (2022) argue that the quality and sophistication of new knowledge a firm acquires influences the firm's dynamic innovation capabilities. Therefore, firms should attach utmost importance to their sources of information. Channels of information and effective knowledge-based human resource practices are key enablers of firm-level innovation. **This objective focuses on firm-level innovation development through two key knowledge management variables- channels of information and knowledge-based human resource practices, and how heterogeneity interactions of competition intensity in a firm's business environment influences this relationship.**

While past studies have focused on human resource management (Al Daboub et al., 2020; Papa et al., 2020), firm external sources of information (Wang et al., 2020; Yuan et al. 2022) and innovation nexus, the relationship remains under explored. Thus, existing studies have several limitations. Wang et al. (2020) acknowledge that conflicting evidence exists regarding the link between firm channels of information, human resource practice and innovation performance. The mechanisms through which firm channels of information and human resource practices influence firm innovation is not sufficiently explored (Al Daboub et al., 2020; Yuan et al., 2022). One key factor that threatens firms' innovation in emerging markets is the level of competition they face (Papa et al., 2020; Zhao et al., 2024). However, the heterogeneity of competition intensity interaction in the relationship between channels of information, knowledge-based human resource practices and innovation performance is missing in the current literature.

The scarcity of research on the moderation role of competition intensity heterogeneity in the relationship between firm information channels, knowledge-based human resource practices, and innovation performance needs to be addressed. In this study, heterogeneity interactions of competition intensity refers to the varying levels in which competition intensity moderates the relationship between firm channels of information, knowledge-based human resource practices and innovation. The focus of this objective is to fill the extant gap in literature by **(i) examining the influence of channels of information and knowledge-based human resource practices on product innovation in moderate and emerging innovative EU markets (ii) exploring how varying**

levels of competition intensity strengthen the relationship between channels of information, knowledge-based human resource practices and product innovation in moderate and emerging innovative EU markets and (iii) **developing a conceptual model from the perspective of open innovation theory, endogenous growth theory**, channels of information, knowledge-based human resource practices, competition intensity and product innovation nexus in moderate and emerging innovative EU markets.

This objective asserts that firm channels of information (standard documents), knowledge-based human factors in the form of planned job rotation, cross-functional groups, and management play a critical role in firm-level innovation. Further to this argument, the study states that competition intensity at varying levels moderates firm channels of information (standard documents), knowledge-based human resource practices (planned job rotation, cross-functional groups) and firm-level innovation connections. Analyzing the linkages between firm channels of information, knowledge-based human resource practices, competition intensity and product innovation offer a better insight into determinants of firm innovation capabilities (Li et al. 2020)

3.1.2 Research Gap for Objective 2

Although our knowledge of how knowledge network activities impact innovation has expanded due to the rising body of research (Desyllas et al., 2018; Shearmur & Doloreux, 2019), there are still limitations that prevent us from fully comprehending the relationship. There is a significant gap in the limited exploration of the role of knowledge networks in facilitating innovation within knowledge intensive business services (KIBS). In the contemporary, swiftly changing global economy, companies increasingly depend on knowledge-intensive business services (KIBS) to propel product innovation (Hall & Williams, 2019). KIBS, which includes professional and technical services such as consulting, research and development (R&D), engineering, and IT solutions, are important knowledge dissemination and application agents that foster an environment conducive for innovation to thrive (Muller & Zenker, 2001). These services serve as intermediaries in knowledge networks, connecting firms to specialised expertise, advanced technologies, and best practices that enhance their innovative aptitudes (Shearmur & Doloreux, 2019). KIBS firms exhibit diverse innovation behaviours across different sectors, which can be attributed to their unique knowledge regimes, which shape their innovation patterns and

performance outcomes (Desyllas et al., 2018). This conclusion implies that KIBS affects the character and course of innovation activities and improves organisations' capacity for innovation.

Existing studies have not focused on analysing how knowledge network activities, particularly in the form of professional and technical KIBS, impact product innovation. This lack of clarity hinders our understanding of how KIBS can effectively contribute to enhancing firms' innovation capabilities. Understanding the impact of knowledge network activities in the form of professional and technical KIBS on product innovation could help firms optimise their collaboration strategies and improve their competitive advantage. **This objective focuses on examining how professional and technical KIBS-driven knowledge network activities impact product innovation and the extent to which regulatory quality and competition intensity moderates the relationship.** To achieve this goal, the study adopts the knowledge production function model and dynamics capability theory. The dynamic capability theory (Teece et al., 1997) provides a useful framework for understanding how firms adapt, integrate, and reconfigure internal and external capabilities to address challenges in the fast-changing environments. This theory suggests that firms develop and adapt their internal competencies by incorporating, adapting, and reconfiguring external knowledge sources (Teece, 2018). Conversely, the knowledge production function is a theoretical framework that elucidates how knowledge is produced, disseminated, and utilised within organisations (Charlot et al. 2015). Under this objective, first the study develops a theoretical model that examines the direct influence of technical and professional knowledge-intensive business services on product innovation. Second, the study investigates the context-based impacts of competition intensity and regulatory quality on the relationship between technical and professional knowledge-intensive business services and product innovation. Regulatory quality, described as the effectiveness of institutions and policies in promoting business activities (Zhu et al., 2024), can significantly influence the proper functioning of knowledge networks and their influence on innovation. Effective regulatory policies could improve firms' aptitudes to innovate by providing vibrant guidelines and plummeting uncertainties connected with compliance (Dunyo & Odei, 2023). Conversely, excessively stringent regulations could stifle creativity and constrain the scope of innovation (Brousseau et al., 2010). Competition intensity refers to the extent of rivalry within a market, reflecting how firms compete for resources, market share, and customers (Anning-Dorson et al, 2017). Increased competition intensity can affect product innovation, as firms are

compelled to differentiate themselves and respond to market demands more effectively (Zhou & Li, 2024).

3.1.3 Research Gap for Objective 3

Globalization is a key driver of knowledge diffusion. Technological innovation and economic growth thrive on knowledge sharing (Khan et al., 2024). Globalization connects people and countries across distances, cultures, easing communications through economic, social and political agreements (Ramzan et al., 2023). However, the relationship between globalization and innovation remains ever more contentious as the pursuit of innovation has heightened. Countries in emerging economies, regardless of their resource constraints, are committing resources to globalization activities and formulating globalization policies to benefit from knowledge diffusion and innovation (Zheng et al., 2023; Hsu et al., 2023). Although widely studied by scholars and discussed by policymakers, it is still largely unclear how specific globalization issues, such as social and political globalization, influence regional innovation performance and the conditions or context under which efficient social and political globalization can be improved to achieve higher regional innovation performance. Understanding how different aspects of globalization influence innovation performance in a region is critical for governments and regional authorities to improve innovation at the national and regional levels. But current studies have mainly focused on globalization in general or the economic aspect of globalization (Feng et al., 2019) and innovation without considering globalization heterogeneity.

Indeed, globalization in general (Feng et al., 2019) foreign direct investment (Huan & Qamruzzaman, 2022), economic globalization (Hurtado et al., 2024) and trade openness (Wang & Zhang, 2021) are typically used in earlier studies to measure globalization. **The KOF globalization index classified and emphasized how each aspect of globalization uniquely influences innovation and environmental sustainability (Abbas et al., 2024).** Following the KOF globalization index, social and political globalization enables tourism, information and cultural exchange, signing treaties leading to knowledge diffusion and exchange for innovation advancement (Niazi, 2025; Feng et al., 2019). A study by Chen et al. (2022) in China revealed that FDI has positive intra-industry effects on the quality and quantity of innovation among firms in China but surprisingly found no significant impact of FDI on firm intra-industry knowledge spillover and productivity. The knowledge spillover effect of FDI on innovation is better

understood when examined among groups of countries than in a single country (Bergougui & Murshed, 2023). Current studies are fraught with inconclusive results, paving the way for further studies into the globalization and innovation nexus. For instance, FDI either positively or negatively impact firm innovation while promoting local competition at the same time (Vujanović *et al.*, 2022). In Sub-Saharan Africa, a study by Nyeadi and Adjasi (2020) involving Nigeria and South Africa showed that FDI has a positive and significant impact on innovation in Nigeria but not in South Africa, and they accept that context and the number of countries involved in the study are critical to the findings. The authors of this study also acknowledged the weakness of the time dynamics phenomenon and recommended that future studies should adopt panel data in the analysis. Globalization matters in innovation. It has the tendency to influence market size and competition. Current economic and innovation literature uses indicators such as trade, domestic competition and transfer of capabilities to measure globalization (Akcigit & Melitz, 2022). Most studies on globalization have been focused on economic globalization at the expense of social and political globalization (Feng *et al.*, 2019). Even though the economic aspect is the principal characteristic of globalization (Faghih & Sazegar, 2019), the influence of globalization on innovation is not completely assessed when social and political aspects of globalization are ignored.

The preceding studies reveal that the role of social and political globalization in regional innovation is less explored. **Also, the context or contingency factors that might weaken or strengthen the relationship** between social and political globalization and regional innovation are not explored. Another setback of current studies on globalization and innovation is that most studies examine globalization measures from a single country perspective, and this does not offer a deeper insight into understanding globalization issues (Bergougui & Murshed, 2023), particularly from the perspective of emerging markets.

This objective seeks to fill the gap in existing literature by examining how social and political globalization impacts regional innovation performance (Patent application) in moderate and emerging innovative EU countries and the extent to which civil liberties moderate the relationship. This reveals the distinctive influence of social and political globalization on regional innovation performance. Since regional innovation is inherently complex and a systematic process that requires new ideas and best practices that might not be available locally (Edeh & Prévot, 2024), this objective departs from the general and economic aspect of globalization and focuses on social

and political globalization, which is rarely explored in current studies. The objective also offers better insight into contextual factors (such as civil liberties) that might strengthen or weaken social factors' impact and political globalizations on regional innovation performance in moderate and emerging innovative EU countries. The following section explains the study aim to address the research gap in current literature.

3.2 Research Aim

Generally, the primary aim of this dissertation is to explore the knowledge-based determinants of knowledge production function (KPF), influence innovation performance in moderate and emerging EU countries and the extent to which factors in the business environment moderate the relationship. The aim is specifically broken into three main objectives.

Objective 1 examines the relationship between knowledge-based management variables (firm channels of information and knowledge-based human resource practices) and innovation performance (product innovation) and the extent to which the business environment (Competition intensity) moderates the relationship.

To fulfill objective 1, the study develops four hypotheses based on the gap in current literature and the gap in current. They are as follows.

H1a: Firms' channels of information have positive and significant impact on innovation product innovation in EU's emerging countries.

H1b: Knowledge-based HR practices have a positive and significant impact on product innovation in EU's emerging countries.

H1c: Competition intensity heterogeneity moderates the positive impact of firm channels of information on product innovation- the higher the level of competition intensity the stronger the effect.

H1d: Competition intensity moderates the positive impact of knowledge-based HR practices on product innovation- the higher the level of competition intensity the stronger the effect.

Objective 2 examines the relationship between knowledge-based network variables (technical and professional knowledge intensive business services) and innovation (product innovation) and the extent to which the business environment (Competition intensity and regulatory quality) moderates the relationship.

To fulfill objective 2, the study develops four hypotheses based on the gap in current literature and the gap in current. They are as follows.

H2a: Technical knowledge-intensive business services have positive and significant impact on product innovation.

H2b: Professional knowledge-intensive business services have positive and significant impact on product innovation.

H2c: Regulatory quality moderates the positive impact of technical knowledge-intensive business services on product innovation-the higher the level of regulatory quality the stronger the effect.

H2d: Competition intensity moderates the positive impact of technical knowledge-intensive business services and product innovation- the higher the level of competition intensity the stronger the effect.

H2e: Regulatory quality moderates the positive impact of professional knowledge-intensive business services and product innovation- the higher the level of regulatory quality the stronger the effect

H2f: Competition intensity moderates the positive impact of professional knowledge-intensive business services and product innovation- the higher the level of competition intensity the stronger the effect.

Objective 3 examines the relationship between knowledge-based diffusion variables (social and political globalization) and regional innovation performance (patent applications) and the extent to which the business environment (Civil liberties) moderates the relationship.

To fulfill objective 3, the study develops five hypotheses based on the gap in current literature and the gap in current. They are as follows.

H3a: Social globalization has a positive and significant impact on patent applications in emerging EU countries.

H3b: Political globalization positive and significant impact on patent applications in emerging EU countries.

H3c: Civil liberties moderate the positive impact of social globalization on patent applications-the higher the level of civil liberties the stronger the impact.

H3d: Civil liberties moderate the positive impact of political globalization on patent applications- the higher the level of civil liberties the stronger the impact.

H3e: The interactions of civil liberties, social and political globalization have positive impact on patent applications- the higher the civil liberties, social and political globalization the stronger the impact.

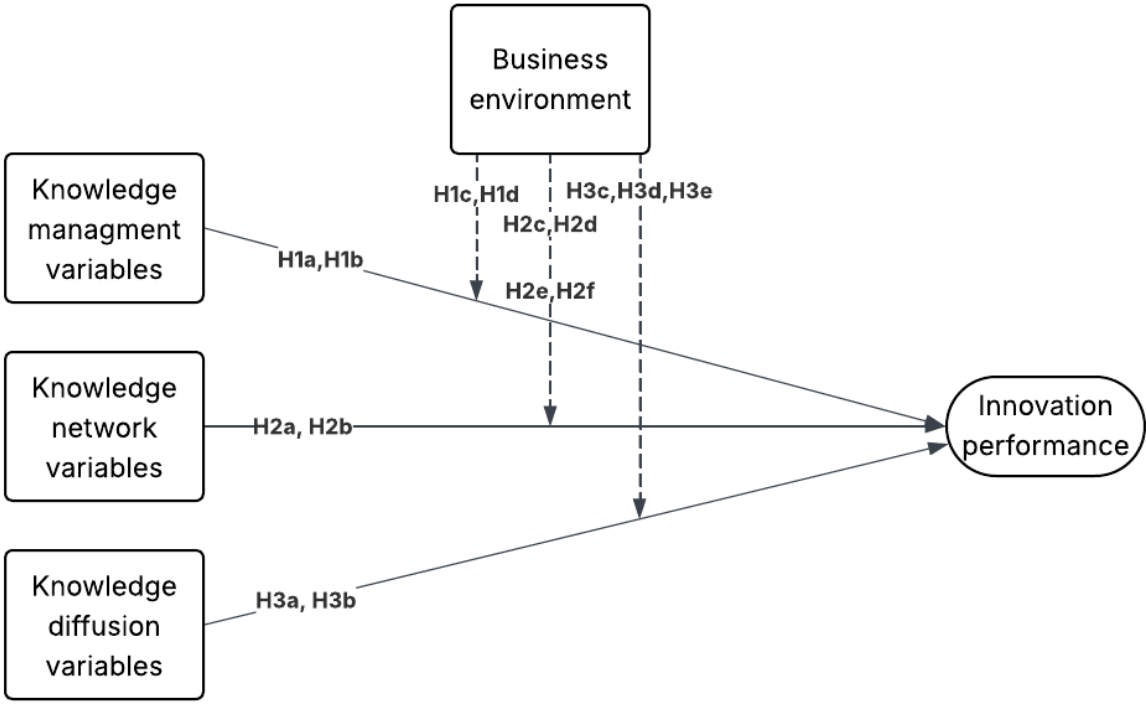


Figure 3: Conceptual framework

4. DATA AND METHOD

4.1 Data Source and Selected Countries

This research aims to explore the impact of the chosen determinants of the knowledge production function on innovation. To accomplish this aim, this study utilizes secondary data for analysis. **Creswell (2021) posits that secondary data sources can be highly beneficial for research analysis and developing a research framework, provided they are trustworthy, dependable, and adhere to ethical data collection standards.** Moreover, the secondary data source must have been employed and cited in existing literature as being of excellent quality for scientific research. This study uses data from the Community Innovation Survey (CIS) 2018, Globaleconomy.com, Eurostat, and the World Bank Enterprise Survey (WBES). These database sources were selected because they offer information on the variables pertinent to this study and have a proven track record of being dependable, valid, and employing ethical considerations in their data collection processes for many years.

4.1.1 Community Innovation Survey 2018

The study sourced secondary data from the Eurostat Community Innovation Survey (CIS), which was conducted between 2016 and 2018. This reliable and valid data source provides insights into innovation activities in European businesses, focusing on process and product innovation, organizational and marketing innovation, barriers, and financing of innovation in manufacturing, service, and small, medium, and large firms in Europe. The CIS 2018 data from EU member states and other European countries allows cross-country comparison and regional analysis. The chosen timeframe represents one of the most recent CIS datasets made available by the Eurostat Safe Centre, and it contains all relevant variables with minimal missing data. The CIS employs a standardized survey to collect information on various topics, including firms' innovation activities spanning various European industries. The questionnaire was distributed via postal means, and stratified sampling techniques were used to select firms to participate in this study. Companies were classified into four strata based on their size: micro firms (10-49 employees), medium firms (50-249 employees), macro firms (250-499 employees), and large (≥ 500 employees). Sectoral categorization primarily revolves around the sector's economic activities and generally encompasses the manufacturing and service sectors. The CIS is a crucial database for

scientific research due to its rigorous procedures that guarantee that data collection and processing meet ethical, valid, reliable, accurate, and quality standards for scientific research. The data provided by CIS offer insights into enterprise or firm attributes (such as size, year of registration, enterprise group, and enterprise marketplace), firm innovation activities (including R&D, new or improved products or processes, factors hindering innovation activities, turnover from new or improved products or processes, public funding for innovation, sources and types of innovation funding, and enterprise expenditure on innovation), and strategies for knowledge flow towards innovation (including patent registration and publication, channels of information, intellectual property rights issues-IPR, and innovation cooperation and co-creation). The data on the variables of interest for the study are available in CIS 2018.

4.1.2 Globaleconomy.Com

GlobalEconomy.com is a highly regarded database website that offers over 300 indicators for 200 countries from 1963 to the present. These indicators cover innovation, the business environment, financial markets, and environmental and social indicators, making it an invaluable resource for researchers, businesses, and policymakers seeking to analyze global economic trends and make national and regional comparisons. The database has been cited as reliable in the existing literature (Klassen et al., 2023; Hilmi et al., 2020). This study used country-level panel data from 2000 to 2022, harmonized from multiple sources, including the World Bank, Heritage Foundation, Transparency International, WIPO, and the United Nations. The database covers various topics, such as GDP and economic growth, consumption and investment, labour market, money, international trade and investment, governance and business environment, environment and energy, and innovation measures. There are no significant issues regarding ethical considerations for secondary data (Odei & Hamplová, 2022). Nonetheless, the study thoroughly evaluated GlobalEconomy.com's data site, methodology, and content to ensure that the data was consistent, reliable, and credible.

4.1.3 Eurostat

The Eurostat database is a reliable and trustworthy data source managed by Eurostat, the statistical office of the European Union. This database provides credible, valid, and objective data across EU member states and other European countries, covering various variables such as GDP, innovation, inflation, education, energy consumption, population demographics, and migration. The data collected in the Eurostat database are obtained using ethical, harmonized, and uniform standards

and methodologies, allowing researchers to make accurate comparisons. The Eurostat database is open-source, and its data can be accessed freely from the Eurostat website in various formats, including CSV, Excel, and PDF. **This study utilized the Eurostat database because of its rigorous quality assurance procedures and high data collection and validation standards.** The Eurostat database also includes data on the variables adopted in this study. However, despite the efforts to provide timely and accurate data, the Eurostat database has limitations. One of the limitations of the Eurostat database is the time lag between data collection and publication. Another limitation is the width and complexity of the data, which can pose a challenge to new users in interpreting and navigating the database.

4.1.4 World Bank Enterprise Survey

The World Bank Enterprise Survey (WBES) is a comprehensive and dependable source of information on the business environment and firm performance across numerous countries to enhance the business climate. The primary goal of WBES is to evaluate the influence of the business environment at the firm level, specifically about productivity, expansion, investment, and innovation, as well as the challenges and opportunities businesses face. The data provided by the WBES cover World Bank projects, national policies, and international research, which are helpful for researchers, policymakers, and governments when making informed decisions. The WBES database contains panel and cross-sectional data on over 190,000 firms in over 150 countries divided into low-, middle-, and high-income countries. The data covers manufacturing, services, and retail trade, enabling analysis across diverse sectors and countries in economic contexts. The WBES covers the business environment, firm performance, government and institutional interactions, innovation and technology, and the workforce and labour market. The WBES uses a stratified random sampling method to ensure fair representation of firms from each country, with carefully designed strata for small, medium, and large firms. Face-to-face interviews were conducted to collect data from the business owners and senior managers. It is a reliable database that other researchers use to examine European innovation performance (Cirera & Muzi, 2020). **However, WBES has drawbacks, including self-reporting biases and data timelines. The WBES database, which is dedicated to ethical and responsible data collection, can be accessed free of charge on its website.** The survey depends on self-reported information from senior managers of companies, which may result in under-reporting of sensitive issues, such as corruption, over-reporting of successful performance outcomes, and other events related to the firm.

4.1.5 Data source for objective 1

The study relied on cross-country data from the CIS 2018 Eurostat database and World Bank Enterprise Survey 2018, targeting 14 moderate and emerging EU countries. The Eurostat database is recognized for its long-standing reliability owing to its credible, ethically sound, and precise data collection methods (Arthur & Stejskal, 2023). This enhances the trustworthiness and validity of the data for research analyses. The survey covers all EU firms engaged in innovation, classified under NACE2, and uses a harmonized questionnaire based on the Oslo Manual (EU, 2020), which aligns with the study's aim. The World Bank Enterprise Survey includes innovation modules covering approximately 14 moderate and emerging EU countries from 2016 to 2018. This survey is acknowledged as one of the most comprehensive and standardized cross-country surveys available. The World Bank Enterprise Survey gathered data on the business environment and investment climate, addressing corruption, competition, access to finance, and performance metrics. Since the 1990s, the World Bank has been conducting firm-level surveys, and since 2005, these efforts have been centralized and standardized to ensure data comparability across countries. The World Bank conducts face-to-face interviews with firm managers or owners to collect insights on innovation, business-government relations, operational challenges, and performance metrics. The dataset includes firms from manufacturing and service sectors and uses a stratified sampling method that categorizes firms by industry, size, and location. Firm sizes were classified as small (5–19 employees), medium (20–99 employees), and large (100 or more employees). The study sample primarily focused on moderate and emerging economies that participated in the survey. **The final dataset comprised random samples from approximately 14 moderate and emerging countries across various industries, including manufacturing and services.**

4.1.6 Data source for objective 2

The study examines the hypotheses using firm-level data from the Community Innovation Survey (CIS) (2018), World Development Indicators (WDI), and World Bank Enterprise Survey (WBES), together with their associated innovation modules, covering moderate and emerging innovative EU countries from 2016 to 2018. These data sources are among the most comprehensive and standardized cross-country survey databases frequently utilized in knowledge and innovation research (Rikap & Lundvall, 2022). The CIS, WDI and WBES collect data on a country's corporate innovation activities, regulatory framework, technical and professional knowledge networks. Information from these sources is centralized and standardized to ensure comparability across

countries. They employ face-to-face interviews with company managers or owners to collect details on innovation, government regulatory activities, and knowledge network operations of firms. The CIS, WDI, and WBES datasets encompass manufacturing and service sector firms. Utilizing a stratified sampling approach, firms are categorized by industry, size, and location. Company sizes were classified as small (5–19 employees), medium (20–99 employees), and large (100 or more employees). The study sample primarily focuses on moderate and emerging EU economies that participated in the survey. **The final dataset comprises random samples of firms from moderate and merging EU countries across various industries, including both manufacturing and services.** The estimation sample of the study consists of approximately 100,034 firms. As part of the data filtering process, all firms with missing information on the variables of interest were excluded.

4.1.7 Data source for objective 3

The study analysis is based on annual panel data comprising 14 moderate moderate (Slovenia, Spain, Czech Republic, Italy, Malta, Lithuania, Portugal, Greece and Hungary) and emerging (Croatia, Poland, Slovakia, Latvia, Bulgaria and Romania) EU countries. The dataset includes information on patent applications, social and political globalization, civil liberties index, foreign direct investment, trade openness, GDP per capita, R&D expenditure and other knowledge diffusion factors. The data source is World Development Indicators (WDI) of the World Bank which is compiled by TheGlobalEconomy.com. **TheGlobalEconomy.com is a reliable database site which harmonizes country and regional level data on socio-economic issues (Halim and Rahman,2022; Radu, 2015).** Its data is from the sites of world bank, UNESCO, OECD, Eurostat, IMF, Transparency International and many other global data sites. It has over 300 indicators for about 200 countries. The source data was adopted because it is credible and reliable. The study concentrated on the period 2000-2023 because it coincides with the period where several countries in the EU such as Finland, Sweden and Denmark are among the top innovative countries in the world. Also, the EU has the biggest regional barrier-free economic area in the world (Svensson-Hoglund *et al.*, 2021).

4.2 Justification for the Selected Countries

The EU was chosen as the study context because of its significant incentives and collaboration among its firms. In 2019, five of the world's top ten most innovative countries were in the EU:

Germany (2nd), Finland (3rd), Switzerland (4th), Sweden (7th), and France (10th) (Scuotto et al., 2020). It must also be stated that several countries in the EU also lag in the pursuit of innovation (Profile, 2024). The EU's high level of innovation makes this an ideal setting for this study. The European innovation scoreboard categorizes innovation performance into four groups. Countries whose innovation performance are way above the EU's average (125%) are referred to as innovation leaders (Denmark, Sweden, Finland, and Netherlands), those with just above EU's average are known as strong innovators (Belgium, Austria, Ireland, Luxembourg, Germany, Cyprus, Estonia and France), countries with innovation performance just below EU's average are referred to as moderate innovators (Slovenia, Spain, Czech Republic, Italy, Malta, Lithuania, Portugal, Greece and Hungary) and countries with innovation performance way below EU's average are known as emerging innovators (Croatia, Poland, Slovakia, Latvia, Bulgaria and Romania). **Although there are 15 moderate and emerging innovative countries in the EU as at 2024 (Profile, 2024), Poland is not included in the study due to lack of data availability.** Specifically, the study focuses on the moderate innovative (Slovenia, Spain, Czech Republic, Italy, Malta, Lithuania, Portugal, Greece and Hungary) and emerging innovative (Croatia, Slovakia, Latvia, Bulgaria and Romania) EU countries because they have several homogeneous features relating to innovation performance, including, for example, 'inadequate infrastructure, insufficient funding, and a lower level of development of innovation systems' (Prokop, et al. 2023, 1804) and 'The shortcomings of their institutional frameworks and the protective strategies adopted by governments are evident in areas such as inadequate investment in skilled human resources and their training, insufficient R&D funding, and fragile inter-organizational collaborations. (Prokop et al. 2025). However, Benetyte and Krusinskas (2019) see these nations are perceived as having significant potential for innovation, yet they remain under-explored. From the perspective of firms' innovation performance and consciousness, moderate and emerging innovative countries and firms have historically been confirmed as those producing lower innovation inputs and outputs compared with their northern and western neighbours (Kijek and Matras-Bolibok 2020). Furthermore, in contrast to the efforts of neighboring countries to enhance their innovation performance, many firms from so-called Eastern bloc and thus carrying the historical legacy of the communist regime have not been improving innovation and the business environment as anticipated. In addition, Coutinho et al. (2023) show that some of these countries experienced deteriorating innovation performance (for example Malta, Bulgaria, Portugal and the Czech Republic). Furthermore, these

countries are seen as having relatively low levels of regulatory efficiency in the business environment as compared with Nordic European countries (Mosconi & D’Ingiullo, 2023). Considering that these countries have received less attention from researchers in the past, the analysis of these countries constitutes an important contribution for other researchers and policymakers, as the study provides them with better insights into issues of knowledge production and innovation performance in the context of the business environment.

4.3 Research Process

The research study begins with examining the current determinants of knowledge production function from the global perspective and to the EU level. At this point, the study focuses on the linkages between the determinants of knowledge production function and innovation performance. Specifically identifying determinants of knowledge production function in current studies, classifying them into knowledge management variables, knowledge network variables and knowledge diffusion. The study identified the methods used and gaps in existing literature. Out of the gaps, the research aim and objectives were formulated. In addition, the research identified factors in the business environment such as regulatory quality and competition intensity that influence the relationship between determinants of knowledge production function and innovation performance. The figure below frames the research process.

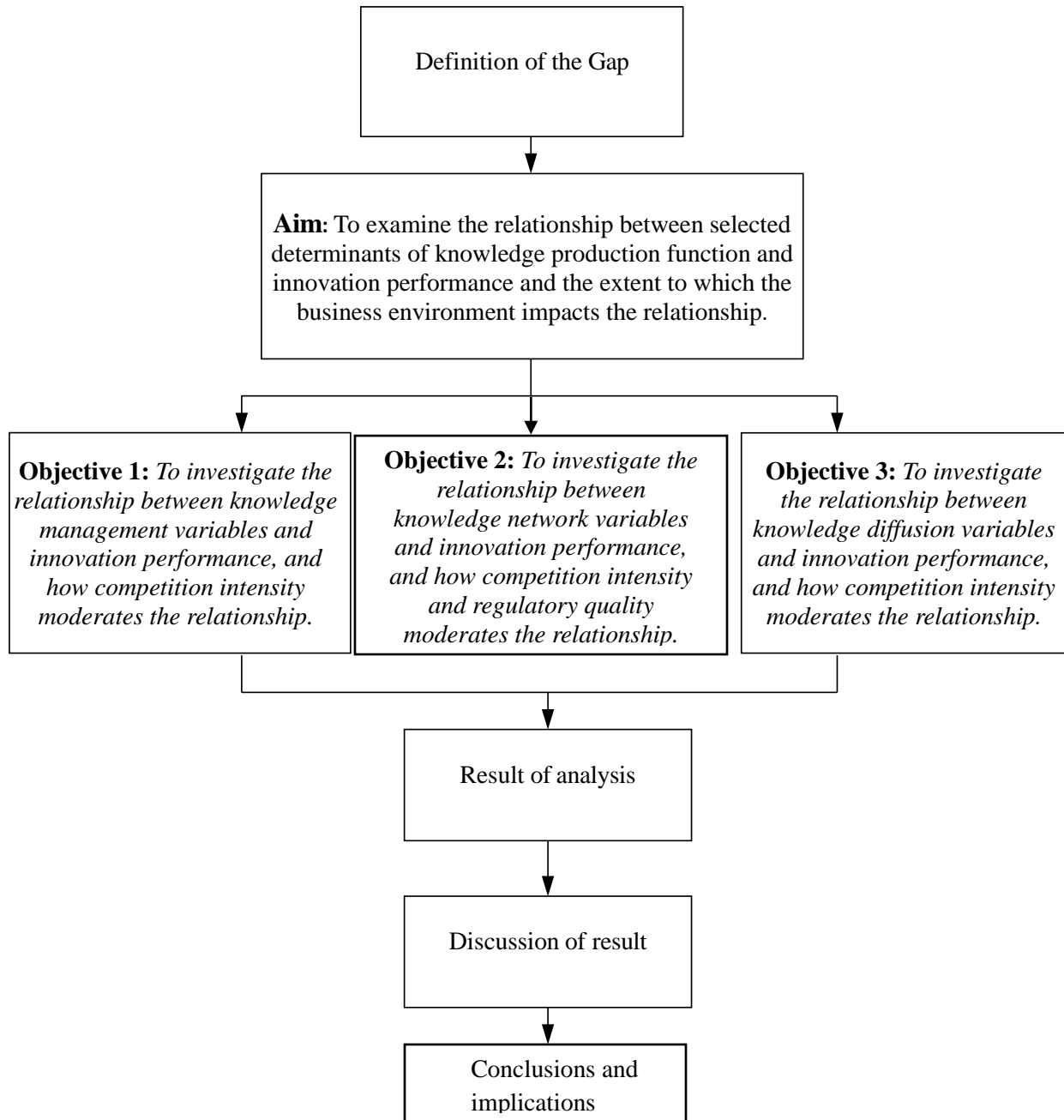


Figure 4: Research process

4.4 Variables for the Objectives

4.4.1 Variables description and measurement- Objective 1

Dependent variable. **The dependent variable for objective 1 of the dissertation is product innovation.** Product innovation is the creation and introduction of significantly new or improved products and services (Arthur & Vanicek, 2024; Lorenz & Pommet, 2021). To investigate this concept, the study utilized a binary variable derived from the question, "Has your establishment introduced new or significantly enhanced products or services in the last three years?" Firms that reported introducing a new product or service were assigned a value of 1, while those that did not were given a value of 0.

Independent Variable. **This study includes two primary variables associated with knowledge-based management to achieve objective 1 of the dissertation.** The first variable pertains to knowledge-based human resource practices, encompassing job rotation and cross-functional groups (Le, 2024). Knowledge-based human resource practices involve strategies and methods for managing knowledge by integrating human resource practices to enhance knowledge creation, sharing, retention, and application (Le, 2024). Within this framework, the human element is considered a vital asset and resource that drives firm innovation. This study assesses the significance of managing knowledge-based human practices, such as planned job rotation and cross-functional groups, for participating firms. Firms were asked the importance they attach to knowledge-based human resource practices (planned job rotation and cross-functional groups) to in their operations. The score 0 indicated no importance, 1 signified low importance, 2 indicated medium importance, and 3 represented high importance. The second independent variable is a firm channels of information channel evaluated through (Standard industry documents) This study examines how firms manage the information acquired from standard industry documents to influence innovation (Foreman-Peck & Zhou, 2023). A score of 1 is assigned if firms utilize channels, such as standard industry documents to acquire information for innovation activities and a score of 0 is given if they do not.

Moderating Variable. **The study considered competition intensity heterogeneity as a moderating variable to achieve objective 1 of the dissertation.** This concept describes the varying levels of competition among businesses in a specific market or industry. The study assessed competition intensity by counting the number of competitors in the field (Klimas et al., 2025) and

applied a natural logarithm (Ln) to reduce bias. A higher level of competition can drive firms towards innovation, with more competitors indicating a more competitive environment.

Control variables. The theoretical framework of the study includes several elements identified by contemporary innovation research as key influencers of a firm's innovative potential. The first variable examined was the firm's age, determined by subtracting the year of establishment from the year the survey was conducted. This factor is crucial as it impacts innovation outcomes, with younger firms frequently introducing new and improved products and processes than their older counterparts (Petruzzelli et al., 2018). The second control variable is trade fairs, which are trade shows or exhibitions where firms showcase their products or services to a target audience. Studies suggest that trade fairs positively affect a firm's innovation capabilities (Silva et al., 2022) because they stimulate creativity, expose firms to competitors' products and help firms gather market intelligence. The value 1 is assigned to firms that used trade fairs as an information source and 0 to those that did not. The third control variable is acquiring technical services, which entails firms obtaining specialized knowledge and expertise from external sources to aid in product innovation development (Foreman-Peck & Zhou, 2023). Firms accessing information through these channels stay updated on industry advancements, enhancing their innovative practices. Controlling for acquiring technical services is vital to ensure the model of the study concentrates solely on the explanatory variables of interest. Lastly, we controlled firm size, measured by the total number of full-time employees. This factor was included because larger firms may have the resources to engage in research and development (R&D) activities, potentially leading to the introduction of new products (Prokop & Stejskal, 2019).

4.4.2 Variables Description and Measurement- Objective 2

Dependent variable. **The study employs innovation in products and services as dependent variable to achieve objective 2.** Product innovation involves developing and introducing substantially new or enhanced offerings to the market. To work with this concept, the study employed a binary variable derived from the question, "Has your establishment launched new or significantly improved products or services in the past three years?" This variable was assigned a value of 1 if the firm reported introducing a novel product or service and 0 if not. This approach to measuring product innovation using a dummy variable has been utilized in previous research employing the World Bank Enterprise Survey (Arthur & Vanicek, 2024; Lorenz & Pommet, 2021)

Independent variable. **This study employs two knowledge intensive network variables as explanatory variable to achieve objective 2.** The first was technical knowledge-intensive business services (T-KIBS) measured by crowdsourcing. Technical knowledge-intensive business services encompass specialized expertise, engineering, IT networking, and consulting services (Horváth & Rabetino, 2019) used by firms within the reporting year. Crowdsourcing, as a proxy T-KIBS, facilitates knowledge networking, knowledge transfer and problem-solving for organizations seeking technical solutions to boost innovation (Miles et al., 2019). The second independent variable was professional knowledge-intensive business services (P-KIBS). It refers to specialized expertise and advisory services provided by professionals and technical institutions (universities and research organizations) to firms. This was represented by technical services from universities (Hertog, 2000). Both crowdsourcing and technical services from universities were measured as dummy variables, with a value of 1 assigned if the firm reported engaging in these activities and 0 if it did not.

Moderating variables. **The study used two moderating variables to partly fulfil objective 2.** Competition intensity and regulatory quality. Competition intensity is the level of rivalry among firms within a specific market or business. The study quantified competition intensity using the number of competitors in the industry (Klimas et al., 2025) and applied a natural logarithm (Ln) to minimize bias. Heightened competition can drive firms towards innovation, with higher numbers indicating more intensely competitive environments. Conversely, regulatory quality pertains to the government's perceived capacity to devise and execute effective and fair policies and controls that enhance market efficiency, social equality, and innovation (Kawabata & Camargo Junior, 2020). The study assessed the regulatory quality of an economy's business environment on a scale of -2.5 (weak) to 2.5 (strong). A higher positive value signifies a better regulatory framework conducive to firm operations.

Control variables. In the conceptual model of the study, the study regulated several variables that contemporary innovation research has shown to impact firms' innovation capabilities. The initial control variable, firm age, is calculated by deducting the year of establishment from the survey year. The study included this because it influences innovative output, as new firms tend to introduce more novel products and processes than their older counterparts (Petruzzelli et al., 2018).

The second control variable was patent publication, which denotes the official release of patents applied for or granted by the relevant authority or patent office. Innovation studies indicate that a

high volume of patent publications positively affects a firm's innovation capacity (Arthur & Vanicek, 2024). The study assigned a value 1 to firms that used patent publications and 0 to those that did not. The third control was trade publications. These refer to specialized journals and online platforms offering industry—or profession-specific news, trends, and technical information (Giannopoulou et al., 2022). Firms accessing information through these sources remain current regarding industry developments, thereby enhancing their innovative practices. Controlling for trade publications is crucial to ensure that the model of the study focuses solely on explanatory variables of interest. The fourth control variable was reverse engineering. Reverse engineering involves deconstructing a product, system, or software to comprehend its workings and components for improvement or replication. Current innovation literature demonstrates that reverse engineering positively impacts innovation performance (Adomako et al., 2024). The study assigned a value of 1 to firms employing reverse engineering for innovation and 0 if otherwise.

Finally, the study controlled for firm size, measured by the total number of full-time employees. This variable was included because larger firms may possess the resources to undertake research and development (R&D) activities, potentially leading to new product introductions (Prokop & Stejskal, 2019).

4.4.3 Variables Description and Measurement- Objective 3

Dependent variable. **In this study, the dependent variable is regional innovation performance for objective 3.** The study uses patent applications as a measure of regional innovation performance following extant studies in emerging economies (Edeh & Prévot, 2024; Ejdemo & Örtqvist, 2020). Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office patent office for exclusive rights for the invention of a product or process that provides a new technical solution to a problem. A patent provides protection for the invention of the patent for a limited period, usually 20 years. Patent filings serve as a consistent metric for assessing technological progress across different regions and nations.

Independent variables. **The main explanatory variables for objective 3 are social globalization and political globalization.** Social globalization is defined on three dimensions as the personal contacts, information flows and cultural proximity that exist among the moderate and emerging innovative EU countries (politic) and measured in points on the index of 0 to 100 with higher values denoting high social globalization. Political globalization is defined as the number of treaties signed

between two or more countries, the number of international organizations to which the country is a member and the number of embassies and high commissions in a country (Ahmed, 2024; Rehman et al., 2024). It is measured in points from 0 to 100 with higher values denoting high political globalization.

Moderating variable. **To partly achieve objective 3, the study uses the civil liberties index as a contingent variable in the relationship between social and political globalization and regional innovation performance.** Civil liberties index is defined as freedom of expression and belief, associational and organizational rights, the rule of law, personal autonomy and individual rights. It is measured in points from 1 (strong liberties) to 7 (no liberties).

Control variables. The study includes several variables that existing literature shows influence on regional innovation performance (Edeh & Prévot, 2024). Regional innovation performance is significantly influenced by R&D expenditure of the countries (Li & Viao, 2023; Zhu & Xu, 2022), human development index (Prasetyo et al, 2023), trade openness (Weresa, 2022; Wang 2022), GDP per capita (Niazi, 2025) and foreign direct investment (Tang & beer, 2022). R&D expenditure is expressed as a percentage of GDP and includes capital and current expenditures in the business, government, higher education and private non-profit sectors. Countries with high R&D expenditure tend to improve innovation performance (Li & Viao, 2023). Hence, the study controlled for the R&D to limit its impact on the outcome variable. The Human Development Index (HDI) is the healthy life, knowledge and decent standard of living of the people in a country (Prasetyo et al, 2023; Ozgen, 2021), and it is measured in points with an index of 0-1. HDI is crucial in knowledge creation and diffusion, influencing regional innovation. Thus, controlling it is essential for the true impact of social and political globalization on regional innovation performance. The level of trade openness in a country influence knowledge diffusion and regional innovation (Wang, 2022). Trade openness measures a country's exports and imports as a percentage of GDP. Weresa et al. (2022) argues that a country that has a high percentage of trade openness contributes to knowledge diffusion and regional innovation. This study controls trade openness, which could potentially influence the outcome variable in the model. Although the countries involved in the study are all moderate and emerging innovative EU countries, there are still differences in the levels of development among them. Hence, the study controls the economic development among the countries using each country's per capita gross domestic product (GDP per capita) as Edeh and

Prévoit (2024) used. Furthermore, the study control foreign direct investment (FDI), which is established as significantly impacting regional innovation performance (Tang & Beer, 2022; Jiang et al., 2022). Hence, the study controlled for foreign direct investment (FDI) per GDP using the inflow of investments to acquire management interest (10% or more of voting stock) in an enterprise operating in an economy other than that of the investor. Lastly, the study incorporates year and industry-fixed effects to mitigate potential endogeneity issues, following Lin and Wooldridge (2019). Table 1 summarizes the indicators and data sources of the variables of the study.

Table 4. Variables and Indicators for the Study

Variables	Indicators	Measures
<i>Dependent</i> Innovation performance	Product innovations Regional innovation performance	New or improved goods and services Patent applications
<i>Independent variable</i> Knowledge-based factors	Knowledge management variables	Knowledge-based human resource practices Channels of information
	Knowledge network variables	Technical knowledge intensive business services (Crowdsourcing) Professional knowledge intensive business services (University technical services)
	Knowledge diffusion variables	Social and Political globalization
<i>Moderating variable</i>	Business environment	Competition intensity, regulatory quality and civil liberties index
<i>Control variables</i>	Firm, country and institutional level characteristics	Firm size, firm age, GDP per capita, trade fairs, technical services, trade publications, patent publications, reverse engineering, R&D expenditure, human development index, trade openness, foreign direct investment, year and industry fixed effects

Source: Author's own

4.5 Methods Description

The earlier sections illustrate that the determinants of the knowledge production function that affect innovation performance primarily in three forms. **These determinants facilitate knowledge management, knowledge network and knowledge diffusion across businesses, countries, and regions.** At present, researchers on the determinants of the knowledge production function and innovation have not reached a consensus on a universally accepted method for measuring the determinants of the knowledge production function and their impact on innovation performance. This study employed quantitative research design. This is due to its objective philosophy (Mohajan, 2020). The quantitative research approach is used to achieve the research objectives.

Quantitative research approach is the process of collecting and analyzing numerical data to test hypothesis, answer research questions and make inferences or predictions with the analysis results (Williams et al. 2023). Quantitative research involves identifying variables, establishing the connection between dependent and independent variables through an appropriate statistical or econometric method. It is mostly employed in social science and natural studies involving numerical data on opinions, attitudes and behaviours of variables (Cresswell, 2021). Quantitative research generally includes empirical research on social phenomena and involves hypothesis testing using numerical variables and statistical tools (Hirose & Creswell, 2023).

Thus, the quantitative research approach enables the examination of variables and establishing their relationships and impacts. This reveals answers to questions about the rate at which a phenomenon occurs over a specific period and the magnitude of how the sampled population influences the phenomenon. This study is empirical and adheres to all scientific principles. This allows for inferences and generalizations of the findings across the European Union. The research undertaken in this study utilized an explanatory method to uncover causal relationships between variables. This approach is deemed essential for comprehending the interplay between the determinants of the knowledge production function and innovation in a specific region. This research's primary objective is to elucidate how a change in one variable influences the outcome variable. The explanatory method was selected for its relevance to practical applications and implications for policymakers and decision-makers. To achieve this aim, the following statistical techniques were employed: Probit regression, instrumental variable probit, conditional fixed effects Poisson regression and marginal effect approach. The well-known statistical software package STATA 17 was utilized for the data analysis.

4.5.1 Objective 1: Probit Regression and Marginal Effect Approach

In pursuit of the research objective outlined above, the study adopted a probit regression model with two-way fixed effects, as recommended by Cruz-Gonzalez et al. (2017). Probit regression is efficient for dummy data (Motta, 2019). This model was selected for its effectiveness in analyzing the outcome variables of product innovation. This method enabled us to identify significant product innovation predictors and gain insights into the nature of these relationships. While the probit model has been applied in similar research (Odei & Appiah, 2023; Okrah & Irene, 2023), the study enhanced it by incorporating two-way fixed effects, following Cruz-Gonzalez et al. (2017). This model is well-regarded for correcting bias in nonlinear panel models (Cruz-Gonzalez et al., 2017). The dataset of the study includes numerous firms from various industries across different countries over time, so the study incorporates industry- and year-fixed effects into the models of the study. These fixed effects help account for unobserved, time-specific factors that could consistently impact product innovation outcomes across industries yearly (Cruz-Gonzalez et al., 2017; Lin & Wooldridge, 2019). The study provides the formula for the probit model, which includes specific variations with industry and year-fixed effects, as follows:

$$\text{Probit (Pr (} Y_{it}=1)) = \beta_0 + X_{it}\beta + \alpha_i + \gamma_t \quad (4)$$

where

Y_{it} represents the likelihood that firm (i) will introduce product innovation during the year (t).

β_0 serves as the intercept,

X_{it} is the vector of covariates for firm (i) in the year (t).

α_i signifies the industry fixed effect pertinent to the industry in which firm (i) operates,

γ_t denotes the year-fixed effect for the particular year (t).

Additionally, marginal effect approach was used to test how the various levels of competition intensity moderate the relationship (Busenbark et al. 2022). The use of margins plot helps to visually understand the moderating effects of competition intensity heterogeneity.

Finally, the study tested for the robustness of the baseline results by introducing additional control variables to test if the direction and coefficient values of the baseline results are robust (Disoska et al., 2024)

4.5.2 Objective 2: Probit regression, Instrumental Variable and Marginal Effect

To achieve the research objective, the study followed the principles in the current literature and employed a probit regression model incorporating two-way fixed effects (Cruz-Gonzalez et al., 2017). Given the dummy nature of the dependent variable, product innovation, the probit model is deemed suitable for empirical analysis. In the CIS (2018), organizations were requested to indicate whether they had introduced a substantially enhanced product or service to the market. Utilizing the probit regression model allowed us to compute firms' product innovation based on various carefully chosen determinants. This approach enabled us to identify the significant predictors of product innovation and establish the directionality of these relationships. While the probit model has been utilized in comparable studies (Okrah & Irene, 2023), the study expanded this approach by incorporating two-way fixed effects, as suggested in extant literature (Cruz-Gonzalez et al., 2017). This model is well known for its capacity to correct bias when dealing with cross-sectional binary models (Cruz-Gonzalez et al., 2017). The dataset comprises firms from diverse industries across multiple countries over time, so the study incorporates industry- and year-fixed effects into the study models. Including these fixed effects helps account for unobserved, time-specific factors that may uniformly influence product innovation outcomes across industries each year (Cruz-Gonzalez et al., 2017; Lin & Wooldridge, 2019). The study presents the formula for the logit model, accounting for specific variations in industry and year-fixed effects, as follows:

$$\text{Probit (Pr (Y}_{it}=1)) = \beta_0 + X_{it}\beta + \alpha_i + \gamma_t \quad (5)$$

where

Y_{it} represents the likelihood of company (i) implementing product innovation in given year (t),

β_0 constant term,

X_{it} signifies the vector of covariates for the firm (i) in the year (t).

α_i the industry-specific fixed effect for the sector in which company (i) operates,

γ_t indicates the year-specific fixed effect for the year (t).

4.5.3 Objective 3: Conditional Fixed Effect Poisson Regression

To achieve objective 3, the conditional fixed-effects Poisson regression model is used to analyze the panel data on patent applications across moderate and merging EU countries over time. This method is suitable for counting data with zero values and offers robust regression coefficients to address issues of autocorrelation and heteroscedasticity (Motta, 2019). The missing

data in the analysis was treated as zeros. Considering the geographical proximity of the countries under examination, it is likely that cross-sectional dependence is present in the data. However, the conditional fixed effect Poisson estimator "falsely" omits cross-sectional dependence and produces effective results due to insufficient observations to reliably estimate cross-sectional covariances (Moundigbaye et al., 2018). According to Diebold (2007, p.45), the "false restrictions" principle can enhance the estimator's performance. Moundigbaye et al. (2018) further argue that, while ordinary least squares (OLS) are commonly used in scientific research, they perform poorly in efficiency and inference for small to moderately sized panel datasets. Patent application, which is the primary outcome variable, is a non-negative count variable and this makes Poisson regression suitable for the modelling approach (Palit et al., 2022; Arthur et al., 2022). The Ordinary least squares (OLS) models are not appropriate for this type of outcome variable due to their assumption of normally distributed errors and the probability of predicting invalid negative values (Eckert & Hohberger, 2023; Cohn et al., 2022). Also, the dataset of the study has a panel structure, including repeated observations of countries over several years. Countries vary in unobserved, time-invariant characteristics such as historical levels of innovation and institutional characteristics. These unobserved effects may influence the level of social and political globalization and patent applications, likely to cause bias in the results. **To tackle this issue, a fixed-effects estimation is used, which controls the unobserved heterogeneity across countries that is constant over a period.** This model also explores the interaction effects of civil liberties, social and political globalization. By using fixed effects, the models help to understand how within-country changes in civil liberties, social and political globalization influence patenting behaviour. Thus, the conditional fixed effects estimation is appropriate to use in this context because it ensures within-country variations, corrects omitted variable bias by differencing out country specific effects, permits inclusion of time-varying covariates (Han & Guo, 2025) and consistent estimations even in the presence of overdispersion-variance of the outcome exceeds the mean (Bates et al., 2024; Tompson et al., 2023).

The variables examined in this study also count data, which had a value of zero in some years. The OLS model could not address this problem effectively. However, the conditional fixed effect Poisson regression model resolves this issue and eliminates the need to exclude such observations. This regression model allows us to avoid biases when analyzing the influence of knowledge diffusion factors on innovation and economic growth, thus providing a more accurate

representation of the relationships involved. Thus, the conditional fixed effects model is rigorous and appropriate for the objective of this study, allowing valid inference on the impact of social and political globalization on regional innovation performance (patent applications). The data for the study is a panel data of 14 moderate and emerging innovative EU countries (r) for 23 years (t) (2000-2023). Given the contemporaneous relationships between social and political globalization, civil liberties and patent applications, the study does not impose a time lag between the outcome and explanatory variables (Edeh & Prévot, 2024; Ejdemo & Ortqvist, 2020). Therefore, the model is specified as

$$\Pr(y_{it} = k | x_{it} a_i) = \frac{e^{-\lambda_{it}} \lambda_{it}^k}{k!} \quad \text{where } \lambda_{it} = \exp(x'_{it}\beta + a_i) \quad (6)$$

where

y_{it} the count-dependent variable (in this case, patent applications) for the unit i at time t ,

x_{it} the vector of explanatory variables (in this case, social and political globalizations),

a_i the unit-specific fixed effects unobserved heterogeneity),

λ_{it} the expected count for y_{it} .

5. RESULTS OF THE STUDY

This chapter presents the results of the study based on the data analysis for objective one, objective two and objective three.

5.1 Analysis and Results of Objective 1

First the study presents descriptive statistics of the study variables for objective 1 (Refer to appendix I). provides a concise overview of the statistical data for the variables utilized in the empirical analyses. The correlation matrix in appendix II indicates that multicollinearity is not a significant concern, as evidenced by the relatively low correlation coefficients between the variables.

Table 5 outlines the results of the probit regression analysis. The first model explores the relationship between specific control variables and product innovation. The second model evaluates how firm channels of information affect product innovation. The third model examines the role of knowledge-based human resource practices in promoting product innovation. The fourth model examines the direct link between competition intensity, which acts as a moderating variable and product innovation. The fifth model investigates the simple slope interaction effect of competition intensity in the relationship between firm channels of information and product innovation. The seventh model analyzes the interaction effect of competition intensity in knowledge-based human resource practices and product innovation nexus. All probit regression models use robust standard errors to reduce the potential impact of variable heteroscedasticity, which could influence the significance and robustness of the probit regression coefficients (Abadie et al., 2023). The findings from Model 1 indicate that both firm size and age have positive and statistically significant coefficients, suggesting that a firm's number of employees and years of operation are likely to enhance its product innovation. These findings are consistent with previous studies (Okrah & Irene, 2023). Additionally, the acquisition of technical services is positively and significantly linked to product innovation, supporting Wang and Fu's (2022) findings. The effect of trade fairs is also positive and significant, which is consistent with the results of Wang et al. (2025). The control of the sector or industry was not statistically significant. In Model 2, firm channels of information have positive and significant coefficient, supporting Hypothesis 1a. Without considering contingency effects, this suggests a positive relationship between firm

channels of information and product innovation (Iftikhar & Javed, 2024). Similarly, in Model 3, knowledge-based-human resource practices have a positive and significant coefficient, supporting Hypothesis 1b. Without accounting for contingency effects, this indicates a meaningful relationship between knowledge-based human resource practices (cross functional groups and planned job rotation) and product innovation. Model 4 reveals that the moderation variable, competition intensity has direct positive and significant effect on product innovation, corroborating the findings of Cui et al. (2024). Model 5 shows a significant negative effect of the interaction of competition intensity in the relationship between firm channels of information and product innovation, contradicting Hypothesis 1c, which posits that competition intensity heterogeneity strengthens the relationship between firm channels of information and product innovation. Similarly, Model 6 indicates a significantly negative moderating coefficient of competition intensity in the relationship between knowledge-based human resource practices and product innovation. This finding contradicts Hypothesis 1c, which suggests that competition intensity strengthens the relationship between human resource practices and product innovation. Busenbark et al. (2022) argued that a simple slope interpretation of moderating effects lacks intuition as it overlooks multiple or different moderating variable values and fails to illustrate an effect trend.

As a result, following the insights from Busenbark et al. (2022), the study utilized a marginal effect method to assess the moderating hypotheses. This allowed us to examine the different levels of interaction variables in their moderating capacity. It also enabled us to ascertain the interaction effect of competition intensity heterogeneity. The findings, shown in Fig. 5, confirm hypothesis 1c. When the varying levels of competition intensity (8.4,9,9.6, 10.3...) interacts with firm channels of information, the likelihood of product innovation increases marginally beyond 0.8 percentage points. Similarly, the data presented in Fig. 6 validate hypothesis 1d. At varying levels of competition intensity (beyond 9) interactions with knowledge-based human resource practices, product innovation increases marginally over 0.8 percentage points.

Table 5. Probit regression results for objective 1

	(1)	(2)	(3)	(4)	(5)	(6)
Firm size	.195** (.006)	.194*** (.006)	.195** (.006)	.199*** (.006)	.198*** (.006)	.198*** (.006)
Firm age	.048*** (.005)	.048*** (.005)	.048*** (.005)	.049*** (.005)	.05*** (.005)	.05*** (.005)
Purch. Tech. serv.	.169*** (.057)	.175*** (.057)	.186*** (.057)	.202** (.058)	.197*** (.058)	.205*** (.058)
Conferences	.108*** (.01)	.1*** (.011)	.091*** (.011)	.11*** (.011)	.105*** (.011)	.095*** (.011)
Sector	.008 (.011)	.008 (.011)	.007 (.011)	.029** (.012)	.031** (.012)	.026** (.012)
Ch. in. (CHN_INFO)		.03** (.015)			.576*** (.08)	
HR practices (HR)			.037*** (.006)			.263*** (.027)
Compt. intensity (CI)				.172*** (.003)	.18*** (.004)	.198*** (.005)
CHN_INFO#CI					-.068*** (.01)	
HR #CI						-.028*** (.003)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-.433*** (.064)	8.209 (7.016)	8.187 (7.016)	5.923 (7.048)	5.688 (7.049)	5.653 (7.05)
Observations	100034	100034	100034	100034	100034	100034
Pseudo R ²	.006	.006	.006	.017	.017	.017

Standard errors are in parentheses,

**** $p < .01$, ** $p < .05$, * $p < .1$*

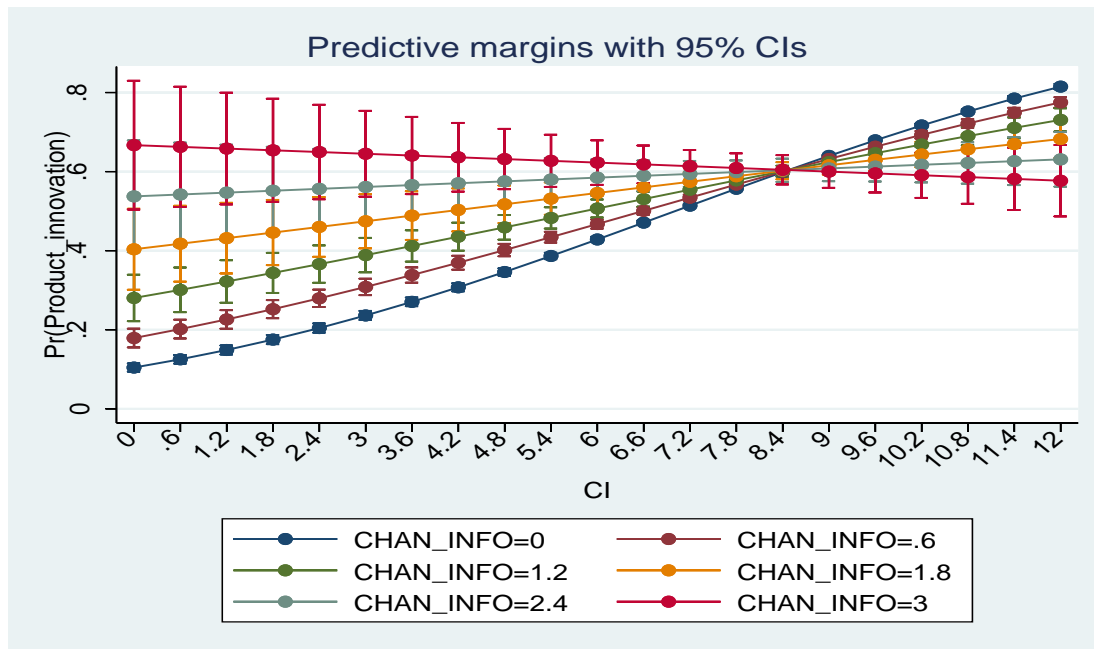


Figure 5. Interaction between channels of information and competition intensity.
 Note: CHAN_INFO- Channels of information, CI-Competition Intensity

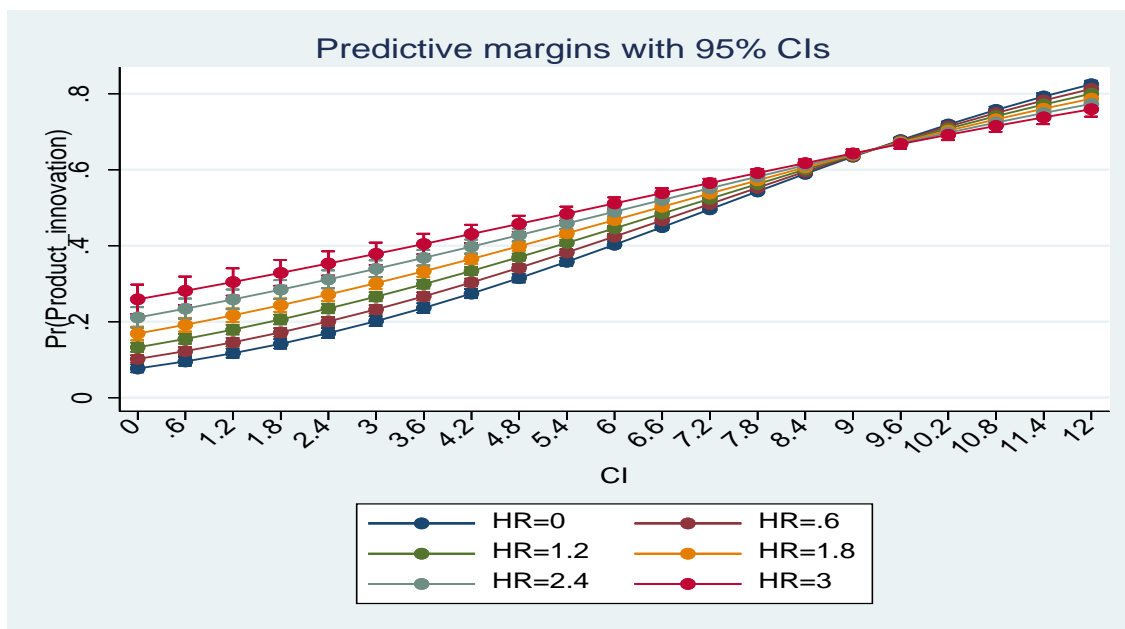


Figure 6. Interaction between knowledge-based human resource practices and competition intensity.
 Note: HR-Knowledge-based human Resource Practices, CI-Competition Intensity.

Robustness Test

The study conducted an additional assessment to confirm the robustness of the initial analysis. The purpose is to verify whether the main conclusions were influenced by the chosen empirical method's characteristics, as Meyer et al. (2020) suggested. The study adds additional control variables known in innovation research as influencing firm innovation to reassess the study model. Stantcheva (2023) pointed out that survey datasets often show diverse response patterns among participants, which can lead to different results. Ignoring this may result in unreliable and inconsistent outcomes. Considering that the data included a variety of enterprises from different sectors across multiple countries (regions), there are strong reasons to expect potential unobserved heterogeneity and endogeneity at the firm, national, and sectoral levels. These differences imply that competition intensity may have varying moderating effects on the relationship between competition intensity, firm channels of information, human resource practices, and product innovation. The study applied year and industry-fixed effects to address potential endogeneity issues, as Lin and Wooldridge (2019) recommended. At the national level, the study considered the differences between countries. Although all economies in the study were moderate and emerging innovative EU countries, additional control variable was introduced across all the model specifications. The study included acquiring intellectual property rights from public research organizations and universities. This additional control variable can affect firms' innovation (Zhao, 2024). At the industry level, the study incorporated sector dummies corresponding to firms' operational sectors because the influence of firm channels of information and knowledge-based human resource practices on innovations may differ across various industries.

Table 6 displays the outcomes of the re-evaluated models, which now incorporate an additional control variable. Including this control variable did not alter the direction or significance of the coefficients in Model 1. This pattern is also evident in Models 2, 3, and 4, which explore the direct effects of firm channels of information, knowledge-based human resource practices, and competition intensity heterogeneity on product innovation. Moreover, when control variables such as the purchase of intellectual property rights from public research organizations or universities are added to Models 5 and 6, which analyze the interactions between competition intensity and information channels as well as competition intensity and human resource practices, the coefficients maintain consistent directions and significance levels. These findings further support the significant results presented in Table 5. As the statistical significance and direction of the

relevant coefficients for the main hypotheses remained unchanged despite introducing different control variables, the study concludes that the results are robust (Disoska et al., 2024).

Table 6. Robustness test for objective 1

	(1)	(2)	(3)	(4)	(5)	(6)
Firm size	.195** (.007)	.194*** (.007)	.195** (.007)	.199*** (.007)	.198*** (.007)	.198*** (.007)
Firm age	.049*** (.006)	.048*** (.006)	.048*** (.006)	.05*** (.006)	.05*** (.006)	.05*** (.006)
Purch. Tech. serv	.156** (.061)	.162*** (.061)	.174*** (.061)	.186*** (.06)	.181*** (.06)	.19*** (.06)
Conferences	.108*** (.012)	.101*** (.012)	.091*** (.012)	.11*** (.012)	.106*** (.012)	.095*** (.012)
Sector	.008 (.012)	.008 (.012)	.007 (.012)	.029** (.013)	.031** (.013)	.026** (.013)
IPR pub.	.285*** (.075)	.279*** (.075)	.273*** (.075)	.346*** (.077)	.337*** (.077)	.337*** (.077)
Channels info		.029* (.017)			.567** (.079)	
HR practices (HR)			.036*** (.006)			.262*** (.026)
Comp.intensi. (CI)				.172*** (.003)	.181*** (.003)	.198*** (.004)
CHN_INFO#CI					-.067*** (.01)	
HR#CI						-.028*** (.003)
Year-fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Cotr. -fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-.479*** (.07)	8.154 (7.015)	8.133 (7.016)	5.852 (7.048)	5.622 (7.048)	5.585 (7.05)
Observations	100034	100034	100034	100034	100034	100034
Pseudo R ²	.006	.006	.006	.017	.017	.017

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

5.2. Analysis and Results of Objective 2

Appendix III presents the summary statistics of the variables used in the empirical estimations. Multicollinearity among the variables is not a significant issue, as shown in the relatively low correlation coefficients of the variables in the correlation matrix table in Appendix IV.

Table 7 presents the comprehensive findings of the probit regression analysis. The initial model examines the link between meticulously chosen control variables and product innovation. The second model evaluates the impact of crowdsourcing (Technical knowledge-intensive business services) on product innovation. The third model assesses the influence of university-provided technical services (Professional knowledge-intensive business services) on product innovation. The fourth model investigates the direct correlation between the first regulatory quality (initial moderating variable) and product innovation, whilst the fifth model explores the direct relationship between competition intensity (second moderating variable) and product innovation. The sixth model incorporates the effect of the interaction between regulatory quality and competition intensity on product innovation. The seventh model introduces the impact of the two-way interaction between crowdsourcing and regulatory quality on product innovation. The eighth model investigates the effect of the two-way interaction between crowdsourcing and competition intensity on product innovation. The ninth model examines the two-way interaction effect of university-provided technical services and regulatory quality on product innovation, while the tenth model tests the two-way interaction of university-provided technical services and competition intensity on product innovation. All probit regression specifications are calculated using robust standard errors to mitigate the potential impact of variable heteroskedasticity that could affect the significance and robustness of the probit regression coefficients (Abadie et al., 2023).

The findings from Model 1 reveal that both firm size and age exhibit positive and statistically significant coefficients. This suggests that a company's number of employees and duration of existence will likely enhance product innovation performance. These outcomes align with research findings (Okrah & Irene, 2023). Conversely, patent and trade publications show negative yet statistically significant associations, indicating they are less likely to boost product innovation performance. These negative correlations support findings from a US-based study (Hedge et al., 2023) but conflict with research conducted in the EU (Arthur & Venicek, 2024). The impact of reverse engineering was insignificant, contradicting studies by Adomako et al. (2024). In Model 2, the crowdsourcing variable, proxy for T-KIBS, demonstrates a positive and statistically significant coefficient, supporting Hypothesis H2a. This indicates a substantial link between crowdsourcing and product innovation performance without considering contingency effects. Similarly, in Model 3, the technical service from the university variable, representing P-KIBS, shows a positive and statistically significant coefficient, supporting Hypothesis H2b. Again, this suggests a meaningful

relationship between university technical services and product innovation performance without accounting for contingency effects. Models 4 and 5 investigate the impact of regulatory quality and competition intensity on product innovation. The findings reveal a significant negative influence of regulatory quality and competition intensity on product innovation. Model 6 demonstrates an insignificant negative effect of the interaction between regulatory quality and competition intensity on product innovation performance. In contrast, Model 7 shows a significant positive moderating coefficient for the interaction between crowdsourcing and regulatory quality. This finding supports Hypothesis H2c, which proposes that regulatory quality enhances the relationship between technical knowledge-intensive business services and product innovation. Busenbark et al. (2022) argued that the simple slope interpretation of moderating effects lacks intuition. It disregards multiple values of the moderating variables and fails to show an effect trend.

Table 7. Probit regression results for objective 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Firm size (FS)	.457*** (.011)	.444*** (.018)	.455*** (.011)	.487*** (.011)	.484*** (.011)	.483*** (.011)	.485*** (.011)	.344*** (.019)	.485*** (.011)	.48*** (.011)
Firm age (FA)	.15*** (.012)	.137*** (.017)	.15*** (.012)	.101*** (.013)	.099*** (.013)	.098*** (.013)	.1*** (.013)	.111*** (.017)	.1*** (.013)	.098*** (.013)
Patent pub. (PP)	-.223** (.087)	.055 (.105)	-.225*** (.087)	-.037 (.075)	-.04 (.074)	-.042 (.074)	-.027 (.075)	.064 (.106)	-.039 (.075)	-.043 (.074)
Reverse eng. (RE)	.034 (.08)	.032 (.12)	.034 (.08)	.000 (.071)	.008 (.07)	.006 (.07)	.013 (.071)	.03 (.121)	.000 (.071)	.004 (.071)
Trade pub. (TP)	-.117** (.045)	.118* (.07)	-.117** (.045)	.086** (.041)	.069* (.041)	.069* (.041)	.103** (.042)	.108 (.071)	.086** (.041)	.073* (.041)
Crowdsour. (CS)		.189*** (.031)					5.393** (2.556)	1.151*** (.138)		
Tech. services (TS)			.644*** (.146)						9.798 (10.658)	11.174*** (1.154)
Regulat. Qual. (RQ)				-1.551* (.931)		-1.137 (1.758)	.659 (1.487)		7.165 (10.176)	
Compet. int. (CI)					-.038*** (.007)	.017 (.219)		-.025*** (.008)		1.003*** (.115)
RQ#CI						-.061 (.24)				
CS#RQ							-5.983** (2.797)			
CS#CI								-.117*** (.017)		
TS#RQ									-9.942 (11.664)	
TS#CI										-1.251*** (.137)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-2.598*** (.056)	-3.011*** (.078)	-3.127*** (.132)	-1.452* (.853)	-2.601*** (.076)	-1.56 (1.608)	-3.46** (1.36)	-2.648*** (.099)	-10.004 (9.299)	-11.892*** (.964)
Observations	100034	100034	100034	100034	100034	100034	100034	100034	100034	100034
Pseudo R ²	.021	.018	.021	.059	.06	.06	.059	.035	.06	.061

Standard errors are in parentheses *** $p < .01$, ** $p < .05$, * $p < .1$

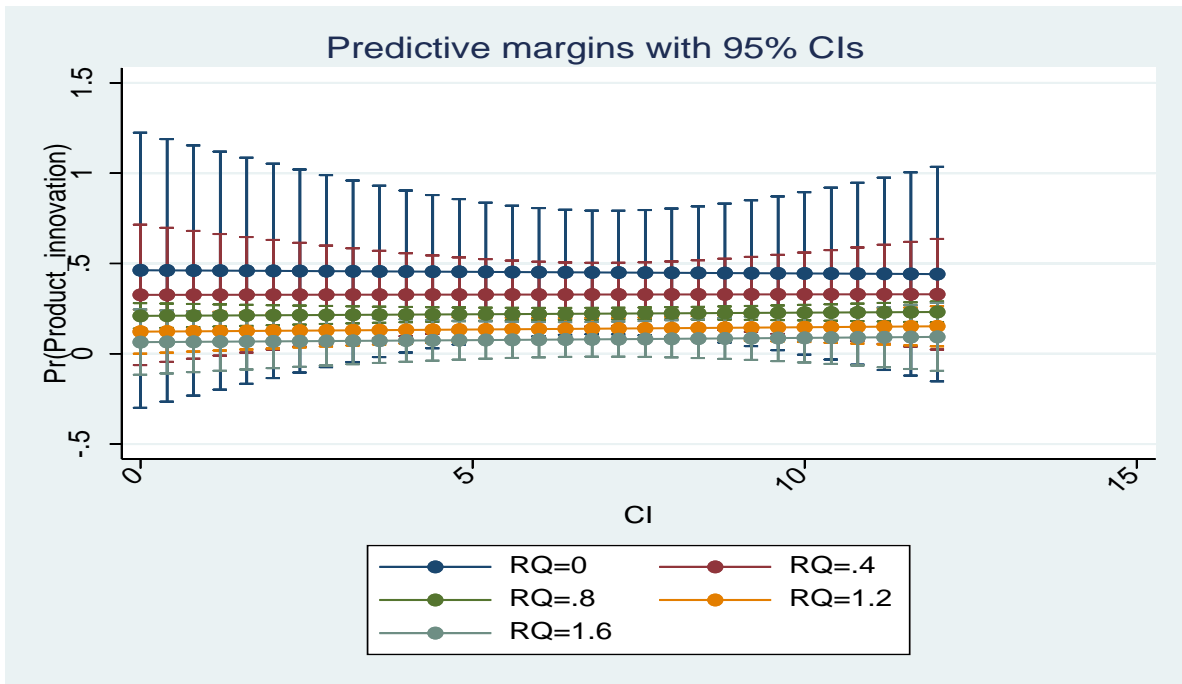


Figure 7. Interaction between competition intensity and regulatory quality.
 Note: CI-Competition intensity, RQ-Regulatory Quality.

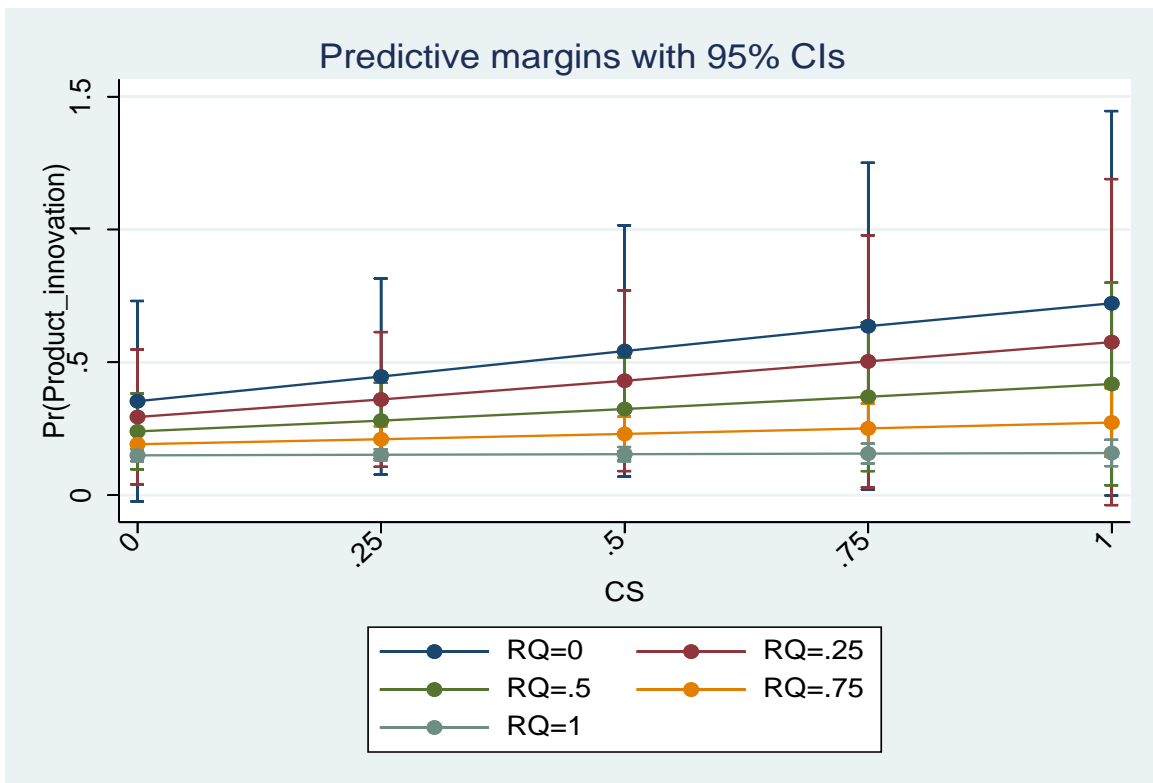


Figure 8. Interaction between crowdsourcing and regulatory quality.
 Note: CS-Crowdsourcing, RQ-Regulatory Quality.

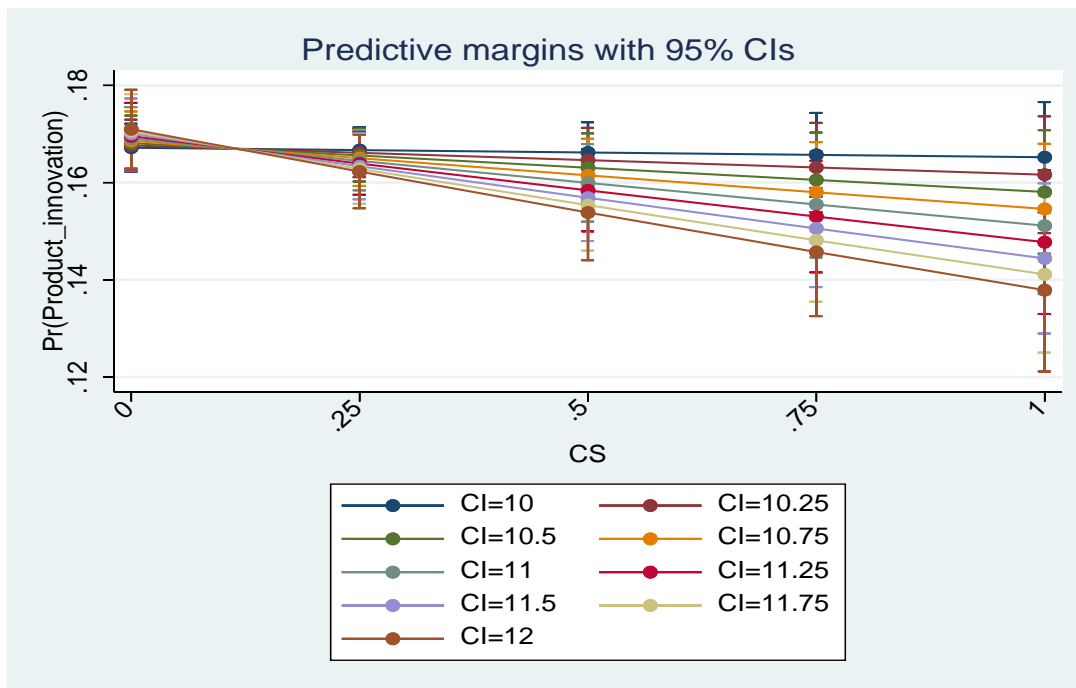


Figure 9. Interaction between crowdsourcing and competition intensity.

Note: CS-Crowdsourcing, CI- Competition Intensity.

Consequently, in accordance with the literature (Busenbark et al., 2022), the study employed a marginal effect approach to test the moderating hypotheses using the different levels of the moderating variables. The results, illustrated in Fig. 8, support Hypothesis H2c. At lower levels of regulatory quality (0), the likelihood of product innovation marginally decreases by about 0.48 percentage points. However, as regulatory quality interacts with crowdsourcing at higher percentiles (0.25, 0.5, 0.75, 1), the likelihood of product innovation marginally increases to over 0.5 percentage points. The interaction is statistically different from 0 at each level of regulatory quality, further supporting Hypothesis H2c. Model 8 reveals a negative and statistically significant coefficient for moderation by competition intensity, contradicting Hypothesis H2d. Nevertheless, as depicted in Fig. 9, the marginal effect approach supports Hypothesis H2d. It demonstrates that the 0th percentile of crowdsourcing with high levels of competition intensity interactions (10, 10.25, 10.5, 10.75, 11, 11.25, 11.5, 11.75, 12) has the highest marginal effect on product innovation, increasing it beyond 0.16. However, as crowdsourcing increases from 0.25 to 1, the likelihood of product reduces.

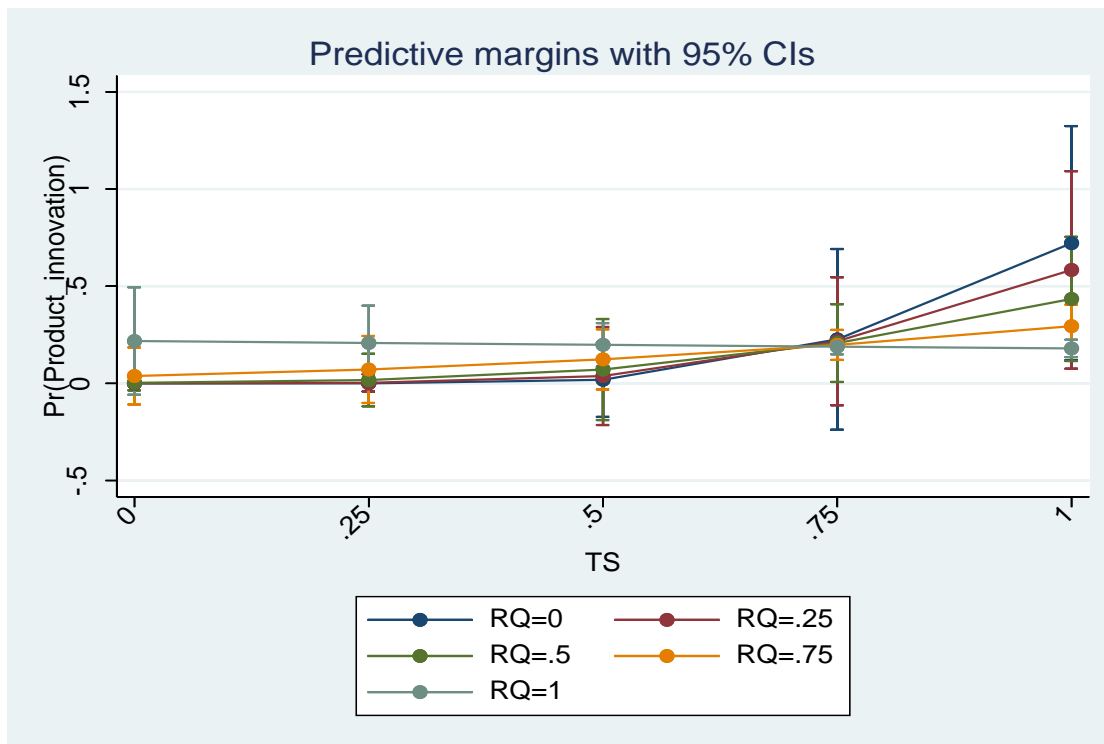


Figure 10. Interaction between technical services from the university and regulatory quality.
 Note: TS-Technical Services from University, RQ-Regulatory Quality.

Model 9 reveals that regulatory quality exhibits a positive yet statistically insignificant interaction effect on the link between university-provided technical services and product innovation. This finding contradicts Hypothesis H2e, which suggests that regulatory quality strengthens the relationship between professional knowledge-intensive business services and product innovation. Nevertheless, further analysis using the marginal effect approach, as illustrated in Fig. 10, supports Hypothesis H2e, demonstrating that at elevated levels of interactions of regulatory quality (0.75, 1) and technical services from universities, product innovation shows a marginal increase exceeding 0.5 percentage points. In Model 10, the competition intensity variable demonstrates a negative and statistically significant effect, which does not support Hypothesis H2f. However, as depicted in Fig. 11, the marginal effect approach confirms Hypothesis H2f. In Fig.11, different levels of competition intensity's interaction with technical services from universities have a marginal effect on product innovation. At the 0th percentile, moderate competition intensity and university technical services have the lowest marginal impact on product innovation. However, at lower percentiles of university technical services (0.25, 0), higher levels of competition intensity (11.75, 12) marginally improve product innovation by about 0.82 percentage points.

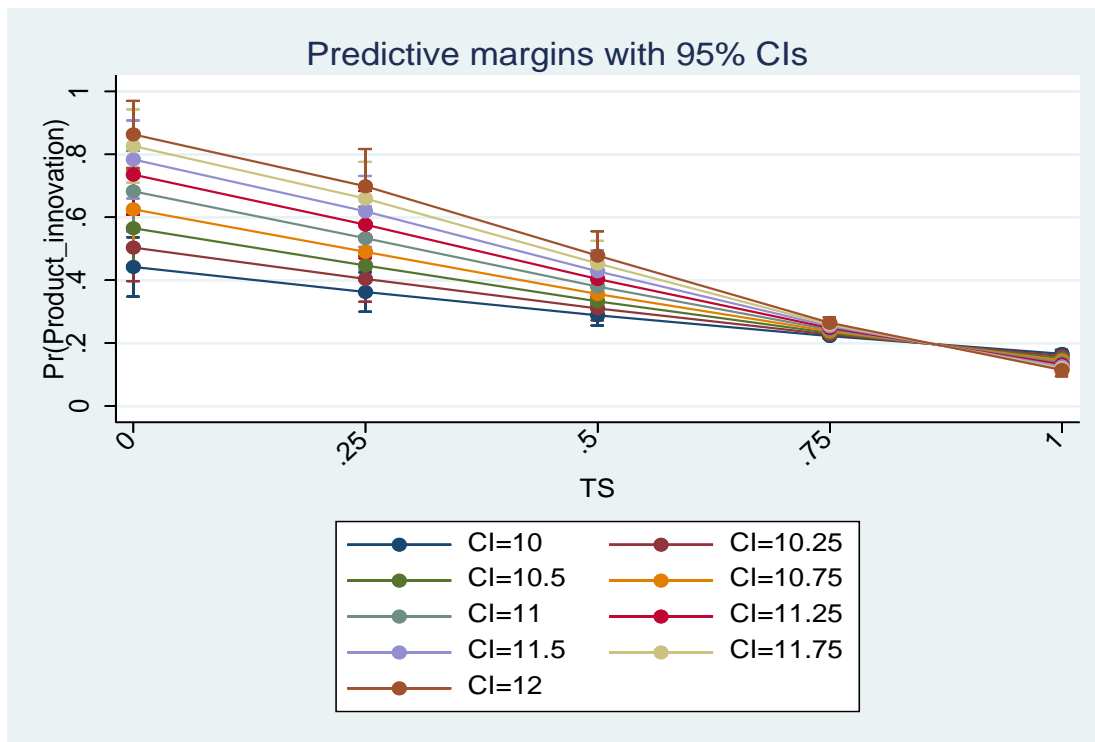


Figure 11. Interaction between technical services from the university and competition intensity.
 Note: CS-Technical Services from the University, RQ-Regulatory Quality.

5.2.1 Robustness Test

A supplementary examination is conducted to reinforce the reliability of the primary outcomes. This evaluation sought to determine if the principal findings were influenced by the attributes of the selected empirical approach, as Meyer et al. highlighted (2017). In line with their recommendations, the study included additional control variables, recognized by innovation research as impacting corporate innovation, to reassess the model. Stantcheva (2023) notes that survey datasets often exhibit varying response patterns among respondents, potentially leading to heterogeneity. Failing to address this heterogeneity could yield unreliable and inconsistent results. Given that the data encompassed diverse enterprises from various sectors across multiple countries (regions), there were compelling reasons to anticipate potential unobserved heterogeneity and endogeneity at firm, national, and sector levels. These variations might suggest that regulatory quality and competition intensity could have differing moderating effects on the relationship between crowdsourcing, university technical services, and product innovation. The study included year and industry-fixed effects to mitigate potential endogeneity issues, following Lin and Wooldridge (2019). At the national level, the study accounted for differences among countries. Despite all economies in the study being moderate and emerging innovative EU countries, the study introduced two additional control variables across all model

specifications. The study included firms that were part of an enterprise group with domestic headquarters and those with foreign headquarters. These additional control variables could influence firms' innovation capabilities ((Disoska et al., 2024). Consequently, regardless of headquarters location, firms belonging to enterprise groups with headquarters at home or abroad leverage group enterprise resources for innovation. At the industry level, the study added sector dummies corresponding to firms' operational sectors, as the impact of crowdsourcing (T-KBIS) and technical services from universities (P-KBIS) on innovations may vary across different industries.

Table 8. Robustness test for objective 2

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Firm size (FS)	.455*** (.011)	.444*** (.018)	.454*** (.011)	.487*** (.011)	.484*** (.012)	.484*** (.012)	.485*** (.012)	.345*** (.019)	.485*** (.011)	.481*** (.012)
Firm age (FA)	.15*** (.012)	.137*** (.017)	.15*** (.012)	.1*** (.013)	.098*** (.013)	.098*** (.013)	.1*** (.013)	.11*** (.017)	.1*** (.013)	.098*** (.013)
Patent pub. (PP)	-.214** (.088)	.058 (.106)	-.216** (.088)	-.041 (.075)	-.044 (.074)	-.045 (.074)	-.031 (.075)	.058 (.106)	-.043 (.075)	-.046 (.074)
Reverse eng. (RE)	.027 (.08)	.027 (.12)	.027 (.08)	.003 (.071)	.01 (.07)	.008 (.07)	.016 (.071)	.032 (.121)	.003 (.071)	.006 (.071)
Trade pub. (TP)	-.107** (.046)	.127* (.071)	-.107** (.046)	.081** (.041)	.066* (.041)	.066* (.041)	.099** (.042)	.102 (.071)	.082** (.041)	.07* (.041)
Ent. group home	.108*** (.032)	.042 (.042)	.113*** (.032)	-.064* (.034)	-.045 (.034)	-.046 (.034)	-.068** (.034)	-.041 (.045)	-.06* (.034)	-.042 (.034)
Ent. group abroad	-.001 (.025)	.022 (.035)	.001 (.025)	.004 (.026)	.011 (.026)	.011 (.026)	.006 (.026)	.049 (.036)	.005 (.026)	.011 (.026)
Crowdsourcing (CS)		.19*** (.031)					5.897** (2.799)	1.151*** (.137)		
Tech. services (TS)			.658*** (.147)						9.778 (10.649)	11.172*** (1.154)
Regulat. Qual. (RQ)				-1.555* (.928)		-1.126 (1.748)	.621 (1.487)		7.148 (10.166)	
Competition int. (RQ)					-.038*** (.007)	.019 (.218)		-.025*** (.008)		1.003*** (.115)
RQ#CI						-.062 (.239)				
CS#RQ							5.313** (2.558)			
CS#CI								-.117*** (.017)		
TS#RQ									-9.928 (11.653)	
TS#CI										-1.251*** (.137)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	-2.652*** (.059)	-3.037*** (.082)	-3.196*** (.134)	-1.422* (.851)	-2.59*** (.077)	-1.559 (1.599)	-3.397** (1.361)	-2.64*** (.101)	-9.958 (9.29)	-11.88*** (.964)
Observations	100034	100034	100034	100034	100034	100034	100034	100034	100034	100034
Pseudo R ²	.021	.018	.021	.059	.06	.06	.059	.035	.06	.061

Standard errors are in parentheses. *** $p < .01$, ** $p < .05$, * $p < .1$

Table 8 presents the results of the re-evaluated models. The introduction of two additional control variables in Models 2 and 3 does not change the coefficient's direction or significance. This trend continues in Models 4 and 5, which examine the direct effects of regulatory quality and competition intensity. Furthermore, adding two extra control variables in Models 6, 7, and 8 - which analyse the interactions between regulatory quality and competition intensity, crowdsourcing and regulatory quality, and crowdsourcing and competition intensity, respectively - produces coefficients with consistent directions and significance levels. Likewise, the coefficient's direction and significance remain unchanged in Models 9 and 10, which explore the interaction between university technical services and regulatory quality and technical services from universities and competition intensity, respectively, with added controls. Finally, the three-way interaction among political instability, foreign technologies, and informal competition retains its positive and statistically significant outcome. These results reinforce the significant findings previously outlined and suggest that they are not a result of peculiarities in the chosen empirical model or estimation method. As the qualitative findings on the statistical significance and direction of the relevant coefficients for the main hypotheses remained stable despite including different sets of control variables, the study concludes that the results of the study are robust.

5.2.2 Instrumental Variable Probit Results

To further assess the robustness of the baseline results and address potential endogeneity concerns, the study employed the instrumental variable approach (ivprobit). According to Oudgou (2021), in instrumental variable analysis, the null hypothesis is rejected if the Wald test of exogeneity yields a p-value below 0.05; otherwise, the study fails to reject the null hypothesis. Although explanatory variables (crowdsourcing and technical services from universities) were carefully chosen, endogeneity issues could still compromise the results' reliability, necessitating resolution. To tackle these concerns, we introduce R&D cost as an exogenous variable (Takauchi & Mizuno, 2022) and R&D tax credit as an instrumental variable (Petrin & Radicic, 2023). Exogenous variables should correlate with the dependent variable but not the instrument, whilst valid instrumental should correlate with endogenous regressors but not the error term. This approach allows for a thorough explanation of how endogenous regressors influence the dependent variable. For firms that receive R&D tax credits, R&D costs decrease, leading to discoveries and inventions that result in more patent publications (Petrin & Radicic, 2023). The Wald test of exogeneity results in Table 9 shows $\text{Chi}^2 = 0.07$: p-value = 0.793. Consequently, the study cannot reject the null hypothesis, indicating exogeneity of the

explanatory variables. This suggests that the variables of interest in the baseline results are not affected by endogeneity. Therefore, the findings regarding the impact of T-KIBS (crowdsourcing) and P-KIBS (technical services from universities) on product innovation are robust and potentially free from biases.

Table 9. Instrumental Variable Probit Results

Variable	Product innovation
Technical services	3.219 (7.124)
R&D cost	.010* (.031)
Crowdsourcing	-.053** (.036)
Firm size	.232* (.168)
Firm age	.079* (.032)
Patent publications	-.116** (.043)
Reverse engineering	.030 (.039)
Trade publications	-.053* (.033)
_cons	-3.823* (8.701)
Wald test of exogeneity	Chi ² = 0.07 Prob = .793
Observations	100034

*Standard errors are in parentheses. *** p<.01, ** p<.05, * p<.1*

5.3 Analysis and Results of Objective 3

First the study presents descriptive statistics of the study variables for objective 1 (Refer to appendix V). In the sample of 14 moderate and emerging innovative EU countries, the mean value of patent applications is 1009, 221. The mean for social globalization is 78.087, and the mean value for political globalization is 84.187. These average values imply high levels of social and political globalization activities among the moderate and emerging EU countries within the study period. As shown in appendix VI, the correlation coefficients in column 1 indicate a good association between the dependent variables (patent applications) and the other variables. The other columns indicate a very low association among the variables, implying that collinearity or multicollinearity is not a significant issue in the study variables. The VIF results

also confirm that all variables have lower correlations, with an overall mean of 2.88, implying no multicollinearity problems with the variables (Odei, 2024).

Table 10 presents the results of conditional fixed-effects Poisson regression estimations. The results in Model 1 show that, except for HDI, all the control variables significantly impact patent applications. While R&D, GDP per capita, and FDI have a significant positive impact on patent applications, trade openness has a significant negative impact. These results are consistent with existing studies (Li & Viao, 2023; Weresa et al., 2022; Wang, 2022; Tang & Beer, 2022) but that of HDI inconsistent with Prasetyo et al, (2023). In Model 2, the first explanatory variable, social globalization is introduced to the model together with the control variables. Social globalization has a statistically significant but economically small positive effect ($p < 0.000$) on patent applications supporting hypothesis H3a. This supports studies by Gao et al. (2022) but contradicts that of Golini and Gualandris (2018). Model 3 shows that political globalization has a statistically significant but economically small positive effect ($p < 0.000$) on patent applications supporting hypothesis H3b. This supports previous studies by Fend et al (2019), highlighting the importance of political globalization in regional innovation advancement. In Model 4, the civil liberties index has a statistically significant and economically strong positive effect ($p < 0.000$) on patent applications. While this contradicts prior studies by Najam et al. (2023), it confirms studies by Alvarado et al. (2023) that the civil liberties index stimulates sustainable innovation. Models 5,6,7, and 8 show the civil liberties index's two-way and three-way interaction. Model 5 shows that the two-way interactions of social and political globalizations positively and significantly impact patent applications. However, in Model 6, the two-way interactions between social globalization and civil liberties index show a statistically significant effect but economically negative effect ($p < 0.000$) on patent applications rejecting hypothesis H3c. In Model 7, a two-way interaction between political globalization and civil liberties index shows a statistically significant but economically negative ($p < 0.000$) impact on patent applications rejecting hypothesis H3d. The model for the three-way interactions of civil liberties index, social and political globalization shows a statistically significant but economically small impact ($p < 0.000$) at the 1% level on patent applications supporting hypothesis H3e. These findings validate empirical studies emphasizing the critical role of civil liberties index in the regional innovation performance. (Ahmed et al., 2024; Alvarado et al., 2023; Crumpton et al. 2021)

Table 10. Conditional fixed-effects Poisson regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D	.884*** (.01)	.878*** (.01)	.662*** (.01)	.879*** (.04)	.616*** (.01)	.8*** (.01)	.652*** (.03)	.606*** (.01)
HDI	-.106 (.121)	-.592** (.15)	-5.472*** (.127)	.659*** (.123)	-6.068*** (.158)	-1.178*** (.152)	-4.689*** (.13)	-5.642*** (.163)
Trade Openness	-.01*** (.001)	-.01*** (.001)	-.005*** (.001)	-.009*** (.001)	-.004*** (.001)	-.009*** (.001)	-.004*** (.001)	-.003*** (.001)
GDP	.011*** (.002)	.011*** (.002)	.010** (.002)	.003 (.001)	.010*** (.005)	.013*** (.002)	.012*** (.005)	.003*** (.010)
FDI	.003*** (.01)	.002*** (.01)	.004*** (.01)	.002*** (.01)	.005*** (.01)	.002*** (.01)	.004*** (.03)	.005*** (.02)
Social glo. (SG)		.005*** (.001)			-.169*** (.005)	.057*** (.002)		-.922*** (.021)
Political glo. (PG)			.066*** (.001)		-.092*** (.004)		.069*** (.001)	-.805*** (.018)
Civil liberties (CLI)				.271*** (.005)		2.043*** (.066)	.53*** (.057)	-35.244** (.935)
SG*PG					.002*** (.004)			.011*** (.012)
SG*CLI						-.023*** (.001)		.453** (.012)
PG*CLI							-.003*** (.001)	.417*** (.011)
SG*PG*CLI								.005** (.006)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	349	349	349	349	349	349	349	349

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

Table 11. Robustness test for objective 3

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
R&D	.955*** (.01)	1.007*** (.01)	.725*** (.01)	.954*** (.02)	.714*** (.01)	.898*** (.01)	.703*** (.06)	.693*** (.01)
HDI	-1.307 (.122)	-1.559*** (.155)	-6.298*** (.13)	.564*** (.124)	-3.188*** (.163)	-.903*** (.156)	-5.466*** (.132)	-2.82*** (.167)
Trade openness	-.01*** (.01)	-.01*** (.002)	-.006*** (.001)	-.009*** (.001)	-.005*** (.001)	-.009*** (.001)	-.004*** (.001)	-.004*** (.001)
GDP	.022*** (.003)	.012*** (.003)	.001*** (.001)	.005 (.003)	.011*** (.010)	.011*** (.001)	.014** (.021)	.001*** (.011)
FDI	.002*** (.01)	.003*** (.01)	.004*** (.03)	.002*** (.01)	.005*** (.01)	.003*** (.01)	.004*** (.04)	.006*** (.02)
Bus. Freedom	.036*** (.002)	.039*** (.002)	.033*** (.001)	.035*** (.002)	.036*** (.001)	.04*** (.010)	.032*** (.002)	.036*** (.001)
Rule of law	.006* (.011)	.073*** (.011)	.222*** (.012)	.062*** (.011)	.395*** (.012)	.056*** (.011)	.282*** (.012)	.354*** (.012)
Social glo (SG)		.03*** (.001)			-.254*** (.005)	.05*** (.002)		-1.013*** (.021)
Political glo. (PG)			.062*** (.001)		-.137*** (.005)		.079*** (.001)	-.87*** (.019)
Civil liberties (CLI)				.246*** (.005)		3.352*** (.067)	1.311*** (.058)	-36.855*** (.955)
SG*PG					.003*** (.002)			.012*** (.011)
SG*CLI						-.041*** (.001)		.476*** (.012)
PG*CLI							-.012*** (.001)	.445** (.011)
SG*PG*CLI								.006*** (.004)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	349	349	349	349	349	349	349	349

Standard errors are in parentheses

*** $p < .01$, ** $p < .05$, * $p < .1$

Robustness Test

The study conducted further analysis to evaluate the robustness of the study's baseline results. To achieve this, the paper incorporated additional explanatory variables into the model that could influence patent applications. The study re-evaluated the findings by examining the same hypotheses. Due to unobserved factors that are correlated with the independent variables and the annual panel data, which might reflect varying dynamics in the countries included in the study, there could be heterogeneity issues (Wooldridge, 2005). When survey data often shows differences in response patterns among various respondent subgroups, neglecting this heterogeneity can result in biased outcomes (Odei, 2024; Liu, 2014). Given that the data originates from diverse institutions and countries, there are strong reasons to suspect that unobserved heterogeneity and endogeneity are influential at both the country and institutional levels, potentially leading to variations in regional innovation performance. The study attempts to address the potential heterogeneity issue by introducing controls at the institutional and national levels (Odei, 2024; Liu, 2014; Wooldridge, 2005). At the national level, the study accounts for variations among nation-states by employing business freedom (Bakry et al., 2025), although all countries in the study are moderate and emerging EU countries. At the institutional level, the study incorporated the rule of law as a potential variable influencing patent applications (Wend & Li, 2024). According to Lu and White (2014), if the directions and significance of the estimated regression coefficients remain consistent with the inclusion of different explanatory variables (business freedom and rule of law), it would indicate that the baseline results are robust and can be reliably interpreted as actual causal effects. The results in Table 11, compared to the baseline regression coefficients in Table 10, demonstrate that their direction and significance remain unchanged. Similarly, the results concerning the moderating role of civil liberties and social and political globalization in models 4-8 remain consistent regarding the direction and significance of regression coefficients. Consequently, the study confirms that all hypothesized relationships, as previously explained, do not vary with the inclusion of other explanatory variables (business freedom and rule of law). This confirms the findings in the baseline results. Based on the results of the robustness test, which includes additional control variables, the study can conclude that the main findings of the study remain consistent.

6. DISCUSSION

6.1 Objective 1

To achieve objective 1, the study develops four hypotheses to investigate the direct influence of firm channels of information (Standard industry documents) and knowledge-based human resource practices and the two-way interaction effects of competition intensity heterogeneity on product innovation. Empirical studies suggest that firms in moderate and emerging innovative EU countries will likely enhance their products by leveraging information channels and knowledge-based human resource practices for effective knowledge management (Le, 2024; Arthur & Stejskal, 2023). This outcome is due to the critical role of acquiring knowledge from standardized documents to improve firm-level knowledge management. When companies in emerging EU countries use information from firm channels of information (standardized documents), they gain essential knowledge and skills for innovation, to enhance their dynamic capabilities. This significantly boosts the country's technology, expertise, and skills for firm level innovation (Dinu, 2022). By integrating information from standardized documents into firm operations in moderate and emerging innovative countries, they significantly improve their innovative outcomes. The study finds a positive impact of firm channels of information on product innovation **supports hypothesis H1a and confirms with previous research (Arthur & Stejskal, 2023)**, which indicates that a firm's information channels affect its innovation performance.

Furthermore, the study finds robust empirical evidence to support the hypothesis that firms' channels of information positively and significantly impact innovation performance in the European Union. **Moderate and emerging EU countries face challenges such as weak innovative ecosystems and limited access to advanced knowledge (Pacheco & Paul, 2025). Standard industry documents provide expert and technical knowledge of the best industry practices to enhance product innovation.**

Firms in these regions can strengthen innovation capabilities by leveraging effective knowledge-based human resource practices such as planned job rotations and cross-functional teams. **The study findings support hypothesis H1b that knowledge-based HR practices improve firm innovation performance. This finding reinforces the results of earlier studies (Le, 2024).** Knowledge-based human resource practices, such as planned job rotations, facilitate knowledge transfer across departments. Employees are exposed to other departments and have different functions and processes. This enriches their knowledge of the tasks across

firms. **However, it is important to note that the ability of firms in moderate and emerging EU countries to benefit from firm channels of information depends on their open innovation policy and absorptive capacity (Song et al., 2020).** To enhance innovation in product development, firms should maintain an open innovation policy that enables networking with external entities for knowledge acquisition.

Additionally, the study finds evidence that in a simple slope interaction, **the intensity of competition does not enhance the link between firm channels of information and product innovation.** By contrast, this link is strengthened when the marginal effects approach is used for the analysis. This method suggests that the relationship between **firm channels of information and product innovation is enhanced in highly competitive environments supporting hypothesis H1c.** Therefore, companies can boost product innovation in a market with high levels of intense competition by using information from standard industry documents. However, such information might not be crucial for product innovation in markets with less competitive pressure. This is especially significant for companies in developing countries, which may not have the necessary internal resources or expertise to remain competitive. Thus, firms need information from standard industry documents to survive high levels of competition intensity. Knowledge-based human resource practices such as planned job rotation and cross-functional teams positively impact product innovation. **However, then simple slope analysis suggests intense competition may reduce this positive effect.** On the contrary, the marginal effect method indicates that varying levels of competition intensity enhance product innovation. **The study supports the hypothesis H1d that competition intensity heterogeneity strengthens the link between knowledge-based human resource practices and product innovation.** In moderate and emerging EU economies, firms often deal with high employee turnover, which can result in the loss of valuable knowledge (Galan, 2023). To mitigate this, strategic knowledge-based human resource practices such as planned job rotation and cross functional groups are essential for knowledge sharing within the firm. This prevents knowledge gaps when employees leave the firm to join other competitors. This strategy not only boosts product innovation but also aligns with the findings of Haughton (2021). In essence, varying or high competition intensity reinforces the connection between channels of information, knowledge-based human resource practices, and product innovation. Firms in highly competitive markets are more likely to introduce new products and enhance their dynamic capabilities.

6.2 Objective 2

To achieve objective 2, study formulates six hypotheses to test the explanatory variables' direct impact and the moderation variables' interaction effect on product innovation. Subsequently, a two-way interaction between regulatory quality and competition intensity is developed. Empirical studies suggest that firms in moderate and emerging innovative EU countries will likely improve their products or services when they access and use T-KIBS through crowdsourcing (Bomm et al., 2023). This outcome may be attributed to the role of T-KIBS in facilitating digital transformation and fostering platform-based knowledge networks. Industry specific innovation hubs and clusters lead to acquiring new knowledge for product innovation. When firms in these EU countries access T-KIBS, they gain crucial knowledge and expertise for innovation development. This substantially boosts these economies' technology, expertise, and skills, allowing firms to innovate their products and services more competitively (Dinu, 2022). By integrating T-KIBS, such as crowdsourcing, into operations, firms in moderate and emerging innovative economies can enhance their innovation and R&D capabilities. **The study finds a positive impact of T-KIBS (crowdsourcing) on product innovation. This supports hypothesis H2a and confirms previous research conclusions (Dinu, 2022),** which state that knowledge-intensive business services influence firm innovation performance.

Firms gain from these technological network services through enhanced product innovation. Furthermore, the study discovers strong empirical evidence supporting the hypothesis that professional knowledge-intensive business services (P-KIBS) significantly affect product innovation. Moderate and emerging innovative EU countries face challenges, such as weaker innovative ecosystems, lower R&D investments, and limited access to advanced knowledge networks (Pacheco & Paul, 2025).

The study results confirm hypothesis H2b that firms in emerging EU countries can strengthen their innovation performance by leveraging P-KIBS, such as university technical services. This reinforces the results of the earlier studies (Dinu et al., 2023). Universities, as professional academic institutions, are hubs for new knowledge. Consequently, firms that collaborate and network with them benefit significantly from innovative product development. **However, it is important to note that the ability of firms in moderate and emerging EU countries to benefit from professional knowledge-intensive services hinges on their open innovation policy and absorptive capacity.** Firms should maintain an open innovation policy that enables networking with external entities for knowledge acquisition and

possess the technical capacity to absorb and effectively integrate new knowledge to enhance product innovations.

The empirical findings confirm hypothesis H2c that regulatory quality strengthens the link between technical knowledge-intensive business services and product innovation.

While the baseline results indicate that T-KIBS positively affects product innovation, this relationship weakens when regulatory quality moderates the model. This adverse interaction hampers the introduction of novel products and services. One potential rationale is that moderate and emerging countries typically have regulatory frameworks that may be unfavourable to access and use T-KIBS easily (Coutinho et al., 2023). The regulatory environment, fraught with bureaucratic and legal ambiguities, renders compliance inefficient, potentially deterring firms from utilizing T-KIBS because of fear of violation. For example, a startup firm employing crowdsourcing for product innovation in these regions might face challenges with slow regulatory approvals and intellectual property rights. This leads to a reluctance to collaborate with external partners and fully integrate external knowledge.

Although T-KIBS (crowdsourcing) enhances product innovation, the interplay between competition intensity and T-KIBS (crowdsourcing) decreases the likelihood of product innovation in moderate emerging innovative EU countries. While competition generally propels product innovation (Chichkanov, 2021), excessive and imbalanced competition within the economic landscape can hinder firms' innovative endeavours, particularly for startups. In a highly competitive economic environment, firms in moderate and emerging innovative EU economies often prioritize immediate survival profits over long-term innovation (Archibugi & Filippetti, 2011). Bhatti et al. (2025) contend that knowledge-intensive business services typically demand time and resources, and firms under intense competition may concentrate on cost reduction and swift product launches.

On the other hand, the marginal effect approach yields a different outcome that contradicts the results of the simple slope analysis. At higher levels of regulatory quality (0.25 to 1) interacting with T-KIBS, product innovation improves marginally by over 0.5 percentage points. **This finding confirms hypothesis H2c that suggests that an improved regulatory quality combined with T-KIBS (crowdsourcing) boosts firm product innovation in moderate and emerging innovative EU countries.** This also implies that low levels of regulatory quality interacting with T-KIBS marginally decrease the chances of introducing new products or services. It can also be explained that as the regulatory framework's

quality improves in an environment where firms utilize T-KIBS, firms are more likely to create new or enhance existing products and services.

While T-KIBS positively influences product innovation, the simple slope approach reveals that this impact diminishes when competition intensity moderates the relationship. The simple slope approach fails to demonstrate a distinct moderating effect across various variable levels. These results differ when the marginal effect method is used to examine the interaction effect. **The interplay between competition intensity and crowdsourcing leads to enhanced product innovation at elevated levels of competition intensity (10–12). The study supports the hypothesis H2d that competition intensity strengthens the link between technical knowledge-intensive business services and product innovation.** The results of these moderation outcomes suggest that, as competition intensity rises, firms engaging in less technical knowledge-intensive activities experience marginal improvements in product innovation. Another way to explain this is that in a highly competitive economic environment, firms that reduce their involvement in technical knowledge-intensive business services, such as crowdsourcing, tend to enhance their product innovations. This aligns with studies by research by (Mishra & Maheshwari, 2024). Thus, due to the infrastructure and resource limitations firms face in moderate and emerging innovative EU countries, firms participate in fewer crowdsourcing (T-KIBS) activities in a more competitive economic environment to cultivate stronger internal innovation capabilities, thereby boosting product innovation.

Moreover, the findings support the hypothesis H2e that regulatory quality strengthens the connection between professional knowledge-intensive business services and product innovation. The simple slope suggests that regulatory quality's interactions with P-KIBS (technical services from universities) do not affect product innovation, **which contradicts extant studies, the marginal effects approach reveals a positive impact on product innovation at higher levels (0.75, 1) of regulatory quality moderation.** This finding confirms (Miles et al, 2021). the claim that a fair and improved regulatory framework reinforces firm collaboration networks and enhances product innovation. These outcomes indicate that firms in moderate and emerging innovative EU countries can leverage new knowledge to enhance product innovation if fair, equitable, and supportive regulatory innovation policies are in place. In essence, improved regulatory quality enhances the product innovation benefits firms derive from university collaborations in technical services. Finally, the study finds evidence supporting the hypothesis that the link between professional knowledge-intensive business services and product innovation is strengthened by competition intensity. **The study finds that the**

likelihood of introducing new products or services marginally increases at various levels of competition intensity.

Consequently, higher levels of interaction between competition intensity and P-KIBS (technical services from universities) marginally improve product innovation by approximately 0.82 percentage points. **This supports hypothesis H3e.** A possible explanation could be that competition motivates firms to seek advanced and novel knowledge beyond their organization (Zhu et al., 2024). In a highly competitive environment, a unique value proposition is crucial for business survival; hence, firms turn to external knowledge to improve products. **Professional knowledge-intensive business services (technical services from universities) are established hubs for new and expert knowledge.** Firms benefit from university-industry knowledge networks to maintain competitiveness (Gustafsson et al., 2023).

6.3 Objective 3

Countries in emerging economies, regardless of their resource constraints, are committing resources to globalization activities and formulating globalization policies to benefit from knowledge diffusion and innovation (Gao & Zhang, 2022; Zheng et al., 2023; Hsu et al., 2023). Although widely studied by scholars and discussed by policymakers, it is still largely unclear how specific globalization issues, such as social and political globalization, influence regional innovation performance and the conditions or context under which efficient social and political globalization can be improved to achieve higher regional innovation performance. Therefore, the study provides new empirical insights into the social and political globalization influence on regional innovation performance in moderate and emerging innovative EU countries and the extent to which civil liberties influence the relationship across the merging EU region. The results of this study make several important contributions to theory and practice.

The study finds that social and political globalization improves regional innovation performance which supports hypotheses H3a and H3b. This is contrary to studies by Stojčić and Orlić (2020) but consistent with (Ahmed, 2024). In other words, the study provides a new insight that moderate and emerging innovative economies in the EU can socially rely on personal contacts (such as international telecom traffic, foreign population and degree of tourism), information flows (such as number of internet users and trade in new papers) and cultural proximity (trade in books and number of foreign restaurants-McDonalds) to exploit knowledge diffusion for enhancement in regional innovation performance. The study provides additional support to prior studies that moderate and emerging innovative economies in the EU

may also depend on political globalization activities such as the number and type of treaties they sign with other countries or international organizations, the number of embassies and high commissions established and the number of international organizations **they join to diffuse and exploit new knowledge to improve regional innovation performance (Furman et al., 2022)**. Regarding the possible reason for the significant effect. Furman et al. (2022) argue that cultural and student exchange programs expose the EU's emerging economies to new global ideas for creativity and innovation. For instance, the Budapest startup scene blends local and Silicon Valley practices, making it thrive in innovation performance. Also, the European Union's flagship programme, Horizon Europe, promotes research and innovation by supporting startups, funding health and climate-related projects and protecting intellectual property. Several economies have significantly benefited from being members of the EU (Soete et al., 2021). For instance, in 2023, Peptomyc SL, a Czech biotech firm, patented a Horizon-funded cancer therapy (Zsár & Angyal, 2023).

Second, the study shows that although civil liberties significantly moderate the relationship between social and political globalization in the two-way interactions, it does not improve regional innovation performance. This rejects hypothesis H3c that “Civil liberties moderate the positive impact of social globalization on patent applications-the higher the level of civil liberties the stronger the impact.” **This finding also rejects hypothesis H3d** that “Civil liberties moderate the positive impact of political globalization on patent applications-the higher the level of civil liberties the stronger the impact. These findings are inconsistent with empirical studies (Ahmed et al., 2024; Alvarado et al., 2023). Thus, the level of civil liberty index such as freedom of expression, belief, associational, organizational and individual rights, rule of law and personal autonomy in moderate and emerging EU economies does not improve the influence social and political activities have on regional innovation performance. One reason for this statistically significant but economically negative moderation effect might be the result of brain drain created by social globalization, where talents leave emerging EU countries for the leading innovative EU countries (Khan, 2021). The context in which elements of knowledge diffusion, such as social globalization, impact regional innovation performance in emerging EU economies is crucial. Nonetheless, even if a region or country is socially (via international telecom traffic, cultural proximity, and tourism), and politically (via treaties and international organizations) connected, weak civil liberties, such as lack of freedom of expression and infringement on organizational and individual rights, can stifle open discussions of new ideas and hinder innovative dissent. Therefore, while social and

political globalization brings external knowledge and facilitates its diffusion, weak civil liberties (such as lack of autonomy in universities and research institutions, media and internet restrictions) limit access to global scientific discussions, reduced tourism and investor confidence, and inadequate enforcement of intellectual property rights. This makes the findings interesting for pursuing higher regional innovation performance because they show that social and political globalization alone is insufficient in moderate and emerging innovative EU economies. **Three-way interaction role of civil liberties, social and political globalization in pursuing regional innovation performance positively and significantly impacts regional innovation performance among moderate and emerging EU countries (de Macedo et al., 2021). This supports hypothesis H3e.** The interactions of civil liberties, social and political globalization positively and significantly affects regional innovation performance among moderate and emerging EU countries (de Macedo et al., 2021).

7. CONCLUSION

The study investigated the influence of selected determinants of knowledge production function on innovation performance. Based on current literature, the study identified determinants that promote knowledge management, knowledge network and knowledge diffusion. Specifically, study explored pathways through which knowledge management variables (such as firm channels of information and knowledge-based HR practices), knowledge network variables (such as technical and professional knowledge intensive business services) and knowledge diffusion variables (such as social and political globalization) impact innovation performance in 14 moderate and emerging innovative EU countries. Again, the study examined the moderation role of the business environment (such as competition intensity, regulatory quality and civil liberties index) in the relationship. Three main objectives were formulated to assess the direct relationship and the indirect (moderation) relationships between the selected determinant of knowledge production function. To achieve the 3 main objectives of the study, four hypotheses were developed from objective 1, six hypotheses from objective 2 and four hypothesis from objective 3. The objectives 1 and 2 were based on firm level analysis with 100034 datasets on firms in the 14 moderate and emerging EU countries. Objective 3 was based on country level analysis. Previous studies have concentrated mainly on developed markets, overlooking the heterogeneity of contextual factors. This has led to a limited understanding of how knowledge management, knowledge network and knowledge diffusion variables influence innovation (Le, 2024; Spatareanu, 2023; Furman et al., 2022). The varied impacts of the determinants of knowledge production function and the mechanisms they influence innovation performance in moderate and emerging EU countries have not been thoroughly explored. By leveraging existing theories related to endogenous and exogenous growth theories, open innovation theory, dynamic capability theory, institutional theories and the knowledge production model, the study proposes a novel theoretical framework to assess the contextual effects of competition intensity heterogeneity, regulatory quality and civil liberties index on these relationships.

For objective 1, the findings reveal that firm channels of information (standard industry documents) and knowledge-based human resource practices (planned job rotations and cross-functional groups) significantly enhance product innovation. This study also asserts that a simple slope approach does not adequately capture the varying interaction effects of competition intensity, weakening the relationships between firm channels of information channels, knowledge-based human resource practices, and product innovation. Conversely, the

marginal effect approach effectively captures different competition intensity levels, strengthening these relationships. **Thus, while the simple slope analysis suggests a significant negative moderation effect of competition intensity on the relationship, the marginal effect approach confirms a significant positive impact of the interaction effect of competition intensity.**

For objective 2, prior research has primarily focused on developed markets, often finding negligible effects of KIBS on innovation; the heterogeneous effect of knowledge-intensive business services and the specific mechanisms it affects product innovation in moderate and emerging EU countries remain insufficiently studied. **The study confirms that technical and professional knowledge-intensive business services enhance product innovation. Also, the study establishes that using the simple slope approach, regulatory quality and competition intensity do not enhance the relationship between technical knowledge-intensive business services and product innovation. However, using the margins approach, regulatory quality and competition intensity strengthen the relationship between technical knowledge-intensive business services and product innovation.** Besides that, while the simple slope analysis reveals an insignificant moderation effect of regulatory quality in the relationship between professional knowledge intensity and product innovation, the margins approach confirms a significant and positive interaction effect of regulatory quality in the relationship between professional knowledge intensity business services and product innovation.

For objective 3, the study focused on knowledge diffusion has driven innovation and economic growth through globalization in EU's moderate and emerging innovative economies. This in turn has improved patent applications and regional innovation performance in the EU. **The study finds that social and political globalization positively and significantly impacts regional innovation performance through high patent applications. Also, the study finds that, a two-way interaction between civil liberties and social globalizations does not improve regional innovation performance. Similarly, two-way interactions between civil liberties and political globalization did not improve regional innovation performance. On the other hand, three-way interaction between civil liberties, social globalization and political globalization positively and significantly improved regional innovation performance.**

Finally, the study concludes **that varying competition intensity and regulatory quality strengthens** the relationship between the determinants of knowledge production function and innovation performance. Also, while civil liberties **do not improve the relationship between**

knowledge diffusion variables (social and political globalization) in a two-way interaction, it significantly improves the relationship in a **three-way interaction** (civil liberties, social and political globalization). **Theoretical and practical implications are discussed in the following section.**

7.1 Theoretical implications

7.1.1 Objective 1

This study provides essential theoretical insights for businesses in moderate and emerging EU countries. The influence of information channels (standard industry documents) and knowledge-based human resource practices (planned job rotation and cross-functional teams) on product innovation has not been extensively explored, particularly in moderate and merging economies where firms encounter technological challenges (Pacheco & Paul, 2025). While earlier studies mainly concentrated on innovation within developed economies (Le, 2024; Arthur & Stejskal, 2023) with limited impact, the research offers new perspectives by illustrating how varying levels of competition intensity can affect this relationship. This study examines the dynamics of knowledge-management strategies in corporate settings by assessing how companies employ diverse knowledge-management strategies. **The findings underscore that the intensity of competition in a firm's business environment significantly influences product innovation outcomes when competition intensity is examined at varied levels using a marginal effects approach.** This study introduces a novel theoretical framework integrating firm channels of information, knowledge-based human resource practices, and competition intensity heterogeneity to demonstrate how they drive product innovation and enhance firms' adaptability.

Additionally, this study broadens the literature on knowledge management variables such as firm channels of information and knowledge-based human resource practices (Akhmadi & Tsakalerou, 2022), **revealing the conditional effects and mechanisms through which varying competition intensity shapes their relationship with product innovation.** These interactions have been mainly overlooked in previous studies. The findings reveal how market competition at different levels can hinder or enhance a firm's ability to innovate. This underscores the necessity of exploring whether different levels of competition intensity in firms' economic environments boost product innovation. This study also advances literature on open innovation theory, which explains how firms achieve a competitive edge in evolving environments through effective intra-firm and inter firm knowledge management. (Lv et al., 2025). **The study findings suggest that varying levels of competition intensity significantly**

impact product innovation through knowledge management strategies such as firm channels of innovation through standard industry documents and knowledge-based human resource practices (cross functional groups and planned job rotation). The marginal effect approach reveals that different levels of competition intensity positively influence innovation in moderate and emerging economies, challenging the simple slope approach that suggests adverse effects on product innovation.

Furthermore, this study contributes to understanding knowledge management strategies and knowledge-based resources in moderate and emerging innovative economies (Bilgili & Bilgili, 2024). While traditional views argue that firms in developing and emerging economies have weak absorptive capacities (Cuervo-Cazurra & Rui, 2017) that limit their ability to acquire and integrate new knowledge, the study results indicate otherwise. The study finds that firms can enhance innovation by incorporating diverse knowledge-management strategies into their innovation processes. Firms in highly competitive business environments improve product innovation by strategically balancing their internal and external knowledge resources. The study findings emphasize that firms in moderate and emerging innovative EU economies can **leverage high competition intensity to sustain innovation and maintain competitive advantage**. Overall, this study enhances our understanding of how firms' innovative activities and capabilities can improve in moderate and emerging markets. By demonstrating the importance of varying levels of competition intensity, the study provides insights into policy and business strategies to foster innovation and strengthen firms' dynamic capabilities in these economies.

7.1.2 Objective 2

The results of this study on objective 2 provide notable theoretical implications for firms in moderate and emerging innovative EU countries. From the theoretical perspective, the positive impact of technical and professional knowledge-intensive business services on product innovation remains understudied, particularly in moderate and emerging EU markets, where firms lag technologically (Pacheco & Paul, 2025). **This crucial finding offers fresh insights into the literature on the influence of knowledge-intensive business services on product innovation, which has primarily focused on developed economies (Spatareanu, 2023) and found negligible effects**. The concept that technical and professional knowledge-intensive business services enhance product innovation, moderated by regulatory quality and competition intensity, contributes novel perspectives to expanding research on firms' knowledge networks, knowledge production function model and dynamic capability theory (Fu et al., 2024).

Exploring how firms leverage heterogeneous knowledge-based resources, such as T-KIBS (crowdsourcing) and P-KIBS (university technical services), to drive product innovation sheds light on the dynamics of knowledge-based resources within corporate environments. The findings that interaction effects at varying levels of regulatory quality and competition intensity improve product innovation demonstrate that the dynamic nature of firms' knowledge-based resources improves product innovation. Analyzing these relationships can provide a comprehensive understanding of how the economic landscape affects the influence of heterogeneous knowledge-intensive business services on firms' product innovation. This finding emphasizes the importance of investigating whether different levels of regulatory quality and competition intensity in firms' economic environments enhance product innovation outcomes. **The novel theoretical model presents a framework that integrates the roles of technical and professional knowledge-intensive business services, regulatory quality, and competitive intensity in the innovation process.** This highlights how varying the levels of the study variables can facilitate new product development.

Second, the research broadens the scope of literature on technical and professional knowledge-intensive business services (Vaillant et al., 2021; Krupskaya & Pina, 2022). **The study revealed the conditional effect and mechanisms by which regulatory quality and competition intensity influence the association between technical (crowdsourcing) and professional (university-provided technical services) knowledge-intensive business services and product innovation.** These relationships have not been explored thoroughly in previous studies. Thus, the study enhances our understanding of how technical and professional knowledge-intensive business services affect firm-level innovation outcomes. Third, the concept that varying levels of regulatory quality and competition intensity affect product innovation offers fresh insights into the existing knowledge of the dynamic capability theory. This study explains how firms can gain a competitive advantage in rapidly evolving environments, such as moderate and emerging innovative EU markets (Fu et al., 2024). The study results demonstrate that an economy's regulatory quality and competition level in a firm's business environment can influence product innovation. Furthermore, the findings reveal that the relationship between regulatory quality and competition intensity at different levels influences product innovation. This deepens our insight into their combined effect, collective impact on product innovation, and implications for firms. **These findings improve our understanding of the determinants of the knowledge production function, knowledge network and collaborations, firms' economic environment, and their role in improving**

product innovation from the perspectives of moderate and emerging innovative EU economies. These findings are particularly relevant for firms in moderate and emerging economies, where market competition and weak institutional conditions pose significant challenges to business operations (Dunyo & Odei, 2023).

The study contributes to the existing studies on the role of knowledge networks and knowledge-based resources in moderate and emerging innovative economies (Bilgili & Bilgili, 2024). Contrary to the simple slope approach indicating that technical and professional knowledge-intensive business services negatively impact innovation, the marginal effect approach reveals that different levels of technical (crowdsourcing) and professional (university technical services) knowledge-intensive business services can positively influence product innovation in firms in moderate and emerging countries. **This outcome challenges the common belief that firms in developing economies possess weak absorptive capacities (Cuervo-Cazurra & Rui, 2017),** which could impede their ability to effectively obtain, integrate, and utilize new technologies and knowledge. The results suggest that enterprises in emerging economies can enhance their product innovation by incorporating diverse knowledge-intensive business services such as crowdsourcing and university technical services into their innovation processes. The research also offers an additional understanding of how firms' innovation activities and capabilities in moderate and emerging markets can be improved and maintained through the moderation role of improved regulatory quality and high competition intensity in the innovation landscape.

7.1.3 Objective 3

The objective 3 of the study makes three theoretical contributions to extant literature. First, social and political globalization is an essential response to market failures in knowledge diffusion and regional innovation performance in moderate and emerging innovative EU countries. **Theoretically, social and political globalization roles are expected to enhance regional innovation performance.** Although prior studies support this assertion (Niazi, 2025; Tang, 2022), their emphasis is mainly on general globalization or economic globalization usually proxied with FDI. Feng et al. (2019) assert that it is crucial to examine globalization from the heterogeneity (economic, social, and political) perspective in the context of knowledge diffusion. Hence,

Third, another important contribution concerns the three-way interaction role of civil liberties, social and political globalization in pursuing regional innovation performance. The three-way

interaction between civil liberties, social and political globalization remains largely unexplored. The study contributes to literature on institutional theory function by showing that emerging economies that seek high regional innovation performance for economic growth should carefully blend and pursue policies and activities that lead to civil liberties, social and political globalization. **These findings remind us that generating and transferring new ideas across moderate and emerging EU countries fundamentally thrives on the interactions of high civil liberties, active social and political globalization (Jahanger et al., 2022).** Given this critical role, emerging EU economies can enhance their institutional capacities and access globalization opportunities to contribute significantly to knowledge production and diffusion at the regional level. **The following section explains the study implications in practice.**

7.2 Practical Implications

7.2.1 Objective 1

Businesses aim to innovate in moderate and emerging markets to boost their dynamic capabilities and compete globally. They encounter obstacles, such as high employee turnover, which results in knowledge loss and restricted access to varied information channels due to cost (Haughton, 2021). To address these challenges, it is crucial to acquire diverse knowledge and implement strategic knowledge-based human resource practices (Le, 2024). **The research highlights the importance of firm channels of information and knowledge-based human resource practices in promoting product innovation in moderate and emerging European Union countries.** Companies can enhance their knowledge-based capabilities and improve innovative outcomes by utilizing resources and strategies such as standardized industry documents, cross-functional teams, and planned job rotations. First, the **findings demonstrate the positive impact of firm channels of information on product innovation through standardized documents.** This offers valuable insights for firms and policymakers. Companies should leverage standard documents rich in industry information to adopt the best practices. Second, the study finds that knowledge-based human resource practices improving product innovation. Firms should develop effective knowledge-based human resource strategies, such as planned job rotations and cross-functional teams, to boost intra-firm knowledge sharing and improve product innovation. **Policymakers should create fair and supportive regulatory frameworks to ensure access to standard industry documents for information, especially in highly competitive business environments.** Enhancing companies' abilities to acquire, integrate, and implement optimal knowledge-based human resource practice strategies is vital for innovation growth. Third, the results indicate that varying competition intensity levels,

information channels, and knowledge-based human resource practices drive product innovation. **Companies must identify the most effective knowledge-management strategy** in a highly competitive business environment. Managers should incorporate risk-management practices **to navigate uncertainties related to competitive pressures**. Overall, companies in moderate and emerging markets should strategically invest in employee training and standardized documents to access, absorb, and apply new knowledge effectively for sustainable innovation and competitive advantage.

7.2.2 Objective 2

In moderate and emerging markets, firms often pursue innovation to gain an edge in a competitive global environment. However, these firms encounter significant challenges in their innovation endeavours (Nuruzzaman et al., 2019). Such challenges include limited technological capabilities, inadequate regulatory frameworks, and difficulties accessing knowledge-intensive resources within their countries. Acquiring diverse knowledge and comprehensive business services is crucial for innovation (Zhou & Li, 2024). **The research indicates that technical and professional knowledge-intensive business services are vital in promoting product innovation among firms in moderate and emerging innovative EU economies.** These firms can leverage technical and professional knowledge-intensive business services, such as crowdsourcing and university technical support, to enhance their technological and knowledge-based capabilities, thereby improving product innovation. First, the findings highlight the positive impact of technical and professional knowledge-intensive business services on product innovation. This has practical implications for firms and policymakers in moderate and emerging innovative countries. Firms operating in these regions should consider implementing strategies to effectively utilize these services to enhance their knowledge networks, knowledge-based resource capabilities, and product innovation processes. This may involve engaging in knowledge-sharing networks and collaborations such as crowdsourcing, utilizing university technical services, and investing in technology acquisition. Policymakers should focus on creating a supportive, fair, and equitable environment that encourages participation **in crowdsourcing activities and university-industry partnerships**. This could include improving regulatory quality, promoting fair competition, and facilitating access to the technological infrastructure. The results suggest that developing the capacity of firms in moderate and emerging innovative countries to acquire, effectively apply, and assimilate technical and professional knowledge-intensive business services is crucial for product innovation development. Firms in these markets should consider investing in such services,

employee training, infrastructure upgrades, and creating an environment conducive to absorbing, assimilating, and applying new knowledge. Second, the findings indicate that improved regulatory quality and competition intensity, combined with technical and professional knowledge-intensive business services, boost product innovation. **This highlights the need for firms to understand the dynamics of regulatory quality and competition levels in their economic environment when formulating innovation strategies.** The reason is that increased intensity in these areas could lead to more proactive product innovation development. Firm managers should incorporate proactive measure such as regular risk assessments, scenario planning, and implementation of risk mitigation measures, to address uncertainties related to the regulatory framework and competition intensity in the economic landscape.

7.2.3 Objective 3

The study findings in objective 3 have several implications for governments, policymakers, and academia, not only in emerging EU economies but also in other emerging economies globally. First, the results show that social and political globalization positively enhances regional innovation performance in the EU's moderate and emerging innovative economies. **The findings urge policymakers on social globalization to prioritize investment in international telecom traffic, tourism promotion, and internet usage.** On political globalization, policymakers should ensure treaties are signed with countries with shared interests and promote knowledge diffusion (Zsár & Angyal, 2023). This is very important given the economic development and innovation performance disparities between emerging EU countries and innovation leaders such as Sweden, Finland, Denmark and Norway. Thus, moderate and emerging EU countries should consider policies promoting social and political globalization with innovative leaders within and outside the EU. Prokop et al. (2021) state that emerging economies are catching up in innovative activities, and their collaborations with innovation leaders (advanced innovative countries) help them to learn best practices to promote their innovation performance.

Second, a high civil liberties index in the form of freedom of expression, associational beliefs, rule of law, personal autonomy, and individual and organizational rights do not strengthen the impact social globalization has on regional innovation performance. Similarly, civil liberties index does not strengthen the impact of political socialization on regional innovation performance. These contradict studies by existing studies (Alvarado et al., 2023). **The reason could be what Haini et al. (2024) referred to as a crowd-out effect of globalization.** The level of civil liberties existing in the moderate and emerging EU countries does not ensure a

positive impact of social globalization and regional innovation performance. The same can be said of the two-way interaction role of civil liberties in political globalization and regional innovation performance. **This implies that regional innovation (domestic patent applications) is suppressed** when there is lack of freedom of speech, violations of individual and organizational rights, lack of personal autonomy, rule of law not working even when moderate and emerging EU countries promote or engage in social and political globalization. Thus, emerging countries should ensure high civil liberties to spur a positive impact of social and political globalization on regional innovation performance.

Finally, the study uniquely finds that a three-way interaction of civil liberties, social globalization and political globalization positively and significantly impacts regional innovation performance in moderate and emerging innovative EU countries. **This implies that, in emerging economies, the joint pursuit of social and political globalization activities should be promoted in the context of high civil liberties.** Emerging economies need to pay particular attention to human rights issues, freedom of expression and the rule of law in promoting social and political globalization towards enhanced regional innovation performance. Clearly, this emphasizes the fact that the connection between civil liberties, social and political globalization improves regional innovation performance. **Hence, emerging economies that seek to promote knowledge diffusion and improve regional innovation performance** should pursue and promote high civil liberties activities, social and political globalization policies without leaving any unexploited.

The next section considers the study limitations and proposals for future research.

7.3 Research Limitations and Suggestions for Future Research

The study has some setbacks that provide the avenue for further research. The following were identified as the most significant: First, although there is no consensus among scholars on how to define and measure innovation (Singh & Aggarwal, 2022), the research is limited to examining innovation performance using indicators such as product innovation and patent applications. **This limits the concept of innovation performance and may be missing other important facets of innovation performance**, such as process improvements, changes in business models, service enhancements, high-tech products, radical and incremental innovations. These are all crucial for a firm's growth and competitive advantage. To address this limitation, the study proposes that future research should take a more inclusive approach to measuring innovation depending on data availability. This broader approach could offer a more

comprehensive understanding of innovation at the firm level and its relationship to market conditions. **Furthermore, the findings should be interpreted cautiously** as the data used to measure the main variables are based on a survey of firm perceptions, reflecting managers' views on the current market and institutional conditions. These perceptions may not accurately depict the actual market and institutional environment, as they could be influenced by biases and misinformation from respondents, which may not always align with the objective reality (Liu et al., 2022). Also, the focus of this study is moderate and emerging innovative EU countries. Although emerging economies share common characteristics, they differ in institutional quality, globalization policies and economic development (Edeh & Prévot, 2024). As this limits the generalizability of the findings, future studies in other emerging economies outside the EU **could examine how economic, social, political and financial globalization and non-institutional factors like R&D tax credit moderate the impact of globalization heterogeneity on regional innovation performance**. In addition, the study did not examine how social and political globalization impact regional innovation performance at different stages. Future studies could use quantile regression to find the various quantiles of regional innovation performance that, social and political globalization affects regional innovation performance at various quantiles (0.25, 0.50 and 0.75). Finally, while the study examines 14 moderate and innovative EU countries in this study, the study did not explore specific country level characteristics that could moderate the impact of social and political globalization on regional innovation performance. Based on data availability, future studies could explore country specific characteristics **such as geographical proximity, system of government and economic structures** as moderators in the relationship between social and political globalization and regional innovation performance.

7.4 Student Contributions

A) Research contributions

The study examines the determinants of the knowledge production function in relation to innovation performance. Theoretically, it contributes to the existing literature on knowledge management, knowledge network and knowledge diffusion variables. First, the findings demonstrate how varying levels of competition intensity positively moderate the relationship between knowledge management variables (such as firm information channels and knowledge-based human resource practices) and firm innovation performance. The study offers insights into policies and strategies to foster innovation and enhance firms' capabilities within moderate and emerging EU economies. Second, through the marginal effects approach, the study

contributes to knowledge and innovation literature that varying levels of regulatory quality and competition intensity improve the influence of technical and professional knowledge-intensive business services on firm innovation performance. Another significant theoretical contribution of this study is the three-way interaction among civil liberties, social globalization, and political globalization in enhancing regional innovation performance. This interaction has not been extensively examined in existing literature. The findings suggest that emerging economies aiming to achieve high regional innovation performance should strategically integrate policies that promote civil liberties alongside social and political globalization. These results imply that generating new ideas in moderate and emerging EU countries is significantly improved by the interplay of robust civil liberties and active social and political globalization.

Practically, the study uniquely reveals that policymakers should create fair and supportive regulatory frameworks to ensure access to standard industry documents for information, especially in highly competitive business environments. Also, enhancing companies' abilities to acquire, integrate, and implement optimal knowledge-based human resource practice strategies is vital for innovation growth. The results suggest that developing the capacity of firms in moderate and emerging innovative countries to acquire, effectively apply, and assimilate technical and professional knowledge-intensive business services is crucial for product innovation development. Thus, firm managers should incorporate proactive measures such as regular risk assessments, scenario planning, and risk mitigation measures to address uncertainties related to the regulatory framework and competition intensity in the economic landscape. Finally, the study emphasizes the connection between civil liberties, social and political globalization, which improves regional innovation performance. Hence, emerging economies that seek to promote knowledge diffusion and improve regional innovation performance should pursue and promote high civil liberties activities, social and political globalization policies without leaving any unexploited.

B) Teaching contributions

The author of this dissertation created teaching resources that align with contemporary theoretical frameworks and practical applications to teach courses like municipal finance, public finance, and the economic and financial aspects of innovation at the Faculty of Economics and Administration at the University of Pardubice. These resources included lecture slides, up-to-date literature, World Bank reports, conference papers, case studies, and practical exercises aimed at enhancing students' understanding of innovation economics, regional

innovation systems, growth theories, and knowledge production function models. The theoretical concepts explored in this dissertation, such as endogenous and exogenous growth theories, regional knowledge production function models, contingency theory, and globalization, provide students with a broad perspective on knowledge management, networks, and diffusion in moderately and emerging innovative EU countries. Additionally, the use of the marginal approach in this dissertation offers students deeper insights into contextual factors, their multilevel dimensions, and their impact on the determinants of knowledge production and innovation performance in moderate and emerging EU economies. The materials developed from this dissertation will be incorporated into student textbooks in the fields of knowledge production and innovation management.

Doctoral. Student's Publication Activities

Journal papers

1. Arthur EE, Gyamfi S, Gerstlberger W, Stejskal J, Prokop V. (2023) Towards Circular Economy: Unveiling Heterogeneous Effects of Government Policy Stringency, Environmentally Related Innovation, and Human Capital within OECD Countries. *Sustainability*.15(6):4959
2. Arthur, E. E., & Vanicek, B. (2024). Assessing the Relationship between Firm Collaboration, Trade Publications, Patent Publications and Firm Innovation Performance: Knowledge Production Function Perspective. *Scientific Papers of the University of Pardubice. Series D, Faculty of Economics & Administration*, 32(3).
3. Gariba, M. I., Arthur, E. E., & Odei, S. A. (2024). Assessing the impact of public digitalization on sustainability: the mediating role of technological innovation in the context of the EU. *Discover Sustainability*, 5(1), 1-16.

Conference papers

1. Arthur, E.E & Stejskal, J (2022). Managing knowledge towards firm performance: The moderation role of the business environment. Proceedings of the 23rd European Conference on Knowledge Management, 20(1), 44-51.
2. Arthur, E. E., & Stejskal, J. (2023, September). Knowledge Management: The Value of Inter And Intra-Firm Activities Towards Firm Innovation Performance. In *ECKM 2023 24th European Conference on Knowledge Management Vol 1*. Academic Conferences and publishing limited.
3. Arthur, E. E., & Stejskal, J. (2024, September). Assessing the Moderating Role of Organizational Culture on the Effect of Knowledge Networks on Firm Innovation in Visegrad Countries: The Perspective of Knowledge Production Function. In *European Conference on Knowledge Management (Vol. 25, No. 1, pp. 32-40)*.

Book chapter

1. Arthur, E. E., Darfo-Oduro, R. K. A., Gyamfi, S., Sein, Y. Y., Stejskal, J., & Prokop, V. (2022). Tax and Non-tax Policies Towards the Finance of Sustainable Economy: The Mediating Role of Eco-Innovation. In *Asia-Pacific Conference on Economics & Finance* (pp. 181-199). Singapore: Springer Nature Singapore.

Submitted papers in Review process

1. The Knowledge Production Function ecosystem: How user-driven and science-driven knowledge sourcing heterogeneity influences firm product innovation in the EU. (Arthur E. E and Stejskal J.) *International Journal of Innovation Science (IJIS)*

2. Unlocking regional innovation performance in emerging EU markets: linking social and political globalizations with the moderating role of civil liberties index. (Arthur E.E. and Proença I.) *Journal of Globalization and Development (JGD)*
3. Knowledge networks and product innovation in emerging markets: Examining the varying moderation effects of competition intensity and regulatory quality. (Arthur E.E., Gariba I. M., Odei Amponsah S., Stejskal J.) *Journal of Entrepreneurship Management and Innovation (JEMI)*
4. The marginal effect approach to assessing the heterogeneity interaction effect of competition intensity in emerging EU countries: Knowledge management and product innovation nexus. (Arthur E. E and Stejskal J) *Journal of Innovation Management (JIM)*
5. Driving Circular Economy Transformation through Technological Innovation: The moderating Role of Regulatory Environment, Human Capital, and Technological Capacity in the OECD States (Arthur E.E., Gariba I. M., Odei Amponsah S., Stejskal J.) *Journal of Humanities and Social Science Communications*

Bibliometric indicators

Scopus: 8 papers, 30 citations, h-index 3

Web of Science: 5 papers, 32 citations, h-index 4

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LIST OF APPENDICES

Appendix I. Descriptive Statistics for objective 1

Variable	Obs	Mean	Std. Dev.	Min	Max
Product innovation	100034	.191	.277	0	1
HR practices	100034	1.122	.522	0	3
Channels info.	100034	.485	.525	0	3
Firm size	100034	1.472	.484	1	3
Firm age	100034	3.684	.514	0	4
Sector	100034	3.454	.247	1	6
Purch. Tech. serv.	100034	.821	.048	0	1
IPR pub.	100034	.188	.045	0	1
Trade fairs	100034	.524	.264	0	1
Comp. intensity	100034	8.39	1.005	0	12.067

Appendix II. Pairwise correlations for objective 1

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Product innovation	1.000									
(2) HR practices	0.038	1.000								
(3) Channels info.	0.023	0.094	1.000							
(4) Firm size	0.116	0.010	0.015	1.000						
(5) Firm age	0.050	0.013	0.011	0.120	1.000					
(6) Sector	0.004	0.009	-0.001	0.003	0.003	1.000				
(7) Purch. Tech. serv	0.018	-0.032	-0.001	0.032	0.003	0.002	1.000			
(8) IPR pub.	0.019	0.024	0.021	0.003	-0.016	-0.001	0.047	1.000		
(9) Trade fairs	0.053	0.239	0.289	0.057	0.046	0.008	0.032	0.002	1.000	
(10) Compt. intensity	0.008	0.068	0.033	0.008	0.019	-0.027	-0.020	-0.010	0.032	1.000

Appendix III. Descriptive statistics for objective 2

Variable	Obs.	Mean	Std. Dev.	Min	Max
Firm size	100034	1.472	.484	1	3
Firm age	100034	3.684	.514	0	4
Product innovation	100034	.191	.277	0	1
Tech serv.	100034	.821	.048	0	1
Ent HQ home	100034	.476	.177	0	1
Ent HQ abroad	100034	.163	.229	0	1
Cross teams	100034	1.183	.538	0	3
Competition intensity	100034	4.305	.667	0	12.067
Regulatory quality	100034	.914	.006	.14	1.81
Sector	100034	3.454	.247	1	6
R&D cost	100034	11.083	.153	0	19.008
Tax Credit	100034	.043	.107	0	1
Patent pub.	100034	.094	.083	0	1
Reverse engineering	100034	.095	.083	0	1
Trade pub	100034	.511	.143	0	1
Crowdsourcing	100034	.215	.306	0	1

Appendix IV. Pairwise correlations for objective 2

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) Firm size	1.000															
(2) Firm age	0.120	1.000														
(3) Product inn.	0.116	0.050	1.000													
(4) Tech serv.	0.032	0.003	0.018	1.000												
(5) Ent gr. home	0.034	0.006	0.015	-0.028	1.000											
(6) Ent gr. abro	-0.096	-0.010	-0.008	-0.022	-0.020	1.000										
(7) Cross teams	-0.077	-0.010	-0.004	0.008	-0.012	0.116	1.000									
(8) Comp.int.	0.012	-0.001	0.001	0.003	0.003	0.001	0.003	1.000								
(9) Regulat. qual.	-0.010	-0.003	-0.007	-0.005	-0.002	0.006	0.000	-0.001	1.000							
(10) Sector	0.003	0.003	0.004	0.002	0.000	-0.005	0.002	-0.025	-0.018	1.000						
(11) RDcost	0.002	-0.004	-0.005	0.000	-0.002	-0.001	0.001	-0.040	-0.001	-0.001	1.000					
(12) Tax credit	0.084	0.030	0.148	0.000	0.018	0.009	0.001	-0.001	0.000	0.000	-0.002	1.000				
(13) Patent pub.	0.000	-0.006	-0.005	0.005	-0.051	0.022	0.061	-0.002	-0.011	-0.006	0.014	-0.009	1.000			
(14) Reverse eng.	-0.004	-0.004	-0.001	0.001	0.008	0.014	0.095	0.001	-0.014	0.007	0.007	-0.004	0.244	1.000		
(15) Trade pub.	-0.002	-0.003	-0.004	0.003	-0.085	0.018	0.114	-0.008	-0.004	-0.003	0.014	-0.018	0.254	0.172	1.000	
(16) Crowdsourc.	0.024	0.011	0.019	-0.001	0.005	-0.016	0.000	-0.001	0.001	0.000	0.000	0.015	0.001	0.003	-0.002	1.000

Appendix V. Descriptive statistics for objective 3

Variable	Obs	Mean	Std. Dev.	Min	Max
Patent applications	349	1009.221	1807.197	2	10281
Social globalization	349	78.087	5.354	55.64	86.62
Political globalization	349	84.187	10.729	50.34	98.34
Civil liberties	349	1.51	.56	1	3
R&D	349	.982	.427	.24	2.56
Human development	349	.833	.041	.709	.926
Trade openness	349	110.653	44.635	45.14	256.89
GDP	349	34933.688	9412.883	12659	61126
FDI	349	10.078	39.058	-40.09	449.08
Business freedom	349	71.794	7.733	54	88
Rule of law	349	.654	.414	-.27	1.61

Appendix VI. Pairwise correlation coefficients for objective 3

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Patent applic.	1.000										
(2) Social globaliz.	0.243	1.000									
(3) Political globaliz.	0.422	-0.018	1.000								
(4) Civil liberties	-0.241	-0.037	0.008	1.000							
(5) R&D	0.234	0.019	0.355	-0.347	1.000						
(6) HDI	0.278	0.090	0.207	-0.148	0.121	1.000					
(7) Trade openness	-0.379	0.054	-0.302	-0.196	0.056	0.223	1.000				
(8) GDP	0.425	0.375	0.287	-0.268	0.196	0.014	0.091	1.000			
(9) FDI	-0.262	0.151	-0.333	-0.103	-0.133	-0.017	0.261	0.023	1.000		
(10) Business freed.	0.211	0.296	0.006	-0.335	0.308	0.381	0.053	0.235	0.008	1.000	
(11) Rule of law	-0.149	0.238	-0.205	-0.059	0.334	0.259	0.274	0.082	0.249	0.434	1.000