Shaping Innovation Capabilities to Enable Transformative Sustainability Transitions in Agriculture

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Abstract

The agro-industrial sector is one of the largest socio-technical systems upon which the prospects of transition to sustainable development critically depend. To meet the food needs of a growing population, it requires profound transformation, new knowledge, advanced technologies, and highly qualified specialists. The agro-industry is moving from traditional schemes to fourth and fifth generation smart models that have innovative potential to ensure food security, heal natural systems, and stimulate economic growth. This potential will be able to be realized only if provided with an appropriate human resource base.

The article uses the example of young agri-preneurs in Malaysia to assess the key components of human capital that determine the performance of modern agro-industry, as well as the potential contribution of the government interventions in strengthening their effects. Three factors are considered - innovativeness, willingness to take reasonable risks, and proactivity. It is found that the presence of targeted governmental support, significantly enhances the influence of the first two on business performance. As for proactivity, its presence does not produce an operational tangible impact on performance, regardless of the context, including the presence of external support. The outcomes from proactivity manifest rather in the distant perspective. The latter circumstance is due to the high uncertainty and turbulence that accompany the activities of the studied sector, caused by uncontrollable, hardly predictable natural and social processes and their consequences. An in-depth understanding of the interrelationship of the factors under consideration can contribute to the development of more effective policies and support systems to foster sustainable growth in the agribusiness sector.

Keywords: agricultural innovations; transitions to new technological modes; highly qualified personnel; agro-entrepreneurs; entrepreneurial orientation; proactivity; government interventions; business performance; Malaysia

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Introduction

Over the last decade, there has been growing interest in academic and political discourses 0n the issues of transformation of large socio-technical systems, upon which the prospects for the transition to sustainable development critically depend (Polzin, 2024; HLPE, 2019; Herren, Herlin, 2020). Basic sectors are studied, the task of which is to ensure survival, the basics of life, and, in the long term, prosperity. Among them is the agro-industrial ecosystem responsible for the food supply. It is expected that by 2050 the world population will reach approximately 10.1 billion people, therefore, the global demand for food will grow by 70% (Rudrakar, Rughani, 2023). In this regard, the agricultural sector is faced with unprecedented production challenges, since it will be necessary to produce more than in all previous history (Fraser, Campbell, 2019). To meet such a demand, the agricultural industry needs a profound transformation with the help of new knowledge and advanced technologies, allowing it to adapt to more complex development models (Bissadu et al., 2024; Naikwade et al., 2023). There has been a shift from the traditional paradigm to a high-tech model, which is manifested in such concepts as fourth- (AG 4.0) and fifth-generation (AaG 5.0) agriculture. The latter takes on the solutions of the problems that the previous version is unable to solve. "Smart agriculture" has enormous potential to contribute to solving complex large-scale problems, such as ensuring food security, improving natural systems, stimulating economic growth, smoothing out inequality, and so on. All this can affect other sectors, create new market niches, and give impetus to their accelerated development.

So far, the implementation of such a "smart model" has been hampered by high entry costs and a certain inertia, which manifests itself in the acute shortage of highly skilled labor and low ability to break path dependence. It is noteworthy that developed countries also face these challenges. Thus, in the United States and Canada, there are noticeable gaps in the supply of skilled labor in the context of the sector in question (Saiz-Rubio, Rovira-Más, 2020; Contreras-Medina et al., 2022). Similar difficulties are typical for Germany, which, despite its solid industrial and technological background, nevertheless has difficulties with the transition of agriculture to a smart model. There is a conceptual contradiction: the ingrained dominant narrative does not allow new alternative approaches to emerge that are capable of balancing economic, environmental, and social components (Polzin, 2024). Many researchers point out that emerging opportunities for a new level cannot be realized, since they are not provided with an appropriate personnel base (Bissadu et al., 2024). Despite this, a number of countries are still dynamically increasing their potential for such a transition.

In the Netherlands, for example, Shell has teamed up with Erasmus University of Rotterdam to launch an innovative education program where students search for innovative, cyclical solutions for agriculture, climate change, biodiversity restoration and improving water availability. It has also developed and practiced technologies to eliminate chemical fertilizers altogether, while increasing crop yields.[1] In other words, research at universities goes beyond previous knowledge into completely new areas and is attempting to unlock the previously unperceived potential of agriculture. This can be seen in the growing and processing of certain crops for use in areas where they have never been used before, including in the construction and chemical industries.

The aim of our study is to assess the key factors that determine the prospects for the agricultural sector to transition to a sustainable, smart model that relies on young, highly skilled entrepreneurs. We study the relationship between their entrepreneurial orientation, innovativeness, proactivity, and ability to take reasonable risks. The results obtained form the information basis for policy in terms of developing measures to support this promising segment of the human resource base in order to accelerate the transition to Model 5.0.

Literature Review

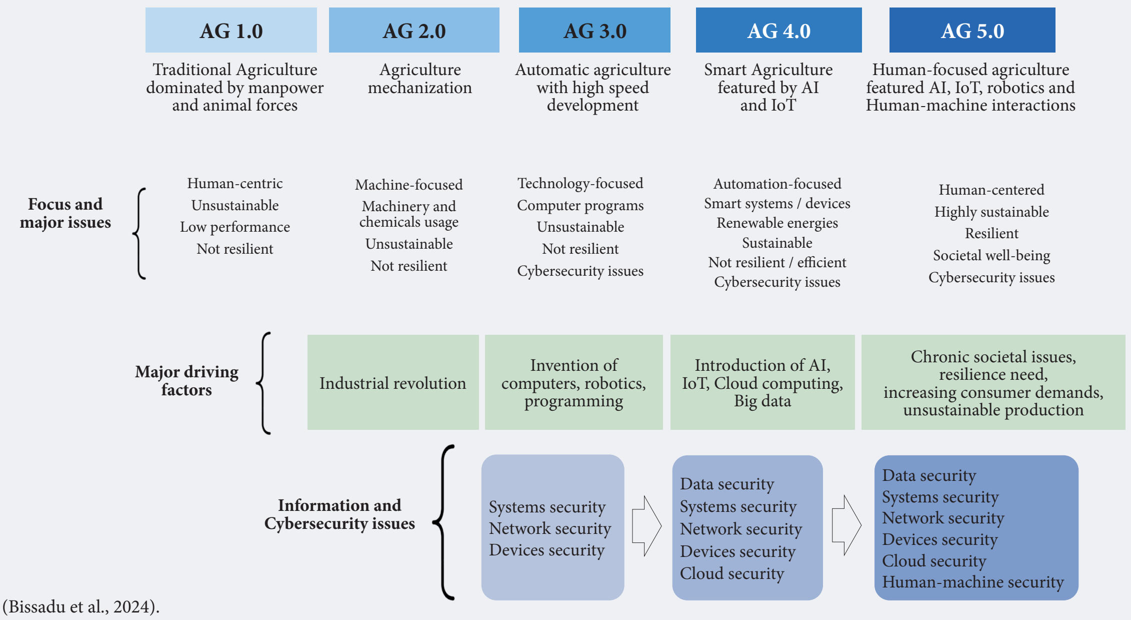
Technological Potential

Based on the scheme of the technological evolution of the agricultural sector, presented in Figure 1, the mainstream topic in the current industry discourse is Agriculture 4.0. In addition, discussions are emerging and gaining momentum about moving toward a more advanced and balanced model – Agriculture 5.0.

The concept of AG 4.0 has brought to the fore a number of competitive advantages, including a new type of management, the efficient use of resources, sustainable production, and the introduction of renewable energy sources (Mourtzis et al., 2022). Their implementation depends on the degree of development of technologies such as artificial intelligence (AI), 5G, big data, robotics, cloud computing, the Internet of Things, robotics, and so on. (Bechar, Vigneault, 2016; Bergerman et al., 2016; Pandrea et al., 2023; Yuniarto et al., 2023) (Figure 1). Here, the emphasis is on the efficiency of production and marketing chains through the internal integration of technologies, which, among other things, will

[1] https://managementscope.nl/en/interview/jan-rotmans-green-industrial-policy, accessed 14.01.2025.

Figure 1. **Evolution of Agriculture from Traditional to Smart Model**



Source: (Bissadu et al., 2024).

increase the efficiency of processes and reduce the burden on the environment (Martos et al., 2021; Ragazou et al., 2022; Tulungen, 2022).

In turn, the AG 5.0 model describes a fundamentally new paradigm of agriculture, which gives priority first of all to people and only then to technological solutions that integrate not only with each other, but also with cultural values (Baryshnikova et al., 2022; Contreras-Medina et al., 2022; Sindhwani et al., 2022). Sustainability in this sense is an imperative for the implementation of bio-based agricultural practices (Sindhwani et al., 2022). While AG 5.0 may use technologies from the AG 4.0 model, their focus, methods, and goals differ significantly (Figure 2). Thus, one of the key objectives of the 5.0 model is to produce the required amount of clean and affordable food in a healthy and protected ecosystem (Fraser, Campbell, 2019).

From a technology perspective, the four main areas that have the potential to transform the sector are AI, cloud computing, robotics, and the Internet of Things (IoT). As of 2023, the AI sector has reached $241.8 billion in annual turnover. It is projected to grow at a compound annual growth rate (CAGR) of 17.3%, which could result in the AI market reaching $738.8 billion by 2030. In the cloud segment, the market will grow at a compound annual growth rate of 12.27% and could reach $1.062 trillion by 2028 (Bissadu et al., 2024). Other emerging technologies include: collaborative robots (cobots), 6G, digital twins, big data analytics, blockchain, edge, cloud, and quantum computing (Table 1).

IoT-enabled devices are expected to increase significantly across all countries by 2030 compared to today's levels. For example, Sub-Saharan Africa has the lowest adoption rates, but even there, the number of IoT devices is projected to reach over 0.26 billion by 2030. The robotics market is not as large but is also growing rapidly, at about 3.83% CAGR, to reach $45.09 billion by 2028. Cobots are seen as disruptive solutions as they can enable the migration of young, promising talent from unproductive and oversaturated sectors to the agricultural sector. 6G technologies, which expand bandwidth to 1 Tbps, will serve as the catalyst for improved IoT sensor connectivity and other innovations. One of the key features of AG 5.0 is the integration of large data sets from different sources, offering holistic knowledge for decision-making leading to the optimal use

Figure 2. **Main Differences between the AG 4.0 and AG 5.0 Models**

Agriculture 4.0		Agriculture 5.0
• Technologies • Green solutions	**Focus**	• Humans • Greener solutions
• Technologies replacing / complement traditional	**Practices**	• Human collaborates with machines • Human intelligence and artificial intelligence co-work together
• Increased productivity • Mass production • Economic growth	**Goals**	• Increased efficiency / productivity • Societal, economic, and environmental sustainability • Mass customization
• 5G technologies • Cloud computing • Artificial intelligence • Robotics • Internet of Things • Digital twins • Remote sensing	**Enabling technologies**	• 6G technologies • Cobots / robots • Artificial intelligence • Remote sensing • Internet of Things • Cloud computing • Smart mobile devices • Quantum computing

Source: (Bissadu et al., 2024).

Table 1. **Enabling Technologies for the Adoption and Implementation of Agriculture 5.0**

Enabling technologie	Descriptions/benefits
Cobot	A collaborative robot designed for direct interactions and collaboration with humans within a shared space, enabling close proximity and collaboration between humans and robots
6G technologies	The 6G network will provide the technological advancements for realizing the full potentials of Agriculture 5.0 through high throughput IoT networks
Artificial intelligence	Provides quick decision making, promotes greater efficiency in operations, high-quality assurance, intelligent automation
Digital twins	Minimize production costs, predicts future actions
Internet of Things	Increased and timely agricultural data collection, intelligent network, efficient supply chain, reduced loss of products and yields
Big data analytics	Enable customization, quick and better decision making, real-time monitoring and predictions
Blockchain technologies	Enhance decentralized management of agriculture IoT, ensure transparency, and security
Edge computing	Improve low latency, increase cybersecurity, reduced data storage costs, boost interoperability
Cloud computing	Offer low-cost operations, increased collaboration, better data management, and shared responsibility economy model, knowledge transfer
Quantum technologies	Offer super-high data transmission and enhanced security capabilities

Source: authors based on (Bissadu et al., 2024).

of resources, the reduction of waste, and increased productivity (Fraser, Campbell, 2019; Chamara et al., 2022). Digital twins provide monitoring of the environmental, social, and economic sustainability of agricultural systems and allow for forecasting their changes (Cesco et al., 2023).

Thus, the entire emerging complex and multidimensional context is reformatting ideas about what the provision of human resources for agriculture should be. New methods of its management involve reliance on highly qualified specialists (Humayun, 2021).

Human and Innovative Potential

In all countries, the agro-industry is experiencing an acute shortage of labor (Naikwade et al., 2023; Rotz et al., 2019; Ragazou et al., 2022). For example, Canada was previously projected to face a critical labor shortage of 113,000 workers this year (Rotz et al., 2019). Changing skill requirements create huge demand for continuous learning, retraining, and the development of dynamic capabilities (Humayun, 2021; European Commission, 2021). They are associated with the ability to create innovations, flexibly adapt to change, break path dependence, and balance the use of existing resources and the search for new assets (Turner et al., 2017). Managing such multi-level processes requires the ability to coordinate the actions of various actors: farmers, agricultural and processing industries, land use planners, environmental, financial and regulatory organizations, markets, specialized educational and design centers, and so on. (Brown et al., 2016; Läpple et al., 2016; Sutherland et al., 2017; Vanclay et al., 2013). It can be said that an agricultural innovation system (AIS) is being formed (Knierim et al., 2015; McDonald, Macken – Walsh, 2016), which integrates agribusiness companies with other stakeholders in extended processes of learning, coordination, and policy improvement (Läpple et al., 2016; Phillipson et al., 2016; Vanclay et al., 2013).

From the perspective of this concept, innovations emerge from a co-evolutionary process of the interactive development of technologies, artifacts, practices, markets, procedures, and socio-institutional mechanisms (Hall, Clark, 2010; Klerkx et al., 2012). It involves actors from different fields: industry representatives, politicians, traders, processors, standard developers, NGOs, and regulatory organizations. Agribusinesses gain a platform upon which to build their innovative and adaptive potential and to form networks for the exchange of knowledge and other resources (Hall, 2005; Leeuwis et al., 2014). Promising models of agricultural production and land use are listed in Table 2.

Three categories of innovative potential are distinguished (Boly et al., 2014; Wang, Ahmed, 2007): (i) scanning for innovative opportunities (Wang, Ahmed, 2007); (ii) adaptability to a dynamic, changing environment (Wang, Ahmed, 2007); and (iii) absorptive capabilities - the acquisition, assimilation, and transformation of external knowledge and resources (Boly et al., 2014; Wang, Ahmed, 2007). The mobilization and reconfiguration of capabilities to shape it occurs at different levels, and implementation requires that agents and resources come together in the right combinations at the right time (Engel, 1995, Klerkx et al., 2010).

Table 2. **Prospective Models of Agricultural Production and Land Use**

Models	Literature
Sustainable or ecological intensification	Petersen, Snapp, 2015; Pretty et al., 2011; Tittonell et al., 2016
Smart agriculture adapted to climate change	Kpadonou et al., 2017; Long et al., 2016
Circular Economy and Bioeconomy	Kristensen et al., 2016; O'Brien et al., 2017
Urban farming	Huang, Drescher, 2015; Pölling et al., 2016
High-tech agriculture based on precision manufacturing, the Internet of Things and Big Data	Eastwood et al., 2017; Poppe et al., 2013; Wolfert et al., 2017

Source: authors based on (Turner et al., 2017).

For the purposes of our study, we will consider how the above processes are implemented in the context of the Malaysian agro-industry.

Dynamics of the Agro-Industry in Malaysia

Along with mining, the agricultural sector has been a cornerstone of the national economy since before independence (Yusoff, 2019). It received a new impetus with the introduction of the National Agricultural Policy (NAP) (Lim et al., 2012; Yusoff, 2019). Small and medium enterprises (SMEs) are the backbone of this industry, accounting for about 90% of all agricultural companies in the country.[2] They play a key role in rural development, employment, and economic growth. The adaptability and innovation of SMEs are vital to improving food security, diversifying agricultural production, and increasing resilience in the context of climate change and global competition (Zainol, Yusof, 2012). However, a key challenge remains: updating the human resources base with young agripreneurs who will determine the prospects for its development according to a smart model (Ahmad, Ngah, 2020). Associated with this, in particular, are the tasks of adapting to changing market conditions, mastering technological advances, and developing entrepreneurial skills, including dynamic capabilities. The Ministry of Agriculture has developed a Program to support young agripreneurs (under 40 years of age) (Young Agropreneur Program)[3], including various training initiatives. However, its full potential is hampered by a lack of understanding of the determinants of entrepreneurial orientation (EO) and its impact upon the performance of young professionals. Addressing this gap will enable the development of more effective and targeted initiatives to foster a thriving agripreneurship ecosystem in Malaysia. Therefore, the objective of this study is to examine the relationship between the entrepreneurial mindset and agripreneurship performance, assess the impact of innovativeness, proactive attitude and risk-taking on performance, and inform the development of policy initiatives and support mechanisms for young agripreneurs.

Research Concepts

A key concept in entrepreneurship research is entrepreneurial orientation (EO), which includes strategies, processes, and decision-making styles of organizations in identifying and exploiting business opportunities. The relationship between EO and business performance is complex and non-linear, and is influenced by a variety of mediating factors (Miller, 1983). We focus on three key aspects: proactivity, innovativeness, and risk-taking, the impact of which on business success is especially significant in turbulent conditions (Lumpkin, Dess, 1996). They are also relevant in the context of agribusiness, which is characterized by instability and fluctuations (weather conditions, etc.). In such conditions, the ability to make the right decisions, despite incomplete data, becomes an indispensable condition for the transition to sustainable, adaptive development.

Research has highlighted the importance of EO in agriculture, particularly as agripreneurs operate in an unpredictable environment. Agripreneurs who are willing to take creative risks are more likely to engage in innovative activities that require a certain amount of courage. Those who actively anticipate market trends will be able to find the best solution to meet demand earlier than others. Players with high EO levels tend to achieve greater success due to their ability to adapt to rapidly changing conditions, create innovations, and overcome resource constraints (Kraus et al., 2022). Access to diverse resources and government support play a decisive role in increasing the effectiveness of software (Al Mamun et al., 2020). Thus, the last of the mentioned factors, which involves stimulating innovation and the resource provision of agricultural enterprises, plays the role of an "intermediary" that ensures the conversion of software into improved business performance (Liguori et al., 2020). Access to technology and training also serve a similar function (Hansen et al., 2011).

This study assesses how agribusiness SME owners perceive the role of public policy in providing support for high-tech development.

Research Structure

This study integrates various theoretical perspectives and empirical data to analyze the relationship between key aspects (risk-taking, innovativeness, proactivity) and the mediating role of government support. Our framework involves developing six hypotheses regarding both the direct impact of the aforementioned aspects of software on company performance and the mediating role of government incentives. Each dimension is operationalized using specific indicators, ensuring that the methodological approach meets the objectives of the study (Figure 3). As a result, a set of hypotheses was formulated that boils down to the fact that there are positive relationships between risk-taking, innovativeness, and a proactive stance, on the one hand, and business performance, on the other (H1, H3, H5), and that government measures play a mediating role in these relationships (H2, H4, H6).

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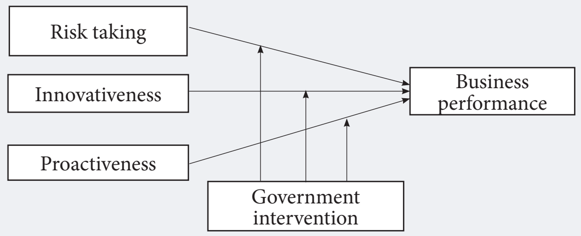
[2] https://www.dosm.gov.my/, accessed 18.12.2024.

[3] https://www.lkim.gov.my/en/young-agropreneur/, accessed 18.12.2024.

Figure 3. **Research Structure**



Source: authors.

Research Methodology

Our study is based on a deductive approach, which involves validating the theories used through hypothesis testing. The approach is complemented with a survey of respondents to collect quantitative data using structured questionnaires designed to explore the factors influencing the activities of Malaysian agribusiness entrepreneurs. Risk-taking is defined as the willingness to commit significant resources and take bold steps despite the turbulent conditions inherent in agricultural activities.

The innovation dimension requires ingenuity in developing original solutions to maintain and expand competitive advantage (Lumpkin, Dess, 2001) and the ability to develop new products or modify existing ones. In turn, proactivity consists of the ability to anticipate trends and introduce offers to the market before other players in order to take a leading position (Lumpkin, Dess, 1996, 2001). The use of a cross-sectional design allowed us to collect data at a specific point in time to gain insight into current trends and the behavior of young entrepreneurs. The target group included emerging potential leaders in the agricultural sector. Data were collected using both self-administered questionnaires and online surveys, which ensured a wide coverage. SPSS and Smart-PLS were used as the main analytical tools, which allowed us to comprehensively study the interrelationships of the data.

Data Analysis and Results

The majority of respondents were men (56.9%) aged 29–40 years (76.6%) (Table 3). Many had an STPM certificate (37.9%) or a bachelor's/master's degree (33.2%). Overall, the level of education of the sample participants could be considered satisfactory. High levels of participation in the Young Agropreneur Program were found in 2022–2023 (58.7%), primarily individual players (80.3%). Most of them (83.9%) have fewer than five employees and annual sales of less than RM100,000 (approximately $23,000) (84.2%). For more details, see Table 4.

Table 3. **Respondent Background**

Indicator	Frequency	Percentage (%)
Gender		
Male	219	56.9
Female	166	43.1
Age		
18-28 years old	90	23.4
29-40 years old	295	76.6
Higher Education		
Standard 6/UPSR	8	2.1
PMR / SPM	97	25.2
STPM / Certificate / Diploma	146	37.9
Bachelor's Degree/ Master	128	33.2
PhD	6	1.6

Source: authors.

Table 4. **Company Background**

Indicator	Frequency	Percentage (%)
Year of Participation in Program		
2014–2015	18	4.7
2016–2017	28	7.3
2018–2019	44	11.4
2020–2021	69	17.9
2022–2023	226	58.7
Legal Status of Firm		
Sole Proprietorship	309	80.3
Partnership	28	7.3
Limited Liability Partnership	5	1.3
Private Limited Company	43	11.2
Sub-sector Currently Operating		
Crop-Farming	150	39.0
Fishery	9	2.3
Livestock Farming	25	6.5
Agro-based	201	52.2
Location of Business		
Northern region	102	26.5
Southern region	150	39.0
East coast region	32	8.3
Central region	74	19.2
East Malaysia	27	7.0
Number of Employees		
Less than 5 employees	323	83.9
5 – 75 employees	59	15.3
75 – 200 employees	3	0.8
Annual Sales Turnover (2018)		
0-RM 100,000	324	84.2
RM 100,000 – RM 200,000	33	8.6
RM 200,000 – RM 300,000	17	4.4
RM 300,000 – RM 1M	5	1.3
RM 1M - RM 7.5M	4	1.0
RM 15M – RM 30M	1	0.3
RM 50M – RM 75M	1	0.3

Source: authors.

Table 5. **Internal Consistency and Convergent Validity Results**

Construct	Loading	AVE	CR
Risk-Taking	0.737	0.783	0.915
Innovativeness	0.501	0.612	0.922
Proactivity	0.595	0.759	0.759

Note: none deleted items.
Source: authors.

Table 6. **Discriminant Validity**

	Business Performance	Innovativeness	Proactivity	Risk-Taking
Business Performance	0.815			
Innovativeness	–0.171	0.782		
Proactivity	0.338	0.054	0.769	
Risk-Taking	0.396	–0.061	0.811	0.885

Source: authors.

Measuring Internal Consistency. This indicator is assessed using composite reliability (*composite reliability,* CR) and convergent validity – through the loading of the items and the average extracted variance (*average variance extracted,* AVE). If the load value exceeds the recommended threshold, we can talk about the reliability and validity of the design, otherwise it is excluded from the analysis. From Table 5 it follows that almost all load indicators exceeded the recommended threshold of 0.708 (Hair et al., 2014). Thus, all relevant constructs were retained.

Assessing Discriminant Validity. Its presence is confirmed by the fact that the specific construct under consideration is under a higher loading from the elements compared to others. The test was performed using the Fornell – Larcker test (Fornell, Larcker, 1981). The average variance extracted (AVE) values presented in Table 6 indicate satisfactory discriminant validity for all constructs.

Path Coefficient Analysis. Risk is a decisive factor in business performance, especially for SMEs. The results provide insight into how different dimensions of risk affect business performance. A significant positive effect of risk willingness was found ($\beta = 0.261$, $p = 0$). This means that the performance of companies open to reasonable risks usually increases. Such players are more likely to implement innovative solutions, explore new opportunities in the face of uncertainty, and increase competitive advantages. In this case, evidence of the relationship between risk willingness and business performance is a fairly high p-value ($p < 0.05$). However, the role of government measures as a factor mediating the relationship between risk strategies and business success turned out to be insignificant ($\beta = -0.049$, $p = 0.401$) (Table 7).

Since the p-value is greater than 0.05, it can be concluded that government initiatives do not have a significant impact on the relationship between risk strategies and business performance. This means that risk-taking players, depending on their own potential, will either develop successfully or lose in the competitive struggle.

Innovativeness is another critical parameter of software, which also significantly influences positive dynamics. The values $\beta = -0.298$ and $p = 0$ indicate a strong negative relationship. However, despite the negative sign, the p-value indicates a stable pattern: the value of efficiency is directly related to the degree of innovativeness. Innovative companies often develop unique products, services, and processes, which distinguishes them from competitors and ensures long-term sustainability.

With respect to innovativeness, the mediating role of government support is more significant ($\beta = 0.168$, $p = 0$). For example, if the government offers support (grants, incentives for research, or favorable legal regulations), innovative firms will be able to take advantage of such opportunities better than others. In contrast, no significant relationship was found between the proactive stance of firms and their performance ($\beta = 0.019$, $p = 0.758$). Although proactivity (the ability to anticipate future trends and act ahead of the curve) is often considered a desirable business characteristic, this study has shown that in this context this quality does not necessarily translate into higher SME performance. Moreover, government support does not significantly affect the relationship between proactivity and performance ($\beta = -0.049$, $p = 0.396$). This may be due to the very nature of proactivity, which involves anticipating and seizing opportunities regardless of external circumstances, in particular government incentives.

Discussion of Results

The results of the study reveal important aspects of the dynamics of agribusiness, including the influence of demographic factors (gender, age, and education) and business structure on entrepreneurial behavior and performance. A gender imbalance was revealed: 56.9% of respondents were men, which indicates systemic barriers or cultural biases that limit women's participation in the business. This finding is consistent with the work (OECD, 2018), which notes the need for special programs to support female entrepreneurs in order to create a more balanced entrepreneurial ecosystem. In terms of age structure, 76.6% of respondents are between 29 and 40 years old. This age group can be considered relatively mature and highly willing to take risks and

Table 7. **Path Coefficient Analysis**

Hypothesis	Relationship	T-Value	P-value	Result
H1a	Risk Taking → Business Performance	3.827	0.000	Significant
H1b	Risk Taking*Government Intervention → Business Performance	0.841	0.401	not significant
H2a	Innovativeness → Business Performance	5.782	0.000	Significant
H2b	Innovativeness *Government Intervention → Business Performance	3.65	0.000	Significant
H3a	Proactiveness → Business Performance	0.308	0.758	not significant
H3b	Proactiveness*Government Intervention → Business Performance	0.849	0.396	not significant

Source: authors.

implement innovations. Their representatives often have the necessary experience for effective strategic decision-making, which ensures more competent risk management.

Agri-entrepreneurship performance is significantly determined by the level of education. Among our respondents, 33.2% have a bachelor's or master's degree, and 37.9% have an STPM certificate or diploma. Higher education builds critical competencies that enhance one's ability to innovate and manage risks (Nabi et al., 2017). The growing interest in agribusiness is evidenced by the fact that 58.7% of respondents were participants in the Young Agropreneur Program in 2022–2023. This surge is likely due to the introduction of new government incentives and increased awareness of the sector's potential. In terms of the business structure, 80.3% of respondents are sole proprietors, which provides them with flexibility and reduces overhead costs. The downside of this status, however, may be limited growth opportunities and difficulties in accessing markets (Andersson, 2023).

In terms of intra-industry diversity, two segments dominate – agricultural (52.2%) and crop production (39.0%), indicating the potential for further diversification and innovation. Agripreneurs should consider alternative business models that could increase scalability and market reach (Evans, 2023).

There is also a regional disparity, with 39.0% of companies operating in the Southern region, and a small number on the East Coast and in East Malaysia. Addressing this will be key to achieving balanced growth and ensuring equal access to resources and opportunities for all participants in the sector. Most of the companies we surveyed (83.9%) have fewer than five employees and their annual sales (84.2% of companies) do not exceed RM100,000, meaning they are at an early stage of development. It is too early to talk about their efficiency and scalability.

Strong internal consistency was found for key aspects of behavior in the field of agribusiness: innovativeness (CR = 0.833), willingness to take risks (CR = 0.933), and proactivity (CR = 0.879). The calculations presented support the theses previously put forward in the literature (Garcia, Martinez, 2023). In particular, the role of reasonable risk in stimulating business growth is substantiated, while a proactive position, despite its importance, does not always directly affect business performance.

Discriminant validity analysis confirmed that each construct used in the study correctly measures the relevant aspects of agribusiness behavior and business performance. This allows for a deeper understanding of specific success dimensions. High average variance extracted (AVE) values for innovativeness, proactivity, and willingness to take risks indicate that all these factors play a significant role in improving process efficiency. Thus, our calculations become empirical confirmation of the theses previously presented in the publication (Garcia, Martinez, 2023).

The identified relationship between various software dimensions and performance allows us to draw important conclusions. The positive role of risk openness ($\beta = 0.261$, $p < 0.05$) indicates that companies willing to take reasonable risks are able to profitably exploit new opportunities and gain competitive advantages. At the same time, the weak mediating effect of government measures ($\beta = -0.049$, $p > 0.05$) suggests that in this context, the internal potential of enterprises is more important than external support.

Notably, there is a negative relationship between innovativeness and business performance ($\beta = -0.298$, $p < 0.05$), indicating that initial costs and problems associated with implementing innovations may hinder rapid improvements in performance.

However, its significance highlights the need for innovative practices ($\beta = 0.168$, $p < 0.05$), and government support significantly enhances the positive effects in this direction (Garcia, Martinez, 2023). On the other hand, proactivity does not significantly affect its effectiveness ($\beta = 0.019$, $p > 0.05$), that is, the preventive strategy may not produce immediate results. Possible explanations include the market situation and resource constraints. The insignificant mediating effect of government measures ($\beta = -0.049$, $p > 0.05$) suggests that, in this context, proactive firms may not receive significant benefits from the government.

Conclusion

This study reveals complex interactions between different dimensions of entrepreneurial orientation and government support in influencing agribusiness performance. Innovativeness and risk-taking are significant predictors of success. The willingness to take calculated risks becomes the key to exploiting new opportunities and achieving competitive advantages. In contrast, proactivity has no direct or indirect effect on performance, suggesting that, particularly in a volatile agribusiness landscape, a proactive strategy alone does not guarantee immediate success. Although government measures do not always play a significant role, this is not the case when it comes to enhancing the benefits of creating and implementing innovations, especially for SMEs. Providing grants, incentives, or resources for research and development can amplify the positive effects of innovation and ultimately improve business performance.

Another important mechanism is the development of individual support programs aimed primarily at improving risk management and the practical implementation of innovative ideas. This approach can significantly increase the effectiveness of initiatives aimed at helping young agribusinesses and promoting business sustainability.

Further research could examine other variables that may influence agribusiness success, including access to resources, market conditions, and socioeconomic factors. An expanded demographic analysis could provide a more complete picture of the challenges and problems faced by agribusinesses in different regions. Such insights could help develop more effective policies and support systems to promote sustainable growth in the agribusiness sector.

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