Factors influencing technological innovation among agribusiness firms: A survey of small agricultural businesses in Ghana

Dongmei Li*, Brako Evans Ntiamoah*, Edmond Yeboah Nyamah**, Martinson Ankrah Twumasi***

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Abstract

Agricultural research in Ghana has resulted in a number of innovations targeted at increasing the productivity of small agricultural businesses. However, none of these studies has investigated the factors that influence the adoption of technological innovation in Ghanaian agriculture businesses. Hence, this study examines the factors that influence the adoption of technological innovation in Ghanaian agribusinesses. Structural equation modeling was used to examine data collected from 1526 agribusiness employees in Ghana using a convenience sampling technique and a questionnaire survey. The findings indicate that internal, and external factors have an impact on information and communication technology (ICT), and new materials and technology (NM & NT), but no or little impact on biotechnology (BT) respectively. Also, the study reveal that human capital factors have a substantial impact on ICT, BT, and NM & NT. Lastly, the findings show that ICT, BT, and NM & NT have a positive and significant impact on technological innovation. The study underscores the need for agribusinesses to focus on internal and human capital factors since they increase employees' productivity and efficiency.

Keywords*: Agribusiness, Internal factors, External factors, Human capital factors, Technological Innovation, Ghana.*

1. Introduction

Ghana's economy is classified as agrarian in nature. Agriculture contributes significantly to the Ghanaian economy, employing 34% of the working population and contributing significantly to gross domestic product and export profits (Bawa, 2019; Mohammed *et al*., 2021). Agriculture's growth has been connected to progress in other industries, which invariably helps to alleviate poverty (Andrianarimanana and Yongjian, 2021). Poverty is unacceptably high in Ghana, with over 19.2% of the population living in abject poverty (Zereyesus *et al*., 2017; Dagunga *et al*., 2020). Over 70% of smallholder farmers farm using rudimentary equipment, and the majority of technical initiatives are outside their financial means (Abokyi *et al*., 2020). Agriculture is also rain-fed, and most farmers lack the necessary resources, putting smallholder farmers

* College of Management, Sichuan Agricultural University, Chengdu, Sichuan, China.
** Department of Marketing and Supply Chain Management, University of Cape Coast, Ghana.
*** College of Economics, Sichuan Agricultural University, Chengdu, Sichuan, China.
Corresponding author: kwamebrako@yahoo.com

in particular at risk, prolonging poverty. When compared to other development sectors of the economy, agricultural growth has a significant influence on poverty because it benefits the bulk of impoverished people. As a result, it is critical that Ghana's agricultural firms stay up with global advances (Banson *et al*., 2018).

Despite these significant contributions to Ghana's economy, the agricultural sector faces a number of problems that make it difficult for it to integrate technological innovations. For example, according to Daum and Birner (2017), agricultural mechanization has been neglected for decades, which has hindered technological innovation in the agribusiness sector. Ghana's Economic and Agricultural Transformation (2019) states that agriculture in Ghana is predominantly small-scale, traditional, and rain-fed, making it prone to low productivity. In a study of urban agriculture in Ghana, Puppim de Oliveira and Ahmed (2021) discovered that land competition, a lack of urban policy directives, discriminatory land use planning, and land tenure decisions are among the sector's significant issues. According to Abdul-Rahaman *et al*. (2021) who conducted a study on farm production efficiency, smallholder farmers, who face substantial constraints such as restricted access to improved production inputs and technology, financial resources, and extension services, dominate Ghana's agricultural economy. All of these factors lead to low agricultural production, restricting Ghana's ability to meet rising food demand resulting from population increase, urbanization, and shifting consumer dietary habits. Consequently, this study intends to analyze the factors influencing technological innovation among small agricultural firms in Ghana by putting the findings of relevant literature to the test in the context of the agribusiness industry.

According to previous studies, Ghanaian agribusinesses have not completely realized their potential because they have not been able to innovate agricultural technology quickly enough to keep up with improvements in agricultural development knowledge (Abban *et al*., 2014; Bosompem *et al*., 2017; Ntiamoah *et al*., 2019). The research of Vlachopoulou *et al*. (2021) has revealed that agribusinesses should be trained and equipped with the latest tools and technologies in order to improve their productivity and profitability. Adoption of new technologies, according to Gaffney *et al*. (2019), is influenced by the interaction of several factors. Farmers' adoption of innovation is influenced by the coordinated distribution of inputs and outputs, the provision of technical support, and a steady price and credit for participating farmers. As a result, investigating employee acceptance of innovations inside organizations is crucial, because if employees do not embrace the innovation, the anticipated benefits will not be achieved, and the firm may eventually forsake the innovation. Unless they are satisfied that the change would directly benefit them, people are naturally averse to change (Ali *et al*., 2021). According to the present literature, we know very little about how agriculture embraces technology innovation and the factors that drive its adoption (Gaffney *et al*., 2019; Luo *et al*., 2017; Murray-Prior, 2020). Accordingly, more research into the effects of organizational, external, and other control variables on agribusiness innovation uptake is required. The goal of this study is to close that gap. The study's purpose is to look into the factors that influence agribusiness's acceptance of technological innovation.

This research contributes to the corpus of knowledge by addressing three major issues. Using technological innovation and agribusiness firms' literature, this research contributes to knowledge in a variety of ways. Previous research has concentrated on the factors that influence technological innovation adoption, impact, and organizational performance in the manufacturing and service sectors; thus, concentrating on the factors that influence technological innovation among agribusinesses will benefit the agricultural value chain. Identifying the internal, external, and human capital elements that drive technological innovation might help policymakers make more informed decisions. This study has given agribusinesses policy recommendations that have the potential to boost productivity and innovation effectiveness.

A literature review, data and methods, results and discussion, and conclusion and policy implications are the remaining components of the study. The literature review portion explains the factors that influence agribusiness technological innovation. The research describes the data and procedures utilized in the research methodology section. The results and discussion section shows the impact of utilizing the dynamic regression model on a data technique. In the section "Conclusion and policy implications," we present the study's main findings as well as policy options to aid agribusiness firms in implementing more effective and efficient innovative methods.

2. Literature review

2.1. *Adoption of technological innovations*

The study's conceptual framework is the concept of technological innovation adoption. Adoption is described by Rantala *et al*. (2018) as the application of transmitted knowledge concerning a technological advance. Farmers' opinions of the benefits that would result from the viable and practical reality of the innovation had the greatest impact (Alomia-Hinojosa *et al*., 2018; Reghunath and Kishore Kumar, 2016). When seen through a broad cross-disciplinary lens, there is widespread agreement that agricultural technology adoption is influenced by a variety of human, social, historical, and economic aspects, as well as the invention's features (Feyisa, 2020; Ruzzante *et al*., 2021). According to an analysis undertaken by Khan *et al*. (2021a/b), education level, capital, revenue, farm size, information availability, positive environmental outlook, environmental consciousness, and use of social networks are all linked to the adoption of optimal management techniques. Sinyolo (2020) emphasized that assessing a technology's adoption potential is multi-faceted, needing knowledge of its farmers' acceptability, biophysical performance under agricultural conditions, and profitability.

2.2. *Adoption of agricultural technology and its determinants*

There is a lot of knowledge on the factors that impact the adoption of agricultural technology. According to the authors Gao *et al*. (2020), the dynamic interplay between the technology's attributes and a variety of events and contexts influences farmers' judgments about whether and how to accept new technology. Diffusion is the consequence of a series of individual decisions to start using a modern technology, decisions that are typically the result of a trade-off between the unknown benefits of the new innovation and the prospective costs of adoption (Omotilewa *et al*., 2019). For both economists studying growth determinants and developers and disseminators of such technology, understanding the factors that impact this decision is crucial (Llewellyn and Brown, 2020; Muriithi *et al*., 2020; Zhang and Wu, 2018).

Personal characteristics and endowments, incomplete knowledge, risk, uncertainty, institutional limits, input availability, and infrastructure have all been used in economic studies of technology adoption in the past (Chibueze and Emmanuel, 2021). Social networks and learning have just been added to the list of variables that influence technology adoption in a new strand of research. Some studies categorize these variables (Ali *et al*., 2021; Batz *et al*., 1999; Kuehne *et al*., 2017; Purnomo *et al*., 2021). Although technology adoption factors are divided into multiple categories, there is no apparent distinction between variables within each category. This research will examine the factors that influence agricultural technology adoption inside an agribusiness, categorizing them as internal, external, and human capital issues. This will allow a thorough examination of how each aspect affects adoption.

2.3 *Agricultural innovations*

Agriculture has long been considered as a technology-driven industry, with research and innovation playing a key role in increasing productivity (Berthet *et al*., 2018). However, studies on innovation and its collaborative networks has primarily concentrated on the manufacturing, high-tech industry, and service sectors, with little emphasis dedicated to agricultural innovations, particularly at the operational, management, and marketing levels (Guo, 2019; Peng *et al*., 2020; Pozo *et al*., 2019; Taques *et al*., 2021). Innovation, according to previous studies Oeij *et al*. (2019), and Hoffecker (2021), is the process of experimenting with and developing novel combinations of production variables in economic activities such as production, operation, and management. They go on to say that agricultural innovation is no different than innovation in other industries in terms of recombining existing and adding new production components to optimize resource allocation, increase added value, and overall productivity (Dziallas and Blind, 2019).

As a result, agricultural innovation can be divided into three categories. The first is innovation in a specific agricultural process, such as biotechnology, precision farming, and natural resource pollution management and treatment technologies (Dimitri and Effland, 2020). In addition, product sales innovation, such as e-commerce and online sales, is rising in tandem with the rapid development of information technologies (Warinda *et al*., 2020). As agricultural growth and the change from production-based to integrated economic, environmental, and social goals progress, it is becoming an emerging need (Sparrow and Traoré, 2018). The second and third categories are both focused on adding value and are often linked, with one on vertical integration and the other on horizontal integration (Klerkx and Begemann, 2020). Vertical integration refers to agricultural enterprises expanding into secondary and service industries, whereas horizontal integration refers to agricultural firms expanding from one site to another using the same brand, production, and management methods. In industrialized countries, agricultural innovations are becoming more common, and much of this knowledge is being exported to developing countries, mainly in Africa (Grovermann *et al*., 2019; Shi and Pray, 2012).

Product sales innovation is also crucial, especially in developing nations like Ghana, where many farmers are accustomed to direct marketing and selling rather than through intermediaries (Rocchi *et al*., 2020). Despite the broad acceptance of internet sales, there is still minimal sophistication in the sales and marketing of farm food, as is widely known and with few exceptions (Morel *et al*., 2020). Consequently, information asymmetry has become a significant issue, with customer demand having minimal bearing on farmer production decisions. This is changing, as more sophisticated internet-based technology enables the agricultural sales sector to undergo fast innovation, particularly in response to client demand (Sitaker *et al*., 2020). New sales and distribution strategies have been created that strengthen the connection between producers and consumers. Contract production and sales, for example, have enabled purchasers meet their individual needs while lowering marketing expenses, reflecting the common interests of both farmers and customers (Fałkowski *et al*., 2019; Morel *et al*., 2020).

Much research has been done around the world to support the significant economic contribution of emerging agricultural innovation. As a result, it is commonly considered as a win-win option for agriculture companies. However, little is known about the factors that affect agricultural innovations or how agribusinesses respond to them. The goal of this research is to fill in this knowledge deficit by identifying the factors that influence technological innovation in Ghana's agribusinesses.

2.4. *Research model and hypothesis*

2.4.1. *Internal factors*

Previous research has shown that the TAM is applicable to a wide range of agricultural systems (Duong *et al*., 2019; Mir and Padma, 2020; Molina-Maturano *et al*., 2020). Farmers and other stakeholders are seen to be more accepting of technological innovation when they have a good understanding of how it will work. Most of the time, an organization's beliefs and ideals reflect its openness to embrace technological advancements. Companies having a long history and strong market performance are more likely to adopt technology than companies lacking those characteristics (Leo *et al*., 2021). Only a few studies have successfully combined personal qualities with the aim to embrace IT/IS improvements, and even fewer have successfully combined personal characteristics with technological acceptance research. According to Rogers' theory of innovation dissemination Sahin (2006), humans form attitudes toward new technology by synthesizing information from a variety of channels.

When exposed to the same types of media, those with higher personal innovativeness are more likely to produce positive ideas about the target technology. Actors have been practicing new ways of doing things for a long time, so adopting new technology isn't as difficult as it once was. Actors with fewer years of experience, on the other hand, are more likely to oppose new technology. They prefer to address all challenges with the knowledge they have (Kuehne *et al*., 2017). The compatibility of technology innovation can either encourage or deter agriculture actors from adopting it. Actors believe that the technology they are about to employ will help them improve their performance because of its perceived utility. Agribusiness enterprises believe that any innovation activity that lowers productivity and income is incompatible with their operations (Ntiamoah *et al*., 2019). In this study, internal factors include PU; perceived usefulness, OC; organizational culture, PI; personal innovation, PE; farmers prior experience, and C; compatibility, as determined by vast literature. Therefore, we posit the following:

H1a: Internal factors have a positive influence on information and communication technology.

H1b: Internal factors have a positive influence on biotechnology.

H1c: Internal factors have a positive influence on new materials and technology.

2.4.2. *External factors*

People who have access to finance are more likely to accept new technologies, according to studies (Chandio *et al*., 2021). Access to credit is likely to stimulate the adoption of high-risk technologies by alleviating liquidity constraints and enhancing households' risk-bearing capacity (Twumasi *et al*., 2020). Enterprises with sufficient funding and other resources can effectively respond to innovations, whereas businesses with inadequate resources are rarely able to withstand industry-wide technical innovation pressures. According to Budzianowski, (2016), organizations in more volatile external environments have a larger potential for innovation because turbulent circumstances compel them to incorporate innovation into their business strategy in order to stay competitive and, eventually, survive (Rossi, 2017). Technology, market data, and government policy measures can all help to underline the importance of innovation and its potential advantages (Ionescu *et al*., 2020). Governments, research institutions, and commercial institutions in developed economies provide resources to the agriculture industry to help it operate better. On the other hand, the agribusiness concept is gaining traction in most emerging economies, including Ghana, and obtaining the necessary support from all stakeholders is a major issue for the industry, despite the fact that there are several prospects. IP; industry pressure, GI; government influence, AC; access to credit, and HC; high cost of agribusiness technology were also derived as external factors for this study. It is, thus, hypothesized that:

H2a: External factors have a positive influence on information and communication technology.

H2b: External factors have a positive influence on biotechnology.

H2c: External factors have a positive influence on new materials and technology.

2.4.3. *Human capital factors*

Human capital is thought to have an important part in agribusiness' decision to adopt new technologies. In order to quantify human capital, most adoption studies looked at the farmer's educational level, age, gender, and household size (Ankrah Twumasi *et al*., 2021a; Twumasi *et al*., 2021). Farmers' education is thought to influence their decision to adopt new technology in a positive way. A farmer's ability to learn, comprehend, and apply knowledge crucial to the adoption of a new technology improves with his education (Marescotti *et al*., 2021). Age is known to have an impact on how quickly people accept new technology. Farmers that are older are said to have accumulated more knowledge and experience over time and are more prepared to evaluate technical data than younger farmers (Marescotti *et al*., 2021; Molina-Maturano *et al*., 2021).

Gender issues in agricultural technology adoption have long been researched, and the plurality of studies have revealed inconsistent data on the distinct roles men and women play in technology adoption (Yovo and Ganiyou, 2021). A household's size is simply a measure of labor availabili-

ty. In a larger family, the work constraints imposed during the introduction of new technology can be reduced, which has an impact on the adoption process (Worku, 2019). Off-farm money has been shown to have a favorable impact on technology adoption. This is because, in many developing nations, rural households rely primarily on non-farm income to overcome credit limits (Twumasi *et al*., 2021). Several scholars have shown a strong link between extension services and technology adoption. Human capital factors were identified as a viable independent influence on technological innovation. A; age, AR; access to resource, HS; household size, FI; farm income, and FE; level of formal education were the resulting factors for human capital elements. Thus, we propose that:
H3a: Human capital factors have a positive influence on information and communication technology.
H3b: Human capital factors have a positive influence on biotechnology.
H3c: Human capital factors have a positive influence on new materials and technology.

2.4.4. *The mediating factors*

According to the research of Hwang (2020), Kijek and Kijek (2019), and Yunis *et al*. (2018), ICT-based innovations and applications have become key drivers of enhanced organizational performance, economic growth, and social change, and ICT use increases technical creativity, according to a study that looked into the relationship between ICT and technological innovation. Jafari-Sadeghi *et al*. (2021) investigated the impact of digital transformation on technological market expansion and discovered that ICT has a key role in market expansion technological innovations. Again, in order to better understand how biotechnology contributes to technological innovations within the food value chain, Foltz *et al*. (2003), Spielman *et al*. (2014), and Goeschl and Swanson (2003) found that biotechnology innovations have enhanced crop yields in recent years, but real policy reforms are needed to foster additional innovation, eliminate regulatory uncertainty, and encourage firm- and industry-level growth, as well as sustained public funding on agricultural research. The study Scarpato and Ardeleanu (2014) looked at the role of biotechnological innovations in food and sustainability, and found that today's major challenge for the agriculture sector is feeding a growing population, and that biotechnology for plant variety improvement is one of the most promising sectors that requires immediate attention.

Furthermore, research has shown the role of novel materials and technologies in the transformation of sustainable food systems. According to a review study on the potential role of technology innovation in the transformation of sustainable food systems Bedeau *et al*. (2021), and Khan *et al*. (2021a), modern technology and innovation are crucial for developing sustainable food systems

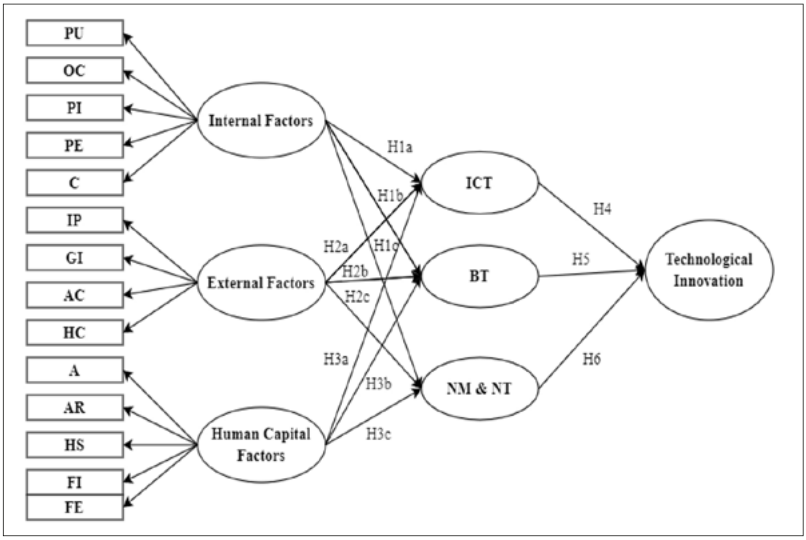

Figure 1 - Conceptual model.

(SFSs) because they can be utilized to answer some of the key questions that will help us better comprehend global food security and nutrition. New materials and agricultural technology breakthroughs are critical for enhancing productivity, sustainability, and resilience in food production and agriculture, according to studies by (Cheng *et al*., 2021; Liu *et al*., 2021; Spielman *et al*., 2009; Zaitsev *et al*., 2020). They also found that new digital agriculture technologies such as the Internet of Things (IoT), artificial intelligence and machine learning, drones, advanced robotics, autonomous vehicles, advanced materials, and gene technology like biofortified crops, genome-wide selection, and genome editing have the potential to transform sustainable food systems. As a result, we propose the following hypotheses:

H4: Information and communication technology (ICT) has a positive influence on TI.

H5: Biotechnology (BT) has a positive influence on technological innovation.

H6: New materials and technologies have a positive influence on technological innovation.

3. Research methodology

3.1. *Data collection and sampling selection*

A pre-testing with ten experts from non-sampled agribusinesses was undertaken prior to data collection to determine the questionnaire's applicability. First, because all of the agribusiness enterprises in the study are members of the Chamber of Agribusiness (CAG), we obtained permission from the CAG and explained the purpose of the study to the respondents before handing out the questionnaires. Following that, we conducted a pilot test with 100 agribusiness practitioners from the research area to analyze the questionnaire's phrasing, clarity, relevance, and time spent (Ebrahimi Sarcheshmeh *et al*., 2018). In terms of phrasing, clarity, and relevancy, the pilot test found no major issues. The questionnaire was deemed simple to understand and fill out, and just a few minor revisions were required, which we dutifully made. Furthermore, Cronbach's alpha was calculated for all of the questionnaire items, and the findings revealed values higher than.70, as predicted by the formula (Ahmadi Dehrashid *et al*., 2021; Hayran *et al*., 2018; Rajabi *et al*., 2012). The questionnaire was divided into two parts. The participants' demographic characteristics were examined in section one, and the respondents' perceptions of the study model's constructs were measured in section two.

Finally, a convenience sample of 2500 self-administered questionnaires were delivered to agribusiness employees in 10 cities: Accra, Cape Coast, Kumasi, Takoradi, Koforidua, Ho, Sunyani, Tamale, Bolgatanga, and Wa. The study's participants came from all of Ghana's regions. Because most agribusiness enterprises are located in urban regions, where labor and markets are readily available, these locations were chosen. Due to resource and time restrictions, a convenient sample was used. This method, on the other hand, is similar to that used by (Piñeiro *et al*., 2021). Four researchers collected data over the course of seven weeks. Due to inaccurate responses and missing data, 974 of the 2500 questionnaires given were discarded. As a result, 1526 valid questionnaires were determined to be analyzable and employed in the research. Males made up 54.6 percent of the responses, while females made up 45.4 percent, according to descriptive statistics. In terms of age, the majority of respondents (37%) are between the ages of 36 and 45, while 25.8% are between the ages of 26 and 35. Furthermore, 64.8 percent of the respondents had earned at least a higher national diploma. In addition, the data revealed that 69.9% of respondents have worked in the agribusiness industry for four years or more, and that 87.5 percent of respondents consider their agribusiness activities to be very innovative. Table 1 shows the complete descriptive statistics for the demographic characteristics of the respondents.

3.2. *Measures*

All of the items were derived from previous literature and modified to fit the study's context in order to ensure and maintain content validity. Our conceptual model consists of 15 constructs, each of which was assessed using a variety of criteria. Internal factors such as perceived usefulness (PU), organizational culture (OC), personal innovation (PI), prior ex-

Table 1 - Demographic data of respondents.

Variable	*Category*	*Frequency*	*%*
Gender	Male	834	54.6
	Female	692	45.4
Age (in years)	18-25 years	112	7.3
	26-35 years	394	25.8
	36-45 years	564	37
	46-55 years	365	24
	56 and above	91	5.9
Level of education	Basic level	189	12.3
	High school level	349	22.9
	Higher national diploma	395	25.9
	Bachelor Degree	413	27.1
	Postgraduate degree	180	11.8
Agribusiness experience (years)	Less than 1 year	103	6.7
	1-3 years	362	23.7
	4-6 years	589	38.6
	7-9 years	336	22
	10 years and above	136	9
Agribusiness firm innovativeness	Excellent	315	20.6
	Very good	412	27
	Good	609	39.9
	Poor	126	8.3
	Very good	64	4.2

perience (PE), and compatibility were assessed using Kuehne *et al*. (2017), and Ntiamoah *et al*. (2019) scales. External factors such as industrial pressure (IP), government influence (GI), access to credit (AC), and high cost of agriculture technology (HC) were assessed using scales developed by Chandio *et al*. (2021), and Twumasi *et al*. (2020) respectively. Human capital factors including age (A), access to resources (AR), household size (HS), farm income (FI), and level of formal education (FE) were all measured using scales developed by Ankrah Twumasi *et al*. (2021), and Twumasi *et al*. (2021). Finally, items derived from Kijek and Kijek (2019), and Yunis *et al*. (2018) were used to assess technological innovation. The questionnaires contained biographical information as well as five-point Likert scale questions ranging from fully agree to completely disagree, with neutral values in the middle. 1, 2, 3, 4, and 5 denote fully disagree, disagree, neutral, agree, and absolutely agree, respectively.

4. Results and analysis

Two steps were involved in the statistical data analysis. The validity of the proposed research paradigm was first determined. The reliability of model components was determined using Cronbach's coefficient. Convergent and discriminant validity, as well as composite reliability, were explored more thoroughly using confirmatory factor analysis (CFA). Structural equation modeling was used to assess the stated study hypotheses (SEM). The data was analyzed using SPSS and AMOS. The reliability study revealed that all coefficients were significantly over the cut-off criterion of 0.700, indicating that each construct had a high level of internal consistency (Table 2) (Mba *et al*., 2021). Cronbach's coefficient values ranged from 0.786 to 0.923 in this study. In addition, all constructs' composite reliability (CR) values were within the range of 0.700, as recommended by Benson *et al*. (2020), ranging from 0.788 to 0.929 (Table 2), indicating appropriate construct internal consistency.

Table 2 - Reliability and validity of the constructs.

Construct	*Indicators*	*Factor Loadings*	*Cronbach's alpha*	*Composite reliability*	*AVE*
Perceive usefulness	PU1	0.733	0.786	0.794	0.698
	PU2	0.818			
	PU3	0.721			
Organizational culture	OC1	0.824	0.810	0.833	0.734
	OC2	0.732			
	OC3	0.801			
Personal innovation	PI1	0.778	0.842	0.854	0.763
	PI2	0.852			
	PI3	0.836			
Farmers' experience	PE1	0.785	0.788	0.797	0.699
	PE2	0.762			
	PE3	0.812			
Compatibility	C1	0.910	0.923	0.929	0.752
	C2	0.894			
	C3	0.811			
Industry pressure	IP1	0.741	0.786	0.788	0.681
	IP2	0.782			
	IP3	0.733			
Government influences	GI1	0.792	0.801	0.825	0.717
	GI2	0.728			
	GI3	0.798			
Access to credit	AC1	0.791	0.814	0.836	0.720
	AC2	0.823			
	AC3	0.754			
High cost of agribusiness technology	HC1	0.811	0.823	0.841	0.734
	HC2	0.737			
	HC3	0.722			
Age	A1	0.877	0.893	0.893	0.767
	A2	0.798			
	A3	0.757			
Access to resource	AR1	0.814	0.820	0.846	0.739
	AR2	0.737			
	AR3	0.721			
Household size	HS1	0.771	0.822	0.839	0.737
	HS2	0.768			
	HS3	0.813			
Farm income	FI1	0.755	0.857	0.864	0.771
	FI2	0.843			
	FI3	0.733			
Farmers' education	FE1	0.889	0.902	0.908	0.758
	FE2	0.832			
	FE3	0.741			
Technological innovation	TI1	0.853	0.881	0.889	0.724
	TI2	0.823			
	TI3	0.791			
	TI4	0.861			
	TI5	0.798			

Note: AVE = average variance extracted.

Table 3 - Means, standard deviation, and discriminant validity.

	M	*SD*	*PU*	*OC*	*PI*	*PE*	*C*	*IP*	*GI*	*AC*	*HC*	*A*	*AR*	*HS*	*FI*	*FE*	*TI*
PU	3.745	0.725	.826														
OC	3.986	0.698	.089	.835													
PI	4.231	0.823	.229	.289	.717												
PE	4.004	0.753	.269	.376	.211	.822											
C	3.244	0.676	.348	.282	.370	.359	.837										
IP	3.986	0.719	.290	.438	.260	.214	.489	.741									
GI	4.084	0.746	.225	.310	.405	.348	.367	.420	.818								
AC	4.032	0.731	.247	.303	.309	.471	.458	.389	.516	.805							
HC	3.902	0.712	.238	.370	.271	.237	.203	.378	.418	.519	.733						
A	4.186	0.823	.248	.223	.243	.385	.349	.293	.471	.487	.671	.854					
AR	4.007	0.737	.343	.337	.329	.262	.336	.120	.460	.499	.534	.648	.861				
HS	4.121	0.667	.228	.322	.431	.380	.479	.231	.325	.541	.424	.486	.639	.819			
FI	4.408	0.781	.386	.336	.358	.298	.221	.308	.290	.514	.588	.498	.534	.748	.727		
FE	4.021	0.729	.243	.420	.338	.373	.491	.489	.145	.466	.515	.548	.557	.535	.635	.811	
TI	4.231	0.739	.353	.395	.310	.388	.485	.437	.326	.542	.523	.612	.641	.645	.654	0.546	.868

Note: PU = perceived usefulness; OC = organizational culture; PI = personal innovation; PE = prior experience; C = compatibility; IP = industrial pressure; GI = government influence; AC = access to credit; HC = high cost of agriculture technology; A = age; AR = access to resources; HS = household size; FI = farm income; FE = level of formal education; and TI = technological innovation.

The validity analysis took into account both convergent and discriminant validity. Table 3 demonstrates that the average variance extracted (AVE) for each construct was greater than the squared correlation coefficient for associated inter-constructs, implying discriminant validity (Benson *et al*., 2020; Rönkkö and Cho, 2022). Furthermore, the fact that all AVEs (see Table 2) were greater than 0.500, ranging from 0.681 to 0.771, confirmed convergent validity. Furthermore, the CFA results in Table 2 give additional evidence for the convergent validity of measures, as all of the calculated loadings were significant at p.001 (Swami *et al*., 2017). The goodness-of-fit test was used to evaluate for sampling correspondence and sampling adequacy. The value of 1.811 for the λ^2/degree of freedom corresponded to the general rule of $1< \lambda^2/df < 5$, showing evidence of a good match. With values >0.9, the CFI (comparative fit index) of 0.955, the NFI (normed fit index) of 0.939, the RFI (relative fit index) of 0.901, the IFI (incremental fit index) of 0.956, and the TLI (Tucker-Lewis fit index) of 0.964 all revealed a very good fit. Finally, the RMSEA value of 0.0025<0.08 indicated that the model was well-fit.

Furthermore, taking into account the validity of self-report questionnaires, this study used Harman's single-factor test to assess for the likelihood of common method variance (CMV) (Fuller *et al*., 2016; Tehseen *et al*., 2017). All of the study items are generally subjected to exploratory factor analysis (EFA) in a single-factor test. CFA can be used instead of EFA when doing Harman's single-factor test. All of the displayed components can be modelled as indicators of a single factor that exhibits technique effects using the CFA approach (Sureshchandar, 2021). In CFA fitness indices, the single-factor model (CMIN/ DF = 3.762, GFI = 0.689, AGFI = 0.659, CFI= 0.523, NFI = 0.541, IFI = 0.558, TLI = 0.518, RMR = 0.061, RMSEA = 0.083) does not yield a better outcome than the current model, indicating that CMV is not a problem in this data set.

4.1. *The structural model analysis*

The assumed correlations among latent variables were tested using the structural model SEM with maximum likelihood estimation. The results are shown in Table 4 and Figure 2. The structural model fits the data well (CMIN/DF =

Table 4 - Standardized path coefficients.

Hypothesis	*Path*	*Estimate*	*SE*	*Composite reliability*	*P value*
H1a	ICT← IF	0.433	0.053	7.940	.000
H1b	BT← IF	0.088	0.042	5.657	.073
H1c	NM & NT ← IF	0.221	0.086	3.120	.000
H2a	ICT ← EF	0.324	0.060	5.234	.000
H2b	BT ← EF	0.095	0.051	1.437	.109
H2c	NM & NT ← EF	0.411	0.047	1.983	.000
H3a	ICT ← HCF	0.678	0.068	7.852	.000
H3b	BT ← HCF	0.252	0.038	6.589	.000
H3c	NM & NT ← HCF	0.336	0.062	3.323	.000
H4	TI ← ICT	0.585	0.056	8.788	.000
H5	IT ← BT	0.462	0.030	9.563	.000
H6	IT ← NM & NT	0.512	0.070	7.899	.000

Note: ICT = information and communication technology; IF = internal factors; BT = biotechnology; NM & NT = new materials and new technology; EF = external factors; HCF = human capital factors; and IT = technological innovation.

2.804, GFI = 0.902, AGFI = 0.867, NFI = 0.889, IFI = 0.906, TLI = 0.901, CFI = 0.913, RMR = 0.036, RMSEA = 0.067), according to the goodness of fit indices. The p value of a path is used to determine its significance in path analysis. The standardized path coefficients (β) and p values are listed in Table 4, and Figure 2 depicts the variance explained by the research model (R^2). The findings revealed that significant factors that affect technological innovations can explain 66.2 %, 48.7%, and 58.6% of the variances in ICT, BT, and NM & NT, respectively, whereas ICT, BT, and NM & NT can explain 74.5 percent of the variance in technical ways to adopt innovations.

The predicted path coefficients of the structural model were then investigated to evaluate the hypotheses after the model was found to be a good fit to the data. The path and significance of causal links between latent variables should be investigated using the structural model Ntiamoah *et al*. (2019). Internal factors (H1a: β = .433, t = 7.940, p = .000), external variables (H2a: β = .324, t = 5.234, p = .000), and human capital factors (H3a: β = .678, t = 7.852, p = .000) all had a substantial impact on ICT, according to the structural model results shown in Table 4 and Figure 2. As a result, H1a, H2a, and H3a were supported. Human cap-

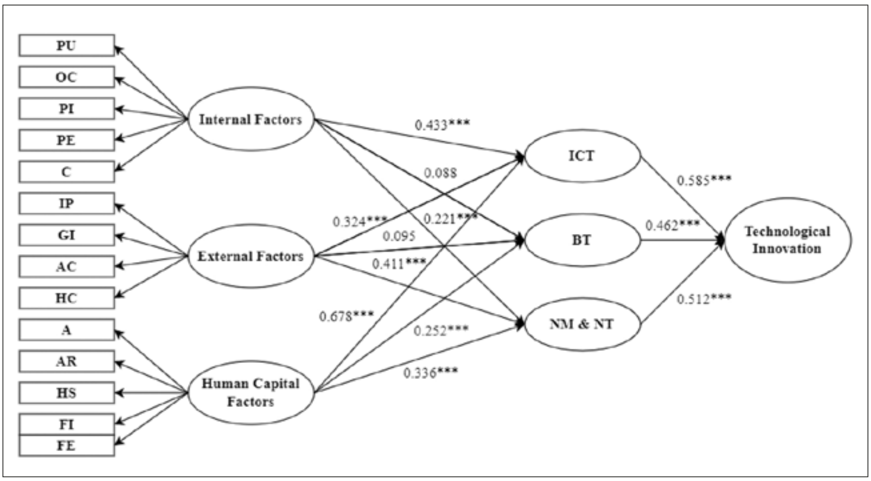

Figure 2 - Results of the model.

ital factors had a substantial impact on BT (H3b: $\beta = .252$, $t = 6.589$, $p = .000$). Internal (H1b: $\beta = .088$, $t = 6.589$, $p = .073$) and external (H2b: $\beta = .095$, $t = 1.437$, $p = .109$) factors, on the other hand, were insignificant. As a result, H3b was supported, but H1b and H2b were not. Internal factors (H1c: $\beta = .221$, $t = 3.120$, $p = .000$), external factors (H2c: $\beta = .441$, $t = 1.983$, $p = .000$), and human capital factors (H3c: $\beta = .336$, $t = 3.323$, $p = .000$) all had a substantial impact on NM and NT, demonstrating that H1c, H2c, and H3c are all supported. Furthermore, the findings reveal that ICT (H4: $\beta = .585$, $t = 8.788$, $p = .000$), BT (H5: $\beta = .462$, $t = 9.563$, $p = .000$), and NM & NT (H6: $\beta = .512$, $t = 7.899$ 4, $p = .000$) have a considerable impact on technical methods to adopting innovation, hence supporting H4, H5, and H6.

5. Discussion

The use of technological innovation by agriculture is seen as a critical component in countering domestic and international rivalry competition among agricultural enterprises. Agribusiness enterprises in Ghana, in particular, are trying to place themselves on par with multinational agribusiness firms in terms of offering excellent services via branding, marketing, and other means. The zeal with which these companies pursued technological innovation has influenced us to study the factors that stimulus the adoption of technological innovation by agriculture companies in Ghana. The impact of internal, external, and human capital determinants on the adoption of technological innovation was investigated in this study. Three (3) mediating factors were used to examine these variables (ICTs, Biotechnology, New materials and technology). The goal of the study was to look at the factors that can influence technological innovation in small agricultural businesses. Based on the findings, our proposed research model was able to achieve a sufficient degree of predictive power for the dependent variables: ICT (66.2%), BT (48.7%), NM & NT (58.6%), and technological innovation (TI) (74.5%). Furthermore, the R^2 value accounted for in technological innovation was within extremely acceptable bounds and exceeded several researchers' proposed values (Durowoju, 2017). In addition, the value of variance is higher than in other similar research studies that looked at organizational technological innovations. For example, Hwang (2020), Niehaves and Plattfaut (2014), Kijek and Kijek (2019), and Yunis *et al*. (2018) explored the correlation between ICT and technological innovation and discovered that ICT-based innovations and applications have become primary factors of improved organizational performance, economic growth, and social change, and that ICT use enhances technological innovation.

Table 4 shows the path coefficient analyses, which show that the research assumptions are generally confirmed. The findings show that all internal factors, such as perceived usefulness, organizational culture, personal innovation, prior experience, and compatibility, have an impact on information and communication technology (H1a) and new materials and technology (NM & NT) (H1c), but not on biotechnology (BT) (H1b). Perceived usefulness, personal innovation, and organizational culture have all been shown to have a strong beneficial impact on behavioral intention to embrace an innovation (Ankrah Twumasi *et al*., 2021b; Haji *et al*., 2020). Surprisingly, respondents' responses to the compatibility questions revealed that prior knowledge of the use of new materials and technology did not always impact technology adoption (Saurabh and Dey, 2021). Internal factors have a greater impact on ICT than BT, NM, and NT, according to the findings (Li *et al*., 2020; Prause, 2019; Takahashi *et al*., 2020). Although biotechnology and new materials and technology are important in increasing productivity and efficiency, most agribusinesses in Ghana think that ICT activities improve yields and efficiency. Our findings are consistent with those of other investigations (Bersani *et al*., 2020; Steinke *et al*., 2022).

External variables such as industry pressure, government influence, financial availability, and the high cost of agricultural technology have a considerable impact on ICT (H2a) and NM&NT (H2c), but have a little impact on BT (H2b). However, respondents claimed that adopting high-cost ICT agriculture technology has a negative impact on a company's profitability and long-term viability, making it less likely to accept technological innovation (Rabadán *et al*., 2019). Within the agro industry, the results demonstrate that external forces have a greater influence on new materials and technologies than information and communication technology and biotechnology (Blichfeldt and Faullant, 2021; Conidi *et al*., 2020; Jambrak *et al*., 2021; Smajlović *et al*., 2019; Zhang *et al*., 2018). Asadi *et al*. (2020) looked at the factors that drive innovation adoption and its prospective effects on performance, and discovered that industry pressure and government influence illustrate the importance and potential of innovation in supporting long-term performance. Furthermore, Wang (2018) found that government is one of the most important determinants of innovation capability, and that government intervention is necessary in innovation because the mark*et al*one cannot provide appropriate incentives for knowledge development. Government intervention, according to the study, increases the technological relevance and scope of innovation.

Human capital factors like age, access to resources, household size, farm income, and level of formal education all have a substantial impact on ICT (H3a), BT (H3b), and NM & NT (H3c). Although all of the contributions are favorable, the findings show that human capital considerations contribute much more to ICT than BT, NM, and NT. This finding lends credence to the study of Gao *et al*. (2020). Furthermore, the findings show that ICT has a considerable impact on technological innovation (H4), BT has a big impact on TI (H5), and NM and NT have a favorable impact on TI (H6). These findings corroborate previous research (Bedeau *et al*., 2021; Foltz *et al*., 2003; Goeschl and Swanson, 2003; Hwang, 2020; Jafari-Sadeghi *et al*., 2021; Khan *et al*., 2021a; Kijek and Kijek, 2019; Spielman *et al*., 2014). Moohammad *et al*. (2014) discovered a relationship between company size, age, and organizational innovation in their study. According to the findings, the size and age of a company have a substantial impact on organizational creativity. In addition, Mazzarol *et al*. (2010) looked at the impact of firm size and age on growth in 143 companies in Australia, France, and Switzerland. According to the study, the size of a company, its age, and the rate at which it grows are all crucial factors in determining how quickly it adopts innovation.

We also discovered that information and communication technology (ICT) aids technical advancement. In comparison to biotechnology and new materials and technology, agribusinesses in Ghana are more familiar with the use of ICT in implementing technological innovation, according to the survey. According to the analysis, biotechnology adds to technical innovation. Seedlings, pesticides, feed, and food firms have all been found to have biotechnology components in recent years, according to the study. However, we noticed that a lot of agribusiness managers are concerned about the consumption of genetically modified (GM) foods and oppose GM crop production. Also, the high cost of biotechnology, predictably, has a negative impact on the firm's overall profitability as well as its day-to-day operations. These findings add to previous study conducted by the author Kim *et al*. (2011). Finally, the study discovered that new technologies and innovation are vital for enhancing production of food because they can be used to answer some of the critical questions that must be addressed in order to reform the global food system and better understand global food security and nutrition. New materials and agricultural technology advances are crucial for increasing food production and agriculture productivity, sustainability, and resilience.

6. Conclusion and policy implications

Agriculture technology innovation is critical for developing countries to achieve broad-based social and economic progress. The sector gives employment to more people than any other in Ghana and the wider region. It is, however, much more than a source of employment and economic stability. Ghana's agriculture sector has contributed significantly to the country's food security. In order to be self-sufficient and able to feed itself despite challenges such as population growth, climate change, and variability, Ghana requires rapid new agricultural innovations that can help agribusinesses build profitable companies that are workable and able to contribute to the global value chain. According to studies in

Ghana, a combination of innovations and operational support services is required to improve agricultural productivity, boost smallholder farmer incomes, and alleviate poverty. Also, the concept of agribusiness and technical innovation has not reached the majority of agrarian companies in developing countries like Ghana.

As a result, it was crucial to shed light on the factors influencing the adoption of agricultural technology innovation in Ghana as a whole using a survey data of 1526 respondents from the ten regions of Ghana. The impact of internal, external, and human capital determinants on the adoption of technological innovation was investigated in this study. Three (3) mediating factors such as information and communication technology, biotechnology, and new materials and technology were used to examine these variables. The findings indicate that internal factors have an impact on information and communication technology (H1a) and new materials and technology (NM & NT) (H1c), but not on biotechnology (BT) (H1b). The results show that external variables have a considerable impact on ICT (H2a) and NM & NT (H2c), but have a little impact on BT (H2b). Also, the study reveal that human capital factors have a substantial impact on ICT (H3a), BT (H3b), and NM & NT (H3c). Lastly, the findings show that ICT has a considerable impact on technological innovation (H4), BT has a big impact on TI (H5), and NM and NT have a favorable impact on TI (H6).

Theoretically, by examining internal, external, and human capital factors, this study has been able to advance the literature relating to the factors that impact technological innovations among small agribusinesses. Previous research has looked at the relationship between agricultural enterprises and technological innovation (Anang, 2018; Danso-Abbeam *et al*., 2019; Martey *et al*., 2014; Tsinigo and Behrman, 2017). No study, however, has looked into the factors that influence agribusiness's willingness to adopt technological innovation. The internal, external, and human capital components investigated had a significant and positive impact on the mediating factors, as well as a favorable effect on the dependent variables, according to the findings. As a result, the proposed and tested model in this study could be used as a reference for any future studies looking at agricultural innovation adoptions. The research is also one of the first to look into the factors that influence technological innovation in the agricultural sector. As previously noted, there is a paucity of empirical research on the factors that influence technical innovation in agribusinesses. This study tried to address that gap, and the findings reveal some major discoveries on the impact of internal, external, and human capital determinants on agricultural innovation in developing countries, greatly expanding and improving the existing literature.

From a managerial perspective, the various impacts of internal, external, and human capital factors on technological innovation via ICT, BT, NM&NT suggest that agribusiness managers should pay close attention to internal and human capital factors because they have a significant impact on employee productivity and efficiency. Employees with past expertise, who are highly innovative, and who have a positive attitude toward new ideas and innovations, for example, are more likely to see innovations as more valuable and impactful to organizational performance. Employees' age, level of formal education, and the company's ability to provide the resources needed to engage in innovative activities can all help to boost organizational productivity and efficiency. Furthermore, the government should develop practical innovation measures to encourage small agribusiness enterprises to incorporate technology innovation into their daily operations, as well as to ensure that recent innovations are extremely profitable, superior, and easy to understand, as well as compatible with existing values, norms, prior experience, and agribusiness demands. In the future, future research could expand on this study by addressing the following constraints. This model can be used in future study to look at the adoption of innovation in various sectors of the economy. Because our research is limited to Ghana, it would be intriguing to see if the findings hold true in other developing nations such as Nigeria, Uganda, Kenya, and Ethiopia, where food security is a concern and novel techniques to feeding a growing population are required.

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