AN EMPIRICAL EXAMINATION OF THE RELATIONSHIP BETWEEN FOREIGN DIRECT INVESTMENT AND AGRICULTURE REGARDING TÜRKIYE[1]

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ABSTRACT

This study examines the influence of Foreign Direct Investment (FDI) inflows on Türkiye's agricultural sector over the period from 1970 to 2023. Using advanced econometric techniques, including the Augmented Dickey-Fuller (ADF) unit root test, Phillips-Perron (PP) unit root test, Autoregressive Distributed Lag (ARDL) co-integration

[1] This article is based on the partial results of the PhD dissertation entitled «*The impact of foreign direct investment on the economy of Türkiye*» (Mehman Karimov, Hungarian University of Agriculture and Life Sciences, 2022). A review, update and extension to the agricultural sector was carried out in collaboration with the rest of the authors. Similar methodological applications and other results have previously been published in Similar methodological applications and other results have previously been published in Karimov & Huseynova (2024), Karimov *et al.* (2024), and Karimov *et al.* (2023).

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test, and the Granger Causality test, this research aims to provide a comprehensive understanding of the long- and short-term dynamics between FDI and agricultural growth. The findings indicate that FDI plays a crucial role in enhancing Türkiye's agricultural sector, particularly in the long run. The results suggest that foreign investment significantly contributes to agricultural growth by improving productivity, modernizing infrastructure, and facilitating technology transfer. However, in the short run, the impact of FDI was found to be statistically insignificant. This suggests that the benefits of FDI take time to materialize, largely due to structural challenges, policy implementation delays, and the time required for investments to translate into tangible sectoral improvements. Moreover, the Granger Causality test highlights a bidirectional relationship between FDI and agricultural expansion. While FDI inflows stimulate agricultural development by providing capital and technological advancements, a growing agricultural sector, in turn, attracts more foreign investors seeking profitable opportunities. This mutual reinforcement underscores the strategic importance of fostering a stable and investor-friendly environment to maximize FDI's benefits. Given Türkiye's increasing role in regional and global agricultural markets, sustaining FDI inflows can serve as a powerful tool for both agricultural and overall economic development. Policymakers should focus on enhancing investment security, reducing bureaucratic hurdles, and implementing targeted reforms to ensure that foreign investment effectively contributes to food security, rural employment, and the sector's long-term resilience.

Key words: Foreign direct investment (FDI), agriculture, Augmented Dickey-Fuller and Phillips-Perron unit root tests, Autoregressive Distributed Lag (ARDL) co-integration test, Granger Causality test, Türkiye

RESUMEN

Este estudio examina la influencia de las entradas de inversión extranjera directa (IED) en el sector agrícola de Turquía durante el período comprendido entre 1970 y 2023. Mediante técnicas econométricas avanzadas, incluida la prueba de raíz unitaria de Dickey-Fuller aumentada (ADF), la prueba de raíz unitaria de Phillips-Perron (PP), la prueba de cointegración de retardo distribuido autorregresivo (ARDL) y la prueba de causalidad de Granger, esta investigación tiene como objetivo proporcionar una comprensión integral de la dinámica a largo y corto plazo entre la IED y el crecimiento agrícola del país. Los hallazgos indican que la IED desempeña un papel crucial en la mejora del sector agrícola de Turquía, particularmente en el largo plazo. Los resultados sugieren que la inversión extranjera contribuye significativamente al crecimiento agrícola al mejorar la productividad, modernizar la infraestructura y facilitar la transferencia de tecnología. Sin embargo, en el corto plazo se encontró que el impacto de la IED era estadísticamente no significativo. Esto sugiere que los beneficios de la IED tardan en materializarse, en gran medida debido a los desafíos estructurales, las demoras en la implementación de políticas y el tiempo que se requiere para que las inversiones se traduzcan en mejoras sectoriales tangibles. Además, la prueba de causalidad de Granger destaca una relación bidireccional entre la IED y la expansión agrícola. Si bien las entradas de IED estimulan el desarrollo agrícola al proporcionar capital y avances tecnológicos, un sector agrícola en crecimiento -a su vez- atrae a más inversores extranjeros que buscan oportunidades rentables. Este refuerzo mutuo subraya la importancia estratégica de fomentar un entorno estable y favorable a los inversores para maximizar los beneficios de la IED. Dado el papel cada vez mayor de Turquía en los mercados agrícolas regionales y mundiales, sostener las entradas de IED podría servir como una herramienta poderosa para el desarrollo agrícola y económico general. Por tanto, los responsables de las políticas deberían centrarse en mejorar la seguridad de la inversión, reducir los obstáculos burocráticos e implementar reformas específicas para garantizar que la inversión extranjera contribuya efectivamente a la seguridad alimentaria, el empleo rural y la resiliencia a largo plazo del sector.

Palabras clave: inversión extranjera directa (IED), agricultura, pruebas de raíz unitaria de Dickey-Fuller aumentada y Phillips-Perron, prueba de cointegración de rezago distribuido autorregresivo (ARDL), prueba de causalidad de

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RÉSUMÉ

Cette étude examine l'influence des flux d'investissement direct étranger (IDE) sur le secteur agricole turc au cours de la période allant de 1970 à 2023. En utilisant des techniques économétriques avancées, notamment le test de racine unitaire de Dickey-Fuller augmenté (ADF), le test de racine unitaire de Phillips-Perron (PP), le test de cointégration à décalage distribué autorégressif (ARDL) et le test de causalité de Granger, cette recherche vise à fournir une compréhension globale de la dynamique à long et à court terme entre l'IDE et la croissance agricole. Les résultats indiquent que l'IDE joue un rôle crucial dans l'amélioration du secteur agricole turc, en particulier à long terme. Les résultats suggèrent que l'investissement étranger contribue de manière significative à la croissance agricole en améliorant la productivité, en modernisant les infrastructures et en facilitant le transfert de technologie. Cependant, à court terme, l'impact de l'IDE s'est avéré statistiquement insignifiant. Cela suggère que les avantages des IDE prennent du temps à se matérialiser, en grande partie en raison des défis structurels, des retards dans la mise en œuvre des politiques et du temps nécessaire pour que les investissements se traduisent par des améliorations sectorielles tangibles. En outre, le test de causalité de Granger met en évidence une relation bidirectionnelle entre les IDE et l'expansion agricole. Alors que les flux d'IDE stimulent le développement agricole en fournissant des capitaux et des avancées technologiques, un secteur agricole en croissance, à son tour, attire davantage d'investisseurs étrangers à la recherche d'opportunités rentables. Ce renforcement mutuel souligne l'importance stratégique de favoriser un environnement stable et favorable aux investisseurs pour maximiser les avantages des IDE. Compte tenu du rôle croissant de la Turquie sur les marchés agricoles régionaux et mondiaux, le maintien des flux d'IDE peut servir d'outil puissant pour le développement agricole et économique global. Les décideurs politiques devraient se concentrer sur le renforcement de la sécurité des investissements, la réduction des obstacles bureaucratiques et la mise en œuvre de réformes ciblées pour garantir que les investissements étrangers contribuent efficacement à la sécurité alimentaire, à l'emploi rural et à la résilience à long terme du secteur.
Mots-clés : investissement direct étranger (IDE), agriculture, tests de racine unitaire augmentée de Dickey-Fuller et de Phillips-Perron, test de cointégration autorégressive distribuée (ARDL), test de causalité de Granger, Turquie

RESUMO

Este estudo examina a influência dos fluxos de Investimento Direto Estrangeiro (IDE) no setor agrícola da Turquia no período de 1970 a 2023. Utilizando técnicas econométricas avançadas, incluindo o teste de raiz unitária Augmented Dickey-Fuller (ADF), o teste de raiz unitária Phillips-Perron (PP), o teste de cointegração Autoregressive Distributed Lag (ARDL) e o teste de Causalidade de Granger, esta investigação visa fornecer uma compreensão abrangente da dinâmica de longo e de curto prazo entre o IED crescimento agrícola. As conclusões indicam que o IDE desempenha um papel crucial na melhoria do sector agrícola da Turquia, especialmente a longo prazo. Os resultados sugerem que o investimento estrangeiro contribui significativamente para o crescimento agrícola ao melhorar a produtividade, modernizar as infraestruturas e facilitar a transferência de tecnologia. No entanto, no curto prazo, o impacto do IDE foi estatisticamente insignificante. Isto sugere que os benefícios do IDE levam tempo a materializar-se, em grande parte devido a desafios estruturais, atrasos na implementação de políticas e ao tempo necessário para que os investimentos se traduzam em melhorias sectoriais tangíveis. Além disso, o teste de Causalidade de Granger destaca uma relação bidirecional entre o IDE e a expansão agrícola. Enquanto os fluxos de IDE estimulam o desenvolvimento agrícola ao fornecer capital e avanços tecnológicos, um sector agrícola em crescimento, por sua vez, atrai mais investidores estrangeiros que procuram oportunidades lucrativas. Este reforço mútuo sublinha a importância estratégica de promover um ambiente estável e favorável aos investidores para maximizar os benefícios do IDE. Dado o crescente papel da Turquia nos mercados agrícolas regionais e globais, a sustentação dos fluxos de IDE pode servir como uma ferramenta poderosa para o desenvolvimento agrícola e económico geral. Os decisores políticos devem concentrar-se na melhoria da segurança do investimento, na redução dos obstáculos burocráticos e na implementação de reformas específicas para garantir que o investimento estrangeiro contribua eficazmente para a segurança alimentar, o emprego rural e a resiliência do sector a longo prazo.
Palavras-chave: investimento direto estrangeiro (IDE), agricultura, testes de raiz unitária Dickey-Fuller e Phillips-Perron aumentados, teste de cointegração Autoregressive Distributed Lag (ARDL), teste de causalidade de Granger, Türkiye

1. INTRODUCTIÓN

Food security is an essential necessity for a sustainable future. Investing in these areas can boost development potential in deprived and emerging countries, where agriculture plays a significant role and employs a sizable number of the population.

Foreign Direct Investment (FDI) has been acknowledged as a crucial driver for global wealth and expansion during the last few decades. Foreign Direct Investments (FDI) contribute significantly to the long-term growth of the nations in which they are based by creating jobs, increasing value-added manufacturing, reducing imports, and transferring knowledge and technology (Calal *et al*., 2023; Karimov *et al*., 2024; Karimov & Huseynova, 2024). As a result, governments compete fiercely to attract more foreign direct investment (Belkania & Karimov, 2018; Karimov *et al*., 2020). It is a core of international economics and trade in which capital crosses across national borders to establish or acquire firms in other countries (Karimov, 2020a). Additionally, foreign direct investment is characterized as a transfer of cash and experience by investors from foreign countries (Karimov, 2020b; Karimov *et al*., 2023).

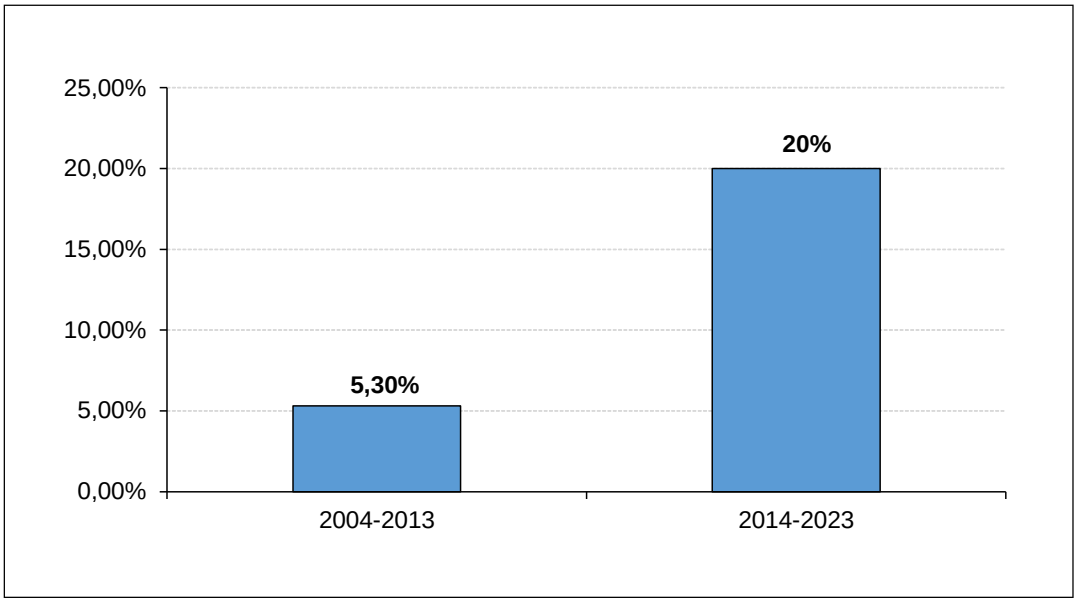
Foreign Direct Investments have a critical role in the strong and sustainable growth, technological transformation and increasing global competitiveness of the Turkish economy (Karimov & Belkania, 2018). FDI is recognized as an essential element of the country's overall economic plan, together with industrial and trade strategies, and it is regarded as a separate policy field within the context of «Türkiye's Foreign Direct Investment Strategy» (Republic of Türkiye Investment Office, 2024).). Türkiye's FDI Strategy (2024-2028) is intended to serve as a road map for attracting competent investments necessary to meet Türkiye's objectives for economic growth at a time when worldwide economic geography is changing and uncertainties are mounting. Main objectives and policy areas of Türkiye's FDI strategy are the followings:

- Target 1: Increasing Turkey's share of global FDI flows to 1.5%.
- Target 2: Increasing Turkey's share of regional FDI flows to 12%.
- Target 3: Reaching the targeted total number of projects in 5 years for each qualified FDI profile.

Türkiye is one of the regions' most FDI-attracting countries. Türkiye is the second most invested economy in the area, attracting 261 billion USD in FDI during the previous two decades (2004-2023), with a 9.8% share of the market. Türkiye is the region's leader, particularly in «food-agriculture» and «manufacturing» initiatives, as well as «expansion» investments. In terms of sectoral allocation of investment projects flowing into the region, it is important to note that the food-agriculture industry has a consistent image, with an average of 100 projects each year. Türkiye has quadrupled its proportion in the food-agriculture industry in the previous decade, attracting one out of each five investments to the area. Figure 1 indicates that Türkiye's share in the region by number of projects increased from 5.3% to 20% within 10 years (Republic of Türkiye Investment Office, 2024).

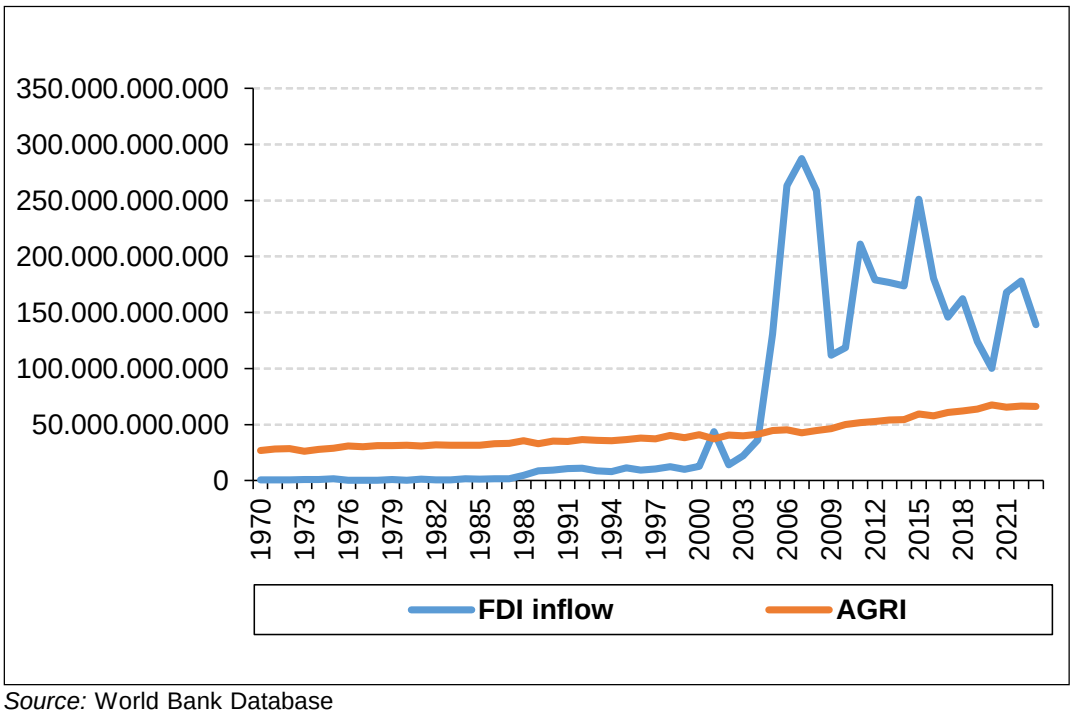
Both similar and different patterns between FDI and agriculture can be observed according to Figure 2. When taking a glance at Figure 2, it can observed that agriculture constantly increases until 2023. In another hand in the case of FDI we can see different sceneries. For instance, from 1970 to 2001 there is a constant slight increase and from 2001 to 2002 there is a drop in FDI inflows into the economy of Türkiye. In contrast to the previous year a sudden growth in FDI inflows into the economy of Türkiye can be observed from 2002 to 2008 until the Great Recession period. This significant growth of FDI inflows into Turkish economy was due to obtained EU membership candidate status of Türkiye and liberalization policies of state. After the Great Recession period economy recovered and of FDI inflows into Turkish economy started to increase from 2010 to 2011. Additionally, another sharp drop in FDI inflows into economy observed in Covid-19 pandemic period.

Figure 1
Türkiye's share in the region by number of projects



Source: Republic of Türkiye Investment Office (2024)

Figure 2
The graphical illustration of FDI inflows and agriculture, forestry, and fishing, value added in Türkiye (1970-2023)



Source: World Bank Database

Table 1 shows us the sectoral distribution of FDI in Türkiye. According to these figures, the most FDI attracted sectors in April 2024 are service (59.7%) and manufacturing (27.4%) sectors. Therefore, the rest of the most attractive foreign investor sectors are the followings mining (9.9%), energy (1.8%), and agriculture (1.2%). As is shown in Table 1, the amount of foreign direct investment in agricultural sector in 2023 was USD 28 million (0.5% of total share of FDI); and on April 2024–just for 1 quarter, it was 21 million USD (1.2% of total share of FDI). Thus, there was a significant growth in the amount of FDI inflows. In the first quarter of 2024, the amount of FDI inflows was 75% of the amount of FDI inflows in 2023. Meanwhile, the total share of foreign investments in agriculture from total FDI inflows into the country increased from 0.5% (2023) to 1.2% (2024/April). Overall, FDI inflows into the agricultural sector in Turkey accounted for USD 817 million

Table 1
Sectoral distribution of FDI (mln USD)

SECTORS	2023 (mln $)	2023 (% Share)	2024/April (mln $)	2024/April (% Share)	2002-2024/April Period FDI-(Million $)	2002-2024/April Period FDI-(% Share)
Agriculture	**28**	**0.5%**	**21**	**1.2%**	**817**	**0.4%**
Mining	**171**	**3.1%**	**167**	**9.9%**	**4.064**	**2.2%**
Manufacturing	**1.706**	**30.6%**	**465**	**27.4%**	**45.533**	**24.2%**
Food-beverage tobacco	124	2.2%	71	4.2%	10.222	5.4%
Chemical	305	5.5%	95	5.6%	7.350	3.9%
Refined petroleum products	61	1.1%	20	1.2%	5.420	2.9%
Primary metal industry	89	1.6%	13	0.8%	4.929	2.6%
Computer-electronic and optical products	394	7.1%	112	6.6%	5.003	2.7%
Non-metallic products	38	0.7%	5	0.3%	2.230	1.2%
Textiles-clothing-leather	45	0.8%	6	0.4%	2.316	1.2%
Rubber-plastics	189	3.4%	9	0.5%	2.114	1.1%
Transportation vehicles	176	3.2%	45	2.7%	2.474	1.3%
Paper	21	0.4%	7	0.4%	1.127	0.6%
Machinery-equipment	114	2,00%	6	0.4%	1.048	0.6%
Furniture	150	2.7%	76	4.5%	1.200	0.6%
Wood and wood products	0	0,00%	0	0,00%	100	0.1%
Energy	**494**	**8.9%**	**30**	**1.8%**	**19.251**	**10.2%**
Services	**3.177**	**57,00%**	**1.012**	**59.7%**	**118.232**	**62.9%**
Finance and insurance	600	10.8%	259	15.3%	57.490	30.6%
Telecommunications	345	6.2%	130	7.7%	16.017	8.5%
Wholesale and retail trade	984	17.6%	442	26.1%	17.997	9.6%
Transportation and Storage	415	7.4%	64	3.8%	9.036	4.8%
Construction	145	2.6%	11	0.6%	5.591	3,00%
Real estate activities	298	5.3%	38	2.2%	3.736	2,00%
Human Health and Social Service Activities	132	2.4%	4	0.2%	2.789	1.5%
Accommodation and Food Service Activities	46	0.8%	30	1.8%	1.837	1,00%
Other services	212	3.8%	34	2,00%	3.739	2,00%
Water supply, waste management	**2**	**0,00%**	**0**	**0,00%**	**81**	**0,00%**
Total	**5.578**	**100,00%**	**1.695**	**100,00%**	**187.978**	**100,00%**

Source: Central Bank of the Republic of Türkiye (2025)

(0.4% of the total FDI) between 2002 and April 2024.

Figure 3 illustrates a sectoral distribution of FDI in Türkiye in April 2024, with the data showing the top sectors for foreign investment. According to this, the proportion of FDI in the agricultural sector was 1.2%.

Figure 3 illustrates a sectoral distribution of FDI in Türkiye in April 2024. According to this, the share of total FDI in the agriculture sector was 1.2% during the first quarter of 2024.

This study aims to investigate the impact of FDI on agriculture in Türkiye. This research would contribute to the existing literature and provide guidance for policymakers, business leaders, and scholars on important agricultural matters in Türkiye. The novelty of this study is that it deals with ARDL (Autoregressive Distributed Lag) model and Granger causality tests, which takes place for the first time in this topic regarding Türkiye over last decades.

2. LITERATURE REVIEW

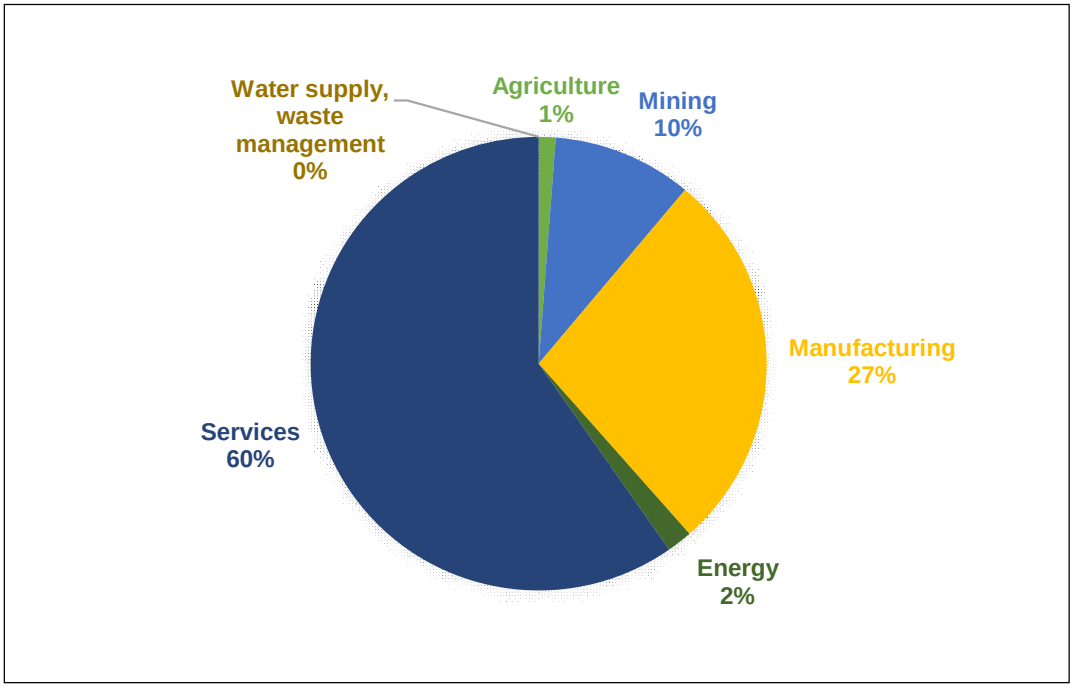
2.1. THEORETICAL LITERATURE REVIEW

Foreign Direct Investment (FDI) is a significant area of study for economists and policymakers, who are interested in how the same could result in growth in diverse sectors, agriculture included. FDI, however, does not work out this way within the agricultural sector or at least not simply. It depends on various factors such as economic status, government policies and societal changes of one country to another. This paper explores FDI's consequences on agriculture by analyzing its key theories.

Neoclassical Theory of Capital Flows

At its core, the neoclassical theory of FDI is based on the idea that money (or capital) tends to flow where it is most needed or will yield the highest return. In simple terms, countries that have plenty of money to invest—often more developed countries—will seek out investment opportunities in countries where

Figure 3
Graphical illustration of sectoral distribution of FDI in Türkiye on April 2024
Source: Central Bank of the Republic of Türkiye (2025)



capital is scarce, such as many developing nations (Kurtishi-Kastrati, 2013). According to this theory, in agriculture, wealthier nations invest in less developed countries with fertile soils and agricultural potentials they cannot explore alone due to their limited resources. For instance, an irrigation company from a developed country may spend money on developing an irrigation facility or propagating new farming technologies in a developing nation. This helps to improve agricultural productivity by surmounting financial and technological constraints.

Eclectic Paradigm (OLI Framework)

John Dunning's Eclectic Paradigm, also known as the OLI Framework, takes a more nuanced approach to FDI. It argues that investment decisions are based on three main factors: Ownership, Location, and Internalization (hence the term OLI) (Dunning, 1977):

- Ownership advantages refer to the strengths that a foreign company brings such as specialized knowledge of farming practices, advanced technology for agriculture or good managerial skills.
- Location advantages are specific features of the host country that attract FDI. In agriculture this could be access to vast arable land, suitable climate for certain crops or lower costs for labor and inputs.
- Internalization benefits are the reasons why a company may choose to internalize production in foreign countries rather than just forming partnerships or outsourcing. A company, for instance, might decide to establish its own agricultural operations in another country to guarantee quality control or to mitigate the risks associated with unstable market situations.

This theory is more inclusive, suggesting that foreign companies consider multiple factors before making decisions on investing in agriculture abroad. It is not only about land and labor availability, but also what they are able to contribute and how well they can manage the farms.

2.2. EMPIRICAL LITERATURE REVIEW

The relationship between FDI and agriculture has lately been an area of interest for significant inquiry in previous studies. The latest empirical researches which made in this area by scholars from all around the World were analyzed in this chapter. Sultana & Sadekin (2023) examined the relationship between Foreign Direct Investment (FDI) and the agricultural sector in Bangladesh for the period 1972-2021. The ARDL approach and F-Bound test were employed for the statistical part of the paper. According to the results of empirical test it was confirmed that foreign direct investment (FDI) had negative impact on the agricultural sector in Bangladesh in the long term. Additionally, it was found that foreign direct investment has no impact in the short run on the agricultural sector of Bangladesh.

Paul *et al.* (2021) investigated the impact of FDI on agriculture and rural development in 46 countries of Asia for the time span 1991-2018. The OLS, POLS, 2SLS, and GMM models were utilized for the empirical part of the paper. The findings of the statistical tests indicated the presence of the association between FDI and agricultural land.

Edeh *et al.* (2020) analyzed the effect of FDI on the agriculture sector in Nigeria from 1981 to 2017. The ADF unit root test, PP unit root test, ARDL approach, FMOLS, and DOLS tests were employed for statistical part of the article. Based on the findings of the empirical tests, the FDI has a positive and significant effect on agricultural sector output in Nigeria.

Nyiwul & Koirala (2022) investigated the impact of foreign capital inflows on the development of the agricultural, forestry and fishing sectors in sixteen developing countries for the period 2001-2020. The panel vector autoregression approach was utilized to accomplish statistical part of paper. According to the findings of the statistical tests it was confirmed that FDI has a medium to long-term positive and significant impact on agriculture value added, forestry and fishing in sixteen developing countries.

Sikandar *et al.* (2021) examined the impact of foreign capital inflows agriculture development and poverty Reduction in

fourteen developing countries from Latin America, Asia, and Eastern Europe. The panel unit root test and pool mean group estimation techniques were employed to fulfil the statistical estimations. The findings of the empirical tests indicated a positive impact of foreign capital inflows on agricultural development in fourteen developing countries.

Ertürkmen (2023) analyzed the impact of FDI and economic growth on agriculture in MIST countries (Mexico, Indonesia, South Korea, and Türkiye) for the period from 1984 to 2021. The cross-section dependence, heterogeneity-homogeneity, CADF unit root, long-term coefficient estimator tests were employed to estimate the relationship between series. Based on the revealed statistical results, all variables had a cross-sectional dependence at the 1% statistical significance level, and a long-term co-integration relationship was retrieved between the series. According to the findings retrieved, for the panel in general, both FDI and economic growth had significant and negative impact on agriculture.

3. MATERIALS AND METHODS

3.1. MATERIALS

The empirical part of the research utilized annual time-series data, sourced from the World Bank Database, covering the period from 1970 to 2023 (53 samples). The econometric analysis for the study was conducted using the Eviews-12 software. The model developed for the study includes the variables listed in Table 2.

3.2. METHODS

3.2.1. AUGMENTED DICKEY AND FULLER, PHILLIPS AND PERRON UNIT ROOT TESTS

Stationarity is a fundamental concept in time series analysis. If the variables under examination are stationary, the regression results may be misleading. To avoid this issue, it is essential to test each variable using unit root tests. In this study, the stationarity of the time series will be evaluated using the Phillips-Perron test (Phillips & Perron, 1988) and the Augmented Dickey-Fuller test (Dickey & Fuller, 1979; Said & Dickey, 1984).

3.2.2. AUTOREGRESSIVE DISTRIBUTED LAG (ARDL) APPROACH

Time-series studies employ a variety of co-integration methodologies to assess long-term connections across the series. The Johansen co-integration (Johansen, 1988), Engle and Granger co-integration (Engle & Granger, 1987), and Johansen and Juselius co-integration (Johansen & Juselius, 1990) studies are three of the most well-known and widely utilized co-integration methods. The primary disadvantage of these studies is that they need all variables to be stable at level one (I(1)). Furthermore, Pesaran & Shin (1995), Pesaran & Smith (1998), and Pesaran *et al*. (2001) addressed this issue by developing the ARDL co-integration test. The ARDL technique has a substantial advantage over other forms of co-integration analysis since all series may be integrated in order 1 I(1), order 0 I(0), or a mix of the two, but not in order 2 I(2). In contrast to prior co-integration analyses, the

Table 2
Description of datasets

Variables	Abbreviation	Measurement unit	Source
Agriculture, forestry, and fishing, value added (constant 2015 US$)) (dependent)	AGRI	Million USD	World Bank
Foreign Direct Investment net inflows (constant 2015 US$)) (independent)	FDI	Million USD	World Bank
Gross domestic product (constant 2015 US$) (explanatory)	GDP	Million USD	World Bank

ARDL technique may be used with small samples. Considering all the previously stated advantages, ARDL technique was chosen for the quantitative part of the study. The generated ARDL statistical model is demonstrated below (1):

$$\Delta AGRI_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i}\Delta AGRI_{t-i} + \sum_{i=0}^{m} \alpha_{2i}\Delta FDI_{t-i} + \sum_{i=0}^{m} \alpha_{3i}\Delta GDP_{t-i} + \alpha_4 AGRI_{t-1} + \alpha_5 FDI_{t-1} + \alpha_6 GDP_{t-1} + \mu_t \quad (1)$$

Where:
«: first difference operator;
$ì_t$: the error term; and,
m: the optimal lag length.

The ARDL method can be applied to examine both long-run and short-run relationships. The null hypothesis suggests that there is no co-integration among the variables being analyzed, while the alternative hypothesis proposes that co-integration exists between the series. To determine whether co-integration is present, the *F*-statistics and the critical upper bound values should be used. If the *F*-statistic exceeds the critical upper bound value, it indicates that co-integration exists among the variables. Conversely, if the *F*-statistic is below the critical upper bound value, it signifies the absence of co-integration between the variables under study.

3.2.3. ERROR CORRECTION MODEL (ECM)

The Error Correction Model (ECM) was developed as part of the broader cointegration theory, primarily by Robert F. Engle and Clive W. J. Granger in the early 1980s. Once the series appears to be cointegrated then the Error Correction Model (ECM) is going to be utilized to analyze the short-term and long-term relationships between variables. It helps capture how deviations from a long-term equilibrium influence short-term adjustments (Engle & Granger, 1987).

3.2.4. DIAGNOSTIC TESTS

Diagnostic tests are essential for verifying the validity of a regression model's assumptions. If these assumptions are not met, the model's estimates may become unreliable, potentially leading to incorrect interpretations. Therefore, tests such as the Breusch-Godfrey Serial Correlation LM test, Breusch-Pagan-Godfrey heteroscedasticity test, Jarque-Bera Normality test, Ramsey RESET test, and CUSUM test will be conducted to assess the robustness of the regression model.

Breusch-Godfrey Serial Correlation LM Test

This test checks for the presence of serial correlation (or autocorrelation) in the residuals of a regression model. Autocorrelation occurs when the residuals from one period are correlated with those from previous periods, violating the assumption of independent errors in ordinary least squares (OLS) regression. Thus, it is crucial to ensure that the errors are not serially correlated (Breusch & Godfrey, 1986).

Breusch-Pagan-Godfrey heteroscedasticity test

This test checks for heteroscedasticity, which occurs when the variance of the error terms is not constant across observations. In other words, some errors may be more spread out than others, which violates the assumption of homoscedasticity in standard regression models. If heteroscedasticity is present, the OLS estimates remain unbiased but are inefficient, and the standard errors may be inconsistent, leading to unreliable hypothesis tests and confidence intervals (Breusch & Pagan, 1979).

Jarque-Bera Normality Test

This test is used to check whether the residuals from a regression model are normally distributed. The normality assumption is important for many inferential procedures, such as hypothesis testing and constructing confidence intervals. While normality is not strictly required for OLS estimation to be

unbiased, it is necessary for making accurate inferences about the coefficients. The Jarque-Bera test checks for both skewness and kurtosis to see if the distribution of the residuals deviates from normality (Jarque & Bera, 1980).

Ramsey RESET Test

This test checks for model misspecification, such as omitted variables, incorrect functional form, or measurement errors in the variables. The RESET test involves adding powers of the fitted values (such as squared or cubed terms) to the regression and testing if they are significant. Model misspecification can lead to biased or inconsistent estimates, so the RESET test helps to identify if the model is incorrectly specified. Ensuring proper specification is key to reliable results and valid inference (Ramsey, 1969).

CUSUM Test

The CUSUM test is used to detect structural breaks in the model, which could be caused by changes in underlying relationships over time. The test analyzes the cumulative sum of recursive residuals to see if they stay within a certain bound. If structural breaks are present and not accounted for, the model's estimates may become unreliable. The CUSUM test helps assess the stability of the model over time and ensures that the relationships being studied remain constant throughout the sample period (Brown *et al*., 1975).

3.2.5. GRANGER CAUSALITY TEST

After confirming the co-integration of the series in this study, the Granger causality test will be applied to examine the causal relationship between the variables. The Granger causality test assesses whether one variable can help predict another in a time series (Granger, 1969). The null hypotheses for the test are as follows:

- X does not Granger cause Y;
- Y does not Granger cause X.

The *p*-value is crucial for determining whether to accept or reject the null hypothesis (indicating no Granger causality between the variables). If the *p*-value is greater than 0.05, the null hypothesis is accepted. If the *p*-value is less than 0.05, the null hypothesis is rejected, and the alternative hypothesis –which indicates Granger causality between the variables, is accepted. Granger causality can be either unidirectional, where causality runs in one direction only, or bidirectional, where causality flows from X to Y and from Y to X.

4. THE RESULTS OF EMPIRICAL TESTS

This section presents and analyzes empirical findings. Table 3 displays the descriptive statistics and the correlation matrix for the dataset utilized in the analysis.

The correlation matrix shows a positive and significant relationship between FDI, GDP, and AGRI. Together with the descriptive statistics, the matrix offers an initial insight into the interactions among these variables. Additionally, econometric methods will be employed to further analyze and clarify these relationships.

4.1. THE FINDINGS OF ADF, PP UNIT ROOT TESTS

This section provides an overview of the empirical results. Before conducting the co-integration analysis, it is essential to check the stationarity of the data. The ARDL test requires the series to be stationary either at the level or first difference. If the series is stationary at the second difference, the ARDL method is not applicable.

The null hypothesis for both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests posits the presence of a unit root at the level or first difference. To reject this hypothesis and accept the alternative, which indicates no unit root at these levels, the *t*-statistics must exceed the critical values, and the *p*-value should be below 0.05. The results from both tests confirm that all series are stationary at the first difference (Table 4).

4.2 THE RESULTS OF ARDL APPROACH

The ARDL bounds test results show that the *F*-statistic (7.292181) exceeds the lower and upper bounds at the 1%, 5%, and 10% significance levels, confirming the presence of co-integration among the variables. The *F*-statistic's *p*-value of 0.000 (< 0.05) further

Table 3
The descriptive statistics and correlation matrix (AGRI, FDI, GDP)

	AGRI	FDI	GDP
Mean	4,15E+10	6,70E+10	4,63E+11
Median	3,72E+10	1,08E+10	3,75E+11
Maximum	6,76E+10	2,87E+11	1,25E+12
Minimum	2,63E+10	1,30E+08	1,16E+11
Std. Dev.	1,21E+10	8,81E+10	3,14E+11
Skewness	0,837254	1,026497	0,943669
Kurtosis	2,472678	2,65449	2,786413
Jarque-Bera	6,934604	9,751857	8,117237
Correlation matrix			
AGRI	1,00000000		
FDI	0,75751541	1,00000000	
GDP	0,99101740	0,77027001	1,00000000

Table 4
The outputs of ADF and PP unit root tests

Variables	ADF (Intercept and trend)		PP (Intercept and trend)	
	At level	At 1st difference	At level	At 1st difference
AGRI	[-0.808742] -(0.95)	[-12.03027] *** (0.00)	[-1.255931] -(0.88)	[-14.19674] *** (0.00)
FDI	[-3.326653] -(0.07)	[-6.388154] *** (0.00)	[-2.575127] -(0.29)	[-7.477671] *** (0.00)
GDP	[1.440313] -(1.00)	[6.438261]*** (0.00)	[3.820856] -(1.00)	[-6.462986] *** (0.00)

Note: In the ADF and PP unit root tests, the parentheses demonstrate p-values, brackets express *t*-statistics, and a sterisks (***, **) denote statistical significance at a 1%, and 5% level respectively. The critical values for this test at 1%, and 5% significance level are -4.32, and -3.58 accordingly

indicates the significance of the model. With an *R*-squared value of 0.993156, the model explains 99% of the variance, and the Durbin-Watson statistic of 2.136900 suggests a low likelihood of autocorrelation in the model (Table 5).

Table 5
The results of ARDL cointegration test

Estimated equation			AGRIt= f(FDIt, GDPt)	
Autoselected lag structure			(2,4,4)	
Cointegration	*F* statistic	Significance	Critical values lower bounds I(0)	Critical values upper bounds I(1)
Yes	7.292181	10%	2.63	3.35
		5%	3.10	3.87
		1%	4.13	5.00
		R-squared		0.993156
		Adjusted R-squared		0.990936
		F-statistic		447.423500
		Prob(F-statistic)		0.000000
		Durbin-Watson stat		2.136900

4.3. THE FINDINGS OF LONG-RUN AND SHORT-RUN ANALYSIS

After establishing co-integration, both long-run and short-run analyses were performed to explore the main relationships. The long-run analysis found a statistically significant and positive relationship between FDI and AGRI (coefficient of 0.017823 with a *p*-value of 0.0253, < 0.05), indicating that FDI positively impacts agriculture over the long term. A similar positive relationship was observed between GDP and AGRI (coefficient of 0.034822 with a *p*-value of 0.0000, < 0.05), implying that a 1% increase in FDI raises AGRI by 0.017%, while a 1% increase in GDP increases AGRI by 0.03%.

In contrast, the short-run analysis using the Error Correction Model (ECM) showed no significant relationship between FDI and AGRI (*p*-value of 0.1365, > 0.05). For GDP and AGRI, the short-run relationship was insignificant and positive (coefficient of 0.011856 with a *p*-value of 0.1374, > 0.05). The ECM coefficient (CointEq(-1)) was negative (-0.722749) and statistically significant (*p*-value of 0.0001, < 0.05), indicating that agriculture adjusts toward its long-term equilibrium at a rate of 72% (Table 6).

4.4. THE FINDINGS OF DIAGNOSTIC TESTS

Diagnostic tests were conducted to verify the model's accuracy. The results confirmed the model's validity, as all null hypotheses were accepted (with *p*-values greater than 0.05) (Table 7).

Table 6
The long-run and short-run analysis

Long-run analysis			Short-run analysis		
Variable	**Coefficient**	**t statistic and Prob.**	**Variable**	**Coefficient**	**t statistic and Prob.**
FDI	0.017823	[2.330542]** -(0.0253)	D(FDI)	0.007275	[1.521968] -(0.1365)
GDP	0.034822	[13.61678]** (0.0000)	D(GDP)	0.011856	[1.518322] -(0.1374)
Constant	2.51E+10	[36.49439] (0.0000)	CointEq(-1)	-0.722749	[-5.615493]** (0.0000)

Table 7
The findings of diagnostic tests

Diagnostic test	χ2	*p*-value	Hypothesizes	Conclusion
The Breusch-Godfrey Serial Correlation LM Test	1.75133	0.18	There is no serial correlation	Accepted
The Breusch-Pagan-Godfrey`s heteroskedasticity test	1.44457	0.19	There is no heteroscedasticity	Accepted
The Jarque-Bera Normality Test	0.2802	0.86	There residual is normally distributed	Accepted
The Ramsey RESET test	1.72608	0.09	The model is stable	Accepted

The CUSUM test was then employed to assess the structural stability of the model. The results showed that the model remained stable throughout the period under study (Figure 4).

4.5 THE FINDINGS OF GRANGER CAUSALITY TEST

Although the ARDL bounds testing method can detect co-integration between the variables, it does not provide information on the direction of their relationships. Thus, the Granger Causality test was needed to ascertain the causality direction among the variables under investigation.

While the ARDL bounds test confirms co-integration among the variables, it does not specify the direction of their relationships. Therefore, the Granger Causality test was used to determine the direction of causality. The Granger causality test results revealed a bidirectional causal relationship: FDI causes AGRI (p-value < 0.05), and AGRI also influences FDI (p-value < 0.05). This bidirectional relationship shows that FDI drives agricultural growth, and agricultural development attracts more FDI inflows into Türkiye (Table 8).

Figure 4
The findings of CUSUM test

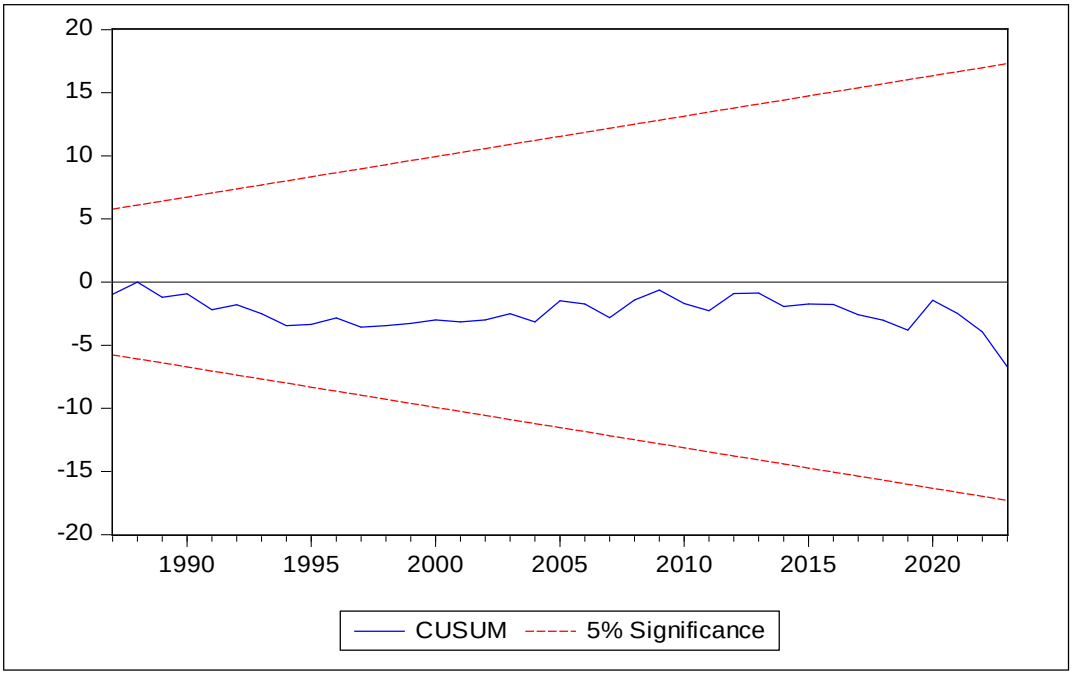


Table 8
The results of Granger Causality test (AGRI and FDI)

Pairwise Granger causality test, Lags 2, Sample 1970-2023, Observations 52		
Null Hypothesis	**F-statistic**	**Prob.**
FDI does not Granger Cause AGRI	4.37109	0.0182
AGRI does not Granger Cause FDI	3.19735	0.0499

The primary aim of this study was to examine the influence of foreign direct investment (FDI) inflows on the agricultural sector in Türkiye, a critical area for a country with significant landmass and a large population. To achieve this, a comprehensive empirical literature review was conducted, analyzing recent studies from scholars around the world. The main findings from these studies displayed significant variation depending on the countries analyzed, the variables and time periods considered, as well as the empirical methods employed. The results of this research are consistent with previous findings from studies such as Edeh *et al.* (2020), Nyiwul & Koirala (2022), Paul *et al.* (2021), and Sikandar *et al.* (2021), which demonstrate a positive and significant relationship between FDI inflows and agricultural development. However, this study's results contradict the findings of Ertürkmen (2023), and Sultana & Sadekin (2023), who reported no significant relationship between FDI and agricultural growth in their respective studies.

5. CONCLUSION

Through the application of the Autoregressive Distributed Lag (ARDL) model, this study confirmed the existence of a long-term relationship between FDI and agriculture in Türkiye. The coefficient for FDI was found to be statistically significant and positive, with a value of 0.017823 and a probability value of 0.0253 ($p < 0.05$). This indicates that a 1% increase in FDI leads to a 0.017% increase in agricultural output over the long term. Similarly, a positive and significant long-term relationship was observed between gross domestic product (GDP) and agriculture, with a coefficient of 0.034822 and a *p*-value of 0.0000 ($p < 0.05$), suggesting that a 1% increase in GDP results in a 0.034% increase in agricultural productivity.

In contrast, the results of the Error Correction Model (ECM) indicated that the relationship between FDI and agriculture in the short run was statistically insignificant, with a *p*-value of 0.1365 ($p > 0.05$). A similar pattern was found regarding GDP, where the short-run relationship with agriculture was also statistically insignificant ($p = 0.1374$, $p > 0.05$). Furthermore, the Granger Causality test results revealed a bidirectional relationship between FDI and agriculture (p-values < 0.05), suggesting that FDI not only influences agricultural growth, but agricultural growth also granger-causes FDI inflows.

Ensuring food security in a country as vast and populous as Türkiye is a complex and multifaceted challenge. The agricultural sector, which plays a central role in feeding the population and contributing to the economy, faces a range of structural and operational issues. Among the most pressing concerns is the rising cost of essential inputs such as fertilizers, electricity, and petroleum –many of which are imported. Additionally, Türkiye's agricultural sector struggles with a lack of access to advanced technologies and modernized production systems, which are crucial for increasing efficiency and yields in the face of growing demand. Moreover, inefficiencies in marketing strategies and the absence of a highly skilled labor force exacerbate the existing challenges, making it difficult for Türkiye to fully unlock the potential of its agricultural industry.

To overcome these obstacles and strengthen the agricultural sector, comprehensive government intervention is required. One effective approach would be for the Turkish government to provide targeted subsidies to local farmers and foreign investors alike, especially for key raw materials and inputs. Such fiscal incentives could lower production costs, making agriculture more competitive and attractive to both domestic and international stakeholders. Additionally, offering tax exemptions or reductions on certain critical agricultural imports, such as advanced farming equipment and technologies, could further encourage investment in modernizing the sector.

In parallel, the rapid global shift toward digitalization and technological innovation poses both opportunities and challenges for Türkiye's agricultural landscape. Many traditional farmers in the country, accustomed to legacy methods of farming, are finding it difficult to adopt and integrate these new technologies into their operations. This digital divide is likely to widen if proactive measures

are not taken. To bridge this gap, the government could initiate extensive training programs to equip farmers with the necessary skills to utilize emerging technologies like precision agriculture, data-driven farming, and automated machinery. Furthermore, promoting knowledge-sharing partnerships between research institutions, universities, and agricultural enterprises –both domestic and foreign, could accelerate the diffusion of these innovations, ultimately boosting productivity and sustainability.

Research and development (R&D) will play a pivotal role in reshaping Türkiye's agricultural sector. Increased investment in R&D projects focused on agriculture could stimulate innovation in areas such as crop resilience, water efficiency, and climate-adaptive practices. Collaborative initiatives between the public and private sectors, as well as international partnerships with foreign investors and multilateral institutions, could serve as a catalyst for these advancements. By fostering innovation and driving the development of new agricultural technologies, Türkiye would be better positioned to enhance food security, promote sustainable agricultural practices, and ensure long-term economic growth.

Beyond technological advancements, a holistic approach to agricultural development would also require improvements in infrastructure, better access to global markets, and enhanced supply chain management. The Turkish government could prioritize the modernization of rural infrastructure – improving roads, irrigation systems, and storage facilities, which would not only boost productivity but also reduce post-harvest losses and increase market access for farmers. At the same time, reforms in agricultural policy could be introduced to align Türkiye's agricultural sector with international best practices and global standards, further opening doors for Turkish agricultural products in international markets.

Finally, fostering stronger connections between agricultural stakeholders, from smallholder farmers to multinational corporations, would ensure that resources, knowledge, and expertise flow more effectively across the sector. A robust public-private partnership model, supported by an enabling policy environment, could drive the sector's development and make it more resilient to both domestic challenges and global disruptions, such as climate change or economic instability. This integrated approach would not only address current shortcomings in Türkiye's agricultural sector but would also lay the foundation for a more secure and prosperous future, contributing to the country's broader goal of achieving sustainable food security and economic growth.

In conclusion, the study underscores the vital role that FDI can play in bolstering Türkiye's agricultural sector, especially in terms of long-term growth. However, to maximize these benefits, concerted efforts are needed from the Turkish government, private sector, and international partners. By providing the right incentives, embracing technological innovation, and fostering collaboration, Türkiye can build a more robust and sustainable agricultural sector capable of meeting the challenges of the future.

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