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The effects of technology spillovers on private sector investment in Iran's food-agricultural industries

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ABSTRACT

Given the importance of food security in the planning of developing countries such as Iran, as well as the significant role of the private sector in food investment, the present study examines the impact of technology spillovers on private sector investment in the agricultural food industries of Iran over a 30-year period. Using a dynamic computable general equilibrium (DCGE) model and the 1390 social accounting matrix, the study evaluates the effects of technology spillovers, including three scenarios: doubling foreign direct investment, improving research and development through enhanced production efficiency considering a technology depreciation coefficient of 0.0062, and a 20% increase in imports of capital and intermediate goods on the private sector investment variable in the agricultural food industries, including four sectors: agriculture and horticulture, livestock, fisheries, and food industries. The results indicate that the first scenario will increase private sector investment in all four sectors. The second scenario does not lead to increased private sector investment in the four target sectors, while the third scenario will not have an impact on increasing private sector investment in the agricultural food industries except for fisheries. Therefore, it is recommended that necessary policies be implemented to attract foreign direct investment and restrict the import of intermediate goods to promote the development of the agricultural food industries in Iran.

1- Introduction

According to estimates by the United Nations, the world's population is projected to reach nearly 10 billion by the year 2050 [1]. Additionally, the demand for food is expected to increase by almost 35% by 2030 [2, 3]. This situation will put increasing pressure on the food and agriculture industries, posing numerous challenges in managing these systems [4]. Today, industries and services related to the production and distribution of food hold a very high position and importance due to their direct impact on the well-being and health of people. Global gross domestic product related to the food industries was approximately $1.68 trillion in 2017, with developing countries accounting for about 3.03% of food production from the global GDP [5]. Therefore, there is a growing need for investment in the food and agriculture industries to enhance food production and ensure global food security.

The development of the food industries in Iran has faced recession in recent years, as evidenced by a study by Fozuni Ardakani et al. in 2016 [6], which showed that from 2002 to 2012, the dairy industry in Iran experienced stagnation and lack of development. Hence, attention to the development of the food industries, considering their role in ensuring food security and the lack of progress in this sector in Iran, is deemed essential. The development of food industries and increased food production require private sector investments, which can play a significant role in financing the food industries and meeting current and future food needs [7]. Financial investment in the food and agriculture sector has significantly grown since the food crisis in 2007-2008, which was accompanied by a sharp increase in food prices and concerns about future food shortages [8]. Researchers in recent decades have paid more attention to the process of investment and financial provision in various industries, including the food and agriculture sector [8, 9, 10, 11, 12, 13]. Private investments vary in scope, institutional design framework, and executive mechanisms [14]. Literature reviews indicate that different forms of private sector investment have become prevalent in various industries in recent years [15, 16, 17, 18, 19].

Policymakers and planners guide private sector investments and capital formation by implementing appropriate policies and creating sufficient motivation to encourage investors to carry out investment projects [20]. One necessary policy in this regard is technology spillover from various channels. Technological spillovers can directly or indirectly affect the host country's economy [21]. Different viewpoints exist in the literature regarding the impact of technological spillovers on the investment flow of private institutions in developing countries, with some individuals believing in positive effects while others remain neutral or even perceive negative impacts [21, 22, 23, 24, 25, 26, 27, 28]. Given the different results of technological spillover effects on private sector investment and economic variables, it is necessary to evaluate the investment flow of private institutions separately for each sector and industry.

The literary review shows that technology spillovers are possible through three main channels: foreign direct investment [21, 28, 29, 30, 31], research and development [22, 32, 33], and imports of capital and intermediate goods [34, 35]. According to Pan et al. (2020) [36], foreign direct investment can facilitate the transfer and overflow of technology from a developed or developing country to another. The study

by Baniasadi and Jala'ee Esfandabadi (2016) [21] concluded that the impact of foreign direct investment as a technology spillover strategy in the short and long term is positive and significant for increasing productivity and developing the agricultural sector. The effectiveness of foreign direct investment on investment flows and economic variables in different sectors of the host country depends on institutional structures, economic equations, support for domestic industries, and trade restrictions [37]. On the other hand, the technology spillover effect through foreign direct investment on macroeconomic variables of an industry has a direct correlation with the productivity gap between foreign and domestic investing companies [38]. Domestic research and development activities lead to the production of tradable goods and services, optimal resource utilization, and the adoption of advanced foreign technology. This reality not only leads to the creation of technology for producing new products but also enhances ways to utilize components or raw materials for production. In fact, the costs and technological improvements of research and development lead to reducing overall production costs for companies, increasing productivity, and promoting export levels. Additionally, fundamental and applied research and development in advanced technology industries are essential conditions for entering international markets [39, 40, 41, 42]. For example, in the study by Soltanisehat et al. (2019) [40], it was revealed that research and development will lead to increased productivity in industries with advanced and medium technology in Iran. Some studies have also shown that knowledge spillover occurs not only through foreign direct investment but also through trade, imports of capital goods, and intermediary goods [43]. In the study by Baniasadi and Jala'ee Esfandabadi (2016) [21], it was found that technology spillover through imports of capital and intermediary goods will improve agricultural productivity in the long term in Iran; however, this result has not been proven in the short term.

Overall, the fundamental question of this study is how technological spillovers impact private sector investment in the food and agriculture industries in Iran and whether it can improve the production of these industries. Literature reviews indicate that this study is the first attempt to address this fundamental question, and such a study has not been conducted separately for the food and agriculture industry in Iran and the world. To address this, a dynamic computable general equilibrium (DCGE) approach has been utilized, which will be further explained in the subsequent sections.

2. Materials and Methods

In order to achieve the objective of the present study, a dynamic computable general equilibrium (DCGE) model based on the social accounting matrix of Iran in the year 1390 was used, and the results were simulated for a 30-year period after the year 2011. The advantage of this model compared to static general equilibrium models is its focus on the time factor in the process of growth and development. In general, one of the ways that enables growth and development to transition from one time period to another is investment in new production capacities, a behavior that can be designed and formulated through dynamic models. Designing investment behavior is one of the essential parts related to the dynamics of the model. In this model, there is a chain of static models that define the relationship between these models

through factors such as population growth and investment. The Lafren model (2001) [44] was used to design the desired static model patterns, which include equations related to domestic production (equations 1 to 5), government sector (equations 6 to 10), savings and investment (equations 11 to 16), household consumption (equations 17 and 18), foreign trade (equations 19 to 21), functions with constant elasticity of substitution and constant returns to scale (equations 22 to 27), and market equations (equations 28 to 30). In this model, it is assumed that the current economic conditions will prevail in all future periods of the economy. In other words, these models are a series of computable static general equilibrium models in different time periods, with inter-temporal relationships established through behavioral equations for endogenous variables like capital accumulation (total capital) and updating of exogenous variables like labor supply. Since the present dynamic general equilibrium model is a recursive dynamic model, it is solved in a periodical manner and the intra-period (static part) and inter-period (dynamic part) components of the model can be distinguished from each other [45]. In this model, designing investment behavior is the main part related to the dynamics of the model. Therefore, dynamic modeling based on investment behavior is carried out through equation (31). Consequently, all model variables and parameters are presented in Table 1.

2.1. Equations

$$VA_j = b_j \prod_h FD_{hj}^{\beta_{hj}} \quad (1)$$

$$X_{ij} = ax_{ij} Y_j \quad (2)$$

$$VA_j = ay_j Y_j \quad (3)$$

$$FD_{hj} = \frac{\beta_{hj}.PN_j}{W_h}.VA_j \quad (4)$$

$$PS_j = ay_j.PN_j + \sum_i ax_{ij}.PQ_1 \quad (5)$$

$$TAX_{ind.j} = tx_j.PS_j.Y_j \quad (6)$$

$$TAX_{dir} = td.\sum_h W_h FS_h \quad (7)$$

$$TARIFF_j = tm_j.PM_j.M_j \quad (8)$$

$$Y_g = TAX_{dir} + \sum_j TAX_{ind.j} + \sum_j TARIFF_j + E_{oil} \quad (9)$$

$$G_i.PQ_i = \lambda_{gi} GDTOT \quad (10)$$

$$\sum ID_i.PQ_i = \mu_i.INVEST \quad (11)$$

$$SAV_{hoh} = s_{hoh}.Y_{hoh} \quad (12)$$

$$SAV_g = s_g.Y_g \quad (13)$$

$$SAVING = (SAV_{hoh} + SAV_g + EXR.SAV_f) \quad (14)$$

$$INVEST_j = \frac{\left(\left(SAV_p + SAV_t\right) * CAP_j\right)}{\sum_j CAP_j} \quad (15)$$

$$SAVING = INVEST \quad (16)$$

$$Y_{hoh} = \sum_h W_h.FS_h + GOVTH + REMIT.EXR \quad (17)$$

$$C_i.PQ_1 = \lambda_{ci}(Y_{hoh} - TAX_{dir} - SAV_{hoh}) \quad (18)$$

$$PE_i = pwe_i.EXR \quad (19)$$

$$PM_i = pwm_i.EXR \quad (20)$$

$$\sum_i pwe_i.E_i + SAV_f + REMIT = \sum_i pwm_i.M_i \quad (21)$$

$$Q_i = \gamma_i(\alpha_{mi}.M_i^{\rho_{mi}} + \alpha_{di} + D_i^{\rho_{mi}})^{\frac{1}{\rho_{mi}}} \quad (22)$$

$$M_{iq} = (\frac{\gamma_i^{\rho_{mi}}.\alpha_{mi}.PQ_i}{(1+tm_i).PM_i})^{\frac{1}{1-\rho_{mi}}}.Q_i \quad (23)$$

$$D_i = (\frac{\gamma_i^{\rho_{mi}}.\alpha_{di}.PQ_i}{PD_i})^{\frac{1}{1-\rho_{mi}}}.Q_i \quad (24)$$

$$Y_i = \theta_i(\beta_{ei}.E_i^{\rho_{ei}} + \beta_{di}.D_i^{\rho_{ei}})^{\frac{1}{\rho_{ei}}} \quad (25)$$

$$E_i = (\frac{\theta_i^{\rho_{ei}}.\beta_{ei}(tx_i+PS_i)}{PE_i})^{\frac{1}{1-\rho_{ei}}}.Y_i \quad (26)$$

$$D_i = (\frac{\theta_i^{\rho_{ei}}.\beta_{di}(tx_i+PS_i)}{PD_i})^{\frac{1}{1-\rho_{ei}}}.Y_i \quad (27)$$

$$\sum_j FD_{hj} = FS_h \quad (28)$$

$$Q_i = C_i + G_i + ID_i + \sum_j X_{ij} \quad (29)$$

$$PINDEX = \sum_i \omega_i PQ_i \quad (30)$$

$$K_{t+1} = K_t(1-\delta) + INVEST_t \quad (31)$$

Table 1- Definition of variables, parameters and indices of the model

Variables, Parameters and Indices	Definitions
VA_j	The composite factor or added value of the j sector
FD_{hj}	Demand for the h production factor by the j sector
Y_j	Gross output of sector j
X_{ij}	The production of sector i, which is consumed as an intermediate input by sector j
PN_j	The added value price of the j sector
W_h	Wages of production factors
PS_j	Supply price
PQ_i	The price of the composite product
Y_{hoh}	Household income
FS_h	The supply quantity of the initial factor h
GOVTH	Government transfer payments to households
REMIT	Net received from outside
EXR	Exchange rate
C_i	The consumption amount of the households from the good of the i sector
TAX_{dir}	Direct tax on household income
SAV_{hoh}	Household savings
$TAX_{ind.j}$	Production tax in each sector
$TARIFF_j$	Import tariff
E_{oil}	Government revenue from oil exports
Y_g	Total government revenue
PM_j	Import domestic price
M_j	Import amount
GDTOT	Total government expenditure
SAV_g	Government savings
G_i	Government expenditure
SAV_f	Foreign savings
ID_i	Domestic investment
SAVING	Total savings
INVEST	Total investment
PE_i	Export domestic price
Q_i	Composite good
D_i	Domestic produced good
PD_i	The price of domestic produced good
E_i	Export amount
PINDEX	Price index
K	Capital (total capital)
i و j	Index of sectors
H	Index of primary production factors or inputs (labor and capital)
t	Time
b_j	Efficiency parameter in the production function
β_{hj}	The share parameter in the production function or production elasticity of sector j with respect to input h
ax_{ij}	The minimum coefficient of intermediate input requirement of sector i to produce a unit of gross output of sector j (input-output technical coefficients)
ay_j	The minimum coefficient of added value needed to produce a unit of gross output
λ_{ci}	The share parameter in the utility function or the share of each good in the household consumption basket
tx_j	Sales tax rate
Td	Direct tax rate
tm_j	Import tariff rate
λ_{gi}	The parameter of the share of government expenditure in each sector
S_{hoh}	Average willingness to save by private sector
S_g	Average willingness to save by government
μ_i	Investment share parameter of sector i
pwe_i	Global export price

pwm_i		Global import price
	γ_i	Efficiency parameter in the production function of composite good
	α_{mi}	Share parameter in the Armington function
	α_{di}	Share parameter in the Armington function
	ρ_{mi}	Exponent of the Armington function or the parameter related to the elasticity of substitution
	η_i	Armington function elasticity
	θ_i	The efficiency parameter of the transfer function
	β_{ei}	Share parameter in the transfer function
	β_{di}	Share parameter in the transfer function
	ρ_{ei}	Exponent of the transfer function or the parameter related to the transfer elasticity
	σ_i	Transfer elasticity
	ω_i	The weight of the price in each sector
	δ	Capital depreciation coefficient

In the following, scenarios examined through the DCGE model are evaluated. These scenarios include:

Scenario 1: Doubling of foreign direct investment.

Scenario 2: Improvement in research and development through enhancing production efficiency considering the technology depreciation rate by 0.0062 (taken from the study by Sheikhiani et al., 2018) [46].

Scenario 3: 20% increase in imports of capital and intermediate goods.

The first scenario is based on the studies by Marzban and Najati (2011) [47, 48], the second scenario is based on the study by Sheikhiani et al. (2018) [46], and the third scenario is based on the country's minimum need for imports of capital and intermediate goods and formulated based on the study by Baniasadi and Jala'ee Esfandabadi [21]. Therefore, technology spillovers in the food-agriculture sector are defined and designed as foreign direct investment inflows, attention to research and development for technology improvement, and increased imports of intermediate and capital goods. The data of the present study includes information from the Iranian social accounting matrix in 2011. The social accounting matrix is the main source of information for calibrating the coefficients of shares and values of exogenous variables in the general equilibrium model. In this study, by combining some sections, a 71-sector social accounting matrix is transformed into a 14-sector matrix and the general equilibrium model designed in the GAMS software is coded and solved.

3. Result and Discussion:

The effects of technology spillovers, including doubling of foreign direct investment (Scenario 1), improvement in research and development through enhancing production efficiency considering the technology depreciation rate by 0.0062 (Scenario 2), and a 20% increase in imports of capital and intermediate goods (Scenario 3) on the private sector investment variable in the food-agriculture industries, including the sectors of agriculture and horticulture, livestock, fisheries, and food industries, were evaluated over a 30-year period, and the results were presented in Figures 1 to 4.

The results in Figure 1 showed that with the implementation of Scenario 1, i.e., doubling of foreign direct investment, private sector investment in the agriculture and horticulture sector is placed at a higher level compared to the base scenario. In this

regard, the positive effect of doubling foreign direct investment on the growth of private sector investment in the agriculture and horticulture sector is greater compared to other scenarios. Meanwhile, the implementation of Scenario 2, i.e., technology spillover through research and development and production efficiency improvement, will not have a significant impact on the growth of private sector investment in the agriculture and horticulture sector. Additionally, the 20% increase in imports of capital and intermediate goods (Scenario 3) will lead to a reduction in the level of private sector investment compared to the base scenario in the agriculture and horticulture sector over a 30-year period.

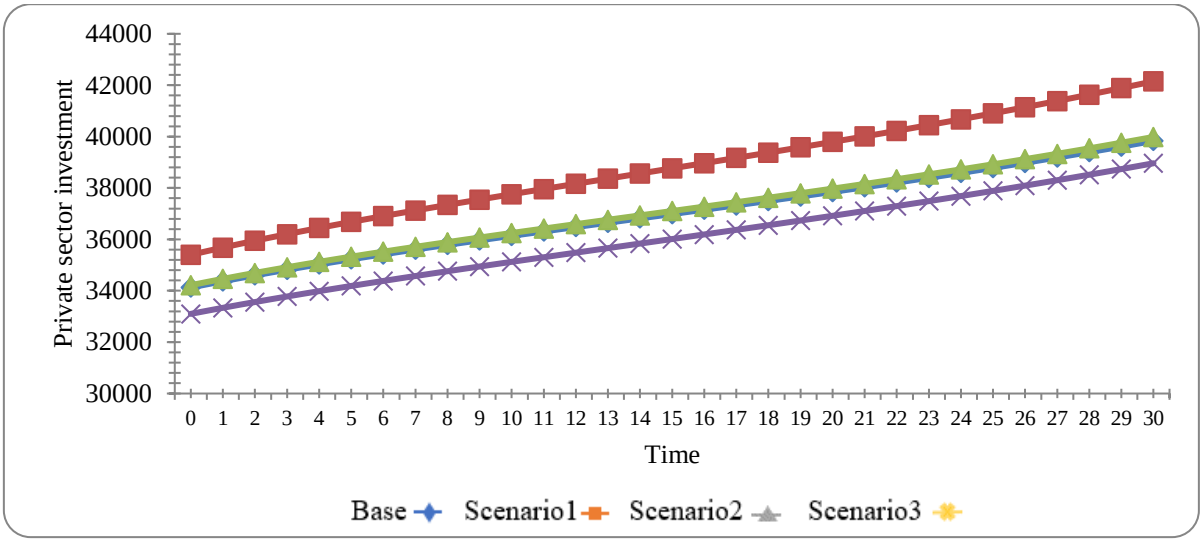

Figure 1- Effects of technology spillover scenarios on private investment in agriculture and horticulture sector

In Figure 2, it is evident that the effects of Scenario 1 on private sector investment in the livestock sector have been positive and similar to the agriculture and horticulture sector. Therefore, the increase in foreign direct investment can stimulate private entities in Iran to invest in the livestock sector. This is while with the implementation of Scenarios 2 and 3, the level of private sector investment in the livestock sector compared to the base scenario will remain almost unchanged over a 30-year period.

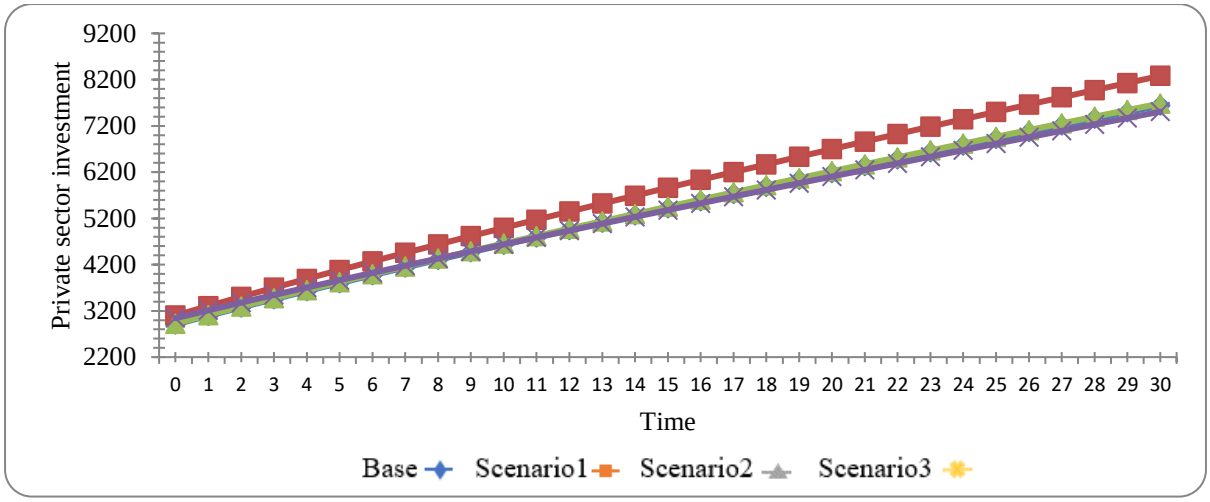

Figure 2- The effects of technology spillover scenarios on private investment in the livestock sector

Based on the results in Figure 3, with the implementation of Scenarios 1 and 3, private sector investment in the fisheries sector is in a more favorable position compared to the base scenario. This implies that doubling foreign direct investment or a 20% increase in imports of capital and intermediate goods can be hopeful in stimulating private entities to invest in the fisheries sector. This is while technology spillover through research and development cannot lead to an improvement in private sector investment in the fisheries sector.

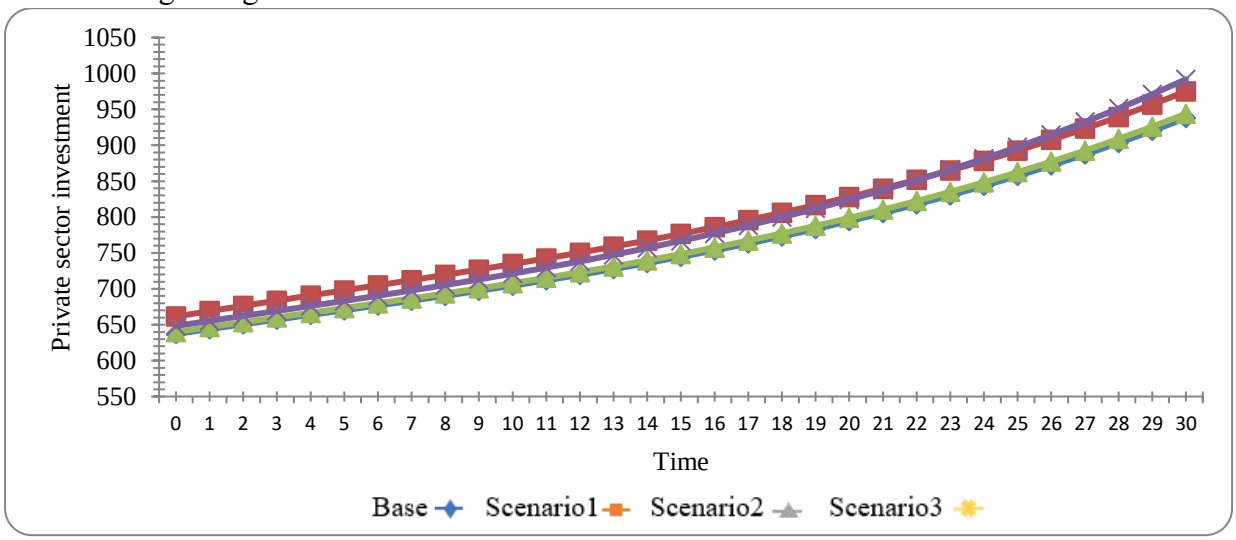

Figure 3- The effects of technology spillover scenarios on private investment in the fisheries sector

The results in Figure 4 indicate that unlike the three sectors of agriculture and horticulture, livestock, and fisheries, private sector investment in the food industries will decrease under all scenarios in the future years. Accordingly, similar to the previous sectors, Scenario 1, which involves doubling foreign investment, will have the greatest positive impact on the growth of private sector investment in the food industries compared to the base scenario. This is while the scenario of technology improvement through research and development will not significantly stimulate private sector investment in the food industries. According to the results,

private sector investment in the food industries under the third scenario involving a 20% increase in imports of capital and intermediate goods will decrease. Additionally, the reduction in investment in the food industries as a result of implementing the third scenario in the initial years will be greater than in the later years.

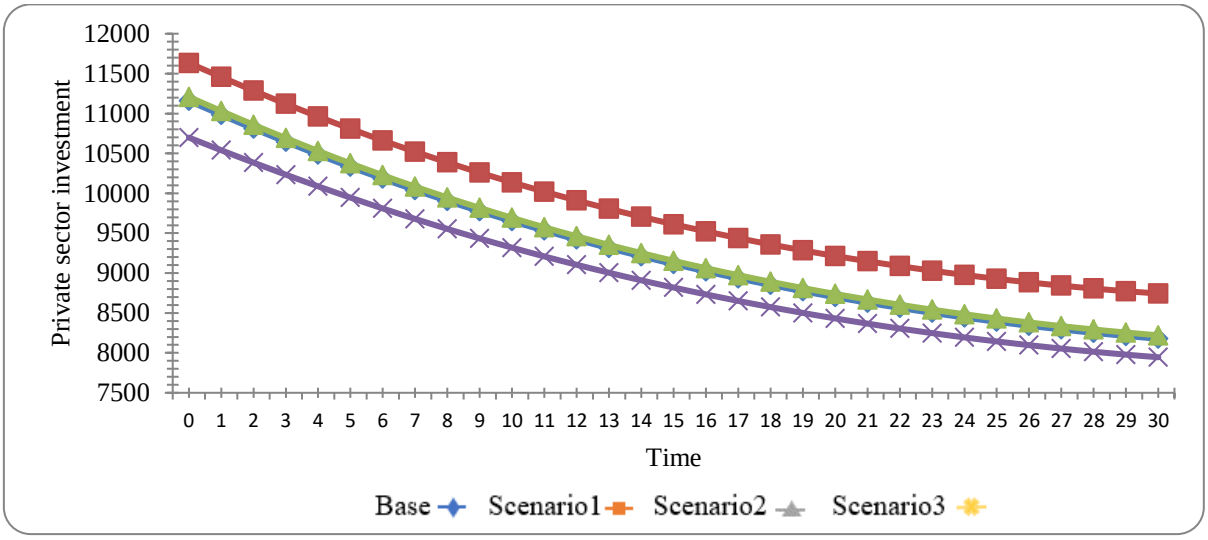

Figure 4- The effects of technology spillover scenarios on private investment in the food industry sector

In general, the consolidation of the results of the sections related to the food industry in agriculture leads to the conclusion that doubling foreign direct investment can significantly help encourage private sector investment in agricultural food industries (including agriculture and horticulture, livestock, fisheries, and food industries). Therefore, the inflow of private sector capital into agricultural food industries requires stimulating liquidity in this sector and attracting new foreign investments. The positive effect of increasing foreign direct investment on private sector investment in various economic sectors has been proven in studies by Najati et al. (2017), Pandya and Sisombat (2017), Shah et al. (2020), and Tung and Thang (2020) [24, 25, 48, 49]. Various studies have found that the complementary nature of domestic private sector investment and foreign investment is a reason for stimulating private sector entities to invest, where foreign investors act as a driving force to kickstart investment. However, studies by Anwar and Sun (2015) and Ivanovich (2015) [50, 51] concluded that foreign direct investment has a negative impact on total private investment in the economy. These studies found that in some industries, foreign investors compete with domestic private sector investors, leading to the displacement and lack of movement of private sector investments in these industries. Another finding is that increasing research and improving efficiency through these studies in agricultural food industries may not necessarily attract private sector investments. In other words, research and development alone, without considering the attraction of foreign investment, may not stimulate domestic investment in these industries. This finding has also been confirmed in studies by Rabiei (2008) and Shoja Haidari (2015) [22, 52]. These studies concluded that research and

development costs will have no impact or a negative impact on domestic investment in various sectors of the Iranian economy. It was also revealed that a 20% increase in imports of capital and intermediate goods will have different effects on domestic private investment in the industries under investigation. For agriculture and horticulture, livestock, and food industries, the impact of increasing imports of capital and intermediate goods on private investment in these sectors will be either neutral or negative. However, for the fisheries sector, an increase in imports of capital and intermediate goods can lead to improvement in private investment in this sector. Therefore, for agriculture and horticulture, livestock, and food industries, imports of capital and intermediate goods without transferring necessary technology will not be accompanied by technology transfer. In other words, with increased imports of these types of goods, technology will not be internalized in these sectors, and the necessary potential to stimulate real production will not be achieved. In a better sense, a 20% increase in imports of intermediate and capital goods will not have an impact on the transfer of knowledge and technology to the country in these industries and will essentially intensify the demand for final goods, subsequently reducing the motivation of private entities to invest in these industries. The findings of the study by Baniasadi and Jala'ee Esfandabadi (2016) [21] also indicate that in the short term, the increase in imports of capital and intermediate goods will not affect the efficiency of the agricultural sector. Therefore, an increase in imports within a certain range of the technology gap between firms can lead to increased productivity. When the technology gap among firms is very large or very small, encouraging entry and increasing imports can have a reverse effect on the growth and development of industries and consequently the overall economy.

4. Conclusion and Recommendations

One of the important issues that planners in developing countries, including Iran, are facing is food security. Achieving food security requires attracting private capital to the agricultural and food industries. Therefore, evaluating solutions to increase domestic investment by private entities in the agricultural food industries can play a fundamental role in improving food security in the country. In this study, the effects of various scenarios on technology spillover were simulated using a dynamic computable general equilibrium model to evaluate solutions to improve investment by domestic private entities in agricultural food industries. To this end, four sectors agriculture and horticulture, livestock, fisheries, and food industries were considered as effective sectors in ensuring food security, and technology spillover scenarios, including doubling foreign direct investment, increasing research and development through improving technology efficiency by 0.0062, and a 20% increase in capital and intermediate goods imports, were modeled. The results showed that in order to stimulate domestic private entities to invest in agricultural food industries, technology transfer and technology spillover through foreign direct investment are necessary. This result indicates that the major problem faced by active companies in agricultural food industries is the lack of liquidity and necessary capital, and increasing productivity and technology improvement through research and development in subsequent stages become important. In other words, with an increase in foreign direct investment, knowledge and

technology transfer to the country will also occur. Therefore, it is suggested that necessary policies to attract foreign investors in various economic sectors be implemented, including improving political relations, implementing incentive policies for foreign investors, and enhancing investment security in the country. Another finding of this study is the negative impact of imports of capital and intermediate goods on stimulating private investment in agricultural food industries, except for the fisheries sector. This finding indicates that the technology gap between domestic and foreign companies in agricultural and food industries is significant, and therefore, imports of capital and intermediate goods cannot lead to technology diffusion and hence strengthen domestic investment in these industries. Therefore, it is recommended that imports of capital and intermediate goods should be carefully reviewed and regulated by the government for agricultural food industries, as such imports, contrary to the views of most policymakers, cannot result in internalizing technology and innovation.

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اثرات انواع سرریزهای تکنولوژی بر سرمایه‌گذاری بخش خصوصی در صنایع غذایی کشاورزی ایران

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چکیده

با توجه به اهمیت موضوع امنیت غذایی در برنامه‌ریزی کشورهای در حال توسعه از جمله ایران و همچنین نقش مهم بخش خصوصی در سرمایه‌گذاری مواد غذایی، مطالعه حاضر به بررسی تاثیر سرریزهای تکنولوژی بر سرمایه گذاری بخش خصوصی در صنایع غذایی کشاورزی ایران در یک بازه زمانی ۳۰ ساله پرداخته است. در این مطالعه با بهره‌گیری از مدل رهیافت تعادل عمومی قابل محاسبه پویا (DCGE) و با استفاده از ماتریس حسابداری اجتماعی ۱۳۹۰، اثرات سرریزهای تکنولوژی شامل سه سناریوی دو برابر شدن سرمایه‌گذاری مستقیم خارجی، بهبود تحقیق و توسعه از طریق بهبود بهره‌وری تولید با لحاظ ضریب کسر فناوری ۰/۰۰۶۲ و افزایش ۲۰ درصدی واردات کالاهای سرمایه‌ای و واسطه‌ای بر متغیر سرمایه‌گذاری نهادهای خصوصی در صنایع غذایی-کشاورزی شامل ٤ بخش زراعت و باغبانی، دام، شیلات و صنایع غذایی، مورد ارزیابی قرار گرفت. نتایج نشان داد که سناریوی اول باعث افزایش سرمایه‌گذاری نهادهای خصوصی در هر چهار بخش فوق خواهد شد. سناریوی دوم نمی‌تواند باعث افزایش سرمایه‌گذاری نهادهای خصوصی در چهار بخش مورد نظر شود و سناریوی سوم تاثیری بر افزایش سرمایه‌گذاری نهادهای خصوصی بر بخش‌های صنایع غذایی-کشاورزی به جز شیلات نخواهد داشت. بنابراین پیشنهاد می‌شود که به‌منظور توسعه صنایع غذایی-کشاورزی در ایران، سیاست‌های لازم جهت جذب سرمایه‌گذاری مستقیم خارجی و محدودیت واردات کالاهای واسطه‌ای بکار گرفته شود.