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PRODUCTIVITY AND SUSTAINABILITY IN AGRICULTURE: A STUDY OF SOES VS. PRIVATE FARMS

The agricultural sector plays a critical role when it comes to economic development, food security, and environmental sustainability. This particular study looks at factors that affect total factor productivity (TFP) in agricultural state-owned enterprises (SOEs) and private farms. The research identified and evaluated land use efficiency, labor productivity, capital investment, and the adoption of sustainable practices for over 11,982 farms in Kazakhstan within a ten-year timeframe.

The results exhibit productivity differences between SOEs and private farms. A larger share of private farms outcompetes SOE due to more efficient labor utilization and allocation of resources while the SOEs are more productive due to self-sufficient capital investment and infrastructure. As expected, lagged TFP (TFP from the last period) turns out to be an important predictor of TFP within the industry, for which there has been a great emphasis in the cross-section analysis. Additionally, the consequences of land use and agricultural sustainability positively contributed to TFP. These results confirm the expectations about responsible farming with a focus on resource optimization. On the other hand, crop yield was discovered to have an inverse relationship with TFP. This implies low levels of TFP growth because of efficiences associated with over-relies on inputs.

This research is useful for policymakers and stakeholders as it expands the range of possibilities for multi-targeted approaches.

Keywords: Total Factor Productivity (TFP), agriculture, capital investment, sustainable farming practices, State-Owned Enterprises (SOEs)

Introduction

Agriculture plays a significant role in global economic development, food security and environmental sustainability. Total factor productivity (TFP) is a key indicator used to measure the efficiency and innovation of an economy, indicating its potential to improve resource use and increase output. Understanding the determinants of total productivity is important for developing policies and practices that promote sustainable and resilient growth in agriculture (specific characteristics and performance) and specific farming.

This study provides valuable information on farming methods by examining key factors such as land use, labor productivity, capital investment and the use of environmentally sound practices. The study also examines the differences between the groups, highlighting the strengths and weaknesses of each type of agriculture and their implications for policy development and management. Comparison of agricultural practices reveals the dynamic processes affecting agricultural production. Furthermore, unexpected patterns, such as the relationship between crop yield and total production, present an important opportunity to rethink agricultural management practices.

This study not only highlights the importance of resource efficiency and sustainability, but also the need for strategies designed to meet the different needs of state and private farms. Understand agriculture and make actionable recommendations to increase productivity, promote sustainable practices, and align agricultural goals with social goals and the environment. Conducts extensive research with the aim of achieving sustainable growth and food security.

This literature review explores key themes, including the impact of resource use, technological advances, productivity, and environmental sustainability on agriculture. Efficient land use and labor productivity are generally considered key factors in overall agricultural productivity. Research has shown that good land management practices, such as crop rotation, crop rotation, and soil conservation, can significantly increase the efficiency of resource use [1]. In particular, productivity in private farming is closely linked to better management and the use of modern agricultural technologies, reflecting the importance of education and skills development [2]. In contrast, inefficient use of land and labor is often considered a key factor in the creation of state-owned enterprises, which prohibit rigid organizations and excessive practices [3]. Capital investment, especially

in infrastructure and mechanization, plays an important role in agricultural development. Studies show that state-owned enterprises benefit greatly from large investments in technology and equipment that can increase productivity through automation and infrastructure development [4]. However, private farms often face difficulties in accessing capital, which limits their ability to achieve similar results. Research also shows that the efficiency of resource allocation varies by farm type, with private farms primarily outperforming resource-based solutions [5]. Studies have shown that practices such as conservation tillage, organic farming, and water management not only contribute to ecological protection, but also have positive effects on the entire ecosystem [6]. These practices increase soil fertility, reduce input costs, and have positive effects on productivity and sustainability. However, adoption varies between state-owned enterprises and private farms, influenced by previous organizational structures and resource availability [7]. Technological advances such as precision agriculture and the use of digital tools have transformed agriculture. This study highlights the role of innovation in reducing the yield gap between SOEs and private farms. While state-owned enterprises generally have easy access to advanced technology due to government support, private farms have shown greater ease in applying and adapting technology to meet their specific needs [8]. Over-reliance on fertilizers and pesticides leads to inefficiency and reduces overall production. Similarly, livestock management may provide short-term benefits but presents unique challenges, while long-term sustainability is often hampered by resource constraints and environmental concerns round difference [9].

The interaction between crop yields and TFP needs further investigation, particularly with respect to the potential for diminishing returns. Additionally, research on differences in permaculture practices across farming types remains limited. Understanding the nuances of upfront capital investment in state-owned and private farms is another area that requires further research.

Materials and methods

The data was selected from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan (https://stat.gov.kz/ and for this study spans ten years (2013-2023) and includes 11,982 farms from diverse regions[10]. The analysis was conducted on Stata software.

Table-1 Panel data structure

Year	**Number of Farms**
2013	856
2014	945
2015	1,011

2016	1,036
2017	1,089
2018	1,110
2019	1,139
2020	1,158
2021	1,189
2022	1,208
2023	1,241
Total	11,982
Note: Complied by authors according to [10]	

According to Table 1, we can see the distribution of farms by year and their annual contributions to the total data.

To assess the relationship between Total Factor Productivity and resource access, we use the following regression model[5]:

$$TFPit = \alpha + \beta 1LandUseit + \beta 2LaborEffit + \beta 3CapitalInvit + \beta 4Ageit + \beta 5CropYieldit + \beta 6LivestockProd + \beta 7Sustainabilityit + \beta 8DebtRatioit + \ + \nu j + \nu t + \nu k + \varepsilon it$$

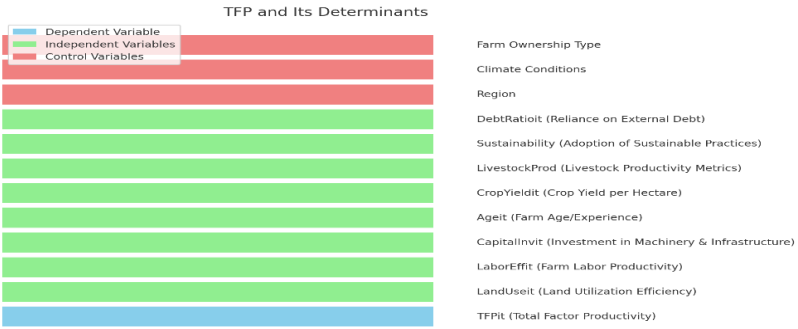

Figure 1 – Factors Influencing Total Factor Productivity

Total Factor Productivity (TFPit), which is the ratio of total output (livestock, crops) to total inputs, can be viewed as the dependent variable. The following are independent variables: LandUseit: Productivity of farm labor; CapitalInvit:

Investment in machinery and infrastructure; CropYieldit: Average crop yield per hectare; LivestockProd: Metrics of livestock productivity; Sustainability: Adoption of sustainable practices; and LandUseit: Efficiency in land utilization. Debt Ratioit: The amount of external debt a farm depends on; control variables include ownership type, climate, and region (see figure 1).

Results and discussion

We have discovered the following outcomes after using and evaluating the relevant data.

Table-2 Descriptive statistics

Variable	**All Firms**	**SOE (State-Owned Enterprises)**	**Private Firms**	**Difference (p-value)**
Total Factor productivity	0.655 (0.412)	0.645 (0.315)	0.875 (0.416)	0.512
LandUseit	0.078 (0.095)	0.076 (0.110)	0.085 (0.145)	0.000
LaborEffit	0.578 (0.201)	0.356 (0.200)	0.411 (0.188)	0.000
CapitalInvit	10.789 (22.783)	8.045 (15.502)	11.650 (19.897)	0.000
Ageit:	198,000 (424,000)	289,000 (162,000)	145,000 (389,000)	0.000
CropYieldi	0.095 (0.429)	0.062 (0.412)	0.095 (0.445)	0.457
LivestockProd	0.976 (0.051)	0.986 (0.054)	0.998 (0.058)	0.000
Sustainability	11.895 (5.025)	11.945 (5.645)	11.987 (5.789)	0.000
DebtRatioit:	0.064 (0.154)	0.062 (0.146)	0.071 (0.165)	0.035
Number of Observations	11,982	3,526 (29.43%)	8,456 (70.57%)	-
Note: Complied by authors according to [10;11]				

Table 2 shows agricultural production and its effects on all sectors, state ownership enterprises (SOEs) and private enterprises. The results revealed significant differences in many dimensions that allowed comparisons between organizational types. The total output average of all companies was 0.655 (SD = 0.412). As a result of the decomposition, the productivity of state ownership enterprises was slightly lower at 0.645 (SD = 0.315) and the productivity of private enterprises was higher at 0.875 (SD = 0.416). However, the difference between SOEs and private sector products was not found to be significant (p = 0.512). The

highest land use belongs to private companies (0.085, SD = 0.145), followed by state companies (0.076, SD = 0.110) and the total of all enterprises (0.078, SD = 0.095). The difference in land use between state ownership enterprises and private enterprises is significant ($p < 0.001$), indicating differences in resource use strategies. The performance of the workforce was better in the private sector (0.411, SD = 0.188) than in SOEs (0.356, SD = 0.200). The overall performance of each enterprise was found to be 0.578 (SD = 0.201). The difference between state economic enterprises and private enterprises is significant ($p < 0.001$), indicating the main areas in which private enterprises outperformed other enterprises. The average capital stock of private enterprises (11.650, SD = 19.897) is higher than the average capital stock of SOEs (8.045, SD = 15.502). The average across all companies was 10.789 (SD = 22.783). This difference is significant ($p < 0.001$), indicating that private companies allocate more resources to capital. The average age of SOEs (289.000, SD = 162.000) is higher than the average age of private companies (145.000, SD = 389.000), while the average age is 198.000 (SD = 424.000). The significant difference in firm age between state ownership enterprises and private enterprises ($p < 0.001$) reflects the establishment date of the state ownership enterprises. As a result of the analysis, the p value was found as 0.457 between state ownership enterprises (0.062, SD = 0.412) and private enterprises (0.095, SD = 0.445) and it was revealed that there was no significant difference in terms of return. However, livestock production in the private sector (0.998, SD = 0.058) has significantly increased compared to state enterprises (0.986, SD = 0.054) and the p value is < 0.001. It is seen that there is a difference of 11.895 (SD = 5.025) points in total between state ownership enterprises (11.945, SD = 5.645) and private enterprises (11.987, SD = 5.789) in the sustainability performance index. Although significant ($p < 0.001$), the magnitude of the difference is small. Private enterprises' debt (0.071, SD = 0.165) is slightly higher than SOEs debt (0.062, SD = 0.146). Total debt is 0.064 (SD = 0.154). The significance of this difference is limited but the difference is significant ($p = 0.035$).

The findings show that private companies generally outperform state-owned companies in key areas such as labor productivity, capital formation, and livestock production, but there are significant differences in these indicators. Although state-owned companies have a longer history and slightly lower debt, these positive results have not led to higher stock prices. These results highlight the resource allocation and efficiency of the private sector in agriculture.

Table – 3 Regression Analysis for TFP

Variable	All Farms (GMM)	All Farms (FE)	SOE (State-Owned Enterprises) (GMM)	SOE (FE)	Private Farms (GMM)	Private Farms (FE)
Lagged TFP (TFPit−1_{it-1}it−1)	0.690 *** (0.018)	0.498 *** (0.005)	0.680 *** (0.013)	0.485 *** (0.007)	0.689 *** (0.032)	0.420 *** (0.017)
Land Use (LandUseit_{it}it)	0.012 *** (0.003)	0.011 *** (0.001)	0.017 *** (0.003)	0.008 *** (0.001)	0.011 *** (0.005)	0.009 *** (0.003)
Labor Efficiency (LaborEffit_{it}it)	0.034 *** (0.009)	0.023 *** (0.001)	0.038 *** (0.010)	0.032 *** (0.002)	0.037 *** (0.019)	0.017 *** (0.045)
Capital Investment (CapitalInvit_{it}it)	0.218 ** (0.044)	0.096 *** (0.014)	0.072 (0.051)	0.131 *** (0.018)	-0.074 (0.116)	0.053 (0.051)
Age (Ageit_{it}it)	0.001 (0.001)	0.002 *** (0.005)	-0.002 *** (0.001)	0.001 *** (0.000)	0.002 (0.002)	0.003 *** (0.001)
Crop Yield (CropYieldit_{it}it)	-0.157 *** (0.018)	-0.264 *** (0.005)	-0.168 *** (0.015)	-0.168 *** (0.005)	-0.136*** (0.032)	-0.137 *** (0.013)
Livestock Production (LivestockProdit_{it}it)	-0.517 *** (0.116)	-1.885 *** (0.082)	-0.841 *** (0.232)	-1.690 *** (0.096)	-0.495 (0.352)	-1.413 *** (0.152)
Sustainability Practices (Sustainabilityit_{it}it)	0.041 *** (0.015)	0.184 *** (0.005)	0.042 *** (0.018)	0.122 *** (0.005)	0.002 (0.016)	0.095 *** (0.009)
Debt Ratio (DebtRatioit_{it}it)	0.012 *** (0.003)	0.009 *** (0.001)	0.013 *** (0.002)	0.011 *** (0.001)	0.009 *** (0.003)	0.008 *** (0.002)
m2 (p-value)	0.724	-	0.440	-	0.731	-
J (Hansen) 0.021 - 0.119 -					0.125	-
Lagged IV	t-2, Δt-1…	-	t-2, Δt-1…	-	t-2, Δt-1…	-
Observations	11,982	11,982	3,526	3,526	8,456	8,456

Note: Complied by authors according to [10;11]						

In Table 3, we can see the determination of total factor productivity (TFP) for each farm using the generalized multivariate method (GMM) and the estimation procedure (FE). Analysis of the role of key elements such as land use, labor productivity, capital investment, and sustainable practices, as well as characteristics such as age and financial status measure. The results are divided into three categories: All farms, state ownership enterprises (SOEs), and private farms. It was found that all product variables have positive and significant effects in all models and groups with lags. This finding shows that past productivity is an indicator of current productivity and that performance development is stable. Land use has a positive effect on overall productivity for all groups. Efficient land use leads to higher yields, suggesting that better land management can help improve yields and resource use regardless of ownership type. A positive effect of labor performance on overall productivity is seen across all groups and models. This suggests that farms that optimize labor distribution or labor productivity can increase overall productivity. In general, capital investment can increase overall productivity, especially in SOEs. This relationship highlights the important role of infrastructure, equipment, and other investments in increasing productivity. However, the results for specific farms based on GMM are less clear and insignificant, which may reflect differences in the use of capital or capital resources. Farm age has a positive effect on TFP in most models, but the magnitude of this effect is small. Older farms may benefit from experience and sustainable practices that increase profitability. In many communities, crop yields have a negative effect on total productivity. This flawed research suggests that improving yields can prevent over-dependence on inputs or diminishing returns, reducing overall profits. The effect of livestock production on total output is mixed. The GMM results show a strong correlation reflecting the effects of short-term effects on livestock. However, the FE model has drawbacks that may reflect the long-term limitations or inefficiencies associated with livestock. Sustainable practices have positive and positive effects on TFP in all types and groups. Agriculture has adopted environmentally sound practices such as conserving resources, reducing environmental impact and achieving higher productivity. Borrowing costs have a positive impact on TFP. Farmers that use external financing effectively can increase profitability by allocating resources to investments that increase production.

When we explain the validity of the models, it is seen that the risk of the product over time is well recognized in both models and its inclusion as a key variable in determining TFP is supported. Hansen J data analysis of the validity of the tools used in GMM estimation. The absence of second order autocorrelation ensures the reliability of the GMM estimation.

All in all,while state enterprises benefit more from capital investment, private farms rely more on labor intensive activities. The results emphasize the importance of sustainable agriculture and resource utilization in a way that benefits all types of farming.

Conclusion

This study provides information on the determinants of total factor productivity (TFP) in agriculture, focusing on state-owned enterprises (SOEs) and private farms. The findings highlight the importance of increasing productivity, group diversity, and the impact on policy and practice. Production efficiency has become an important predictor of overall productivity, reflecting the sustainability of performance improvements over time. This highlights the importance of continuing professional development and training. Land-use efficiency and changes in productivity have been identified as important and mutually beneficial factors for TFP, emphasizing the need for resource management and efficiency. It is good for improving agriculture. The impact of capital investment on total output has been reported in state-owned enterprises, which appear to benefit significantly from infrastructure and technology development. However, this effect is less pronounced for private farms, perhaps reflecting differences in water supply or importance. The adoption of environmentally friendly practices has a positive impact on overall productivity in all types of agriculture, supporting the mission of resource conservation and environmental responsibility in agriculture.

Labor productivity is higher in private farms than in state ownership enterprises, which is consistent with their higher productivity. This shows that private enterprises are effective in optimizing resource use. In contrast, state ownership enterprises rely more on investment to improve production, which shows their advantage in using their resources to improve infrastructure and equipment. Although state ownership are generally older due to their historical background, these characteristics do not lead to increased productivity. This suggests the need to reorganize practices regardless of the organization's mission. This may indicate that the decline is due to oversupply or inefficient farming. Crop production results provide a mixed picture. While overall productivity increases in the short term, these positive effects may be offset in the long term by resource constraints or inefficiencies in livestock production.

The findings highlight the importance of promoting sustainable agriculture that not only delivers high productivity but also meets environmental objectives. The private agricultural sector should consider strategies to increase investment efficiency, while SOEs can benefit from improved operational management. Priority should be given to eliminating inefficiencies in crop production and livestock management to reduce production losses and ensure overall development.

In summary, this study highlights various factors that determine the overall productivity of agricultural products and identifies differences between SOEs and private enterprises. The findings highlight the importance of adapting strategies to specific strengths and weaknesses of various agricultural systems while promoting sustainable practices and resource use to support long-term production.

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АУЫЛ ШАРУАШЫЛЫҚ САЛАСЫНДАҒЫ ӨНДІРІСТІЛІК ПЕН ТҰРАҚТЫ ДАМУ: МЕМЛЕКЕТТІК ҚӘСІПОРЫНДАР МЕН ЖЕКЕ ШАРУАШЫЛЫҚТАРҒА ҚАТЫСТЫ ЗЕРТТЕУЛЕР

Ауыл шаруашылығы секторы жаһандық экономикалық даму, азық-түлік қауіпсіздігі және экологиялық тұрақтылық үшін маңызды рөл атқарады. Бұл зерттеу ауыл шаруашылығындағы жиынтық

факторлық өнімділікті (TFP) анықтайтын факторларды зерттеуге бағытталған, мемлекеттік кәсіпорындарға (МК) және жеке шаруашылықтарға баса назар аударылған. Қазақстандағы 11 982 шаруашылық туралы он жылдық мәліметтер негізінде жерді пайдалану тиімділігі, еңбек өнімділігі, капиталға инвестициялау және тұрақты тәжірибелерді енгізу сияқты негізгі аспектілер қарастырылады. Зерттеу нәтижелері МК мен жеке шаруашылықтар арасындағы айтарлықтай айырмашылықтарды анықтады. Жеке шаруашылықтар жоғары еңбек өнімділігі мен ресурстарды тиімді бөлудің арқасында жоғары өнімділік көрсетсе, МК инфрақұрылым мен капитал салымдарының артықшылықтарын көбірек пайдаланады. Кешіктірілген TFP көрсеткіші ағымдағы өнімділіктің маңызды болжаушысы болып табылады, бұл уақыт өте келе тиімділіктің тұрақтылығын көрсетеді. Жерді пайдалану және тұрақты тәжірибелер TFP-ге оң әсер етеді, бұл ресурстарды оңтайландыру мен экологиялық жауапты шаруашылық жүргізудің маңыздылығын көрсетеді. Сонымен қатар, өнімділіктің TFP-мен теріс корреляциясы байқалады, бұл ресурстарға тым тәуелділікпен байланысты тиімсіздік пен азаюшы қайтарымдылықты көрсетеді. Бұл зерттеу саясатты әзірлеушілер мен мүдделі тараптар үшін практикалық ұсынымдар береді, әртүрлі шаруашылық түрлерінің бірегей артықшылықтары мен мәселелерін ескере отырып, жекелендірілген стратегиялардың қажеттілігін атап көрсетеді. Тұрақты тәжірибелерді ілгерілету және ресурстарды пайдалануды оңтайландыру өнімділікті арттырып, ауыл шаруашылығы мақсаттарын кеңірек экономикалық және экологиялық міндеттермен сәйкестендіруге мүмкіндік береді.

Кілтті сөздер: жиынтық факторлық өнімділік (TFP), ауыл шаруашылығы, капиталға инвестициялау, тұрақты ауыл шаруашылық, мемлекеттік кәсіпорындар (МК).

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ПРОИЗВОДИТЕЛЬНОСТЬ И УСТОЙЧИВОЕ РАЗВИТИЕ В СЕЛЬСКОМ ХОЗЯЙСТВЕ: ИССЛЕДОВАНИЕ ГОСУДАРСТВЕННЫХ ПРЕДПРИЯТИЙ И ЧАСТНЫХ ФЕРМ

Сельскохозяйственный сектор играет ключевую роль в глобальном экономическом развитии, обеспечении продовольственной безопасности и экологической устойчивости. В данном исследовании рассматриваются факторы, определяющие совокупную факторную производительность (TFP) в сельском хозяйстве, с акцентом на государственные предприятия (ГП) и частные фермы. На основе данных за десять лет о 11 982 фермах Казахстана исследуются такие ключевые аспекты, как эффективность использования земли, производительность труда, инвестиции в капитал и внедрение устойчивых практик.

Результаты исследования выявляют значительные различия между ГП и частными фермами. Частные фермы демонстрируют более высокую производительность, что в значительной степени обусловлено более высокой эффективностью труда и распределением ресурсов, тогда как ГП получают больше выгоды от капитальных вложений и инфраструктуры. Отложенный показатель TFP является критическим предиктором текущей производительности, подчеркивая устойчивость улучшений эффективности с течением времени. Использование земельных ресурсов и устойчивые практики положительно влияют на TFP, что отражает важность оптимизации ресурсов и экологически ответственного ведения сельского хозяйства. В то же время урожайность имеет отрицательную корреляцию с TFP, что указывает на неэффективность и убывающую отдачу, связанную с чрезмерной зависимостью от ресурсов.

Данное исследование предоставляет практические рекомендации для разработчиков политики и заинтересованных сторон, подчеркивая необходимость индивидуальных стратегий для учета уникальных

сильных сторон и проблем различных типов хозяйств. Продвижение устойчивых практик и оптимизация использования ресурсов позволят повысить производительность, согласовывая сельскохозяйственные цели с более широкими экономическими и экологическими задачами.

Ключевые слова: совокупная факторная производительность (TFP), сельское хозяйство, инвестиции в капитал, устойчивые сельскохозяйство, государственные предприятия (ГП).

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