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# Unravelling risk factors in Turkish wheat in a changing global landscape

*Huseyin Tayyar Guldal*[1], *Ozdal Koksal*[1]*, *Osman Orkan Ozer*[2], *Onur Terzi*[3], *Erdogan Gunes*[1], *Aysegul Selisik*[4]

[1]*Department of Agricultural Economics, Ankara University, Ankara, Türkiye*
[2]*Department of Agricultural Economics, Adnan Menderes University, Aydin, Türkiye*
[3]*The Economy Bank of Türkiye, Istanbul, Türkiye*
[4]*Food and Agriculture Organization of the United Nations, Ankara, Türkiye*

**Corresponding author: okoksal@ankara.edu.tr*

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**Abstract:** This study comprehensively examines multifaceted risk factors influencing wheat production among Turkish farmers, aiming to deepen understanding of how these factors shape farmers' perceptions and decision-making processes. Utilising Structural Equation Modeling (SEM), we analysed the interplay of climate-related issues (F1), market dynamics (F2), and external events (F3), like COVID-19 and wars, alongside socio-demographic factors such as education, income, and land ownership. Findings revealed that higher education and increased agricultural income reduced price-related risks while expanding wheat cultivation areas heightened risk perceptions. Farmers in irrigated regions prioritised cyclical risks, whereas those in dry areas perceived climatic risks as more severe. Capital-intensive practices and storage facilities mitigate climate change and market variability risks, with committed wheat producers showing lower climate change risk perceptions. External factors like the Russian-Ukrainian war and the COVID-19 pandemic disproportionately impact irrigated area farmers. This study contributes to the existing literature by using empirical evidence from Turkish wheat farming to explore diverse risk perceptions, employing SEM to unravel complex risk factors and decision-making processes, thereby offering new insights for future agricultural risk management research.

**Keywords:** climate change; COVID-19; food security; Russian-Ukrainian war; Structural Equation Modeling

Wheat, a cereal crop boasting a rich historical legacy, has played a pivotal role in the development of human civilisation. Originating from the wild species *Triticum monococcum* and *Triticum boeoticum* in the Near East approximately 10 000 years ago, it became one of the first cultivated grasses and significantly influenced the establishment of settled societies and the oldest cities in Anatolia (Boissier 1849). Presently, wheat retains paramount importance as a staple crop, meeting nearly half of the world's daily energy needs. Given its strategic significance, the sustenance and productivity of wheat are subject to various risks, which hold profound implications for global food security (Shiferaw et al. 2013).

The escalating global population growth further accentuates the critical role of wheat in ensuring food sufficiency. Given its extensive utilisation as a primary source of human nutrition, any disruption in wheat production can precipitate far-reaching consequences.

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However, the future of wheat production faces mounting challenges. Recent studies have issued warnings regarding ongoing wheat yield losses attributable to changing climate patterns (Zhang et al. 2021). The impact of these changes is expected to be particularly pronounced in the ensuing years (Luo et al. 2007; Juroszek and von Tiedemann 2013; Trnka et al. 2014; Clarke et al. 2021; Kusunose et al. 2023).

While wheat yields are under pressure due to climate change, the outbreak of COVID-19 has brought agriculture and food supply chains, especially wheat, into sharp focus. While uncertainties in the market pushed wheat prices up (Vercammen 2020), the importance of the agricultural sector in the pandemic period was once again emphasised in terms of food security and food supply (Balwinder-Singh et al. 2020).

Amidst the escalating global challenges to wheat production, geopolitical conflicts have emerged as a critical risk factor, casting ominous shadows over food supply and demand patterns. The ongoing devastating war between major grain producers, Russia and Ukraine, the largest wheat exporters [in the 2022/23 production season, Russia accounted for 21.0% of global wheat exports, while Ukraine contributed 7.7 % to the total world wheat exports (TEPGE 2023)] exemplifies how territorial disputes can profoundly disrupt wheat production, accessibility, and pricing (Novotná et al. 2023). Historically, political and security instability has threatened food security (Genung 1940; Gibson 2012), affecting the livelihoods of rural populations (Moffat 2022; Manaye et al. 2023). Indeed, Deininger et al. (2023) reported a 17% decrease in winter wheat production in 2022 due to the war, while the United States Department of Agriculture (USDA) report indicated a decrease of 13.5 million tons in wheat production compared to the previous season (USDA 2022).

The ramifications of this ongoing conflict extend beyond regional borders, sending shockwaves throughout the global food security landscape and intricately influencing international trade dynamics (Ben Hassen and El Bilali 2022; Deininger et al. 2023). It is asserted that the war has led to increased wheat prices (Kebe and Nadarajah 2023) and posed a serious threat to food security (Wudil et al. 2022), particularly in African countries where over one-third of wheat imports originate from Russia and Ukraine. The price of bread wheat, standing at USD 250 per tonne before the pandemic, surged to USD 450 per tonne with the onset of the pandemic, and further escalated with the advent of the war. This escalation, when reflected in other grain and food products, propelled food inflation to unprecedented levels, elevating food security to the forefront of national concerns. Prolongation of the war may also precipitate disruptions in the fertiliser logistics of Russia, a global fertiliser supplier.

On February 24, 2022, with the commencement of Russia's aggression against Ukraine, numerous grain cargo ships in Ukraine's Black Sea ports found themselves unable to depart. Addressing the complexities arising from these risks and the imperative to remove grain from ports via suitable routes, a pivotal step was taken with the signing of the Grain Corridor Agreement in July 2022. This landmark agreement facilitated the opening of three key ports on the Black Sea in Ukraine, enabling the transportation of approximately 25 million tonnes of grain to the global market. A primary objective of this accord, forged between Ukraine and Russia, was to enhance grain trade and foster price stabilisation within the corridor. Türkiye, acting as a mediator, played a crucial role in temporarily ensuring control over this critical process.

Türkiye stands as one of the most significant wheat-producing countries globally, with Russia and Ukraine serving as its primary wheat importers. Türkiye primarily imports its wheat from Russia and Ukraine. While the quantity of wheat imported from Russia has shown an increasing trend over the years, the proportion of Russian wheat in Türkiye's total imports has declined from 90% to 72% by 2021. This shift was attributed to the growing demand for imported wheat within Türkiye, prompting the entry of new suppliers into the market. Consequently, significant wheat purchases from Ukraine, Moldova, and Canada began in 2021, compared to minimal purchases in 2012. Despite these developments, Türkiye remains the largest buyer of Russian wheat. Following Türkiye, Egypt and Azerbaijan are the primary purchasers of Russian wheat. Additionally, Türkiye ranks as the third-largest importer of wheat from Ukraine. In summary, Türkiye holds a crucial position among global wheat buyers. Therefore, it is inevitable that the war between Russia and Ukraine, which are Türkiye's most important importers, will have an impact on wheat production and trade in Türkiye. The wheat sector is currently grappling with a variety of risk factors, such as climate change, global economic crises, the COVID-19 pandemic, and geopolitical conflicts, making the responses of Turkish wheat farmers and the policies implemented to mitigate these risks crucially important.

Particularly, given that approximately 90% of Türkiye's farmers are small-scale and are especially vulnerable to these pressures (Manaye et al. 2023), un-

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derstanding their responses to risk factors in terms of sustainability becomes essential. Our study provides a comprehensive analysis of how wheat farmers respond to various risks, while also contributing new insights into the global wheat production landscape, even though it focuses specifically on Türkiye. By using a model that explores the complex relationships between socioeconomic characteristics and risk factors, we aimed to uncover how these factors influence farmers' risk perceptions and decision-making processes. This approach not only helped us understand how farmers react to such risks but also offered a deeper understanding of the multifaceted nature of agricultural risk management.

Previous research emphasised the significant role of socioeconomic factors in shaping risk perceptions (Etana et al. 2021; Osiemo et al. 2021; Yarong and Minpeng 2021). However, considering the negative effects of geopolitical risks on agricultural markets (Tiwari et al. 2021), Türkiye's unique geopolitical position and its critical role in global wheat production make this study stand out from others.

**Türkiye's position in the wheat sector.** Situated at the intersection of Asia, Europe, and the Middle East, Türkiye boasts a strategic geographical location that fosters a diverse range of agro-climatic conditions conducive to wheat cultivation. This unique positioning affords the country a crucial role in both winter and spring wheat production, thereby making significant contributions to the global wheat supply chain.

The extensive cultivation of wheat across Türkiye further underscores its significance as a major wheat-producing nation. Wheat ranks foremost in terms of both cultivation area and production volume, solidifying its status as a strategic crop within the country's agricultural landscape. With a diverse array of microclimates and growing conditions, Türkiye successfully cultivates wheat in nearly every region, enhancing its resilience against climate-induced risks and vulnerabilities. This adaptability is pivotal in ensuring a consistent and stable wheat output, thereby contributing to overall food security, not only within Türkiye but also on a global scale. Despite significant decreases in wheat cultivation areas over the last decade, wheat production has remained stable and even increased in some instances. For instance, in 2012, Türkiye produced 20.1 million tonnes of wheat on 7.5 million hectares of land, whereas in 2022, 19.8 million tonnes of wheat were harvested on 6.6 million hectares of land (TurkStat 2023).

The significance of wheat for the Turkish economy extends beyond production. As one of the foremost exporters of flour and pasta worldwide, Türkiye also imports wheat from abroad to supplement domestic production. This strategic approach not only ensures high utilisation rates for domestic producers but also facilitates foreign currency inflow to the country. Prior to the pandemic, Türkiye imported between 6 to 7 million tonnes of wheat, a figure that surged to over 10 million tonnes during the pandemic period. Failure to achieve sufficient wheat production in Türkiye or address the raw material deficit could potentially lead to idle capacity issues within the domestic industry (Table 1).

Wheat serves as a fundamental staple in Türkiye, akin to numerous countries worldwide. Flour derived from wheat finds application in the production

Table 1. Wheat balance sheet in Türkiye

| Indicators | Season | | | | |
|---|---|---|---|---|---|
| | 2021/22 | 2020/21 | 2019/20 | 2018/19 | 2017/18 |
| Production (tonnes) | 17 650 000 | 20 500 000 | 19 000 000 | 20 000 000 | 21 500 000 |
| Cultivation area (ha) | 6 744 666 | 6 922 237 | 6 846 327 | 7 299 271 | 7 668 879 |
| Harvest losses (tonnes) | 970 750 | 1 127 500 | 1 045 000 | 1 100 000 | 1 182 500 |
| Supply = use (tonnes) | 26 204 316 | 27 610 481 | 28 748 317 | 25 367 562 | 26 427 069 |
| Usable production (tonnes) | 16 679 250 | 19 372 500 | 17 955 000 | 18 900 000 | 20 317 500 |
| Imports (tonnes) | 9 525 066 | 8 237 981 | 10 793 317 | 6 467 562 | 6 109 569 |
| Domestic use (tonnes) | 19 114 670 | 18 934 082 | 20 069 822 | 18 804 861 | 18 186 979 |
| Human consumption (tonnes) | 15 184 041 | 14 782 565 | 16 034 511 | 14 714 796 | 14 107 643 |
| Seed use (tonnes) | 1 214 040 | 1 246 003 | 1 232 339 | 1 313 869 | 1 380 398 |
| Animal feed (tonnes) | 2 145 110 | 2 338 951 | 2 267 299 | 2 212 504 | 2 093 098 |
| Exports (tonnes) | 7 898 297 | 7 583 765 | 7 530 767 | 7 873 454 | 7 489 664 |

Source: TurkStat (2023)

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of various foods such as pasta, bulgur, noodles, couscous, biscuits, crackers, wafers, cakes, bagels, pastries, breakfast cereals, snack foods, starch, vital gluten, and starch-based sugars. Bran obtained from wheat grinding primarily serves the feed industry.

## MATERIAL AND METHODS

**Research region and data collection.** In Türkiye, there exist 19 provinces with wheat production exceeding thirty thousand tonnes. These provinces collectively contribute to approximately 45% of Türkiye's wheat production (TurkStat 2023). Among these provinces, a subset of eight was meticulously selected for research purposes, with careful consideration given to factors such as dry and irrigated areas, as well as bread and durum wheat production. This meticulous selection process aimed to ensure representation from various regions, thereby augmenting the research's regional validity.

The selected provinces, namely Konya, Ankara, Şanlıurfa, Diyarbakır, Tekirdağ, Adana, Kahramanmaraş, and Yozgat, serve as focal points in Türkiye's wheat production landscape, collectively contributing to approximately 40% of the nation's wheat output. According to data from the Farmer Registration System (FRS), an estimated 56 478 farmers primarily engage in wheat production within these provinces. However, conducting a comprehensive survey encompassing all these enterprises proved unfeasible due to constraints such as time, cost, and labour. Therefore, a proportional sampling method was adopted to determine the number of wheat producers to be interviewed in the selected provinces, resulting in a meticulously calculated sample size of 311. Map of the research area is presented in Figure 1.

The calculation method was realised as follows Newbold et al. (1995):

$$n = \frac{Np(1-p)}{(N-1)Q_{px}^2 + p(1-p)} \tag{1}$$

where: $n$ – sample population; $N$ – total number of wheat farmers; $p$ – proportion of wheat production area (37.27%) within the total wheat production area of the eight provinces included in the sample. For the study, the number of questionnaires was determined with 92.5% confidence and a 5% margin of error. The confidence interval was set at 3.75% two-sided.

The field study encompassed several provinces, and surveys were conducted in specific districts within each province. To ensure comprehensive coverage and consider various factors such as production areas, logistics facilities, and prior field expertise of experts, the following districts were selected for the fieldwork in each province:

– Konya; Çumra, Ereğli, Ilgın, Karapınar, Kulu, Sarayönü ve Yunak

– Şanlıurfa; Harran, Siverek, Haliliye, Eyyübiye, Karaköprü, Bozova

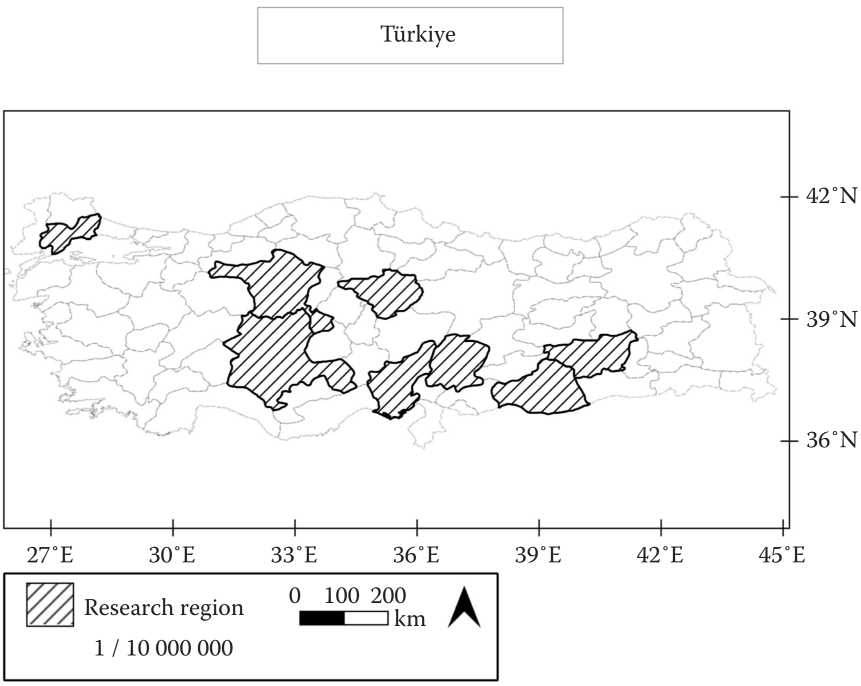


Figure 1. Map of research area

Source: Author's own elaboration

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– Tekirdağ; Süleymanpaşa, Muratlı, Hayrabolu
– Adana; Ceyhan, Çukurova, Karataş, Sarıçam, Yüreğir, Kozan
– Ankara; Polatlı, Evren, Bala, Haymana, Şereflikoçhisar
– Diyarbakır; Yenişehir, Sur, Bismil
– Kahramanmaraş; Türkoğlu, Pazarcık
– Yozgat; Yerköy, Şefaatli

The field study concluded on January 16, 2023, encompassing the situation and risks observed prior to the February 6, 2023, Kahramanmaraş earthquake. On February 6, 2023, two catastrophic earthquakes struck the Pazarcık and Elbistan districts of Kahramanmaraş, with magnitudes measuring 7.7 and 7.6, respectively. These seismic events had epicentres located at focal depths of 8.6 km and 7 km. Subsequently, on February 20, 2023, at 20:04 Türkiye time, another earthquake, registering a magnitude of 6.4, occurred with its epicentre in Yayladağı, Hatay. These three earthquakes resulted in extensive damage and destruction across 11 provinces, affecting a total of 14 013 196 individuals, which accounted for approximately 16.4% of the country's population in 2022.

**Statistical analysis.** In the study, we conducted face-to-face surveys with 311 wheat farmers. Data scaling involved categorising education levels into primary school (primary and middle school), high school, and university degrees, while income levels were assessed using five scales. These scales ranged from farmers with an income of less than USD 532.48 to those with incomes of USD 2 129.94 or more per month. Additionally, data related to wheat production areas in the farms were included in the model as continuous data. The study also considered the type of wheat produced, distinguishing between bread wheat (1), durum wheat (2), and certified wheat seed (3) producers. Other variables incorporated into the model encompassed wheat production in irrigated areas, non-agricultural income, storage capabilities post-production, and the availability of tools and machinery (Table 2).

For our analysis of wheat producers' perceptions of risk factors based on socioeconomic criteria, we employed structural equation modelling (SEM). This method allows us to establish three latent structures in the model by directly incorporating risk factors (F) and socioeconomic variables to explain these structures.

Table 2. Descriptive statistics

| Variables | Description | Min. | Max. | Mean | SD |
|---|---|---|---|---|---|
| Education | 1: Primary school<br>2: High school<br>3: University | 1 | 3 | 1.54 | 0.75 |
| Income | 1: ≤ USD 532.48<br>2: USD 532.49–1 064.96<br>3: USD 1 064.97–1 597.44<br>4: USD 1 597.45–2 129.93<br>5: ≥ USD 2 129.94 | 1 | 5 | 3.04 | 1.48 |
| Land | wheat cultivated area (ha) | 10 | 7 000 | 607.89 | 913.25 |
| Wheat_type | 1: bread wheat<br>2: durum wheat<br>3: certified seed | 1 | 3 | 1.44 | 0.69 |
| Irr_land | 0: no<br>1: yes | 0 | 1 | 0.39 | 0.49 |
| Non_agri_income | 0: no<br>1: yes | 0 | 1 | 0.61 | 0.49 |
| Storage | 0: no<br>1: yes | 0 | 1 | 0.53 | 0.50 |
| Tools_equipment | 0: no<br>1: yes | 0 | 1 | 0.64 | 0.48 |

1 USD= 18.78 Turkish lira as of January 16, 2023
Source: Own calculation

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Descriptive statistics for the risk factors are provided in Table Sl the Electronic Supplementary Materials (ESM).

SEM represents a powerful amalgamation of statistical techniques, combining elements from factor analysis and multiple regression. Its primary objective is to examine the relationships between one or more independent variables and one or more dependent variables. Notably, both the dependent variable (F) and independent variables (socioeconomic variables) can take on continuous or discrete forms (Nokelainen et al. 2007).

The essence of SEM lies in its ability to investigate intricate associations between explicit (observed, measured) and latent (unobserved, unmeasured) variables, encompassing both causal relationships (indicated by one-way arrows) and correlational connections (indicated by two-way arrows) (Hoyle 1995). It serves as a confirmatory rather than exploratory approach, shedding light on potential relationships between variables and estimating measurement error (Suhr 2002).

The SEM method has proven useful in various studies, exploring the interconnections between environmental, social, and economic indicators in the context of adopting sustainable agriculture (Sarkar et al. 2021), examining the impact of technological knowledge transfer on the adoption of novel technologies (Toma et al. 2018), and investigating the intricate links between climate change, irrigation water, agriculture, rural livelihoods, and food security (Usman et al. 2023). These examples showcase SEM's versatility and effectiveness as a robust analytical tool in diverse research domains.

We collected data during the survey phase by assessing wheat producers' views on six different uncertainties. Respondents used a 10-point scale to indicate potential crop loss percentages, ranging from 1 (indicating a 10% crop loss) to 10 (indicating a 100% crop loss) for each uncertainty. The survey included questions such as 'To what extent will you lose crops if irregular rainfall occurs?' or 'To what extent will you lose crops if you cannot find foreign labour?'. These scale values were later incorporated as dependent variables in the SEM model.

The risks and uncertainties addressed in the survey encompassed irregular rainfall, drought, diseases and pests, fluctuations in product prices, fluctuations in input prices, agricultural supports, cyclical events (e.g. COVID-19, Ukraine-Russia war, etc.), foreign labour (comprising seasonal agricultural workers and refugees engaged in agriculture), and agricultural insurance. Participants estimated the percentage of potential crop losses in wheat production in response to each of these risks and uncertainties, based on the survey questions, such as 'How much would your estimated crop loss be if you do not apply for agricultural insurance or do not receive government support?'.

To investigate the influence of socioeconomic characteristics on producers' perceptions of risks, we included socioeconomic variables as independent variables in the SEM model. These variables were collected through the questionnaire and encompassed education level, age, income, non-agricultural income, type of wheat production (bread, durum, and certified wheat seed producers), irrigation capabilities for the wheat area, land size, and adequacy of equipment and machinery. Furthermore, in order to explore the mutual effects of risk factors, the decision of whether or not to produce wheat in the future was added as an independent variable.

The variables incorporated into the model are widely recognised in the global literature as key factors influencing farmers' risk attitudes (Akhtar et al. 2018; Farhan et al. 2022). Socioeconomic and demographic factors, such as age, education level, income, and land ownership, have consistently been shown to shape farmers' risk perceptions and decision-making processes in various agricultural contexts. For example, studies from Europe and North America, including Meuwissen et al. (2001), highlight the significant role of these variables in determining risk management strategies. Jankelova (2017) identified a positive correlation between certain socioeconomic variables, such as land size, the number of years in a farm (the duration of time farmers have spent working on the farm), and price risk perceptions. Similarly, Hayran and Gül (2015) found comparable results, emphasising the impact of these socioeconomic factors on farmers' risk attitudes. Ullah et al. (2015) further asserted that household characteristics, such as the age and education level of the household head, off-farm income, and access to informal credit, significantly influenced farmers' risk attitudes. Sánchez-Cañizares et al. (2022) also emphasised how socioeconomic factors, such as farm size and labour type, influenced farmers' risk management decisions in Mediterranean agriculture. Harrison et al. (2007) found that risk aversion tended to decrease with age, particularly beyond 40, while higher education levels were associated with greater risk aversion. By integrating these factors into our SEM model, we aimed to explore the complex relationships between socioeconomic characteristics and risk perceptions in the context of wheat farming in Türkiye. This approach offers a comprehensive view of how farmers respond to risks like climatic change, market volatility, and external events such as pandemics and wars. Con-

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sequently, our study contributes to a deeper understanding of the multifaceted nature of agricultural risk management. Within the scope of the research model, the hypotheses were tested using structural equation modelling. The hypotheses addressed were as follows:

$H_1$: Socioeconomic variables significantly influence the perception of risk factor F1 (irregular rainfall, drought and diseases and pests).

$H_2$: Socioeconomic variables significantly influence the perception of risk factor F2 (input price, market price and subsidies)

$H_3$: Socioeconomic variables significantly influence the perception of risk factor F3 (cyclical events like COVID-19 and wars, foreign labour and agricultural insurance)

$H_4$: Risk perception significantly impacts wheat farmers' willingness to continue production in the future.

The identification and definition of risks are the foundational steps in any risk management process. Researchers have grouped agricultural risk factors in various ways. For instance, Hardaker et al. (2015) distinguish two main types of risks in agriculture: *i*) business risks, including production, market, institutional, and personal risks, and *ii*) financial risks, which arise from different methods of financing farm businesses. Similarly, Lucas and Pabuayon (2011) categorise risks into financial, production, and environmental risks.

In our study, we categorised the risk factors into three groups, corresponding to F1, F2, and F3.

F1, which focuses on irregular rainfall, drought, and pests, falls within the scope of production and environmental risks as described by Lucas and Pabuayon (2011). The unpredictability of weather patterns and the emergence of pests are known to significantly impact agricultural yields, as confirmed by the work of Trnka et al. (2015), who demonstrated the vulnerability of crops to climate variability.

F2, which addresses input prices, market prices, and subsidies, aligns with the market risk component of business risks as defined by Hardaker et al. (2015). Particularly, low wheat prices have been shown to reduce farmers' profitability and investment capacity, leading to a negative impact on productivity (Läänemets et al., 2011). These findings highlight how price volatility in agricultural markets shapes farmers' risk perceptions and influences their production decisions.

F3, which examines cyclical events such as COVID-19, wars, foreign labour, and agricultural insurance, can be classified under institutional risks, reflecting the broader global challenges that impact agricultural systems. These risks can also be categorised as catastrophic risks. Baum et al. (2013) emphasised in their discussion of global catastrophic risk that such events are disasters that lead to permanent declines in global human civilisation. The effects of pandemics and geopolitical tensions on agriculture were highlighted by Torero (2020), who discussed how these events disrupt supply chains and labour markets.

By categorising the risk factors in this way, our study aligns with the existing literature, while also contributing new insights specific to wheat production in Türkiye.

Table 3 shows standard goodness of fit measures.

Table 3. Standard goodness-of-fit measures

| Fit measures | Good fit | Acceptable fit |
|---|---|---|
| $\chi^2$ / SD | $0 \le \chi^2 / SD \le 2$ | $2 \le \chi^2 / SD \le 3$ |
| *RMSEA* | $0 \le RMSEA \le 0.05$ | $0.05 \le RMSEA \le 0.08$ |
| *SRMR* | $0 \le SRMR \le 0.05$ | $0.05 \le SRMR \le 0.10$ |
| *NFI* | $0.95 \le NFI \le 1.00$ | $0.90 \le NFI \le 0.95$ |
| *NNFI* | $0.97 \le NNFI \le 1.00$ | $0.95 \le NNFI \le 0.97$ |
| *CFI* | $0.97 \le CFI \le 1.00$ | $0.95 \le CFI \le 0.97$ |
| *GFI* | $0.95 \le GFI \le 1.00$ | $0.90 \le GFI \le 0.95$ |
| *AGFI* | $0.90 \le AGFI \le 1.00$ | $0.85 \le AGFI \le 0.90$ |

Comparative Fit Index (*CFI*): The *CFI* compares the fit of the proposed model to that of a null model (a model with no relationships between variables). A *CFI* value close to 1 indicates a good fit, with values above 0.95 generally considered acceptable. Adjusted Goodness of Fit Index (*AGFI*): The *AGFI* adjusts the *GFI* by considering the degrees of freedom in the model. Higher *AGFI* values suggest a better fit, and a value above 0.90 is typically deemed satisfactory. Goodness of Fit Index (*GFI*): The *GFI* assesses how well the model's predicted covariance matrix matches the observed covariance matrix. Values closer to 1 indicate a better fit, and a *GFI* value above 0.90 is often considered acceptable. Root Mean Square Error of Approximation (*RMSEA*): The *RMSEA* evaluates the discrepancy between the model and the observed covariance matrix, adjusted for model complexity. Smaller *RMSEA* values indicate a better fit, and a value below 0.08 is often considered indicative of an acceptable fit. $\chi^2$ index: The $\chi^2$ index evaluates the difference between the observed and predicted covariance matrices. A non-significant *P*-value (typically set at 0.05) suggests a good fit; however, this measure is sensitive to large sample sizes, making it less informative in such cases.
Source: Schermelleh-Engel et al. (2003)

## RESULTS AND DISCUSSION

In the study, confirmatory factor analysis was applied to categorise the nine risk factors identified through the questionnaire into three distinct factor groups. Cronbach's α values were calculated for each of these

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groups, indicating the internal consistency of the factors (F1 = 0.705, F2 = 0.676, F3 = 0.607) (Figure 2). The *CFI* (Comparative Fit Index) and *GFI* (Goodness of Fit Index) values obtained in the confirmatory factor analysis exceed 0.95, indicating the reliability of the results.

In SEM analyses, fit indices were scrutinised to assess the compatibility between the datasets obtained in the research. It was determined that the SEM, incorporating the factors and socioeconomic variables considered within the scope of the research, predominantly exhibited acceptable goodness of fit.

An analysis revealed that the education variable exhibited a negative impact on the perception of risk losses associated with the F2 factor. Similarly, both income level and non-agricultural income demonstrated a negative effect on F1 risk perception. Conversely, having non-agricultural income had a positive effect on F2 risk perception. As a result, an increase in the level of education and the income of the enterprise from agriculture led to a decrease in risk perceptions towards prices. In contrast, Aydogdu and Yenigun (2016) found that as the level of education decreases, so does the perception of risk. This discrepancy may be attributed to differences in regional or agricultural contexts or perhaps to the adoption of varying risk management strategies by less educated farmers in certain situations. This phenomenon suggests that farmers with higher education levels and higher agricultural income possess an enhanced capacity to devise strategic responses when confronted with potential risks in business decision-making processes. Such findings resonate with prior research studies (Harrison et al. 2007; Ullah et al. 2015). Notably, non-farm income emerges as a factor amplifying the perception of risk towards prices. As Rizwan et al. (2020) argue, farmers without non-farm income may perceive higher risk due to the lack of sufficient financial resources to withstand uncertainties. SEM diagram is shown in Figure 3.

As farmers expand their wheat cultivation areas, there is a corresponding increase in all risk perceptions. It can be inferred that as the wheat production area of land expands, farmers attach greater importance to all risk perceptions (Lucas and Pabuayon 2011). The expansion of land size within enterprises heightens the likelihood of diseases and pests spread-

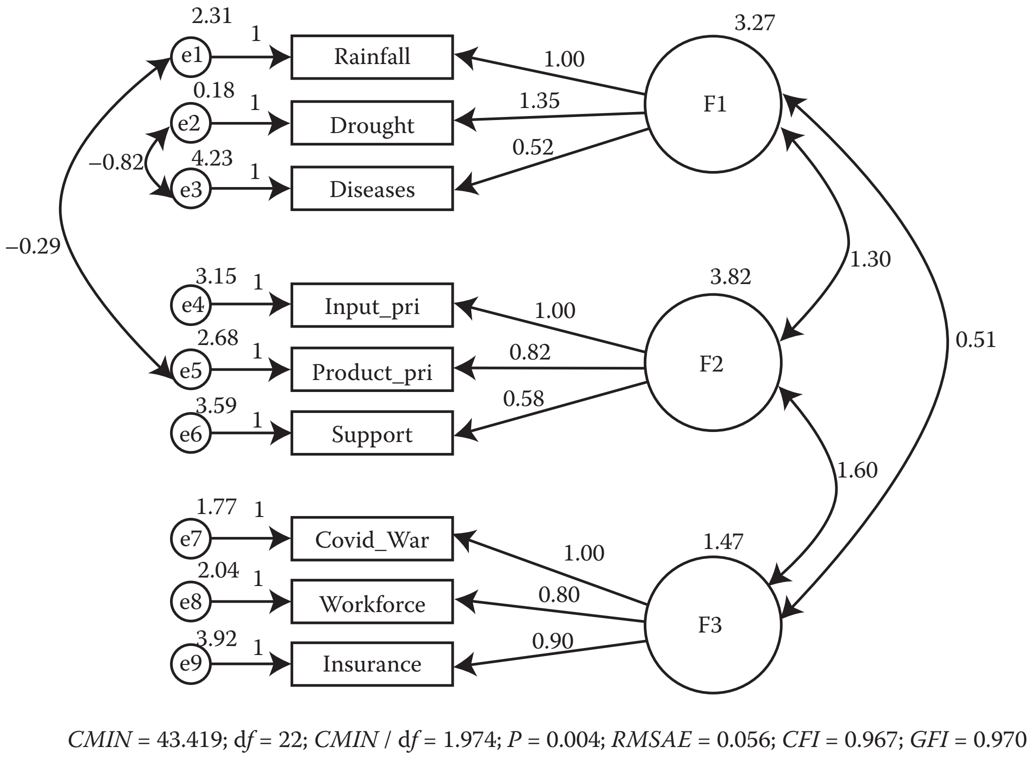


Figure 2. Diagram for confirmatory factor analysis

*CMIN* – Chi-squared ($\chi^2$) statistic; *RMSAE* – root mean square error of approximation; *CFI* – comparative fit index; *GFI* – goodness of fit index

Source: Own calculation

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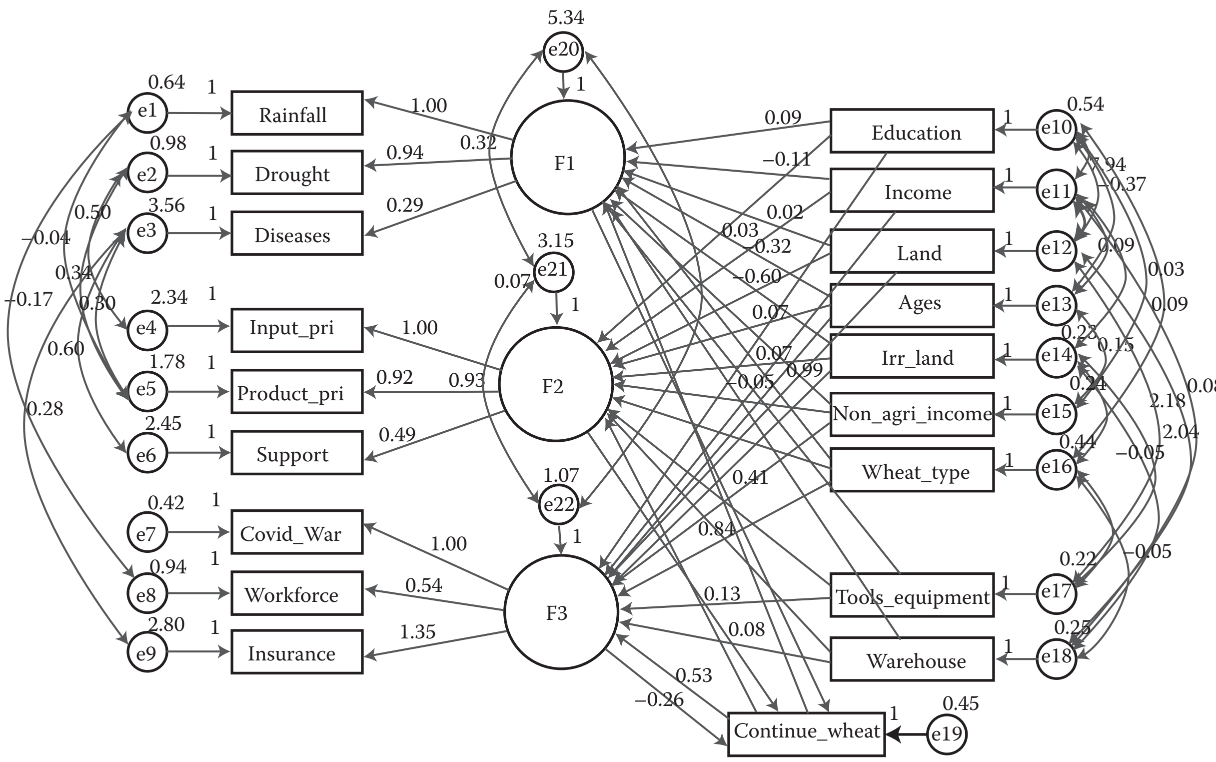


*CMIN* = 194.035; d*f* = 100; *CMIN* / d*f* = 1.940; *P* = 0.000; *RMSAE* = 0.055; *CFI* = 0.940; *GFI* = 0.999

Figure 3. SEM diagram

*CMIN* / d*f*: 1.940 (good fit); *RMSAE*: 0.055 (acceptable fit); *CFI*: 0.940 (acceptable fit); *GFI*: 0.999 (good fit); *AGFI*: 0.998 (good fit); *NFI*: 0.901 (acceptable fit); *CMIN* – Chi-squared ($\chi^2$) statistic; *RRMSAE* – root mean square error of approximation; *CFI* – comparative fit index; *GFI* – goodness of fit index; *AGFI* – adjusted goodness of fit index; *NFI* – normed fit index

Source: Own calculation

ing across larger areas, leading to increased crop losses. Additionally, as the land size grows, a greater demand arises for advanced agricultural mechanisation and digitalisation techniques. However, due to the high costs associated with such investments, farmers may be reluctant to take on these financial risks without sufficient government support (Guldal and Ozcelik 2024). Such circumstances may jeopardise production continuity by disrupting financial sustainability. Conversely, no statistically significant relationship was identified between the age of the business owner and risk perceptions (Table 4).

F1, pertaining to wheat farmers' irrigation capabilities, exerted a negative influence on risk perception. Conversely, F3, which encompassed cyclical risks, demonstrated a positive impact on farmers engaged in wheat production within irrigated agricultural areas. The primary rationale behind this observation lies in farmers' ability to mitigate potential droughts and similar climatic challenges through irrigated agriculture. While cyclical risks held greater significance for those practising irrigated agriculture, farmers engaged in dryland farming perceived climatic risks to pose more substantial threat (Arshad et al. 2013; Zhang et al. 2021). Consequently, drought emerged as the most critical risk factor for farmers with dry farmland, wherein production and yield were directly contingent upon rainfall.

For farmers who possessed storage facilities for the wheat produced within their enterprise, the perception of F1 risk exhibited a negative increasing effect. Moreover, both F1 and F2 risk perceptions demonstrated a negative impact on farmers equipped with sufficient machinery and equipment. This suggests that the adoption of capital-intensive production practices reliant on machinery and the availability of stor-

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Table 4. SEM Results

| Factors | Variables | $B_0$ | $B_1$ | SE | *CR* | *P*–value |
|---|---|---|---|---|---|---|
| F1 | Education | 0.092 | 0.030 | 0.203 | 0.454 | 0.650 |
| F2 | Education | –0.552 | –0.212 | 0.152 | –3.634 | 0.000*** |
| F3 | Education | –0.067 | –0.044 | 0.095 | –0.704 | 0.481 |
| F1 | Income | –0.107 | –0.072 | 0.080 | –1.342 | 0.180 |
| F2 | Income | –0.121 | –0.095 | 0.063 | –1.913 | 0.056** |
| F3 | income | –0.051 | –0.068 | 0.038 | –1.331 | 0.183 |
| F1 | non_agri_income | –0.689 | –0.151 | 0.277 | –2.488 | 0.013** |
| F2 | non_agri_income | 0.918 | 0.234 | 0.239 | 3.848 | 0.000*** |
| F3 | non_agri_income | –0.081 | –0.036 | 0.140 | –0.583 | 0.560 |
| F1 | irr_land | –0.721 | –0.156 | 0.276 | –2.612 | 0.009*** |
| F2 | irr_land | 0.205 | 0.052 | 0.217 | 0.948 | 0.343 |
| F3 | irr_land | 0.264 | 0.115 | 0.139 | 1.909 | 0.056** |
| F1 | land | 0.021 | 0.339 | 0.003 | 6.088 | 0.000*** |
| F2 | land | 0.009 | 0.170 | 0.003 | 3.202 | 0.001*** |
| F3 | land | 0.005 | 0.177 | 0.002 | 2.922 | 0.003*** |
| F1 | ages | 0.030 | 0.014 | 0.114 | 0.263 | 0.792 |
| F2 | ages | –0.072 | –0.039 | 0.107 | –0.674 | 0.501 |
| F3 | ages | –0.086 | –0.081 | 0.062 | –1.386 | 0.166 |
| F1 | tools_equipment | –0.986 | –0.208 | 0.279 | –3.533 | 0.000*** |
| F2 | tools_equipment | –0.407 | –0.100 | 0.233 | –1.748 | 0.080* |
| F3 | tools_equipment | –0.131 | –0.056 | 0.148 | –0.882 | 0.378 |
| Rainfall | F1 | 1.000 | 0.941 | – | – | – |
| Drought | F1 | 0.940 | 0.905 | 0.062 | 15.057 | 0.000*** |
| Diseases | F1 | 0.294 | 0.330 | 0.043 | 6.771 | 0.000*** |
| Input_pri | F2 | 1.000 | 0.782 | – | – | – |
| Procuct_pri | F2 | 0.915 | 0.796 | 0.064 | 14.240 | 0.000*** |
| Support_ | F2 | 0.485 | 0.511 | 0.054 | 9.038 | 0.000*** |
| Covid_War | F3 | 1.000 | 0.863 | – | – | 0.000*** |
| Workforce | F3 | 0.543 | 0.530 | 0.061 | 8.875 | 0.000*** |
| Insurance | F3 | 1.351 | 0.668 | 0.142 | 9.503 | 0.000*** |
| F1 | warehouse | –0.610 | –0.136 | 0.230 | –2.647 | 0.008*** |
| F2 | warehouse | –0.112 | –0.029 | 0.184 | –0.606 | 0.545 |
| F3 | warehouse | 0.077 | 0.035 | 0.118 | 0.654 | 0.513 |
| F1 | Wheat_type | 0.637 | 0.381 | 0.120 | 5.325 | 0.000*** |
| F2 | Wheat_type | 0.711 | 0.246 | 0.171 | 4.152 | 0.000*** |
| F3 | Wheat_type | 0.071 | 0.021 | 0.198 | 0.359 | 0.720 |
| F1 | Continue_wheat | 3.345 | 0.730 | 0.825 | 4.055 | 0.000*** |
| F2 | Continue_wheat | –0.915 | –0.233 | 0.594 | –1.542 | 0.123 |
| F3 | Continue_wheat | 0.532 | 0.234 | 0.345 | 1.540 | 0.124 |

*, **, *** $P < 0.01$, $P < 0.05$, and $P < 0.01$, respectively; SEM – Structural Equation Modeling; *B* – regression coefficients; *CR* – critical ratio

Source: Own calculation

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age facilities contributed to a reduction in F1 and F2 risk perceptions. Such infrastructure enables farmers to mitigate threats stemming from price risks through storage, both during and after production (Saha and Stroud 1994; Santeramo et al. 2014). However, it is essential to acknowledge that farmers may not always accurately predict returns from storage and could face downside price risk as a consequence (Cardell and Michelson 2023). The robust mechanisation infrastructure of farmers provides them with the capability to intervene in production process risks promptly and effectively, leveraging adequate technology.

The type of wheat cultivated significantly influenced F1 and F2 risk perceptions, exhibiting a positive effect. Risk perception increased incrementally from bread wheat to certified wheat production. In essence, F1 and F2 factors emerged as more pronounced risk factors for durum and certified wheat farmers compared to bread wheat farmers. The fact that certified seeds cater to a more niche market, are of higher quality, and typically command higher prices (Kugbei 2011) can be seen as contributing factors to the emergence of more pronounced risk factors.

The F1 risk factor positively affected the inclination to continue wheat production in the future. Given wheat's relatively higher resilience compared to other crops adaptable to both wet and dry conditions, it is reasonable to anticipate that farmers will favour wheat with lower risk exposure. The F1 factor inherently encompassed risks critical to production and achieving desired yields. In other words, it can be said that the F1 risk factor became a prerequisite for production. Furthermore, it can be posited that the adverse impact of this risk perception diminished as farmers enhanced their capacity to combat climate change and pest infestations. This assertion stems from the notion that even if prices of fundamental agricultural inputs like seeds, fertilisers, and pesticides decrease or receive subsidies through support policies, they are likely to pale in comparison to the challenges posed by unfavourable climate conditions. Moreover, the emergence of disease-resistant varieties (Singh et al. 2016) has further encouraged farmers to continue wheat production.

When analysing the F3 risk perception, which encompasses factors related to COVID-19 and the Ukraine-Russia war, it becomes evident that farms engaged in irrigated areas are most affected. Afterwards, the increase in wheat cultivation area increases the F3 risk. Given the paramount importance of high productivity for farmers involved in irrigated wheat production, characterised by enterprises with extensive cultivation areas and intensive production, chemical fertilisers assume a critical role. Russia, a leading global supplier of nitrogen, ascended to the position of the world's largest fertiliser exporter in 2020, boasting an estimated export volume of USD 7.6 billion (Anonymous 2024). The potential repercussions of the war on global fertiliser markets, Türkiye's reliance on importing these inputs from conflict zones, alongside the export of Turkish wheat to countries embroiled in conflict, collectively elevate risks in both input and product markets. Furthermore, disruptions in the agricultural supply chain following the COVID-19 pandemic (Urak 2023) and turbulence in the global economy and energy markets (Ali et al. 2020; Shaikh 2022; Wang et al. 2022) were poised to amplify F3 risk factors.

Upon comprehensive evaluation of the hypotheses, it is evident that socioeconomic variables, excluding age, significantly influenced risk perceptions ($H_1$, $H_2$, and $H_3$ hypotheses were accepted). Additionally, the hypothesis regarding the correlation between risk perception and wheat producers' inclination to sustain their production activities in the future was also confirmed.

## CONCLUSION

Wheat production holds substantial socioeconomic significance in Türkiye, with tens of thousands of farmers relying on its cultivation for livelihoods and a nationwide industrial infrastructure depending on it as a primary raw material. Climate-related risks, particularly drought (F1 risk factor), are among the most impactful challenges facing wheat production. For farmers, selecting the appropriate wheat variety is crucial, especially in terms of quality and resilience. Updating spring and winter wheat varieties offers a strategic approach to reduce risk exposure and bolster the sector's resilience against climate challenges. For policymakers, the role of agricultural insurance becomes equally vital. Subsidising insurance premiums for farmers, particularly for climate-related risks, would provide critical protection and financial security, ensuring the continuity of wheat production even under adverse environmental conditions. To strengthen the resilience of wheat production systems in Türkiye, the adoption of alternative agricultural techniques is essential, particularly in the face of challenges such as insufficient land reclamation, soil degradation, and low organic matter levels, along with rising fertiliser and irrigation costs (F2 risk factor). For farmers, adopting soil fertility-conserving practices, such as crop rotation, legume cultivation, green manure application, and no-tillage methods, can significantly

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enhance soil health and improve productivity. These methods not only improve soil quality but also help mitigate the risks associated with rising input costs. For policymakers, supporting these practices through targeted subsidies and educational programs is crucial. Promoting the use of organomineral fertilisers and modern irrigation techniques through financial incentives can help farmers reduce costs while maintaining soil fertility. Additionally, policies that facilitate access to these techniques, particularly for small-scale farmers, would further strengthen Türkiye's agricultural resilience against environmental and economic challenges. During our fieldwork in 2022, the Grain Corridor Agreement was in effect, facilitating global grain trade through Türkiye. However, in 2023, Russia withdrew from the agreement, citing discrepancies in its implementation, which deviated from the original objective of ensuring global food security. This development has significant implications for global grain markets and highlights Türkiye's critical role in stabilising wheat supply chains. The situation underscores the importance of understanding F3 risk factors, which include cyclical events like wars and global trade disruptions. Such events directly impact agricultural markets and increase uncertainty for wheat producers in Türkiye.

For Türkiye, the timing and volume of wheat imports under the agreement remain key considerations. A surge in imported wheat, particularly during the domestic harvest season, could result in an oversupply, leading to decreased prices for locally produced wheat. To address this, policymakers must implement measures to protect domestic farmers, such as regulating the timing of wheat imports and establishing minimum price guarantees for domestic wheat during peak harvest periods. These strategies are essential to preserving the integrity of Türkiye's wheat industry and ensuring fair market conditions for local producers in the face of F3 risks like geopolitical tensions and market volatility.

**Directions for future research.** While this study provides valuable insights into the risk factors influencing wheat production in Türkiye, future research could delve deeper into specific dimensions of these risks. For instance, further investigation into the long-term impacts of cyclical events such as wars and pandemics (F3 risk factor) on agricultural markets would be beneficial. Understanding how these events reshape risk perceptions and production strategies could provide more comprehensive risk management frameworks.

Additionally, given the growing challenges posed by climate change (F1 risk factor), future studies should explore adaptation strategies that farmers can employ to mitigate these risks. Research focusing on innovative agricultural technologies and practices, such as drought-resistant crop varieties and sustainable farming techniques, could offer critical insights into how farmers can enhance resilience against increasingly severe environmental conditions.

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