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Wheat Supply Security in the Context of Türkiye's Flour Industry:

Strategic Limits of the "Twin Transformation" Rhetoric and the Need for Radical Autonomy

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ABSTRACT

Türkiye has maintained its position as the world's leading flour exporter for eleven consecutive years. This success is largely built upon a model dependent on imported wheat processed under the Inward Processing Regime (IPR). However, two structural vulnerabilities are increasingly calling into question the sustainability of this model: first, climate change is raising the likelihood of simultaneous droughts across major wheat-producing regions — a phenomenon referred to as Multiple Breadbasket Failure (MBBF); second, the weakening enforcement capacity of the WTO is eroding the reliability of long-term supply agreements. When these two risks converge, Türkiye's import-dependent flour processing model exhibits significant vulnerability with respect to access to physical raw materials. The "Twin Transformation" (digitalization and green transition), positioned at the center of the sector's 2026 roadmap, does not address this vulnerability. Regardless of how digital or green factories become, production ceases if wheat is unavailable. This study argues that raw material supply security must take precedence over all other strategic priorities in the industrial agenda. It proposes strengthening domestic production and reinforcing the trade regime through WTO-aligned bilateral agreements.

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1. Introduction: Leadership and Structural Fragility

Türkiye has sustained its global leadership in flour exports for eleven consecutive years. As of 2025, with an export volume of approximately 2.5 million tons reaching over 160 countries, this performance is underpinned by the strategic institutionalization of an intermediate industrial model that processes raw agricultural inputs for re-export. Under the Inward Processing Regime (IPR), wheat imported at low cost—primarily from the Black Sea basin—is processed in high-capacity mills and supplied to global markets. This structure has positioned Türkiye as a unique nodal actor in the global food chain. With an annual milling capacity approaching 30 million tons, the country has evolved into a processing platform that adds value between production regions and consumption markets.

This success stems from the symbiotic interaction of three key factors: first, geographical advantage: proximity to the Black Sea production basin combined with simultaneous access to wheat-deficit regions such as the Middle East, North Africa, and Sub-Saharan Africa creates a unique logistical advantage in global grain trade.Second, industrial capacity: a milling sector modernized over three decades, equipped with AI-supported monitoring systems, advanced blending capabilities, and product flexibility, enabling customized production for diverse markets. Third, trade policy architecture: The IPR supports export-oriented production, transforming Türkiye into a trans-terminal processing hub within global grain flows rather than merely a production site.

However, this very model also generates structural fragility. Despite its leadership in flour exports, Türkiye's position is not anchored in a production base it directly controls but rather in the continuity of global wheat flows. In a world where global trade is increasingly shaped by geopolitical power dynamics and where climate change is reshaping agricultural geographies, this structural dependency is evolving from a matter of economic competitiveness into one of supply security.

This study advances three central arguments: (1) Climate change is increasing the probability of simultaneous production shocks — Multiple Breadbasket Failure (MBBF) — in the primary wheat-producing regions from which Türkiye imports, thereby threatening physical access to raw materials. (2) The erosion of the WTO's enforcement capacity undermines the reliability of long-term bilateral supply agreements as a sufficient safeguard. (3) In this context, the "Twin Transformation" agenda is a tool, not an objective. Without ensuring raw material supply security, the level of digitalization or environmental performance of factories has limited strategic relevance. Based on these arguments, the study advocates prioritizing the strengthening of domestic wheat production and establishing a legally grounded trade architecture as primary policy objectives.

2. Biophysical Risk: Climate Change and the Threat of Multiple Droughts

Conventional economic models typically treat climate change as an externality that gradually increases production costs and can be absorbed through market mechanisms. However, this approach is insufficient in the context of wheat production. Agricultural output is not governed solely by economic incentives but is constrained by biophysical thresholds. When price signals fail to increase production, market equilibrium mechanisms break down—not due to insufficient incentives, but because biological limits have been reached. Therefore, modeling the impacts of climate change on agriculture solely through price dynamics systematically underestimates the true extent of vulnerability.

Thermal Tolerance Thresholds and Heat-Induced Sterility

Wheat (Triticum aestivum) operates within a narrow thermal tolerance range, and its production performance depends critically on the delicate balance between phenological timing and temperature regimes. The primary determinant of agricultural risk is not the rise in average temperatures, but short-duration extreme heat events occurring during critical growth stages. Exposure to temperatures above 32–33°C for only a few hours during the flowering phase can lead to significant pollen sterility. This results in "sterile spikelets," causing yield losses in the range of 30–40%, even under adequate irrigation conditions

(Asseng et al., 2015). This is not a cost increase that can be offset by price signals; it is an irreversible biological failure.

Rising baseline temperatures also shorten the grain-filling period, compressing the plant's biological timeline and reducing yield potential. A shortening of this critical phase—during which carbohydrates produced via photosynthesis are stored as starch within the grain—even by a few days leads to a significant decline in thousand-kernel weight. Technological interventions such as fertilization, irrigation, and genetic improvement can partially mitigate these effects. However, once thermal thresholds are exceeded, the production system encounters a biophysical ceiling. This limit arises not from insufficient investment, but from inherent biological constraints.

The Risk of Multiple Breadbasket Failure (MBBF)

Historically, the global food system has relied on geographic diversification as a form of insurance: production losses in one region could be offset by gains elsewhere. As in conventional portfolio management logic, production risks have been assumed to be geographically independent, and global grain trade has functioned as a balancing mechanism drawing on this independence. However, structural changes in atmospheric circulation caused by climate change are increasingly invalidating this assumption.

The Arctic is warming significantly faster than the global average (a phenomenon known as Arctic amplification). This reduces the temperature gradient between the poles and mid-latitudes, weakening jet streams and enabling the persistence of atmospheric blocking systems that generate prolonged heatwaves and droughts across major grain-producing regions (Francis & Vavrus, 2012). Weakened jet streams also increase the amplitude of Rossby waves, causing weather systems to remain stationary for extended periods. Critically, these atmospheric structures operate not locally but at hemispheric scales. The same Rossby wave pattern can simultaneously generate temperature anomalies across the central regions of North America, the European plains, and the Eurasian steppe belt.

This risk, referred to as Multiple Breadbasket Failure (MBBF), denotes the possibility that the world's major grain-exporting regions—including Russia, Ukraine, the United States, Canada, the European Union, Australia, and Argentina—are exposed to the same climatic shocks simultaneously or in close succession (Gaupp et al., 2020). In such a scenario, the global trade system ceases to function as a balancing mechanism because no compensating production region remains. Agriculture is not scalable in the short term; constraints such as land availability, soil quality, and planting cycles delay supply responses. Prices may rise, but higher prices do not translate into increased supply.

Financial Implications: From Price Volatility to Physical Liquidity Crisis

The economic consequences of MBBF extend beyond conventional commodity market dynamics. Traditionally, supply shocks manifest through price increases and volatility. However, when physical supply contracts significantly, the system transitions from a "price volatility" phase to a "physical liquidity crisis". Margin calls and price spikes in futures markets strain the cash flows of commercial actors. Countries dependent on commodity imports face increased pressure on foreign exchange reserves, and food inflation escalates into macroeconomic instability. However, the most critical aspect of this process is as follows: financial instruments—including insurance mechanisms, derivative products, and hedging strategies—can manage volatility, but they cannot compensate for physical scarcity. For Türkiye, this risk is particularly acute in the 2025–2026 period, when wheat imports are approaching the 10 million ton threshold.

3. Institutional Risk: The Erosion of WTO Authority and the Emergence of "Law of the Jungle" Dynamics

The global trade system is currently in a critical phase where legal continuity and governance capacity are increasingly decoupled. Approximately 70% of global trade still operates under WTO rules and frameworks. However, the mechanisms that ensure enforcement in cases of violation have become significantly weakened. The effective paralysis of the WTO Appellate Body since 2019 has shifted the multilateral trading system toward a domain of unenforceable norms. The system persists—but its authority is contested.

This erosion has tangible and escalating consequences. Russia's instrumentalization of wheat exports in 2022, India's suspension of wheat and rice exports in 2022–2023, and the widespread export restrictions imposed by numerous countries during the pandemic illustrate the WTO's limited ability to prevent such interventions. The common denominator across these cases is clear: when physical supply constraints collide with legal norms, rule-based systems fail precisely when they are most needed.

For Türkiye, this represents a direct strategic threat. A significant portion of its wheat imports originates from the Black Sea basin—a region where climatic vulnerability overlaps with geopolitical tension. Given that supply disruptions in this basin may be triggered by both biophysical and geopolitical factors, declining confidence in long-term supply agreements constitutes a critical strategic vulnerability.

Bilateral Agreements: Necessary but Not Sufficient

Long-term bilateral procurement agreements are widely regarded as a key instrument for securing supply. Such agreements facilitate market diversification and provide a certain buffer against short-term price volatility. However, in an environment where the enforcement capacity of the WTO is weakening, the legal reliability of these agreements has diminished significantly. When exporting countries prioritize domestic markets, existing trade commitments may fail to prevent sudden export restrictions. In times of crisis, "financial capacity" does not necessarily translate into assured access; rather, access may be determined less by market competition and more by political relations and strategic alliances.

For Türkiye, the appropriate strategy is to combine the flexibility of bilateral agreements with the legal framework of WTO norms. Bilateral agreements designed in alignment with GATT Article XXIV, the Agreement on Agriculture, and TBT/SPS mechanisms provide a normative basis that can be invoked in potential disputes, while also serving as an institutional safeguard against the complete subordination of trade to geopolitical power dynamics. Moreover, the development and food security flexibilities granted to developing countries under the WTO's Agreement on Agriculture—commonly referred to in the literature as the "Development Box"—already provide the necessary legal foundation for Türkiye to establish strategic wheat reserves and sustain producer support mechanisms. In other words, the objective should not be to position bilateral agreements as an alternative to the multilateral system, but rather as its extension and reinforcement.

4. Strategic Limits of the Twin Transformation: Tool or Objective?

The "Twin Transformation" agenda (digitalization and green transition) occupies a central place in the Turkish flour industry's 2026 roadmap. It is a necessary and valuable process in terms of operational efficiency and regulatory compliance. AI-driven monitoring systems, energy efficiency investments, and ESG alignment enhance competitiveness and facilitate access to EU markets. This reality cannot be ignored. However, clearly distinguishing between the risks these tools can address and those they cannot is critical to setting the right strategic priorities.

Green Transformation: Symptom Management or Solution?

Green transformation investments reduce the carbon footprint of industrial facilities, lower energy costs, and ensure compliance with regulatory frameworks such as the EU's Carbon Border Adjustment Mechanism (CBAM). These are tangible gains; such compliance requirements, increasingly functioning as a form of "technical passport" for access to global export markets, cannot be ignored. However, solar panels installed on factory rooftops do not reverse heat-induced sterile spikelets, improvements in energy efficiency do not reduce the risk of Multiple Breadbasket Failure (MBBF) in global wheat supply, and carbon accounting does not ease geopolitical tensions in the Black Sea basin.

The positive indicators produced by sustainability reporting may create the impression that the system is environmentally secured. In reality, however, the core risk is concentrated at the very beginning of the production chain—on the field. "Greenwashing" should not be understood solely as a deliberate attempt by firms to mislead, but also as a systemic outcome of misaligned risk prioritization: when carbon reduction–oriented investments foster the illusion of securing raw material supply, more demanding and long-term domains—such as production autonomy, water management, and local agricultural capacity—tend to be deprioritized. An industry with strong ESG scores but fragile access to raw materials remains fundamentally vulnerable, regardless of how positive its reporting metrics may appear.

Digitalization: The Data Paradox

AI-driven optimization systems (such as Kurgan, Vedas, and similar platforms) enhance energy and production efficiency, improve supply chain planning, refine inventory management, and enable predictive maintenance to anticipate production disruptions. These gains are real. However, all of these improvements rest on a common assumption: that the system's primary input—wheat—is physically available. When the flow of raw materials is disrupted, digital infrastructure merely enables more precise measurement of absence. Algorithms can reduce inefficiencies along the production line, but they cannot guarantee the availability of the raw materials required to feed it.

This phenomenon can be described as a "data paradox": the more digitalized a system becomes, the greater the perceived level of control; yet if actual control over physical production capacity is lacking, the strategic value of this perception remains limited. This paradox becomes particularly pronounced in Türkiye's import–processing–export model built upon the IPR. Advanced data analytics and supply optimization tools may improve short-term operational performance, while simultaneously diminishing the visibility of underlying structural vulnerabilities. This, in turn, creates a false sense of security at the policy level: the problem has not been resolved, but merely managed in a more transparent and measurable way.

In summary, the Twin Transformation produces smarter and greener factories. However, without access to wheat, these factories cannot operate. The strategic value of the Twin Transformation lies not in treating it as a final solution, but in positioning it as a necessary—yet insufficient—component of a broader resilience architecture.

5. Türkiye's Structural Challenge: Disconnection from Producers and the Limits of the Hub Model

Türkiye's processing-centered model has led to an increasingly pronounced divergence between industrial capacity and domestic agricultural production. Projections for the 2025–2026 season indicate that wheat imports may approach the 10 million ton threshold. This figure reflects not merely a commercial volume, but a structural reality in which the industry's raw material requirements have far exceeded domestic production capacity. The IPR has thus evolved from a strategic choice into a practical necessity.

In this context, the disengagement of domestic producers from agricultural activity is accelerating. Rising input costs—fertilizers, energy, seeds, and irrigation—are directly affecting the production decisions of small and medium-scale farmers. The price benchmark established by imported wheat narrows the competitive space for domestic producers, distorting the risk–return balance of agricultural activity. As a result, many producers are either reducing cultivated areas, shifting to alternative crops, or withdrawing from production altogether and abandoning rural regions. This process cannot be measured solely by a decline in output; it also reflects the erosion of the social and technical capacity required to scale up production during times of crisis.

Knowledge and Cultural Erosion

Agricultural production is not merely a function of land and equipment; it relies on tacit knowledge accumulated over generations—local climate awareness, soil management practices, seed selection experience, and region-specific production reflexes. Anatolia is one of the historical centers of wheat domestication. The aging of farmers and their withdrawal from production do not only imply the loss of a single harvest, but also the erosion of the social and technical capacity that enables a return to production during crises. Once lost, this knowledge ecosystem cannot be rapidly reconstructed through economic incentives. The core risk Türkiye faces is not only external dependency, but also the potential loss of the production memory required to reduce that dependency when necessary.

Limits of the Hub Model

Türkiye's hub model is a product of a period characterized by relatively stable and fluid global trade. Under conditions of abundant supply, open trade routes, and a functioning rule-based system, this model represented a highly rational economic structure. However, its success rests on two often implicit assumptions: that global trade will continue uninterrupted, and that physical supply will always remain accessible. Today, both assumptions are increasingly fragile.

In a world where supply is becoming a geopolitical instrument, the hub model generates structural vulnerability. Rather than functioning as an active coordinator within global trade networks, Türkiye risks becoming a dependent node reliant on the continuity of external supply flows. While the hub model generates high value-add in the short term, it transforms into a reactive, dependent variable when supply is disrupted. Its limitation emerges not in terms of economic efficiency, but in strategic resilience.

6. Policy Recommendations: Transition to Radical Production Autonomy

The concept of "Radical Production Autonomy" advocated in this study does not imply an inward-looking economic policy. Rather, it represents a resilience doctrine that repositions physical production capacity at the center of strategy while preserving global trade integration. The objective is not to withdraw from trade, but to prevent trade dependency from evolving into systemic vulnerability during periods of crisis. Anatolia's domestic production capacity is not merely an economic alternative, but a form of systemic insurance against global supply shocks. Strengthening local production does not eliminate the hub model; on the contrary, it enhances its resilience. The proposed framework is structured around two pillars.

Pillar 1: Rebuilding Domestic Production Capacity

Domestic wheat production should be positioned not merely as a rural development issue, but as a fundamental pillar of national economic security. In times of global supply shocks, domestic production may not always be the cheapest option, but it becomes the most reliable. Key priorities include:

1. Designing a support architecture that ensures predictable producer profitability. The core issue is not low productivity but income instability; long-term price guarantees, input subsidies, and climate insurance mechanisms can restore the economic attractiveness of agricultural activity.

2. Redirecting technological investments from factories to the field. Drought-resistant seed development, precision irrigation systems, soil moisture monitoring technologies, and climate-informed planting strategies can enable producers to manage climate risks more effectively. In this context, the digital dimension of the Twin Transformation should extend beyond factory optimization to encompass agricultural adaptation.
3. Redesigning the IPR in alignment with supply security objectives. Mechanisms that incentivize the use of domestic wheat and provide advantages linked to local sourcing ratios should be integrated, transforming IPR from a system that reinforces import dependency into one that balances it.
4. Strategic wheat reserves should be increased through the TMO and managed dynamically via public–private sector cooperation. Reserves should be positioned not merely as instruments of price stability, but as the physical guarantee of industrial continuity.

Pillar 2: WTO-Oriented Bilateralism

Trade strategy should combine the flexibility of bilateral agreements with the legal framework of WTO norms, without succumbing to unregulated power competition. This approach not only generates commercial value, but also serves as an institutional safeguard by increasing the diplomatic and economic costs of sudden export restrictions during crises, thereby preventing trade from becoming fully subordinated to geopolitical power dynamics.

1. Bilateral agreements should be structured in alignment with GATT Article XXIV, the Agreement on Agriculture, and TBT/SPS mechanisms. This alignment ensures not only legal legitimacy but also provides a normative foundation for dispute resolution.
2. Market diversification should be deepened. Dependency on the Black Sea basin should be reduced, while alternative supply corridors—such as Central Asia, South America, and Australia—should be further operationalized. This diversification enhances flexibility under potential MBBF scenarios.
3. The “Development Box” flexibilities under the WTO Agreement on Agriculture should be used proactively. These provisions already provide the legal basis for Türkiye to establish strategic wheat reserves, support producers, and implement market stabilization policies. Reinforcing these flexibilities through bilateral agreements would enhance Türkiye’s negotiation capacity.
4. Long-term agreements should be developed with structurally wheat-deficit regions such as the Middle East, North Africa, and Sub-Saharan Africa in order to create forms of mutual interdependence. The food security of these regions is structurally linked to Türkiye’s processing capacity; embedding this relationship within formal legal frameworks would generate value in terms of both commercial stability and diplomatic leverage.

7. Conclusion

As the global food system enters the post-2026 period, a fundamental assumption is rapidly eroding: “If we have the money, we can buy it.” For a long time, the abundance of global supply and the continuity of trade networks rendered the physical constraints of production invisible under the shadow of economic power. However, the biophysical limits imposed by climate systems and the increasing geopolitical nature of trade demonstrate that this assumption is no longer sustainable. In a world where physical production is exposed to simultaneous shocks, financial capacity alone does not guarantee access.

The picture that emerges from this study is clear: although Türkiye possesses a highly advanced processing capacity in global flour trade, its control over the raw material flows that sustain this capacity remains limited. Climate-driven MBBF risks further weaken this control, while the declining enforcement capacity of the WTO undermines confidence in existing trade agreements. Taken together, these risks reveal that the current strategic framework—focused on technological modernization—does not adequately address the absence of guaranteed physical access to raw materials.

Türkiye's strong industrial base, extensive logistics network, and deep trade experience are strategic assets that must be preserved. However, their value depends on the physical availability of wheat. The Twin Transformation does not create this condition; it assumes it. Therefore, the hierarchy of priorities is clear: first ensure raw material supply security, then pursue all other investments. A flour mill may be made as digital and green as possible, but without wheat, it cannot operate.

If Türkiye can successfully implement this transition—repositioning domestic production as a strategic insurance mechanism, embedding its trade architecture within a robust legal framework, and correctly situating the Twin Transformation as a tool rather than an end—it can evolve from being merely a processing hub into a foundational actor in global food security architecture. Otherwise, the hub model, currently perceived as a competitive advantage, risks becoming the primary mechanism of dependency in the future.

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