The Price of Prediction: Algorithmic Food Security and the Illusion of Control

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Abstract. Food security governance in import-dependent economies has shifted toward algorithmic anticipation, with forecasts guiding procurement and reserve decisions in staple food markets. This paper argues that this shift reflects a reordering of coordination signals rather than a purely technical gain in prediction. I develop a parsimonious model of an accountability-constrained political planner contrasting price-signal governance with forecast-signal governance. Forecast-based policy can reduce visible price volatility under routine conditions but weakens price-mediated feedback and shifts risk toward the tails of the distribution. When forecast errors are correlated, centralized anticipation synchronizes policy responses, increasing systemic fragility and the likelihood of rare but severe disruptions despite headline stability. The analysis highlights a fundamental trade-off between visible stability and resilience and underscores the value of hybrid governance arrangements in which algorithmic forecasts complement, rather than replace, price-based coordination.

Keywords: Food security, algorithmic governance, price signals, political accountability, systemic risk.

1 Introduction

Food security governance in the Middle East and North Africa (MENA) is increasingly shifting toward anticipatory control [1] [2] [3]. Yield nowcasts, import-gap projections, price-risk dashboards, and algorithmic early-warning systems are now embedded in procurement agencies and ministries overseeing staple food markets. In a region marked by structural import dependence, limited fiscal space, and the political centrality of basic food prices, policy performance is judged primarily through visible stability. Algorithmic systems promise to translate global volatility into administratively tractable risks and to manage scarcity over prediction rather than contemporaneous market adjustment.

This paper argues that the diffusion of algorithmic food security constitutes a reordering of coordination signals with distinct political-economic implications. In the standard logic of agricultural markets, prices aggregate dispersed information and induce decentralized adjustment across producers, traders, and consumers. In the emerging algorithmic regime, forecasts increasingly replace prices as the primary signal guiding policy, while prices are treated as residual outcomes to be stabilized. This shift is

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consequential, as price-based coordination disperses error and generates continuous feedback, whereas forecast-based coordination centralizes decision rules and exposes governance to the structure of model error, particularly when errors are correlated across institutions and time.

MENA region provides a structurally revealing setting for analyzing this transformation. Staple food systems in the region are characterized by centralized import procurement, strategic reserves, thin hedging markets, and durable political commitments to price stability, with wheat markets offering a particularly clear illustration [4] [5] [6] [7]. Procurement agencies exert substantial influence over import timing, tender design, and stock management, while retail prices remain politically constrained. Empirical evidence shows that procurement institutions shape price formation and bargaining outcomes, indicating that prices already embed administrative choices alongside market forces [8]. At the same time, climate stress and geopolitical shocks interact with import dependence, reinforcing systemic vulnerability and strengthening incentives to privilege anticipatory tools over contemporaneous market feedback [9] [10] [11] [12].

Recent academic work helps explain why algorithmic governance appears attractive. Machine-learning approaches have demonstrated strong predictive performance in identifying food insecurity under large shocks using pre-crisis information [13] [14], while early-warning systems integrating remote sensing, climate indicators, and market data generate alerts with meaningful lead times [15] [16]. Forecasting research in agricultural commodity markets similarly highlights the growing reliance on algorithmic and hybrid models that smooth short-run noise and improve point predictions [17] [18] [19]. Yet this inference is fragile in governance environments where outcomes are assessed by headline stability rather than probabilistic performance. Food security policy is evaluated by the absence of visible disruption, such as price spikes, shortages, or rationing, not by the distributional properties of forecast errors.

By modeling food security governance as the problem of an accountability-constrained political planner, the paper shows that algorithmic anticipation can compress visible volatility under routine conditions while shifting risk toward the tails of the distribution. This effect arises not from forecast bias but from correlated error: shared data infrastructures and convergent model architectures synchronize decisions across agencies and time, weakening price-mediated feedback and amplifying exposure to rare but severe shocks. The analysis therefore supports hybrid governance arrangements in which algorithmic forecasts complement, rather than replace, price-based coordination.

The paper proceeds as follows. Section 2 develops a formal model of governance with an accountability-constrained planner and defines price- and forecast-signal regimes. Section 3 presents the main propositions and their economic and political implications. Section 4 concludes.

2 A model of algorithmic governance under political accountability

2.1 Economic environment

Time is discrete, indexed by $t = 1, 2, \ldots$. The economy consumes a staple food commodity that is produced domestically with a production lag and supplemented by imports. Aggregate demand is given by

$$D_t = \bar{D} - \eta P_t + \epsilon_t$$

where P_t denotes the domestic market price, $\eta > 0$ the price elasticity of demand, and ϵ_t a mean-zero demand shock capturing transitory consumption pressure or income variation. Domestic production is subject to time-to-produce constraints. Output available at time t depends on expectations formed at $t - 1$:

$$Q_t = q(\mathbb{E}_{t-1}[P_t]), \quad q'(\cdot) > 0$$

This structure reflects standard supply-response behavior in agriculture [20] [21] and captures the limited ability of domestic production to absorb short-run shocks, a salient feature of staple markets in import-dependent economies. On the other hand, imports M_t are chosen by a centralized public buyer or procurement authority. Imports are the primary short-run policy instrument and may be released directly to the market or through public stocks. Market clearing implies:

$$P_t = \varphi(Q_t + M_t - D_t) \qquad \varphi'(\cdot) > 0$$

Prices therefore adjust to residual imbalance after production and import decisions are realized.

2.2 Political planner and accountability constraint

Food security policy is conducted by a political planner whose performance is evaluated on visible outcomes, rather than on aggregate welfare. We represent this by assuming that the planner chooses imports M_t to minimize a loss function defined over politically salient price outcomes:

$$\mathcal{L}_t = \omega(P_t - \bar{P}) - \chi \cdot 1\big(P_t \geq \tilde{P}\big)$$

where $\bar{P}$ is a reference price associated with political acceptability, $\tilde{P}$ is a crisis threshold beyond which shortages or unrest become publicly salient, and $\omega, \chi > 0$ weight routine volatility and crisis events, respectively. The planner is subject to an accountability constraint:

$$\mathbb{P}\big(P_t \geq \tilde{P}\big) \leq \kappa$$

where κ represents the maximum tolerable probability of crisis consistent with political survival. This constraint captures the institutional reality that governments are penalized discontinuously for visible failures in staple food provision, while routine price movements carry lower political cost. This formulation abstracts from distribution-neutral welfare objectives and reflects empirical findings that public procurement and price stabilization policies prioritize headline stability and crisis avoidance over efficiency [22] [23] [24]. Within this environment, governance is evaluated by its capacity to manage appearance of stability under uncertainty.

2.3 Governance regimes and information structure

The planner's decision problem depends critically on the signal used to anticipate imbalance. We distinguish two governance regimes.

Price-signal governance: In the benchmark regime, imports respond to observed price deviations:

$$M_t^P = \alpha(\bar{P} - P_{t-1}), \quad \alpha > 0$$

Prices serve as the primary coordination signal, aggregating dispersed information about demand pressure, private storage, and expectations. Policy reacts *ex post* to revealed imbalance. Errors are dispersed across agents, and adjustment proceeds through continuous feedback as prices evolve.

Forecast-signal (algorithmic) governance: In the algorithmic regime, imports respond to an AI-based forecast of net shortage:

$$\hat{S}_t = \mathbb{E}_t^{AI}(D_t - Q_t), \quad M_t^{AI} = \beta \hat{S}_t, \quad \beta > 0$$

The forecast integrates market data, remote sensing, and auxiliary indicators, consistent with contemporary early-warning systems [15] [16]. Forecast error is modeled as

$$\hat{S}_t = (D_t - Q_t) + u_t$$

with $\mathbb{E}(u) = 0$, $\sigma_{u_t u_{t-1}} = \rho\sigma_u^2$, $\rho > 0$. The parameter ρ captures correlated error arising from shared data infrastructures and convergent model architectures, a documented feature of algorithmic governance in the public sector [25] [26] [27]. Under this regime, imports are determined *ex ante* on the basis of forecasts, and prices clear residual imbalance. Prices therefore lose their disciplinary role as policy signals.

2.4 Economic intuition

The two regimes differ not in predictive ambition, but in signal hierarchy. Price-signal governance preserves decentralized feedback and disperses error across agents and time. Forecast-signal governance centralizes coordination and synchronizes action. From the planner's perspective, the algorithmic regime is attractive because it reduces visible volatility under routine conditions, lowering expected political loss and facili-

tating *ex ante* commitment. At the same time, correlated forecast errors transform misjudgment into a systemic event. When forecasts err, import timing, reserve releases, and procurement strategies err together. The accountability constraint therefore induces a governance trade-off: lower observed volatility in normal times at the cost of increased exposure to rare but severe disruptions. This mechanism parallels findings in the literature on algorithmic pricing and forecasting, where predictive systems displace prices as coordination devices and generate new forms of systemic fragility [28] [29].

3 Main results and implications

3.1 Main results

Result 1 (*Displacement of price signals*): When policy decisions are conditioned primarily on algorithmic forecasts rather than observed prices, prices lose their informational centrality in coordinating market adjustment. In the forecast-signal regime, imports and reserve actions are determined *ex ante*, and prices clear residual imbalance *ex post*. As a consequence, contemporaneous price movements no longer discipline policy responses. This result follows mechanically from the planner's information set. Under price-signal governance, prices aggregate dispersed information and trigger incremental adjustment. Under forecast-signal governance, prices enter the loss function only through visible deviations from politically acceptable thresholds. Their role shifts from signal to outcome. This aligns with recent evidence that algorithmic decision systems can crowd out traditional feedback mechanisms by privileging centralized signals [30] [31] [32].

Result 2 (*Apparent stabilization under routine shocks*): For weakly correlated forecast errors and moderate shocks, forecast-signal governance reduces measured price volatility relative to price-signal governance. The planner's accountability constraint induces a preference for policies that minimize headline fluctuations. Acting on forecasts allows the planner to pre-empt expected imbalance and smooth outcomes under normal conditions. This produces lower short-run variance in prices, consistent with findings from the forecasting literature showing improved point predictions and reduced noise when algorithmic models are deployed [17] [18] [33]. Importantly, this stabilization is visible and therefore politically valuable.

Result 3 (Systemic fragility under correlated error): As forecast-error correlation increases, the probability of extreme price realizations rises under forecast-signal governance, even as average volatility declines. This captures the central paradox of algorithmic food security. Forecasting systems built on shared data infrastructures and convergent model architectures generate correlated errors that synchronize policy responses across time and institutions. Import timing, reserve releases, and procurement decisions therefore err together, weakening decentralized adjustment and amplifying tail risk. The outcome is lower variance in routine periods alongside greater exposure to rare but severe disruptions, a pattern consistent with evidence from algorithmic pricing and automated forecasting environments [34] [35]. **Figure 1** illustrates this trade-off. Expected political loss displays a pronounced U-shape in forecast reliance β, reflecting

under-reaction at low reliance and over-reaction when policy becomes excessively sensitive to noisy signals. It should be noticed that the simulation is illustrative and designed to visualize mechanisms rather than to provide quantitative predictions.

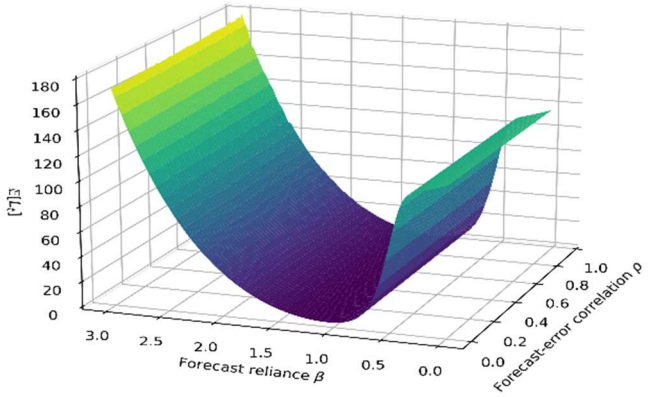

Fig. 1. Expected political loss under forecast-signal governance. Simulated expected political loss is shown as a function of forecast reliance β and forecast-error correlation ρ, based on Monte Carlo simulations with time-to-produce supply, endogenous price clearing, and persistent forecast error. Loss penalizes routine price deviations and discrete crisis events. Parameter values are $\bar{P} = 10$, $\tilde{P} = 14$, $\omega = 1$, $\chi = 80$, , $\eta = 1$, $\varphi = 0.15$, $q_l = 0.4$, $\sigma_\epsilon = 4$, and $\sigma_u = 6$. Reported values are time-averaged after burn-in and illustrate an interior optimum in forecast reliance and rising loss with correlated error.

For intermediate values of β, anticipatory imports partially offset expected imbalances and reduce routine price volatility, yielding an interior minimum in expected loss. At the same time, the entire loss surface shifts upward as forecast-error correlation ρ increases. Higher correlation induces persistence and synchronization in forecast errors, transforming localized misjudgments into sustained policy mis-timing. As a result, even optimally tuned forecast-based policies become increasingly fragile as common-mode error rises, highlighting that improved anticipation cannot fully substitute for decentralized price-mediated feedback.

Result 4 (*Downward incidence of adjustment*): Under forecast-signal governance, the burden of adjustment following forecast errors is disproportionately borne by actors with limited hedging capacity, including smallholders, informal traders, and low-income consumers. Because imports and reserves are fixed *ex ante*, unanticipated imbalance is absorbed through market prices, rationing, or informal channels. The accountability constraint protects the planner from visible failure up to the crisis threshold, while residual risk is displaced downward. This result echoes empirical findings that price stabilization policies often mask distributional stress and shift volatility to margins less visible to policy-makers [36] [37].

3.2 Implications for governance and policy design

The results speak directly to the design of food security governance in politically constrained environments. The central lesson is that how forecasts are institutionalized matters as much as how accurate they are. In forecast-signal regimes, improved predictive performance can reduce visible volatility under routine conditions, but it does so by displacing price-mediated feedback and reshaping coordination. As a result, governance risks trading frequent, low-intensity adjustment for rarer but more severe disruption, particularly in food systems with correlated shocks and limited adjustment margins. Evaluations based solely on average volatility or forecast error therefore provide an incomplete measure of resilience [38] [35].

Algorithmic governance also reshapes accountability and discretion in politically consequential ways. By enabling *ex ante* commitments based on formalized predictions, forecast-driven systems privilege auditable signals and procedural consistency over adaptive judgment, narrowing the scope for discretionary intervention [19] [39]. This helps explain their appeal to policy-makers facing high political costs of visible failure, while implying that delayed responses to emerging stress are an endogenous outcome of governance arrangements conditioned on model confirmation.

The analysis further underscores the importance of signal redundancy and hierarchy. Systems relying on a single privileged signal, whether prices or forecasts, remain vulnerable to systematic failure. More robust regimes preserve price-mediated discipline while using forecasts to inform planning, consistent with arguments in the early-warning literature emphasizing multiple feedback channels rather than single dashboards [40] [41]. Forecast-signal governance also has distributional consequences, shifting adjustment toward less visible but more costly margins for vulnerable actors, as documented in studies of price stabilization and procurement [42]. Finally, the results point to the need for institutional stress testing of algorithmic governance that focuses on correlated error, tail risk, and interaction effects rather than point prediction alone [43] [38].

4 Conclusion

This paper has interpreted algorithmic food security as a reconfiguration of governance rather than a narrow improvement in prediction. Modeling food policy as the decision problem of an accountability-constrained political planner shows how algorithmic forecasts can acquire institutional primacy and reshape coordination. Under forecast-signal governance, predictions guide action *ex ante* while prices increasingly function as managed outcomes, weakening feedback and concentrating risk. The central insight is a trade-off between visible stability and systemic resilience: forecast-driven governance smooths routine price movements and supports advance commitment, but exposes policy to correlated error and tail risk, with adjustment pressures disproportionately borne by actors with limited buffering capacity. The contribution lies in endogenizing the informational role of prices within a political–economic framework and showing how algorithmic anticipation alters this role by elevating forecasts within decision hierarchies.

For policy design, the implication is to reconsider the institutional use of algorithmic tools. Governance regimes that rely on a single privileged signal, whether prices or forecasts, remain vulnerable to systematic failure. More robust arrangements preserve price-mediated feedback while using forecasts to inform planning and contingency preparation. In import-dependent regions such as MENA, where centralized procurement and political sensitivity are structural features, resilience depends on hybrid regimes that balance anticipatory control with decentralized correction.

Future research can test the hypotheses that could be derived using variation in forecasting adoption, procurement rules, and market depth across countries and time, and extend the framework to incorporate storage dynamics, learning, and fiscal constraints. More broadly, the analysis suggests that evaluating AI in economic policy requires moving beyond predictive accuracy to examine how algorithms reconfigure coordination, discretion, and accountability. In food systems, the challenge is to govern with uncertainty without silencing the signals that enable adaptation.

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