Conduct and Volatility in Food-Price Determination:

VAR Evidence from Turkish Agriculture

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Abstract

The relationship between price volatility and competition is examined. Atheoretic, vector autoregressions on farm prices of wheat and retail prices of derivatives (flour, bread, pasta, bulgur and cookies) are compared to results from a dynamic, simultaneous-equations model with theory-based farm-to-retail linkages. Analytical results yield insights about numbers of firms and their impacts on demand- and supply-side multipliers, but the applications to Turkish time series (1988:1-1996:12) yield mixed results. *Key words: conduct, volatility, food marketing.*

That prices of farm commodities are more volatile than prices in other sectors is generally accepted. The usual argument relates inelastic farm-gate demand to shocks in supply due to biological and climatic factors. This paper employs a simple model of farm-to-retail price determination to examine the extent to which monopoly power in the food manufacturing sector may also affect price instability. The issue is investigated through successive applications to Turkish agriculture. These applications are interesting for three reasons. First, food-manufacturing in Turkey is highly concentrated, with levels of agglomeration in many marketing channels similar to those of the beef sector in the United States. Second, recent contributions using VAR techniques (eg., Orden and Fackler, Robertson and Orden, Dorfman and Lastrapes), have focused on developed-economy agriculture. The Turkish economy, with greater macroeconomic and trade instabilities, provides an important contrast with these studies. Third, argument that monopoly in processing may exacerbate price instability has received scant attention in the literature. Here, we argue, this hypothesis provides an appealing explanation of observed volatilities in commodity prices.

Conventional Wisdom

The main ideas that underlie conventional wisdom are articulated in the following quotation (Robertson and Orden, p.161): "At issue are whether levels of agricultural and nonagricultural prices respond proportionally to changes in the level of the money supply and whether there are predictable deviations from such neutrality in the short run. An important hypothesis concerning these issues is that agriculture is a competitive sector in which prices are more flexible than those in nonagricultural (fix-price) sectors. Under this hypothesis, it has been argued that expansionary monetary policy [read, 'demand shocks'] favors agriculture and may cause short-run agricultural prices to over-shoot their long-run equilibrium levels, while contractionary monetary policy [read, 'supply shocks'] shifts relative prices against agriculture." The justifications for interpreting expansionary policies as demand shocks and contractionary ones as supply shocks are twofold. First, expansionary policies that lead to hyperinflations of the type encountered in Turkey are likely to have their initial impacts on high-velocity markets. These markets are characterized by demand-side atomism and a high rate of repeat purchases. Second, contractionary policies that restrict access to capital markets, retard entry and exit from farming and impede adjustment efficiencies, are likely to have had initial impact on supply-side agents. We argue that in vertical farm-to-retail systems the former is best interpreted as a demand-side effect and the latter a supply-side effect. The substantive issue that we examine is whether competition mitigates or amplifies the impacts of these effects on farm prices.

VAR Evidence from the Turkish Wheat Sector

Figure 1 presents results of VAR applied to time series (1988:1-1996:12) on each constituent (flour, bread, pasta, bulgur and cookies) of the wheat-marketing channel. The VAR are ordered 'consumer-price index (CPI), farm-price, retail price' and the plots depict impulse responses to a one-standard-error increase in the CPI. In all but one case, (bread) the impulses are monotonically increasing in the shock. In general, when measured relative to their means, the shocks are larger in the farm sector. The question we ask, specifically with reference to the farm price, is whether these responses would be greater under more competitive conditions. Criticisms of VAR are well-documented (see, for example, Darnell and Evans and the literature cited therein). Among the major criticisms is the lack of an (economic) theoretic basis for the estimating equations. This limitation is important in the current context. Accordingly, we develop a simple simultaneous-equations model.

A Simple Explanation

The Robertson-Orden hypothesis (that competition leads to greater volatilities in farm-price movements) can be substantiated with monopoly as basis, in the following way. Let i, $i = 1,2..N$, index processors and consider production of a food product, y_i, from combining a farm commodity, x_i, with another variable input, z_i, in the technology, $y_i = \min\{x_i, z_i\}$. Demand is $p = A - aY$ and supply is $w = B + bX$, where $Y = \Sigma y_i$; $X = \Sigma x_i$; A, a, B, b are positive parameters; and, because technology is fixed proportions, we set $y_i = x_i = z_i$, and focus on the farm-to-retail part of profits. Processors maximize $\pi_i(y_i) = (A - a\Sigma y_i)y_i - (B + b\Sigma y_i)y_i$ and the corresponding first-order conditions yield, at the symmetric, Nash-equilibrium, $Y = N(A - B)/(N+1)(a+b)$. Substituting for output in the commodity-supply relation yields comparative statics with respect to two effects, namely, a demand shock, $\Delta A > 0$, and a supply shock, $\Delta B > 0$. In particular, $\partial w / \partial A = Nb/(N+1)(a+b)$ and $\partial w / \partial B = 1 - Nb/(N+1)(a+b)$. Both effects are positive, but, whereas the first effect is increasing in N, the second declines. Thus, interpreting N as 'the degree of competition,' we obtain a basis for the hypothesis, that demand-side shocks to farm price are greater the greater the degree of competition.

Reduced-Form, Farm-to-Retail Linkages

Consider, now, the full reduced form that generates these comparative statics. From the structural equations underlying the equilibrium, the reduced-form linkages are

(1) $$\mathbf{y} = \mathbf{z}\ \boldsymbol{\eth},$$

where $\mathbf{y} \equiv (\mathrm{p}, \mathrm{w})$, $\mathbf{z} \equiv (\mathrm{A}, \mathrm{B})$, and π, the matrix of reduced form coefficients, is

(2) $$\boldsymbol{\eth} \equiv \begin{pmatrix} \pi_{11} & \pi_{21} \\ \pi_{12} & \pi_{22} \end{pmatrix},$$

where $\pi_{11} \equiv 1 - \frac{\mathrm{a}}{\mathrm{a}+\mathrm{b}} \frac{\mathrm{N}}{\mathrm{N}+1}$, $\pi_{12} \equiv \frac{\mathrm{a}}{\mathrm{a}+\mathrm{b}} \frac{\mathrm{N}}{\mathrm{N}+1}$, $\pi_{21} \equiv \frac{\mathrm{b}}{\mathrm{a}+\mathrm{b}} \frac{\mathrm{N}}{\mathrm{N}+1}$, and $\pi_{22} \equiv 1 - \frac{\mathrm{b}}{\mathrm{a}+\mathrm{b}} \frac{\mathrm{N}}{\mathrm{N}+1}$.

The coefficients π_{11} and π_{12} denote the impact of demand and supply shocks on retail price, while π_{21} and π_{22} denote their impacts on farm price. A pattern emerges when the within-industry effects (retail-to-retail and farm-to-farm) are compared with the cross-industry effects (retail-to-farm and farm-to-retail). Increased competition, here exemplified by a larger value of parameter N, dampens the impact of the direct effects (retail to retail and farm-to farm), but amplifies the magnitude of the indirect effects (retail to farm and farm to retail). The parameter definitions that generate these results are important for two other reasons. First, a useful pair of within-equation restrictions, $\pi_{11} + \pi_{12} = 1$ and $\pi_{21} + \pi_{22} = 1$, can be used to improve precision of estimation. Second, a set of cross-equation relations that follow from the parameter definitions play a key role in subsequent analysis. They are:

Lemma1: $$\begin{aligned} \pi_{11} - \pi_{21} &= \frac{1}{\mathrm{N}+1} \\ \pi_{22} - \pi_{12} &= \frac{1}{\mathrm{N}+1} \\ \pi_{11} - \pi_{21} + \pi_{22} - \pi_{12} &= \frac{2}{\mathrm{N}+1} \\ |\ \boldsymbol{\eth}\ | \equiv \pi_{11}\pi_{22} - \pi_{21}\pi_{12} &= \frac{1}{\mathrm{N}+1} \end{aligned}.$$

To the extent that equation (1) can be estimated given data on p, w, A and B, these definitions provide potentially useful estimators of the number of firms in the marketing channel. They are, thus, central to the exercise.

Dynamic Perspectives on the Comparative Statics

Analyses of volatility is incomplete without reference to dynamic adjustments. Lagged responses in commodity supply motivate concerns about adjustments in the farm sector, but the potential dynamic effects at the consumption level are less clear. Nevertheless, own consumption by farmers and, with it, storage and interseasonal linkages are likely important in developing countries. We therefore consider price-lagged specifications of demand and supply equations and leave the matter of their significance to the empirics that follow. In this respect, and with the aid of a little algebra, the comparative statics results of the previous section can be given a dynamic interpretation. Consider the specifications of the exogenous variables A and B,

(3) $$A \equiv \alpha_0 + \sum_{i=1}^{D} \alpha_i z_{dit} + \alpha p_{t-1},$$

(4) $$B \equiv \beta_0 + \sum_{i=1}^{S} \beta_j z_{sýý} + \beta w_{t-1},$$

where the α_i's and β_i's are parameters of indeterminate sign; the z's denote relevant, contemporaneous demand and supply shifters; p_{t-1} and w_{t-1} denote lagged realizations of the endogenous variables; and α and β their respective, initial impacts. Importantly, the values α and β cannot be constrained from any theoretical basis and, ultimately, remain an empirical matter. However, like the parameter restrictions in lemma1, they play an important role in subsequent analysis. At points in the discussion it will prove useful for pedagogic reasons to normalize them both to one. In this case the reader should keep in mind that the one-step-ahead impacts of changes in the lagged prices are the same as those derived above, with respect to the shifts in A and B. Turning to these dynamic impacts and following a standard treatment (Greene, pp. 619-25), the reduced-form for the two prices is

$$\text{(5)} \qquad \mathbf{y}_t = \mathbf{z}_t \mathbf{Ø} + \mathbf{y}_{t-1}\boldsymbol{\Delta} + \mathbf{v}_t, \qquad t = 1,2..T,$$

where $\mathbf{y_t} \equiv (p_t, w_t)$ denotes contemporaneous observations on the endogenous variables; $\mathbf{z}_t \equiv (z_{d1t},.., z_{dDt}, z_{s1t},..z_{sSt})$; denotes observations on the demand and supply shifters; $\mathbf{y}_{t-1} \equiv (p_{t-1}, w_{t-1})$ denotes lagged observations on the endogenous variables; $\mathbf{Ø}$ denotes the instantaneous impacts of changes in the components of $\mathbf{z}$; and the coefficient matrix of the lagged effects,

$$\text{(6)} \qquad \Delta \equiv \begin{pmatrix} \Delta_{11} & \Delta_{21} \\ \Delta_{12} & \Delta_{22} \end{pmatrix},$$

is related to the matrix $\mathbf{ð}$ in (2) by the condition

$$\text{(7)} \qquad \Delta = \mathbf{È}\ \mathbf{ð},$$

where $\mathbf{È}$ is a (2×2) matrix with parameters α and β on the diagonal, and zeros elsewhere. Thus, with α and β normalized, $\mathbf{È}$ becomes the identity matrix and $\mathbf{Ä}$ reduces to $\mathbf{ð}$. We are interested in dynamic responses to exogenous shocks, whether the model is stable, and the pattern of adjustments to a stable equilibrium if, indeed, one exists. We are also interested in the extent to which competition affects any of these characteristics. The dynamic multipliers, stability conditions and adjustment paths depend crucially on the elements of the matrix $\boldsymbol{\Delta}$. Thus, in characterizing these effects we will make use of the equality in (7) and, specifically, the relations below, which that follow from combining lemma1 with (7),

$$\text{(8)} \qquad \begin{array}{cccc} \theta_1 & \equiv & \Delta_{11} - \Delta_{21} & = \dfrac{\alpha}{N+1} \\ \theta_2 & \equiv & \Delta_{22} - \Delta_{12} & = \dfrac{\beta}{N+1} \\ \theta_3 & \equiv & \Delta_{11} - \Delta_{21} + \Delta_{22} - \Delta_{12} & = \dfrac{\alpha+\beta}{N+1} \\ \theta_4 & \equiv & \left| \Delta \right| \equiv \Delta_{11}\Delta_{22} - \Delta_{12}\Delta_{21} & = \dfrac{\alpha\beta}{N+1} \end{array}.$$

Except for the presence of the α and β terms, these conditions are identical to those of the lemma. As such, they do not yield any additional insights; but when combined in a particular fashion, they do. Specifically, combining the first, second and fourth relations in (8), we have

$$\text{(9)} \qquad \begin{array}{lllll} \theta_5 & \equiv & \dfrac{\theta_4}{\theta_2} & = & \alpha \\ \theta_6 & \equiv & \dfrac{\theta_4}{\theta_1} & = & \beta \end{array},$$

and combining these two relations with the four in (8) we have

$$\text{(10)} \qquad \begin{array}{lllll} \theta_7 & \equiv & \dfrac{\theta_5}{\theta_1} - 1 & = & N \\ \theta_8 & \equiv & \dfrac{\theta_6}{\theta_2} - 1 & = & N \\ \theta_9 & \equiv & \dfrac{\theta_5 + \theta_6}{\theta_3} - 1 & = & N \\ \theta_{10} & \equiv & \dfrac{\theta_5 \theta_6}{\theta_4} - 1 & = & N \end{array}.$$

It is worth noting that each of the restrictions in (10) yields identical estimates of N. But we have yet to draw a relationship between N and the dynamic impacts of the shocks. The short-run effects of changes in the exogenous variables are contained within the coefficients of the matrix $\mathbf{Ø}$. They are discussed above. From (5), the dynamic, cumulative and long-run multipliers are, respectively, $\mu_t \equiv \mathbf{Ø}\Delta^t$, $\sum_{t=0}^{T} \mu_t = \sum_{t=0}^{T} \mathbf{Ø}\Delta^t$, and $\sum_{t=0}^{\infty} \mu_t = \mathbf{Ø}(\mathbf{I} - \Delta)^{-1}$. They are void of analytical results. Thus, we turn to the relationship between competition and the stability conditions. Let λ_i, $_{i01,2..m}$, denote the roots of the characteristic equation, $|\,\mathbf{\ddot{A}} - \lambda\,\mathbf{I}\,| = \mathbf{0}$. Stability requires $|\,\lambda_i\,| \le 1 \;\forall_{\,i\,=\,1,2..m}$. Real-valued $\lambda_i > 0$ $(\lambda_i < 0)$ add damped exponential (saw-tooth) terms, whereas λ_i complex adds a sinusoidal term. The roots solve $\lambda^2 + \delta_1\lambda + \delta_2 + = 0$, where $\delta_1 \equiv -(\Delta_{11} + \Delta_{22}) = \text{trace}(\mathbf{\ddot{A}})$ and $\delta_2 \equiv \Delta_{11}\Delta_{22} - \Delta_{12}\Delta_{21} = |\,\mathbf{\ddot{A}}\,|$. Clearly, the question of whether $\mathbf{\Delta}$ converges depends crucially on the parameters α and β. Inevitably, this can only be resolved empirically. However, momentarily fix α and β at one. In terms of (7), **È** reverts to the identity matrix and **Ä** = **ð**, permitting us to focus on the parameter definitions below (2). Signing the roots and examining their magnitudes is now a simple matter employing two standard results (e.g., Chiang, p. 505-06), namely, $\lambda_1\lambda_2 = |$ **ð** $|$ and $\lambda_1 + \lambda_2 = \text{trace}($ **ð** $)$. Making use of the definitions below (2), and the fourth line of the lemma, we have the two conditions

(11) $$\lambda_1\lambda_2 = \frac{1}{N+1} > 0,$$

(12) $$\lambda_1 + \lambda_2 = \frac{N+2}{N+1} \in [1, 3/2].$$

Thus, both roots have the same sign and must sum to a positive number. Therefore, they are both positive. The radical in the solutions, $\text{trace}($ **ð** $)^2 - 4|$ **ð** $| = (\pi_{11} - \pi_{22})^2 + 4\pi_{12}\pi_{21}$ is positive, so sinusoidal effects are ruled out. Thus, the time path offers either dampened or explosive exponential terms, and depends on the dominant root. It may be greater than one but, from (12), in the limit as N gets large, both roots are fractional. It follows accordingly that for small N, a window of opportunity for instability exists, and vanishes as the degree of competition rises. Specifically, and in contrast to the Robertson-Orden prediction, competition may induce stability. That is, the greater the degree of competition, the less likely are price explosions. That these results depend on assumptions (viz., $\alpha = \beta = 1$) that may be invalid, generates scope for empirical inquiry.

Empirical Evidence

We seek to identify the magnitude of responses to shocks in marketing system and identify a correspondence between it and the number of firms. The coherent Bayes solution is to parameterize the structural system over N and derive conditional distributions of the dynamic multipliers, whereupon the effect of N is easily established. Arranging the observations on the variables $\mathbf{y}_t$, $\mathbf{z}_t$ and $\mathbf{y}_{t-1}$ we can rewrite (5) as

$$\mathbf{Y} = \mathbf{Z}\,\mathbf{Đ} + \mathbf{V}, \tag{13}$$

where $\mathbf{Y}_{(T\times M)}$ are T observations on $\mathbf{y}_t$; $\mathbf{Z}_{(T\times K)}$ are T observations on the M components of $\mathbf{y}_{t-1}$ and the L components of $\mathbf{z}_t$; and $\mathbf{V}_{(T\times M)}$ is a matrix of error terms assumed to be distributed $N(\mathbf{0}, \mathbf{Ù} \otimes \mathbf{I})$, where $\mathbf{0}_{(T\times M)}$ is a null matrix, $\mathbf{I}_{(T\times T)}$ is the T-dimensional identity matrix and $\mathbf{Ù}_{(M\times M)}$ specifies covariance among the columns of $\mathbf{V}$. Because the posterior distributions have well-known forms, they lend themselves readily to investigation through resampling techniques. Our approach is to work recursively through equations (8), (9) and (10); obtain estimates of α, β and N and, then, conditional on the estimates of α and β, obtain a sequence of estimates for the dynamic multipliers from the sequence of posterior distributions conditioned by chosen values of N. We do this by resampling from the coefficient matrix of the reduced form. Specifically, let $\{\mathbf{Ù}(s)\ s = 1,2..S\}$ and $\{\mathbf{Đ}(s)\ s = 1,2..S\}$ denote a sequence of draws from the posteriors corresponding to (13), where the draws in the second sequence are conditioned by the ones in the first. Then, from the draws on the coefficient matrix, we extract estimates of the restrictions in equations (8), $\{\theta_i(s)\ s = 1,..,S\ \ i = 1..4\}$; (9), $\{\theta_i(s)\ s = 1,..,S\ \ i = 5,6\}$; and (10), $\{\theta_i(s)\ s = 1,..,S\ \ i = 7..10\}$; plot posterior distributions for, α, β and N; compute their means,

$$\begin{aligned}
\hat{\alpha} &= \frac{1}{S}\sum_{s=1}^{S}\theta_5(s) \\
\hat{\beta} &= \frac{1}{S}\sum_{s=1}^{S}\theta_6(s) \\
\hat{N} &= \frac{1}{S}\sum_{s=1}^{S}\frac{1}{4}\sum_{i=7}^{10}\theta_i(s)
\end{aligned}, \tag{14}$$

and then derive conditional estimates of the dynamic multipliers of farm- and retail-price responses in relation to a change in the CPI. Unfortunately, space limits the presentation to just one of the groups. Figure 2 reports results for the flour-milling sector. The first column in the figure reports distributions based on samples of size S=100,000. In each case, the endpoints of the support and the means of the samples are reported. Both α and β have well defined distributions over a narrow range, with means of 0.81 and 0.89, respectively. The distribution for N is less well defined and has negative components. The second and third columns in the figure report the multipliers of a CPI shock on retail and farm prices. The first row in these two columns reports plots of the unconditional estimates and the second and third rows report the multipliers obtained when N is set at one and one-hundred, respectively. With reference to the retail price, the effect of constraining N is to lower, slightly, the magnitude of the multipliers, but then increase them substantially and, for N=100, the market becomes unstable. With reference to the farm price, increasing N leads to increased but convergent effects, beyond which, at some N < 100, explosion occurs. Thus, the effect of competition seems on the one hand to contradict the results of the dynamic SEM, but substantiate the notion espoused by Robertson and Orden, namely that competition leads to volatility. Space limitations prevent reporting results for the remaining sector but, briefly, they can be summarized as follows. Bread: Competition raises the initial impact of the shocks but lowers the length of their intertemporal effects, and generates stable equilibria. Pasta: Competition is once again stable, leads to larger initial impacts and shortened duration of effect. Bulgur: Competition leads to stable equilibria and lengthened duration of effect. Cookies: Competition leads to instabilities.

Conclusions and Extensions

Empirical evidence in support of the competition-breeds-volatility hypothesis is mixed. In two cases (flour and cookies) it appears to be confirmed. The remaining examples seem to conform with an alternative thesis derived from a two-equation, dynamic simultaneous equations model. This is that competition enhances the likelihood of stable price movements.

More work is needed before any firm conclusions can be drawn, and the results thus far are subject to a number of limitations. The, most notable of these is the assumption of constant variance. Plots of residuals based on posterior means suggest that there are at least two, possibly three, distinct regimes within the time series. Consequently, work continues along the lines of a recent contribution to mixed-density estimation (Lavine and West).

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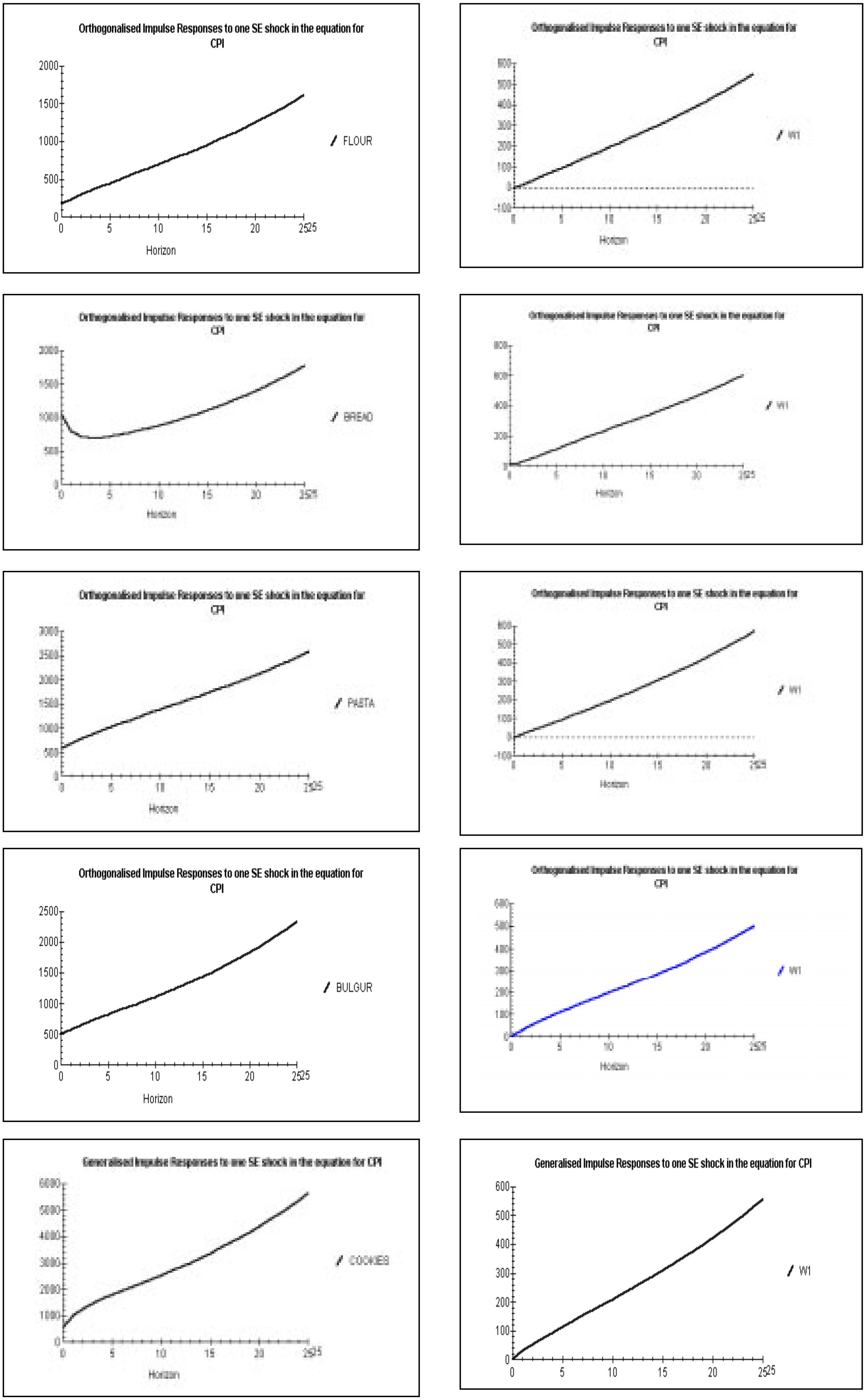
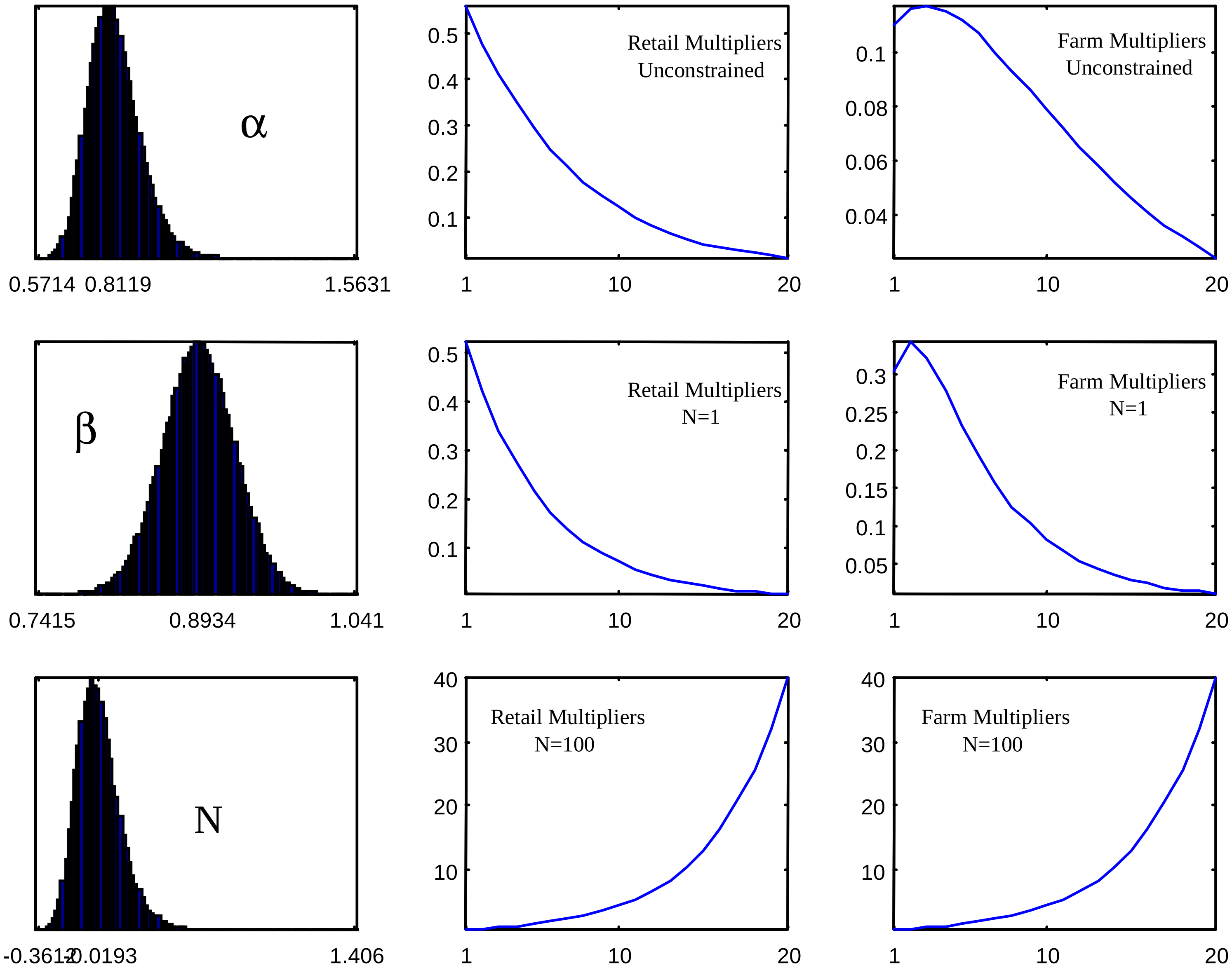


Figure 1. Impulse Responses

Figure 2.


α
0.5714 0.8119 1.5631
Retail Multipliers
Unconstrained
Farm Multipliers
Unconstrained
β
0.7415 0.8934 1.041
Retail Multipliers
N=1
Farm Multipliers
N=1
N
-0.3612 0.0193 1.406
Retail Multipliers
N=100
Farm Multipliers
N=100