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Towards a Theoretical Framework for Policy Behavioral Equations

John C. Beghin

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NORTH CAROLINA STATE UNIVERSITY
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ABSTRACT

A game-theoretic framework unifies the revealed preference approach to government objectives and the policy behavioral equation methodology. Public policies are the equilibrium outcome of a cooperative game among interest groups and the policy maker. This study stresses the interdependence between policies and players' bargaining strength, and derives their comparative statics with respect to a changing economic environment. It provides a specification of behavioral equations consistent with the underlying bargaining process. An analysis of the political economy of food and agricultural price policies in Senegal illustrates the proposed framework.

*Assistant Professor, Department of Economics and Business, North Carolina State University, Raleigh, North Carolina, Telephone (919) 737-3881. The author thanks L. Karp, J. Harsanyi, and I. Adelman.

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Endogenous public policy is a familiar concept in the agricultural economic literature. Rausser and Stonehouse, and Abbott have formulated and estimated policy behavioral equations to analyze changes in policy decisions in response to exogenous shocks. Abbott assumes that domestic price and import policies are influenced by international variables (e.g., world prices, foreign exchange reserves). Rausser and Stonehouse explain policy instruments by variables representing the interest of pressure groups. These policy behavioral equations are essentially partial reduced forms; no structural identification is claimed. The predictive and explanatory (high R^2) power is the principal motivation.

The revealed preference approach (Rausser and Freebairn, Sarris and Freebairn, and Paarlberg and Abbott) explicitly acknowledges the existence and influence of pressure groups in the policy decision-making process. The policy maker maximizes a weighted objective function reflecting the welfare of lobbying groups, and reveals his preferences through the weights he attributes to the different objectives. This approach has been successful in explaining agricultural policies; however, it does not provide a formal structure of the political economy underlying the objective function of the policy maker.

Cooperative game theory provides a formal model of the bargaining process among lobbying groups and the policy maker that leads to the criterion function of revealed preference (Harsanyi 1963, and Zusman). This framework has been applied to the political economy of food price policies in Israel (Zusman and Amiad) and Senegal (Beghin and Karp). Rausser, Lichtenberg, and Lattimore summarize these three approaches. Finally, recent literature emphasizes the oligopolistic nature of the environment of the policy decisions (Sarris and Freebairn, Paarlberg and Abbott, among others.)

The objective of this paper is to provide a game-theoretical framework of the bargaining process determining simultaneously the endogenous policies and the bargaining strength of the interest groups involved in lobbying. The economic environment (e.g., world prices, fixed inputs) changes and alters the solution of the game, the equilibrium policies, and distribution of bargaining power among the players. The proposed methodology predicts how equilibrium policies and bargaining power distribution are displaced by these exogenous shifters.

The proposed framework links the behavioral equation approach to the revealed preference-game-theoretic model with two methodological contributions. First, it indicates which exogenous variables influence the policy decisions and hence, which ones should be included in specification of the behavioral equations. They are the very same shifters as those displacing the bargaining game. The suggested specification of policy behavioral equations is entirely consistent with the underlying bargaining game among interest groups. Second, and most important, the game-theoretic framework permits one to quantify directly the impact of exogenous shocks on the policy variables without resorting to the econometric estimation of behavioral equations. The game provides an alternative way to predict endogenous policy changes. Signs and magnitudes of the influence of the exogenous shifters on the policies are computed relying solely on information yielded by the estimated game. Comparison of the two sets of estimated multipliers provides an informal check of the validity of the methodology[1].

The approach is illustrated with an analysis of food and agricultural price policy changes in Senegal. Urban dwellers consuming imported cereals, groundnut farmers, and a marketing board with market power are involved in a game determining the consumer price of cereal imports, and the producer price for groundnuts and agricultural inputs. We estimate the influence of world prices, the exchange rate and some other shocks on both the players' bargaining power and on price policies.

The game-theoretic framework is presented in the next section with emphasis on the complementarity of revealed preference and cooperative game theory. The comparative statics of the equilibrium strategies (i.e., the policy instruments) are derived with respect to changes in the predetermined economic environment and a proper specification for policy behavioral equations is suggested. In the third section, we present the application to the political economy of price policies in Senegal, and introduce the Senegalese context with the markets, policies, and players involved in the game. The econometric estimation of the game yields estimates of the players' bargaining strength, of their derivatives with respect to the exogenous shifters, and of the impact of these shifters on the equilibrium price policies. Next, we estimate behavioral equations; and the consistency of the multipliers obtained with the two approaches is checked. Conclusions follow in the last section.

A Cooperative Game Framework

The bargaining process among pressure groups and the policy maker often leads to enforceable agreements among the players, making plausible the use of cooperative game solutions (Shubik). From the possible solution concepts, we choose the reference point solution (Thomson 1981). Reference points are payoffs to which players refer when they evaluate payoff proposals. The Nash conflict point and the point of minimum expectation are examples of reference payoffs. This solution concept assumes less about the behavior of the players, since it does not require specification of their reference points. It is also assumed that the payoff set and its frontier change with the economic environment. Hence the players' payoffs, their bargaining powers, and the equilibrium strategies are displaced by exogenous shocks (e.g., world prices and exchange rate).

Friedman and Thomson (1981) present the axioms characterizing the reference point solution as representing a generalization of the Nash axioms. If the reference point meets some regularity conditions (Thomson 1981), a solution that satisfies the four axioms maximizes the modified Nash product

$$(1) \qquad \prod_{i=1}^{n} (CV(s(z),\ z)_i - g(\mathbf{P},\ \mathbf{d})_i),$$

where $\mathbf{CV}=(CV_1,\ CV_2, \ldots,\ CV_n)$ is the vector of utility of payoff of the n players and belongs to the utility set $\mathbf{P(z)}$; $\mathbf{g(P,\ d)}$ is the reference point of the players; $\mathbf{d}$ is the conflict point; the variable $\mathbf{s}$ is the vector of strategies available to the players; and $\mathbf{z}$ is the vector of exogenous variables displacing the game. For $\mathbf{P}$ convex and compact, the solution $\mathbf{CV}^*$ satisfies the necessary and sufficient conditions

$$(2) \qquad H(CV_1^*,\ CV_2^*, \ldots,\ CV_n^*,\ z)=0, \text{ and}$$

$$(3) \quad a(z)_i(CV(s(z),z)_i^* - g(P,\ \mathbf{d})_i) = a(z)_j(CV(s(z),\ \mathbf{z})_j^* - g(\mathbf{P},\ \mathbf{d})_j) \text{ for all } i,\ j;$$

where $a(z)_i = \frac{\partial H(\mathbf{CV}^*,\ \mathbf{z})}{\partial CV_i}$. The $a(z)_i$'s represent the bargaining-power coefficients of the players. H is the implicit function describing the frontier of the payoff set $\mathbf{P}$. Under the same assumptions for $\mathbf{P}$, it is equivalent to maximizing the weighted sum of utilities W

$$(4) \quad W = a(z)_1 CV(s(z),\ z)_1 + a(z)_2 CV(s(z),\ z)_2 + \ldots + a(z)_n CV(s(z),\ z)_n .$$

Equation (4) represents the objective function of revealed preference. First order conditions in the strategy space can be derived by maximizing either (4) or (1),

$$(5) \qquad \sum_{i=1}^{n} a(z)_i \frac{\partial CV(s(z),\ z)_i}{\partial s(z)_k} = 0 \quad \text{for } k= 1, \ldots,\ t.$$

To derive the comparative statics of the equilibrium strategies with respect to changes in the exogenous variables of the game, the envelope theorem is applied to (5),

$$(6) \qquad \sum_{i=1}^{n} \left[\frac{\partial CV_i}{\partial s_k} \frac{da_i}{dz_j} + a_i \frac{\partial^2 CV_i}{\partial s_k \partial s} \frac{ds}{dz_j} + a_i \frac{\partial^2 CV_i}{\partial s_k \, \partial z_j}\right] = 0 \; ;$$

where z_j refers to the jth shock; $\frac{\partial^2 CV_i}{\partial s_k \partial s}$ is the vector of derivatives of $\frac{\partial CV_i}{\partial s_k}$ with respect to s; the scalar $\frac{\partial^2 CV_i}{\partial s_k \partial z_j}$ is the cross derivative of CV_i with respect to s_k and z_j; and the vector ds/dz_j gives the response of the equilibrium strategies **s** (i.e., the policy variables) to changes in z_j. There are tm equations (6), for t strategies and m shocks. The system of equations for a given shock z_j is

$$(7) \qquad \sum_{i=1}^{n} \left[\frac{da_i}{dz_j} \frac{\partial CV_i}{\partial s'} + a_i \frac{\partial^2 CV_i}{\partial s' \partial s} \frac{ds}{dz_j} + a_i \frac{\partial^2 CV_i}{\partial s' \partial z_j}\right] = 0 \, .$$

Equation (7) is solved for the vector ds/dz_j:

$$(8) \quad \frac{ds}{dz_j} = - \left[\sum_{i=1}^{n} a_i \frac{\partial^2 CV_i}{\partial s' \partial s}\right]^{-1} \left[\sum_{i=1}^{n} \left[\frac{\partial CV_i}{\partial s} \frac{da_i}{dz_j} + a_i \frac{\partial^2 CV_i}{\partial s' \partial z_j}\right]\right] \quad \text{for } j=1,\ldots,m.$$

The right-hand side of (8) shows the effects of the shock on the bargaining power structure, and on the derivatives of the utility functions. The first effect is da/dz_j or $\frac{\partial(\partial H/\partial CV)}{\partial z_j}$; the second one is $\frac{\partial(\partial CV/\partial s)}{\partial z_j}$. The sign of the multipliers ds/dz_j is analytically ambiguous. The multipliers ds/dz_j are computable once estimates of $\frac{\partial CV_i}{\partial s'}$, $\frac{\partial^2 CV_i}{\partial s' \partial s}$, $\frac{\partial^2 CV_i}{\partial s' \partial z_j}$, and da/dz_j are available.

Based on ds_k/dz, the linear approximation of the behavioral equation for the kth policy, $s_k = f(z)$, is

$$(9) \qquad s_k \approx (ds_k/dz)' \, z + s_k^0 \, ,$$

where s_k^0 is a constant term. With an additive error term, (9) provides a linear specification for the eventual estimation of the behavioral equations consistent with the bargaining process described by (1) to (5); the multipliers ds_k/dz are the regression coefficients in this case.

The Senegalese Application

The application concerns the political economy of food and agricultural prices in Senegal for the period 1960 to 1980, a period of stability and continuity in institutions and policies. Pressured by international donors, the Senegalese government undertook profound structural reforms in the early 1980s, considerably disrupting policies and institutions. The Senegalese case is exemplary because of its similarities with several African countries (Bates). Agricultural and food policies are the outcome of a bargaining process among economic groups and the government. Commodity taxation and institutionalized market power are the main tools to generate and transfer rent from the rural sector to government bureaucracies and urban consumers. The government relies on its legitimacy to carry its policies. Hence, the actual price policies are not as taxing as pure monopoly/monopsony theory predicts, since if they were they would ruin the rent-generating mechanism by inducing riots and loss of legitimacy.

The Senegalese game contains three representative players, farmers in the groundnuts basin growing groundnuts and millet; urban dwellers consuming rice and wheat products; and the few government agencies determining the food and agricultural price policies and that will hereafter be referred to as the marketing board. Groundnuts is the major cash crop of Senegal and millet is the traditional rural staple food. The farm price of groundnuts is fixed below the world price by the marketing board, which has a monopsony on the crop. The marketing board delivers subsidized inputs (mostly fertilizer) on credit to the farmers, who pay for them during the groundnuts marketing season. This subsidy/credit policy attempts to offset the supply response to low groundnut producer prices. The marketing board is a monopolist in the fertilizer market. Millet is affected by groundnuts and inputs price policies through intermarket links, since the two crops compete for the same inputs. However, the marketing board is not involved in millet marketing, which remains a rural nontraded staple. If the prices fixed by the marketing board are too unfavorable, farmers may retaliate by changing their crops pattern, smuggling their cash crops to bordering countries, defaulting on input loans, and by withdrawing their political support. Imported rice and wheat products are the major urban staples. The marketing board fixes the retail prices and has a monopoly on imports of these products. Consumer taxes on rice are moderate and sudden increases in import cost are absorbed by the marketing board; wheat consumption is subsidized. In case of high cereal consumer prices, urban dwellers can create political unrest and weaken the legitimacy of the political decision maker.

The indirect utility of the representative farmer, U_1, is

$$(10) \qquad U_1 = U_1(P_m,\ \mathbf{P}_{-m},\ m_1(P_g,\ P_m,\ P_f,\ z_1) - C_1) \ ,$$

where P_m, $\mathbf{P}_{-m}$, P_g, and P_f are the price of millet, the price vector for consumption goods other than millet, the producer price of groundnuts, and the producer price of fertilizer. The variable z_1, a subset of z, expresses the influence of some of the exogenous variables on the restricted profit function (i.e., rural labor, land and rainfall). The restricted profit function m_1 minus the cost of implementing conflict strategies, C_1, constitutes the net income of the farmer[2]. At the cooperative solution, C_1 is equal to zero because conflict strategies are not used. By Hotelling's lemma, the supplies of groundnuts and millet, ${}_g q^s$ and ${}_m q^s$, and the demand for fertilizer ${}_f q^d$, are derived. The farmer markets his whole groundnut production. Roy's identity gives the farmer's demand for millet, q_m^d. The farmer's payoff function is defined as the negative of the compensating variation for changes in prices and income,

$$(11) \quad CV_1 = -[e_1(P_m, \mathbf{P}^o_{-m}, U_1^o) - e_1(P_m^o, \mathbf{P}^o_{-m}, U_1^o) - m_1(P_g, P_m, P_f, z_1) + m_1^o \; (P_g^o, P_m^o, P_r^o, z_1) \;] \quad ;$$

where m_1 and P_m refer to the current period, and m_1^o and P_m^o are their counterparts in the starting period, 1960; e_1 is the expenditure function of the farmer. We do not consider changes in the price $\mathbf{P}_{-m}$ and assume that the compensating variation and millet demand depend only on the price of millet and income. Millet supply and demand must be equal at the market equilibrium, since millet is a nontraded commodity. Each farmer takes prices as given, but at the market level changes in the groundnuts and fertilizer prices affect the price of millet. Computation of the derivatives of the payoff functions with respect to the price policies includes these general equilibrium effects.

A typical urban consumer has an indirect utility function U_2, with consumption prices and income as arguments:

$$(12) \qquad U_2 = U_2(P_r, P_w, \mathbf{P}_{[-r, -w]}, m_2 - C_2) \quad ,$$

with P_r, P_w, $\mathbf{P}_{[-r, -w]}$ being the prices of rice, wheat products, and other goods. Income of the urban consumer is equal to the exogenous wage income m_2 minus the cost of applying conflict strategies C_2 (e.g., cost of rioting or striking). At the cooperative equilibrium C_2 is equal to zero, since the threat strategies are not implemented. Roy's identity gives cereal demands q_r^d and q_w^d, which are assumed to be functions of the rice and wheat consumer prices, and of income. The payoff function of the urban consumer is the negative of its compensating variation

(13) $CV_2 = -(e_2(P_r, P_w, P^o_{[-r, -w]}, U^o_2) - e_2(P^o_r, P^o_w, P^o_{[-r, -w]}, U^o_2) - m_2 + m^o_2)$,

with the superscript o denoting 1960 and e_2 being the expenditure function of the urban consumer.

The marketing board chooses the price policy variables P_g, P_f, P_r, P_w to maximize the sum of net tax revenues in the four markets. This assumption is not very restrictive because it does not specify how the surplus generated through taxes is allocated (e.g., investment or maintenance of bureaucracy). Under this assumption the marketing board can both extract or transfer surplus depending on the players' bargaining strength. The tax revenue function TR is

$$(14) \qquad TR=(WP_g-P_g)q^s_g + (P_f-WP_f)q^d_f + (P_r-WP_r)q^d_r + (P_w-WP_w)q^d_w - D_1 - D_2 ,$$

where WP_g, WP_r, WP_w are the world prices of groundnuts, rice and wheat, and WP_f is the ex-factory price of fertilizer. All these prices are exogenous; the world prices are multiplied by the nominal exchange rate and expressed in CFA franks. The nominal exchange rate (cost of dollars in CFA franks) is also exogenous. Variables D_1 and D_2 represent the cost to the marketing board of being in conflict with farmers and urban dwellers. The payoff function of the marketing board[3], CV_3, is the change in tax revenues when prices move from the starting to the current level,

$$(15) \qquad CV_3 = TR(P_g, P_f, P_r, P_w) - TR(P^o_g, P^o_f, P^o_r, P^o_w).$$

Necessary and sufficient conditions (3) and (5) are applied to the Senegalese case. The strategies of the marketing board are the four price policies P_g, P_f, P_r, and P_w. Farmers and urban dwellers have political strategies that, although not observed, influence the behavior of the marketing board. Recall that farmers can smuggle their cash crop, default on loans, or withdraw their support to the existing political system; urban consumers can riot, go on strike, or shirk. The first order conditions to maximize the welfare function W are

$$(16)\qquad a(z)_1 \left(\frac{dCV_1}{dP_i}\right) + a(z)_3 \left(\frac{dCV_3}{dP_i}\right)=0 \quad , \text{ for } i = g,\ f \ ; \text{ and}$$

$$(17)\qquad a(z)_2 \left(\frac{\partial CV_2}{\partial P_k}\right) + a(z)_3 \left(\frac{\partial CV_3}{\partial P_k}\right)=0 \quad \text{for } k = r,\ w.$$

Total derivatives are taken in equation (16) to account for the intermarket relationships between the millet, and groundnuts and fertilizer markets. Before estimating (3), (16), and (17), we must specify the influence of z on the bargaining power coefficients a's. This step is necessary in order to recover the coefficients $a(z)_i$'s and their derivatives da_i/dz. We approximate the ratios of the bargaining coefficients as linear functions of exogenous variables,

$$(18)\qquad \frac{a_2(z)}{a_3(z)} = a_{23}+a_{231}WP_g \quad , \text{ and}$$

$$(19)\qquad \frac{a_3(z)}{a_1(z)} = a_{31}+a_{311}WP_r+a_{312}dol +a_{313}pop \quad ;$$

with pop denoting the total population of Senegal, and dol being the exchange rate. Attempts to include the other exogenous variables of the model (land, rainfall, per capital income of the urban consumer, world price of wheat, and ex-factory price of fertilizer) into the ratios (a_i/a_j) proved unsuccessful. We recover the bargaining coefficients and their derivatives as follows. First, the bargaining coefficients are normalized to sum to one. The normalization, (18) and (19) are solved for the three coefficients,

$$(20)\qquad a(z)_1= \frac{1}{(1+(1+a_{23}+a_{231}WP_g)(a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop))} \quad ,$$

$$(21)\qquad a(z)_2= \frac{(a_{23}+a_{231}WP_g)\ (a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop)}{(1+(1+a_{23}+a_{231}WP_g)\ (a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop))} \quad , \text{ and}$$

$$(22)\quad a(z)_3 = \frac{(a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop)}{(1+(1+a_{23}+a_{231}WP_g)\ (a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop))}\ .$$

Then the derivatives da_i/dz_k are computed taking into account that $\sum_{i=1}^{n} da_i/dz_k=0$. Even if a specific exogenous variable enters only one equation - (18) or (19) - it influences the whole bargaining-power structure via the normalization of the a's. Equations (18) and (19) are substituted into (3), (16) and (17) to form the system

$$(23)\quad CV_3=(a_{23}+a_{231}WP_g)\ (CV_2+b_{23})\quad ,$$

$$(24)\quad CV_1=(a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop)\ (CV_3+b_{31})\quad ,$$

$$(25)\quad \frac{\partial CV_3}{\partial P_i}=-(a_{23}+a_{231}WP_g)\frac{\partial CV_2}{\partial P_i},\quad \text{for } i = r, w; \text{ and}$$

$$(26)\quad \frac{dCV_1}{dp_k}=-(a_{31}+a_{311}WP_r+a_{312}dol+a_{313}pop)\frac{dCV_3}{dp_k},\quad \text{for } k = g, f.$$

Equations (23)-(26) are estimated with time series data from 1960 to 1980. The estimation is organized in two steps. First, the supply (millet, groundnuts) and demand (millet, fertilizer, imported cereals) equations are estimated to generate measurements of the payoff functions and their derivatives with respect to the price policies. Then the game is estimated. The first step of the estimation and the time series data are reported in an appendix, available upon request. Since the payoff functions and their derivatives are endogenous variables, an instrumental variable technique is required. The payoff functions and their derivatives are the equilibrium outcome of the game; hence they are simultaneously determined. We use iterative two stage least squares. Two stage and three stage least squares yield comparable results. The parameter estimates are shown in Table 1, with the bargaining-power coefficients implied by these estimates. At the sample mean the bargaining coefficients estimates are a_1=.6096, a_2=.1323, a_3=.2580, respectively, for the farmer, urban consumer, and the marketing board. The larger magnitude of a_1 is unexpected because of the price policies favoring urban consumers and the marketing board. It is explained as follows. Farmers' conflict point is closer to their optimum payoff than are those of the urban consumers and the marketing board. In case of conflict farmers have their subsistence crop as an alternative; conversely, the marketing board and urban consumers have more to lose in a disagreement. They will be much worse off, since their conflict points are further away from the optimum solution and this weakens their bargaining strength[4] (Thomson 1987).

The derivatives of the coefficients a_i's with respect to the four exogenous variables are calculated at the mean with the regression estimates of Table 1 and are reported in the same table. The farmers and the marketing board enhance their bargaining position with a higher world price of groundnuts. More expensive rice imports disadvantage urban consumers and the marketing board relatively to the farmers. Less intuitive directions are obtained for the two other exogenous variables. Population and exchange rate influence positively the bargaining position of urban consumers and the marketing board to the prejudice of farmers.

With estimates of da/dz, $\partial CV_i/\partial \mathbf{s}'$, $\frac{\partial^2 CV_i}{\partial \mathbf{s}' \partial \mathbf{s}}$ and $\frac{\partial^2 CV_i}{\partial \mathbf{s}' \partial z_j}$, we compute the multipliers ds_k/dz_j as in (8). We consider seven possible shocks. They are changes in the world price of groundnuts, wheat, and rice, WP_g, WP_w, WP_r, in the exchange rate, dol, in the ex-factory price of fertilizer, WP_f; and change in population, pop, and in the income of urban consumers, m_2. The multipliers $\frac{ds}{dz_j}$ are presented in Table 2 at the sample mean and in elasticity

Table 1. Estimation of the game with iterative 2SLS regression

Parameter	Estimate	Std. Error	Asympt. T Ratio
a_3	0.01089	0.0024	4.39
a_{313}	1.76E-07	6.99E-08	2.52
a_{311}	-2.00E-05	2.98E-06	-6.71
b_{31}	-70.34579	30.69248	-2.29
a_{31}	-2.45668	0.78836	-3.12
a_{23}	1.28022	0.23308	5.45
a_{232}	-1.75E-05	3.94E-06	-4.44
b_{23}	-158.24	43.2921	-3.66

Bargaining coefficients and their derivatives

Variable	Mean	Std. Error
$\partial a_1/\partial WP_g$	0.00063111	0.00015377
$\partial a_1/\partial WP_r$	0.00267636	0.00082118
$\partial a_1/\partial pop$	-0.00000010	0.00000003
$\partial a_1/\partial dol$	-0.00434306	0.00142050
$\partial a_2/\partial WP_g$	-0.00094887	0.00032176
$\partial a_2/\partial WP_r$	-0.00081574	0.00037535
$\partial a_2/\partial pop$	0.00000003	0.00000001
$\partial a_2/\partial dol$	0.00080209	0.00081789
$\partial a_3/\partial WP_g$	0.00031776	0.00018591
$\partial a_3/\partial WP_r$	-0.00186062	0.00080528
$\partial a_3/\partial pop$	0.00000007	0.00000003
$\partial a_3/\partial dol$	0.00354097	0.00111909
a_1	0.60963159	0.13013256
a_2	0.13232257	0.05713033
a_3	0.25804585	0.08212880

Table 2. Impact of exogenous shocks on price policies $\frac{ds/s}{dz_j/z_j}$. The game-theoretic approach.

Price	WP_g	WP_r	pop	dol	m_2	WP_w	WP_f
P_g	2.333	-1.378	-1.930	-1.954	0	0	-2.531
P_f	-0.683	-5.272	4.082	13.169	0	0	1.935
P_r	1.073	-0.451	3.414	4.955	-1.281	-0.144	0
P_w	-2.888	9.375	14.520	23.475	1.508	-6.114	0

form $(\frac{ds/s}{dz_j/z_j})$. The groundnut producer price is negatively related to most variables except the world price of groundnuts. The fertilizer producer price decreases with higher world prices of groundnuts and rice, and increases with rising population, exchange rate, and ex-factory price of fertilizer. The rice consumer price is negatively influenced by a rise in cereal world prices and urban income. Opposite effects are obtained for the world price of groundnuts, population and exchange rate. Higher urban income, population and world price of rice induce increases in the wheat consumer price; whereas exchange rate, world prices of wheat and groundnuts lower the same consumer price.

We estimate behavioral equations with the time series data included in the appendix. The behavioral equations are specified linearly as in (9), with the shocks considered in the previous section as explanatory variables. This allows comparison of the two approaches for the same set of exogenous shocks. The equations are

(27) $P_i=\beta_{i0}+\beta_{i1}WP_g+\beta_{i2}WP_r+\beta_{i3}pop+\beta_{i4}dol+\beta_{i5}WP_f$, for i =g, f; and

(28) $P_k=\beta_{k0}+\beta_{k1}WP_g+ \beta_{k2}WP_r +\beta_{k3}pop +\beta_{k4}dol +\beta_{k5} m_2 +\beta_{k6}WP_w$, for k =r, w.

Assuming additive error terms that satisfy the Gauss-Markov assumptions, (27) and (28) are estimated with ordinary least squares, and the results are presented in Table 3. Overall, the regressions give good fit (high R^2), although some variables are not statistically significant (low T value). The multipliers ds/dz based on the regressions are presented in elasticity form in Table 4.

In more than 75 percent of the cases, the two approaches give the same impact directions, but the estimated magnitudes of the multipliers differ. The

Table 3. Price Policy Behavioral Functions. OLS Regressions.

	P_g	P_f	P_r	P_w
Intercept	33275.344	18120.779	-29010.569	21946.423
	(2.851)[a]	(3.040)	(-1.309)	(1.194)
WP_g	53.852	-.930	7.496	-4.851
	(4.067)	(.138)	(.479)	(-.371)
WP_r	9.176	-22.072	95.396	37.542
	(.518)	(-2.438)	(3.450)	(1.624)
pop	-.003	-.001	.002	.004
	(-3.420)	(-3.136)	(2.220)	(4.540)
dol	-42.735	-9.201	21.419	-38.797
	(-1.415)	(-.596)	(.333)	(-.706)
WP_f	-.172	.067	-	-
	(-.964)	(.736)	-	-
m_2	-	-	1.443	.322
			(3.596)	(.961)
WP_w	-	-	-207.206	28.367
			(-1.085)	(-.178)
F test	9.474	5.951	.081	8.257
R^2	.761	.665	.776	.780
DW	1.961	2.079	2.489	2.289

a. Figures in parentheses are T-values.

Table 4. Elasticities $\frac{ds/s}{dz/z}$ based on behavioral equations

Price	WPg	WP_r	pop	dol	m_2	WP_w	WP_f
P_g	0.580	0.056	-0.767	-0.602	0	0	-0.199
P_f	-0.020	-0.273	-0.726	-0.262	0	0	0.156
P_r	0.047	0.342	0.377	0.181	1.524	-0.485	0
P_w	-0.021	0.093	0.444	-0.221	0.235	-0.046	0

game approach tends to yield larger multipliers. Discrepancies between the two sets of results occur with regard to the impact of the world price of rice on the groundnuts and rice price policies, the influence of the population variable and exchange rate on the fertilizer price, and the effect of urban income on the rice consumer price.

Conclusion

Cooperative game theory was used to develop an analytical framework unifying revealed preference and policy behavioral equations. The game-theoretic framework contributed in two directions to the prediction of the response of the price policies to exogenous shifters. First, it spelled out the bargaining process underlying the price policies. This enabled identification of the exogenous shocks displacing the bargaining game and its equilibrium. It also permitted derivation and quantification of the impact of these exogenous shifters on the game and the policy variables. Policy responses were obtained relying solely on the information of the game. Second, this approach provided for the price behavioral equations a specification consistent with the bargaining process.

We applied our approach to the political economy of food and agricultural prices in Senegal. We computed the effect of exogenous variables on the price policies predicted by our bargaining model. We also estimated econometrically the usual behavioral equations and compared the two sets of multipliers. The results of the former sometimes contradicted implications of the latter. The two approaches should be considered complementary rather than competing explanations. If the two explanations are consistent, then some confidence can be put in the policy predictions and the methodology.

NOTES

1. In our attempt to unify the policy behavioral equation methodology and the revealed preference-game theory approaches, we voluntarily omit the imperfect world market aspects of Sarris and Freebairn and others. World prices are assumed given in our approach.

2. The variable C_1 could be modified to include the cost of influencing the policy maker during the bargaining process (e.g., PAC contributions).

3. Other definitions of the utility function CV_3 were tried. When we assume an altruistic marketing board caring about both tax revenues and the income distribution between the urban and farm sectors, we obtain nonsensical results. We do not find evidence showing that the marketing board cares about the welfare of the other players outside of the bargaining process.

4. Possible mispecification of the payoff functions of the players could also bias the a's estimates.

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