Food Security and Agricultural Protection in South Korea

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Abstract

As part of its food security policy, South Korea has been pursuing food self-sufficiency using high tariffs and high administrative prices in key agricultural and food markets. Using a dual approach to trade and trade restrictiveness indices, we analyze the impact of these market distortions on welfare and trade volume. Then, we compute optimum distortions, which minimize the welfare costs of observed self-sufficiency and production objectives. We rationalize these optimum distortions to what could be claimed as legitimate protection under a "food security" (FS) box in World Trade Organization negotiations. FS-box protection is sensitive to changes in the definition and the extent of the FS objectives. We show that FS via production targets and reliance on imports would be more palatable to consumers and trade partners while preserving rents to the farm sector.

Key words: agricultural distortions, food security, Korea, protection, targeting, WTO negotiations.

FOOD SECURITY AND AGRICULTURAL PROTECTION IN SOUTH KOREA

Introduction

The Republic of Korea has supported its agricultural sector at a relatively high level compared to the policies of other member countries of the Organization for Economic Cooperation and Development (OECD). Public intervention mainly consists of high production prices supported by government purchases, together with high tariffs that protect domestic producers from foreign competition and, implicitly, from tax consumers. Trade liberalization recently took place in certain sectors, and Korea is now a major importer of oilseeds and coarse grains. However, Korea only reluctantly exposed its agricultural sector to the provisions of the Uruguay Round Agreement on Agriculture (URAA) (IATRC 1997). It has kept very high tariffs in the rice, meat, and dairy sectors; high production subsidies in most other sectors; and significant non-tariff trade barriers on many commodities, including administrative barriers (import monopolies) and sanitary restrictions (IATRC 1994; Thornsbury et al.).

Exporting countries have stressed that Korean farm policy imposes high food costs on consumers and increases the cost of labor for its manufacturing sector. By artificially maintaining resources in agriculture, Korean agricultural policy allegedly slows the growth rate of the entire domestic economy. Other World Trade Organization (WTO) member countries complain that Korea, while benefiting from global manufacturing export opportunities, imposes considerable obstacles to other countries' exports of food products (Diao et al.).

In current WTO negotiations, the Korean government promotes "non-trade concerns" in agriculture, such as food security (FS) objectives (WTO 2000b), and emphasizes the need for ensuring an adequate supply of food in all market conditions. Korea makes a strong case that Net Food Importing Developing Countries (NFIDCs) should be able to support the domestic production of staple crops and argues that such measures should be exempted from reduction commitments on the grounds of FS (WTO

2001b). This stance is consistent with developing countries' proposals for "food security" and "development" boxes, which would legitimize larger support to domestic production and trade barriers. Recent debates under the auspices of the World Bank (2001) show a large coalition of sympathizers with Korea's position on FS. Free trade, it is argued, is not a guarantee of reliable access to cheap food under all conditions.[1]

Korea defines FS as a perplexing joint reliance on trade, domestic production, and self-sufficiency (WTO 2000a,b; 2001b). Despite some trade concessions under the URAA, Korea has nevertheless openly pursued food self-sufficiency as the desirable way to achieve FS. FS based on self-sufficiency is a recurrent theme among developing members of the WTO. For instance, India has proposed an "FS" box (WTO 2001a). However, self-sufficiency objectives are detrimental to (poor) consumers, and alternative policies, such as production subsidies, are a more targeted way to achieve FS objectives. Korea and India's promotion of self-sufficiency, which penalizes consumers, looks inconsistent with their endorsement of FS as "access to food for all," proposed during the World Food Summit of the Food and Agriculture Organization (FAO).

Our paper contributes to the agricultural trade policy debate by providing a rigorous assessment of current agricultural policies in South Korea and, more generally, of FS strategies promoted by many developing economies. A first contribution of our paper is to estimate the welfare costs and trade implications of Korean agricultural policy, using a multimarket dual approach to trade based on Anderson and Neary 1996. We consider major policy instruments such as tariffs, price support, input subsidies, and consumption taxes. A comparison of these costs since 1979 makes it possible to assess how the policy changes that took place in the 1990s translate into welfare.

Second, Korea is part of a multilateral trading system that relies on the most-favored-nation clause, implying some import volume expansion. We measure the degree of restriction, expressed in volume of trade that is generated by Korean agricultural policy, using the "mercantilist" indicator of trade restrictiveness (Anderson and Neary 2000). This index provides a metric of foregone trade opportunities by other WTO members.

Finally, we estimate how Korea could rationalize its policy instruments for several FS objectives. We begin with self-sufficiency in staple crops and meat and present the structure of optimal consumption taxes and production subsidies, together with their welfare and trade impacts. We then look at FS attained under joint reliance on imports and production targets. We show the sensitivity of the level and nature of protection to the commodity coverage of the target through cross-price effects in production and consumption. We conclude the targeting section by drawing implications on strategic considerations for trade negotiations regarding support levels under the development or FS box.

The policy recommendation punch line of our paper is that developing members of the WTO who endorse FS should advocate deficiency payments for their agricultural production and open their borders simultaneously. This would represent a tit-for-tat strategy with major players such as the United States. This strategy is much less antagonizing than self-sufficiency for trade partners and much more beneficial to consumers and small producers who are net buyers of food. Policy rents to farmers would be little affected.

The Analytical Framework

We use a multimarket model of Korean agriculture and food markets embedded in a dual approach to trade to estimate the supply and demand response to government intervention and the subsequent welfare effects. Following Anderson and Neary (1996 and 2000), these distorted markets are treated as being separable from the rest of the economy. The set of policy instruments that is considered here affects the output prices, consumption prices, and input prices. Tariffs and government purchases translate into producer and consumer prices higher than the border price. Input subsidies and direct payments are modeled by lower input prices that are commodity-specific in the case of fertilizer taxes, irrigation subsidies, and subsidized interest rates. Consumption subsidies are modeled by lower consumer prices. We cover rice, wheat, barley, corn, soybean milk, beef, pork, and poultry. Details on the policy instruments and information on the data are provided in Appendix A.

Demand for food is represented by an incomplete Linquad demand system calibrated to existing estimates of income and price elasticities for agricultural and food products (LaFrance; Lafrance et al.). The sub-demand system for agricultural and food products is constructed assuming that other consumption goods are a composite single good. Homogeneity in prices of the complete system is accounted for by expressing all prices relative to the price index of the composite non-agricultural good.[2] Let *x* be an *n*-vector of agricultural goods on demand, *q* be an *n*-vector of corresponding consumptions prices, and q_z be the consumption price of non-agricultural goods *z*. Variable *y* is an *m*-vector of agricultural netputs, including *n* (positive) agricultural outputs and *m–n* (negative) inputs, and *p* is the corresponding price *m*-vector. Variable *M* is total income or expenditure; p^* denotes the *m*-vector or world prices for agricultural inputs and outputs. The Linquad expression of the vector of Marshallian demands for agricultural and food goods is

$$x^M = \varepsilon + Vq + \chi(M - \varepsilon' q - \tfrac{1}{2} q' Vq - \delta(q_z)), \tag{1}$$

corresponding to the expenditure function

$$e(q, q_z, u) = \varepsilon' q - \tfrac{1}{2} q' Vq - \delta(q_z) + \theta(q_z, u) \ \exp(\chi' p). \tag{2}$$

The elements of the *n*-vectors ε and χ in equation (1), together with the elements of the n×n matrix *V,* are calibrated using the procedure described in Appendix B. The calibration imposes homogeneity of degree one in prices for *e* and symmetry of the Hessian of *e*. Concavity is verified locally.

The whole production sector of the economy is represented by a gross domestic product (GDP) function $gdp(p, p_z, \phi)$, with p_z denoting the price of non-agricultural netputs, and ϕ denoting a vector of fixed endowments and the technology. We assume that *gdp* is separable into the agricultural and non-agricultural components, Π and *g*, so that

$$gdp(p, p_z, \phi) = \Pi(p, y_f) + g(p_z, y_{-f}), \tag{3}$$

where y_f denotes the agricultural endowments. Component Π is represented by a quadratic revenue function

$$\Pi(p, y_f) = \eta p + p' Wp + h(y_f), \tag{4}$$

leading to supply functions being linear in relative prices. As for the demand system, the price responses of agricultural supply and demand for inputs are calibrated using prior information on price elasticities. Homogeneity of degree zero in netput price and symmetry are imposed at the sectoral level, and convexity is verified locally. This multimarket model is then imbedded in a dual approach to trade, namely, the Balance of Trade (BoT) function.

The BoT function, *B*, is defined as the sum of the value of a consumer's excess demand over income at external prices. It is built up from the consumer's expenditure function and the revenue (GDP) function, net of the government tax revenue function, or

$$B(p, p_z, q, q_z\ u, \phi, y_f, \beta) = e(q, q_z, u) - gdp(p, p_z, \phi) - [(q - p^*)' x(q,u) - (p - p^*)' y(p, y_f)] + \beta, \quad (5)$$

where β is the sum of the tariff revenue on non-agricultural goods and the net financial transfers from abroad, both of which are assumed constant in the rest of the paper. We assume perfect competition and exogenous world prices. Derivative properties applied to *e* and *gdp* yield compensated consumption and output quantities and their difference yields imported quantities.

The BoT function *B* includes a general equilibrium concept. Expenditure and revenue functions characterize the private sector structure of supply and demand of the distorted sectors analyzed in the economy. However, because of the tax revenue raised by distortions, both government and private behavior are summarized by $B(p,q,p^*,u,\gamma)$, where γ represents the constant elements $(p_z, q_z, \phi, y_f, \beta)$. The BoT function represents the external budget constraint and is equal to the net transfer required to reach a given level of aggregate domestic welfare, *u*, for a given set of domestic prices. Net government revenue from agricultural and food distortions is equal to $[(q-p^*)' x(q,u) - (p-p^*)' y(p)]$, where the fixed endowments are ignored to simplify notation. Consumption subsidies are captured by (*q*–*p*) negative, the cost of tariffs and taxes to consumers by $(q-p^*)$, and the producer prices, including support and subsidies, by $(p-p^*)$.

Subtracting the partial derivatives of the BoT function with respect to domestic prices (*p*, *q*) yields $-\nabla_p B$ and $-\nabla_q B$, the vectors of marginal welfare costs of domestic price distortions in production and in consumption, respectively. As *dp* and *dq* represent the producer and consumer price distortions, the total deadweight loss from these distortions is equal to minus the change in the foreign exchange to support *u*, or minus $(\nabla_p B dp + \nabla_q B dq)$. This is the additional foreign exchange required to compensate for a change in distorted prices (*dp*, *dq*) in order to maintain the initial welfare level. Variables

TABLE 1. Support in Korean agriculture

	Period (3-Year Average)		
	1979-81	**1990-92**	**1998-2000**
GDP, 10^9 wons at 1995 prices	118,302	284,851	435,779
Share of agriculture in GDP[a]	13.1%	6.7%	4.2%
% PSE (OECD)	56%	77%	65%
% CSE (OECD)	56%	72%	63%
Consumption at domestic price/ consumption at world prices[b]	2.23	3.21	2.27
Production at domestic price/ production at world prices[b]	2.35	4.04	3.05

[a] Commodities covered by OECD's PSEs only.
[b] Laspeyres index, fixed production and consumption weights.

$\nabla_p B$ and $\nabla_q B$ can be derived from totally differentiating *B*, and they can be parameterized and estimated using the calibrated food demand and supply responses.

Welfare Costs of Korean Agricultural Policy

As shown in Table 1, the producer support estimate (PSE), measured by the OECD and expressed as a percentage of the value of production, reaches 74 percent in Korea compared to an OECD average of 40 percent in 1999. The Korean government provides a few direct payments and some input subsidies (fertilizers and interest subsidies). The main policy instruments are transfers from consumers, which account for 95 percent of the support to farmers (OECD 2001). Many consider such forms of public intervention most distortionary and believe that they impose welfare costs on the society as a whole.

The welfare effect of the various policy instruments can be derived from the BoT function by constructing the Trade Restrictiveness Index (TRI), which is a welfare-based single tariff equivalent of the various policy instruments (Anderson and Neary 1996). The TRI is the uniform scaling factor (or uniform price deflator Δ) that, when applied to period 1 prices, permits the representative consumer to attain his or her initial level of utility u^0 while holding the BoT constant at its original (period 0) level b_o:

$$\Delta\left(p^1, q^1, u_0, z\right) \equiv \left[\Delta : B\left(p^1/\Delta, q^1/\Delta, u_0, z\right) = b_0\right]. \qquad (6)$$

The scalar Δ is the uniform deflator, which, if applied to all imported goods prices, would ensure a constant balance of payments at the initial level of utility. Consider the case where the comparison is between a protected situation 0 and free trade (i.e., $p^1 = q^1 = p^*$ or $\tau^1 = 0$, with the equality $p^i = (1+\tau^i)p^*$ defining the ad valorem uniform tariff $\tau^i, i = 0,1$). Then we have the equivalence between deflator (1/Δ) and uniform tariff factor $(1+\tau^0)$:

$$B\left(p^* / \Delta, u_0, z\right) = b_0 = B\left((1+\tau^0)\, p^*, u_0, z\right). \tag{7}$$

The uniform tariff equivalent, $\tau^0 = (1/\Delta - 1)$, leads to period 0 welfare when applied to the set of world prices.[3] In our case, specific production and consumption price distortions exist, and the TRI methodology applies to any subset of price distortions in any sector of the economy. In the rest of the paper, Δ is referred to as the uniform deflator and $\tau^0 = (1/\Delta - 1)$, as the uniform unit price distortion. In the general case, without a general equilibrium model, the changes in Δ have to be locally approximated. Total differentiation of *B* in equation (6) yields the percentage change in Δ as a local approximation of the change in welfare $\nabla_p Bdp + \nabla_q Bdq$ normalized by the factor $\nabla_p Bp + \nabla_q Bq$, or

$$\dot{\Delta} = \frac{\nabla_p Bdp + \nabla_q Bdq}{\nabla_p Bp + \nabla_q Bq}, \tag{8}$$

where the derivatives of *B* are evaluated by $(p^1/\Delta, q^1/\Delta,\ u_0)$. That is, the change in the TRI deflator is a weighted average of the proportional changes in domestic prices. The weights are the shares of marginal deadweight loss due to each policy-induced price variation. The numerator of equation (3) measures the deadweight loss of the distortion changes and corresponds to the change in compensation measures (EV or CV) induced by *dp* and *dq*, or the change in the money metric utility for the same *dp, dq* up to normalization by the shadow price of foreign exchange (Anderson and Martin). Table 2 provides the deadweight loss of the agricultural policy based on estimates of the components of $\nabla_p B$ and $\nabla_q B$. When comparing the observed (distorted) situation 0 and the situation 1 without public intervention (at the vector p^* of free trade prices without input and consumption subsidies), it is possible to calculate the different components of the numerator of equation (8). The figures shown in Table 2 are in billion won at 1995 prices.

The results provided in Table 2 show how costly the social transfers induced by Korean agricultural policy are in terms of welfare. The deadweight loss associated to the transfer of 10 wons to farmers amounts to roughly 5.8 wons. This is mainly caused by the particular policy instruments fully coupled to production and taxing consumers. High tariffs and administrative prices reflect the Korean preference for self-sufficiency objectives, regardless of the cost for consumers in sectors such as rice, pork, or poultry. Table 3 provides a measure of the TRI uniform distortion equivalent relative to free trade. Equation (8) leads to the proportional change in the uniform tariff. When comparing the observed (distorted) situation 0 and the situation without public intervention, equation (9) provides an approximation of $\tau^0/(1+\tau^0)$:

$$\dot{\Delta} = \frac{d\Delta}{\Delta} = -\frac{d\tau^0}{1+\tau^0} = \frac{\tau^0}{1+\tau^0}. \qquad (9)$$

Scalar τ^0 would lead to the present welfare if the reference prices were increased by this amount (i.e., if all the components of p^*, the vector of netput prices in the free trade situation without intervention, were increased by a factor $\tau^0 p^*$). Expression $\nabla_q^{'} B^0 (p^* - q^0) / \nabla_q^{'} B^0 q^0$ is the weighted sum of the unit distortion of consumption prices; the weights are the deadweight loss associated with the unit distortion on a

TABLE 2. Transfers and welfare losses induced by Korean agricultural policies (all figures in billion 1995 wons)

	Period (3-Year Average)			
	1979-81	1990-92	1998-2000	Cumulative 1979-2000
Increase in agricultural revenue	6,640	10,982	10,571	218,595
Tariff and tax revenues	1,762	1,532	1,228	26,258
Deadweight loss consumption	1,557	3,015	2,430	49,976
Deadweight loss production	1,553	3,650	3,722	69,277
Deadweight loss total	3,111	6,665	6,152	119,254

TABLE 3. Trade Restrictiveness Index and related indicators

	Period (3-Year Average)		
	1979-81	**1990-92**	**1998-2000**
(1) dΔ/Δ	0.58	0.74	0.67
(2) Uniform unit distortion	1.39	2.87	2.15
(3) Marginal welfare-weighted percentage distortion on consumption prices	0.59	0.73	0.67
(4) Consumption-weighted distortion on consumer prices (% actual value)	0.55	0.69	0.54
(5) Marginal welfare-weighted percentage distortion on output prices	0.58	0.75	0.67
(6) Production-weighted distortion on output prices	0.58	0.75	0.66

particular good. The comparison of this indicator (row 3 in Table 3) with the sum of each consumption distortion weighted by the consumption of each good *n* (row 4) shows that the use of the marginal deadweight loss on consumption as a weight results in a larger overall index. In a similar way, the deadweight loss weighted average of the production distortions $\nabla_p^{'} B^0 (p^* - p^0) / \nabla_p^{'} B^0 p^0$ (row 5 of Table 3) is larger than the average distortion weighted by the share in production (row 6).

The Effect of Korean Agricultural Policy on Each Agricultural Sector

The relative impact of the various policies can be seen by simulating the effect of the whole set of taxes and subsidies on a particular commodity. This requires taking into account the specific measures for each input, such as irrigation subsidies, capital grants, subsidies for fertilizer use, etc. These inputs were allocated to each production using annual input/output coefficients (see Appendix A), and a reference price was constructed for each commodity-specific input by allocating a detailed set of subsidies to the various agricultural productions based on the allocation used by the OECD for the calculation of the PSEs.

The deadweight loss in consumption corresponding to the commodity *i* is estimated by the expression $\nabla_q^{'} B^0 (p_i^* - q^0)$, where the elements of p_i^* are the reference price in the case of the commodity *i* and the commodity-specific input and are the observed prices q^o

in other cases. A similar computation is made for estimating the deadweight loss on the production side. The sum of the two components provide the total welfare effect associated with the government intervention on commodity *i*, which includes the market price support, the output enhancing subsidies, and the subsidies to the input used in the production of *i* (Table 4, row 5). The contribution of the commodity-specific policy to the overall welfare is expressed as a percentage (Table 4, row 6).

The effect of the policy on the revenue of agricultural producers can be derived from the sectoral GDP function. The derivatives of Π relative to distorted prices $\nabla_p \Pi$ give the amount of income resulting from an increase in output (decrease in input) prices. Because of Hotelling's lemma, these are the elements of the production vector.

TABLE 4. Commodity-specific effect of Korean agricultural policy (figures in billion 1995 wons; all figures are average 1998-2000)

	Rice	Wheat	Barley	Corn	Soybean	Milk	Beef	Pork	Poultry	Overall
Value of output at domestic prices	8,474	6	189	-	251	1,050	1,883	1,966	619	14,438
Value of output at reference prices	1,957	5	41	-	35	328	739	1,332	503	4,940
Consumption at domestic prices	8,140	631	215	1,593	665	1,215	3,132	2,009	693	18,293
Consumption at reference prices	1,935	629	73	1,585	444	388	1,197	1,385	575	8,211
Product-related deadweight loss (consumption; production)	3,569 (948) (2,680)	-0.3 (-0.3) (-)	59 (57) (-)	0 (0) (-)	80 (26) (55)	726 (325) (401)	1,442 (927) (516)	466 (144) (322)	147 (3) (144)	6152 (2,430) (3,722)
Contribution to total welfare costs	55%	0%	1%	0%	1%	11%	22%	7%	2%	-
Income transfers to producers[a]	7,151	0	161	-	229	793	1,269	793	173	10,571
Transfer efficiency[b]	67%	-	73%	-	74%	52%	47%	63%	54%	63%
Direct welfare effect	2,708	0	100	0	81	586	1,348	378	44	-
Cross-commodity welfare effect	-27	-0.2	-48	0	-16	2	-96	-98	-21	-
Input welfare effect	888	-	7	-	15	138	190	193	124	-

[a]Includes input subsidies.
[b]Defined as transfers/(transfers+deadweight loss).

That is, the income effect of the agricultural policy is approximated by $\nabla'_{p}\Pi(p - p^{*})$. A similar approach is used for estimating the revenue effect of the agricultural policy on a commodity-specific basis.

The efficiency of the agricultural policy, defined as the overall cost to the society of transferring income to producers, can be estimated by the deadweight loss (on both the consumption and production sides) associated with one unit of the extra producer income resulting from the policy. It therefore is defined as one plus the ratio of the revenue effect $\nabla'_{p}\Pi dp$ to the welfare effect $\nabla_{p} Bdp + \nabla_{q} Bdq$ and is provided in Table 4, row 6. Rice growers get the largest transfer, followed by beef, pork, and milk producers. Rice policy has the highest contribution to foregone welfare, followed by beef, dairy, and pork. Beef has the lowest efficiency of transfer, at around 47 percent. The effect of government intervention on a particular product has implications in terms of substitution on both the production and consumption of other products when prices are influenced. The deadweight loss generated by a commodity-specific policy can be decomposed in terms of an own-price effect, a cross-price effect, and an input effect that measure the impact of the public policy (both on output and input through prices subsidies) on input use. Input distortions have the largest amounts of welfare losses in the rice and pork sectors, where they account for one-fourth and one-third of the deadweight losses in these respective sectors. However, deadweight loss levels induced by input subsidies are nearly negligible in all other sectors, except for beef, dairy, and poultry.

Trade Impacts of Korean Agricultural Policy and Mercantilism

As a member of the WTO, Korea had to convert quantitative restrictions on imports into bound tariffs, reduce these tariffs over an implementation period, open its market to imports under the minimum access provisions, and reduce the most trade-distorting forms of domestic support in 1994. However, Korea applied the Uruguay Round provisions so that it could protect its producers from foreign competition in key sectors (IATRC 1997). For example, Korea postponed the tariffication of rice for 10 years and negotiated an obligation to import only 4 percent of its consumption by 2004. In most of the staple foods, Korea has also kept import restrictions under domestic special rules. Prohibitive tariffs and administrative barriers still restrict imports of many agricultural goods to

Korea (IATRC 1994). Self-sufficiency remains a policy objective (see Table 5), particularly in the rice sector, because of the cultural content of this good and because of the possible reunification with North Korea, which has been experiencing dramatic shortages of rice, making this issue particularly sensitive.

From the point of view of the other countries involved in the trade negotiations, the variable of interest is the volume of imports and exports of the given country, rather than its welfare. This motivates an evaluation of the restrictiveness of trade policy using trade volume as the reference standard rather than the utility of the representative consumer (Salvatici, Carter, and Sumner). Anderson and Neary (2000) have proposed the mercantilistic trade restrictiveness index (MTRI), which relies on the idea of finding a uniform tariff that yields the same trade volume as the original tariff structure. The definition of the MTRI shares the basic BoT framework of the TRI. It provides a metric of foregone trading opportunities induced by a set of distortions, while holding constant the BoT function but not utility.

Define m^c as a vector of Hicksian import demand functions. This is the vector derived from the expenditure and revenue function:

$$m^c(p,q,u) = \nabla_q e(q,u) - \nabla_p \Pi(p), \tag{10}$$

where the set of variables γ is innocuously omitted. The general-equilibrium Marshallian import demand function depends on domestic and world prices and on exogenous income

TABLE 5. Self-sufficiency in Korean agriculture

	Rice	Wheat	Barley	Corn	Soybean	Milk	Beef	Pork	Poultry
Production (10^3 tons) 1998-2000	5,217	4	271	0	128	2,186	327	911	346
Consumption (10^3 tons) 1998-2000	5,148	3,113	469	9,438	1,667	2,595	547	959	401
Net imports in % consumption 1979-81	19%	97%	21%	100%	66%	-0.1%	19%	14%	-0%
Net imports in % consumption 1990-92	0%	99%	15%	100%	85%	6%	53%	-0%	9%
Net imports in % consumption 1998-2000	-1%	99%	42%	100%	92%	16%	40%	5%	14%

b for the entire economy, $m(p,p^*,b)$. Anderson and Neary (2000) relate the Hicksian import demand function to the GE Marshallian one, as both coincide when the balance-of-payments equilibrium holds: in other words, when the BoT equates the lump sum transfer from abroad b, i.e., $B(p,q,p^*,u)=b$. This makes it possible to define the equivalent of a Slutsky identity for the import demand function and to relate both import demand functions, i.e.,

$$\nabla_\pi m(p,q,p^*,b) = \nabla_\pi m^c + \nabla_u m^c \frac{du}{d\pi} = \nabla_\pi m^c - \nabla_b m \nabla_\pi^{'} B\,, \qquad (11)$$

where π is used as a synthetic notation for either p or q vectors. The scalar import volume function, M, corresponding to the Marshallian import demand $M(p,q,p^*,b)$ in equation (12) gives the volume of imports at world prices when domestic prices equal (p,q) and the trade balance equals b:

$$M(p,q,p^*,b) = p^*.m(p,q,p^*,b)\,. \qquad (12)$$

We use equation (11) and $\nabla_b M = p^* \nabla_b m = \left[1-(q-p^*)\nabla_I x^M(q,I)\right]^{-1} p^* \nabla_I x^M(q,I)$, where x^M denotes the Marshallian consumer demand, to retrieve the price derivatives of the Marshallian import demand function $\nabla_\pi M$ as shown in equation (13):

$$\nabla_\pi M = p^* \nabla_\pi m^c - p^* \nabla_b m \nabla_\pi B\,. \qquad (13)$$

Note that $\nabla_b M$ is the marginal propensity to consume tariff-constrained imports; $[1-(q-p^*)\nabla_I x^M(q,I)]^{-1}$ is the shadow price of foreign exchange and $\nabla_I x^M$ is the marginal income response vector for the n consumption goods (Anderson and Neary 2000).[4] The Marshallian MTRI is the most relevant index for measuring the overall trade impact of distortions. The MTRI gives the uniform price deflator μ which, when applied to the prices in the new equilibrium situation 1 yields the same volume (at world prices) of tariff-restricted imports as in the initial situation 0:

$$\mu \ (p^1, q^1, M^0) \equiv \left\{\mu : M\left(p^1/\mu \ , q^1/\mu, p^*, b_0\right) = M^0 = M\left(p^0, q^0, p^*, b_0\right)\right\}. \qquad (14)$$

As was the case with the TRI, if p^1 equals its free trade values p^*, the scalar (1/μ–1) is the uniform tariff, which is equivalent in import volume to the initial tariff-distorted trade structure.[5] The effect of tariff changes in the MTRI can be approximated by using price derivatives of the Marshallian import demand function $\nabla_\pi M$, evaluated at (p^1/μ, p^1/μ):

$$\dot{\mu} = \frac{d\mu}{\mu} \approx -\frac{\nabla'_p M.\ dp + \nabla'_q M.\ dq}{\nabla_p M.\ p + \nabla_q M.\ q}. \qquad (15)$$

Using the vector of prices in the absence of distortion as the reference situation 1, and the observed prices as situation 0, the MTRI change is estimated using the expression of the demand system (2) and the sectoral GDP function (3) to retrieve the derivatives of the import demand functions (13). Table 6 provides the results. The change in the MTRI in equation (15) is a weighted sum of the proportional changes in consumption and production prices between the observed situation and the situation in the absence of public intervention. The weights are the marginal volumetric shares of each price change.

TABLE 6. Trade volume restrictiveness of Korean agricultural policy

	Period (3-Year Average)		
	1979-81	**1990-92**	**1998-2000**
Volume of trade restriction (billion 1995 wons)	2,138	2,120	2,273
dμ/μ	0.50	0.51	0.39
Uniform tariff τ	1.03	1.07	0.66
Trade-weighted percentage distortion on consumption prices [a]	-0.44	-0.45	-0.27
Marginal trade-weighted distortion on consumption prices	-0.47	-0.47	-0.33
Trade-weighted percentage distortion on production prices [a]	-0.44	-0.57	-0.45
Marginal trade-weighted distortion on production prices	-0.55	-0.58	-0.49

[a]The unit distortion is measured as $(q_n^*-q_n)/q_n$ for consumption prices and as $(p_n^*-p_n)/p_n$ for production prices.

The uniform tariff equivalent has decreased dramatically during the 1990s. Recall that this is the tariff that should be applied to all goods under consideration (i.e., the list of the agricultural goods covered by the OECD PSEs) as this would give the actual level of imports in these goods. The decline by one-third of this indicator between 1990-92 and 1998-2000 is mainly a result of the surge in imports of corn, wheat, and soybeans at relatively low tariffs and an increase in the imports of beef (see Table 5).

Table 6 shows that weighting individual tariffs (or, more exactly, their impact on both production and consumption prices) by the marginal trade impacts, as expressed by the MTRI, leads to slightly higher measures of trade restrictiveness than those found using standard import-weighted average distortion.

Agricultural Policy in a Second-Best Framework

The special session of the WTO Committee on Agriculture was established for the purpose of agricultural trade negotiations during the years 2000 and 2001. Proposals made during the session show that many developing and food-importing countries share Korea's concerns about food dependency and possible price hikes, leading to difficulties in financing normal levels of commercial imports.[6] Most of them are also unsatisfied by the practical effect of the 1994 "Decision on Measures Concerning the Possible Negative Effects of the Reform Programme on Least-Developed Countries and NFIDCs" that accompanied the URAA. The "Decision" was supposed to address their concerns about FS.[7]

We have shown in the two previous sections that Korean food policy has costly welfare effects that may frustrate mercantilist aspirations of trade partners by restricting agricultural trade. In this section, we take FS as a premise and investigate optimum distortion structures for several definitions of FS, including self-sufficiency.

Tax Structure for Self-Sufficiency Targets

First, consider Korea's negotiating claim that WTO commitments should allow it to pursue desired FS and rural development policies, by setting an objective of a given degree of self-sufficiency in the grain sector, in the meat sector, and for a set of commodities that Korea actually produces (meat, grains, dairy). Within a second-best framework, it is possible to provide optimization of the tax structure for achieving a given level of self-sufficiency $\alpha=(\alpha_1, \alpha_2,..,\alpha_n)$ for $\alpha_n x_n = y_n$, with the subscript referring to commodity *n* and with $0 \leq \alpha_n \leq 1$ for all *n*. From the targeting principle in a small economy (Bhagwati, Panagariya, and Srinivasan; Vousden), the optimum distortion structure calls for a production subsidy and a consumption tax that is equal to α, the production subsidy. In addition, input subsidies are inferior to output subsidies and should not be used; that is, marginal rates of technical substitution should be left undistorted (Bhagwati, Panagariya, and Srinivasan).

Formally, consider the (specific) tax on consumption $\tau_n^c = q_n - p_n^*$ and the tax on production $\tau_n^p = p_n - p_n^*$ for good *n*. Efficiency costs should be minimized under the constraint of the distortion structure satisfying the self-sufficiency target. Imports represent a predefined proportion of demand at the distorted prices:

$$\alpha_n x(p^* + \tau_n^c, u) - y_n(p^* + \tau_n^p) = 0 . \qquad (16)$$

Differentiating equation (16) and the BoT function leads to the following system of equations:

$$\begin{cases} \left((1 - \frac{\partial x_n^M}{\partial I} \tau_n^c \right) \frac{\partial e}{\partial u} du = -\tau_n^p \frac{\partial^2 g}{\partial^2 p_n} dp_n + \tau_n^c \frac{\partial^2 e}{\partial^2 q_n} dq_n \\ \alpha_n \frac{\partial^2 e}{\partial q_n \partial u} du + \alpha_n \frac{\partial^2 e}{\partial q_n q_n} dq_n = \frac{\partial^2 g}{\partial^2 p_n} dp_n \end{cases} . \qquad (17)$$

Rearranging leads to the expression of *du,* in terms of *dq* and the first-order condition:

$$\frac{du}{dq_n} = 0 \Rightarrow \tau_n^c - \tau_n^p \alpha_n = 0 . \qquad (18)$$

That is, a necessary condition for the second-best tax structure is that the relative consumption and production taxes verify $\tau_n^c = \alpha_n \tau_n^p$ for all *n*. To solve for the optimum level of τ, define the excess demand for import relative to the self-sufficiency target *i* at non-distorted prices, based on equation (16): $A_i(p,u) = \alpha_i x_i(p^*,u) - y_i(p^*) \Rightarrow \alpha_i dx_i - dy_i = -A_i$. This excess demand's response to optimum distortions is

$$\frac{\partial A_i}{\partial \tau_j^p} = \alpha_i \alpha_j \frac{\partial x_i^H}{\partial p_j} - \frac{\partial y_i}{\partial p_j}$$

for targeted self-sufficiency levels α_i, and α_j for *i* and *j*. The optimum distortion reduces the excess demand (over the target) and minimizes welfare losses relative to a free trade situation, as expressed by the following equations:

$$\sum_j^K \tau_j^p \frac{\partial A_i}{\partial \tau_j^p} + \alpha_i \frac{\partial x_i^M}{\partial I} \frac{\partial e}{\partial u} du = -A_i \tag{19}$$

for *K* self-sufficiency targets at level α_j with *i* and *j*=1,…,K, and

$$\frac{\partial e}{\partial u} du = \frac{\sum_i^K \sum_j^K \frac{\partial A_i}{\partial \tau_j} \tau_i \tau_j}{\left(1 - \sum_i^K \alpha_i \tau_i \frac{\partial x_i^M}{\partial I}\right)}, \tag{20}$$

to be minimized. The latter expression comes from the differentiation of the BoT function. Minimizing welfare losses (19) subject to (20) yields the optimum τ structure.

In a first set of simulations, we define the optimal tax structure under the constraint of achieving the historical level of self-sufficiency over the 1998-2000 period. Simulations were conducted in two ways: imposing the observed levels of self-sufficiency for the whole set of commodities, and on a commodity-per-commodity basis. Table 7 shows that the present structure of taxes and subsidies is close to the one recommended for maximizing welfare under the constraint of the existing rate of self-sufficiency. Rows 2 and 3 of Table 7 show that the ratio of the actual tax on consumption and subsidy of production is close to satisfying condition $\tau_n^c = \alpha_n \tau_n^c$. This is particularly the case for soybeans, a commodity whose production is supported at very high levels but for which consumers face relatively few taxes. This suggests that, if one focuses on a self-sufficiency objective, relatively little can be gained from a reform of the tax structure under these constraints, except for the input subsidies distorting marginal rates of substitution in production. The gains from such a minor tax reform would be limited to 1,540 billion wons at 1995 prices.

Table 7. Targeting historical levels of self-sufficiency (all figures are 1998-2000 averages)

	Rice	Wheat	Barley	Corn	Soybean	Dairy	Beef	Pork	Poultry
Actual production support (ad valorem equivalent)	360%	-	377%	-	688%	222%	172%	52%	26%
Actual consumption tax	352%	0%	215%	1%	54%	215%	167%	48%	23%
Ratio production/ consumption tax	0.96	-	0.55	-	0.08	0.96	0.94	0.83	1
Historical rate of self-sufficiency	1.02[a]	0	0.58	0	0.08	0.85	0.60	0.95	0.87
Second-best tax on production	342%	0	366%	0	696%	238%	233%	51%	25%
Second-best tax on consumption	342%	0	214%		52%	200%	129%	47%	20%

[a]We constrain α=1 for rice.

Self-sufficiency targets mean restricting demand by imposing high prices to consumers, which can lead to the absurd situation where a country insulates itself from the vicissitudes of world markets by starving its consumers. Consider the hypothetical case in which Korea would decide to become self-sufficient in proteins. In spite of a very high level of subsidies (equivalent to paying producers more than six times the world prices), Korean production of soybeans covers less than 10 percent of actual consumption. Simulations with the above model show that any self-sufficiency target could be achieved only by a choking contraction of demand, where very high consumption taxes would restrict the use of soybeans to a level that would be close to actual production. In Korea, self-sufficiency in pork and poultry production is achieved only by importing large quantities of soybeans and corn, which is less absurd than producing the feed domestically, but still less effective than importing meat in a land-scarce country. These commodities face a relatively low tariff, while tariffs on meat are prohibitive. On this basis, self-sufficiency can hardly be defended on national security grounds: corn is supplied mainly by a single country, and the world market for soybeans has experienced some shortages in the past. This suggests that Korean self-sufficiency objectives in these sectors merely reflect simple tariff escalation and effective protection of meat products.

Finally, although we do not address this point formally, self-sufficiency penalizes poor consumers the most because it imposes on them a large expenditure share for food; this policy hardly qualifies under the objective to “provide food access to all.”

Tax Structure Supporting Production Targets for Food Security

A reasonable alternative would be to set production levels as targets in staple foods and rely on imports for additional sourcing of food items. Low or no tariffs on the consumer side would result in a higher demand, and the self-sufficiency ratio would decrease dramatically. However, domestic production would be maintained and would represent some insurance against world market uncertainty. The effect of this policy on domestic supply “security” would be the same as that of self-sufficiency policy, without distorting consumption decisions.

Setting the constraint of achieving historical production levels leads to fixed output subsidies but no consumption tax (Bhagwati, Panagariya, and Srinivasan; Vousden). The corresponding level of output subsidy on a subset of targeted commodities k=1,…K can be found by solving the program $\tau^p = [\partial y / \partial p]^{-1}(\bar{y}\ \ (p\ + \tau^p) - \bar{y}(p^*))$, where $\bar{y}_j(p^* + \tau)$ is the level of production target for commodity j, and j and k describe the K commodities that are targeted by the FS objectives. The elements of τ corresponding to non-targeted commodities are equal to zero. Matrix $\partial y/\partial p$ is $k \times k$. Simulations show that this objective leads to production subsidies comparable to the present situation, which is not surprising, given the limited production impact of Korean input subsidies.

Table 8 makes this point vividly. It compares the deadweight loss (EV from free trade) in the actual situation (column 1). It also shows the trade implications of the alternative approaches to FS, which are full self-sufficiency (columns 2 to 4), historical levels of self-sufficiency as a target (columns 5 to 7), and historical production levels as a target, as resulting from a policy based on deficiency payments and no tariffs (columns 8 to 10). The second row of Table 8 gives the value of imports of all commodities at world prices under the four situations. The third row provides an indicator of the trade restriction caused by the corresponding tax structure, as measured by the numerator of the MTRI. Finally, row 4 provides the uniform MTRI tariff, i.e., the tariff that should be

Table 8. Welfare and market access under self-sufficiency and production targets, 1998-2000 average (all figures in 10^6 won at 1995 prices, except those in percentages)

		Full Self-Sufficiency Target (α=1) on Subsets of Goods			Historical Self-Sufficiency Target on Subsets of Goods			Production Target, Historical Levels		
	(1) Actual Situation	(2) Staple Grains only	(3) Meat Only	(4) Grains, Meat Milk	(5) Staple Grains Only	(6) Meat Only	(7) Grains, Meat, Milk	(8) Staple Grains Only	(9) Meat Only	(10) Grains, Meat, Milk
Deadweight loss EV [a]	6,152	2,725	4,001	9,730	2,540	1,444	4,614	1,716	475	2,506
Value of imports world prices	3,275	4,843	3,702	2,270	4,842	4,357	3,381	5,044	5,065	4,431
Trade restriction impact	2,272	694	1,835	3,310	690	1,164	2,164	515	485	1,132
Uniform equivalent tariff	66%	19%	56%	98%	19%	35%	63%	14%	14%	32%

[a]Relative to absence of public intervention.

imposed on all prices of tradable commodities in order to lead to the volume of trade at a world price that corresponds to a given tax structure.

Besides the welfare aspects, setting production targets rather than self-sufficiency targets represents a more palatable situation for mercantilist partners within the WTO and should facilitate the negotiation of large deficiency payments. This policy, which has been used in the main U.S. programs for years, makes it possible to avoid the present deadweight losses on the consumption side. This generates extra Korean imports and a loss of limited tariff revenue that can no longer be redistributed to consumers. However, the decrease in food costs for consumers, as well as the increase in consumption, results in significant welfare gains, sufficient to pay for the farm program and more. Targeted deficiency payments in the staple grains sector (rice and barley) that achieve historical production levels, while removing tariffs on imports, would result in a significant welfare improvement (the deadweight loss would be reduced by 72 percent compared to the actual situation, to 1,716 billion wons at 1995 prices). It would also result in a significant expansion of market opportunities. The MTRI uniform tariff equivalent, a synthetic indicator of these market opportunities, would fall from 66 percent to 14 percent, and the volume of trade foregone would fall from 2,272 billion wons to 515 billion at 1995 prices.

Conclusions

Despite partial trade liberalization under the URAA, South Korea has been pursuing a policy of food self-sufficiency using trade restrictions and administrative prices in key agricultural and food markets, while following production targets with partial trade opening in lesser markets. These measures are part of a declared policy of food security, or FS. We analyzed the impact of these market distortions on welfare and trade volume and we computed optimum distortions, which minimize the welfare cost of observed self-sufficiency and production objectives. We also computed optimum distortions for FS relying on domestic production and imports for all products. We rationalized these optimum distortions as what could be claimed as legitimate protection under an “FS” box in the new round of WTO negotiations.

Because Korea uses policy instruments that involve large production distortions and impose high prices to consumers, we find that the present policies result in considerable welfare losses. The efficiency of transfers to producers is poor; each won transferred to farmers costs consumers and taxpayers roughly 1.6 trillion won, and the objectives of self-sufficiency are obtained through a significant contraction of demand and high prices that are unlikely to make food access easier for the less-favored consumers.

Compared to optimal self-sufficiency policies, the observed system of taxes and subsidies is nearly optimal to achieve self-sufficiency. Nevertheless, similar objectives of FS could be achieved through production targets and open borders without the actual (considerable) welfare losses. While the administration of programs such as deficiency payments might be difficult in some developing countries, which lack administration capacities and a large taxpayer basis, it is unlikely to impose more of an administrative burden than the actual agricultural policy, characterized by a high degree of state intervention.

There is growing pressure for consideration of an FS box in a future WTO agreement and a growing recognition from developed countries that some of the NFIDCs’ concerns in this area are legitimate. However, genuine concerns for FS should not be used as a justification for what is actually effective protection. From this point of view, the present Korean policy in the meat sector appears inconsistent. Most of the local production is achieved thanks to large amounts of imported feedstuffs, and the Korean policy corresponds mainly to tariff escalation rather than to FS concerns.

The setting of self-sufficiency targets appears to be dominated by other strategies when pursuing FS. Reliance on free trade with production targets is more rational and could provide the same level of protection to producers while reducing consumers' welfare cost. We found that the welfare gains of such a policy are considerable, even when maintaining present levels of production. Such a reorientation of policy instruments also would increase demand and hence exports from mercantilist trade partners who find current Korean policy of nearly prohibitive agricultural tariffs unpalatable.

To conclude, our policy recommendation is that developing members of the WTO who endorse FS should advocate deficiency payments for their agricultural production and open their borders. This tit-for-tat strategy, which mirrors U.S. policy, is much less antagonizing than self-sufficiency for trade partners and much more beneficial to consumers and small producers who are net buyers of food. Policy rents to farmers would be unaffected.

Endnotes

1. Several arguments have been made for this being the case. Food aid often decreases when world prices rocket and when aid is most needed. The European Union export tax set on grains in 1996, a poor harvest year, signaled that domestic consumers of exporting countries could matter more than NFIDCs consumers, in case of a grain shortage. Successive U.S. embargoes (for example, the 1973 soybean exports ban) and the versatility of the foreign policy of successive U.S. administrations are hardly perceived as a motive for trust by these countries.

2. In the following notations, p, q, and p_z express nominal prices deflated by the aggregate price index of non-agricultural goods.

3. Note that in more general cases, where the comparison holds between two protected situations, the TRI is the uniform tariff surcharge equivalent that keeps period 0 welfare when applied to period 1 prices of imported goods.

4. The MTRI could be defined from the Hicksian volume import demand, which would help isolate the roles of substitution and income effects. The MTRI constructed from the compensated import demand function does not capture the whole effect of the tariff structure on imports, because it keeps the utility constant. Hence, it ignores the redistribution of the tariff revenues and taxes to the aggregate consumer.

5. In more general cases, the $(1/\mu - 1)$ is the uniform tariff surcharge that when applied to the situation 1 prices would lead to the same volume of trade at world prices as in situation 0.

6. See, for example, the "Proposal by Cuba, Dominican Republic, Honduras, Pakistan, Haiti, Nicaragua, Kenya, Uganda, Zimbabwe, Sri Lanka and El Salvador: Special and Differential Treatment and a Development Box," G/AG/NG/W/13 (WTO 2000c). See also the proposals by India in the area of FS in G/AG/NG/W/102 (WTO 2001a), and the statement by Brazil, G/AG/NG/W/62 (WTO 2000d).

7. The "Decision" was a response to the fears of many low-income countries that trade liberalization would open their domestic food markets to volatile world prices and would threaten to undermine their FS. The Decision mentions four specific responses to this difficulty: food aid, favorable treatment with export credits, concessional financing for food imports, and technical and financial assistance to increase agricultural productivity and production. Matthews (2001) shows that in practice, the Decision did not address the main concerns of these countries. Makki et al. provide an interesting analysis of buffer stock and trade as a strategy to hedge price volatility.

Appendix A

Data

The analysis is based on the commodities covered by the OECD PSE database, including rice, wheat, barley, corn, soybean milk, beef, pork, and poultry. This covers 62 percent of the value of Korean agricultural production in 1979 and 56 percent in 2000. Fruits and vegetables are not included. Sugar and sheep meat are not considered here because of the low degree of government intervention. Wheat and corn are considered only on the consumption side because of the very low level of production over the period.

Output prices p and quantities y, consumption prices q and quantities $x_{i,}$ and reference prices p^* (i.e., international prices at the border or other non-distorted prices) are obtained from the PSEs and CSEs of the OECD dataset. In the case of dairy products, as there is no trade in fluid product, the convention adopted by the OECD is to use the producer price in a reference country where there is no public support (e.g., New Zealand is used as a reference and to adjust for transportation costs, differences in fat content, and to calculate a market price support; see OECD 2001). In the case of pork, the reference price is constructed on the basis of the Japanese wholesale price. Unpublished OECD data made it possible to allocate the various subsidies and to include them either as input price reduction or as output price supplement. The prices of input in the distorted situation are set to one and the non-reference input price is calculated using the (commodity-specific) input cost reduction. The allocation of input quantities to each product relies on the 1995 input-output table of the Bank of Korea. All prices are converted into 1995 prices deflated by the producer price index for agricultural, forestry, and fishery products and the consumer price index for food products.

The Linquad system parameters and the supply response system parameters are calibrated using the elasticities of the SWOPSIM (Static World Policy Simulation) database of the U.S. Department of Agriculture, and data from the Food and Agricultural Policy Research Institute, Namdoo (1996), Chul-Hyun (1997), and from background (unpublished) documents of the OECD (1998). The price responses of inputs are recovered using economic properties such as homogeneity condition and symmetry condition.

Appendix B

Calibration for the Linquad Demand System

Parameters of equation (1) are identified by solving the following system of equations:

$$\begin{cases} \dfrac{\bar{x}_i^M - \chi_i \bar{M}}{\chi_i} = \left(\dfrac{1}{\chi_i} - q_i\right)\varepsilon_i + \left(\dfrac{q_i}{\chi_i} - \frac{1}{2} q_i^2\right)v_{ii} - \sum_{j \neq i} \varepsilon_j q_j - \frac{1}{2} \sum_{j \neq i} v_{jj} q_j^2 - \sum_{j \neq i} \left(v_{ij} \dfrac{q_j}{\chi_i} - \frac{1}{2} q_i q_j\right) - \frac{1}{2} \sum_{j \neq i} \sum_{k \neq i} v_{jk} q_j q_k \\ \dfrac{\partial x_i^M}{\partial p_j}_{|\bar{x}} = v_{ij} - \chi_i \varepsilon_j - \chi_i v_{jj} q_j - \chi_i \sum_{k \neq j} v_{jk} q_k \\ \dfrac{\partial x_i^M}{\partial p_i}_{|\bar{x}} = v_{ii}(1 - \chi_i q_i) - \chi_i \varepsilon_i - \chi_i \sum_{j \neq i} v_{ij} q_j , \end{cases}$$

where the derivatives $\partial x/\partial p$ are estimated thanks to prior information on local elasticities at the reference point, denoted by a bar above the variables. The calibration is sequential. First, the elements of χ, i.e., the slope of income response of consumption of agricultural goods, are calibrated using estimates of the income demand elasticities (see Appendix A). Then the estimated χ is used in the system of equations shown above, which is linear in unknown parameters ε and v. Elements v_{ik} are set equal to zero for cross-price responses $\partial x_i/\partial p_k$, for which no prior information is known. The system is exactly identified. Calibration makes it possible to express the functional form of the Marshallian demand system (1), and to retrieve the right-hand side of the derivatives shown above. The expression $\partial x^H \big/ \partial p = V +$ $\chi(M - \varepsilon' q - \frac{1}{2} q' V q)\chi'$ for the Linquad Hicksian price response, is derived from the Slutsky identity with the calibrated values of the elements of V and e, that is, in a vector form. This expression makes it possible to infer demand under different price systems.

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