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Optimal Price Stabilization Policies for Staple Grains: The Case of Maize in Eastern and Southern Africa

Abstract: In the context of (a) stability in domestic maize production, (b) a significant divergence between import and export parity prices for maize, and (c) random variability in world maize prices, Eastern and Southern African governments have for many years attempted to reduce the instability in domestic maize prices. However, governments face a trade-off between the fiscal costs of price stabilization and the degree of price variability allowed. This paper presents a dynamic stochastic simulation model that not only explores the nature of this trade-off, but also determines optimal government policies for domestic target prices and domestic target levels of stock in order to minimize the expected fiscal costs of maintaining given degrees of price stability.

INTRODUCTION

Governments of Eastern and Southern African countries such as Kenya, Malawi, Tanzania, Zambia and Zimbabwe have for many years operated price stabilization programs for their staple food grain, maize.

Generally speaking, prior to each marketing year, governments have announced the official producer and consumer prices for maize that are to prevail in the coming year. Then, as the year has unfolded, governments have attempted to enforce these official prices by means of an internal government monopoly and by quantity adjustments — either in government held stocks, in international trade, or in some combination of the two.

However, in the current economic climate of macroeconomic and sectoral structural adjustment, governments are realizing that their attempts to enforce such perfect price stability within years have been very costly.

On the one hand, they are starting to liberalize their domestic maize markets and to allow some intra-year price variability. On the other hand, in their particular situation, they may rationally choose not to deregulate domestic maize markets completely. They seek some optimal trade-off between the fiscal cost of price-stabilization and the degree of price variability allowed.

BACKGROUND

In a closed economy, in the absence of intertemporal exchange, the domestic consumption of maize will equal the domestic production of maize in any given year. Random variability in production, resulting (primarily) from changes in the weather, will require year to year variability in domestic prices in order to clear domestic markets. Given an intertemporal elasticity of substitution close to unity[1] this is unlikely to be Pareto optimal.

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If institutional constraints prevent private markets from bringing about a better intertemporal distribution of consumption[2], then the government could, as a first option, establish a domestic buffer stock to reduce intertemporal variability in consumption. However, the annual storage losses associated with a buffer stock operation reduce the potential Pareto improvement[3]

As an alternative, the government could establish a buffer fund — exporting surpluses in good years and importing in bad years — while earning interest on the capital invested in the fund rather than incurring storage losses on the capital invested in a buffer stock. However, the price spread between import and export parity prices increases the cost of a buffer fund. Additions to the buffer fund occur at the (lower) export parity price, while withdrawals occur at the (higher) import parity price[4]

Given random variability in world maize prices in addition to random variability in production, the optimal policy will probably involve some combination of a buffer stock and a buffer fund. Without knowledge of the government's intertemporal preferences, it is not possible to determine the optimal degree of price stability enforced[5] However, it is possible to map the trade-off between fiscal costs and price stability. For each degree of price variability allowed, it is also possible to determine the optimal domestic target price in relation to world prices and domestic self-sufficiency prices, and the optimal balance between a domestic buffer stock and a buffer fund.

THE MODEL

The complete model is presented in Table 1. Both domestic demand and supply curves are constant elasticity functions[6] while the supply curve incorporates both a Nerlovian partial adjustment process and a random component. Both demand and expected supply are known to the government. The expected self-sufficiency price (the intersection of the domestic demand and expected supply curves) is above the export parity price but below import parity — the typical situation in Eastern and Southern Africa (see also Figure 1).

The world price is modeled as a log-normally distributed random walk. The government's target price, P_t^*, is modeled as a weighted average of the expected self-sufficiency price for the current period and the world price of the previous period:

$$(1)\quad P_t^* = (1-\omega)SSP_t + \omega MP_{t-1,} \qquad 0 \leq \omega \leq 1$$

The government's target level of stocks is a percentage of the expected domestic demand:

$$(2)\quad SK_t^* = \gamma QD(P_t^*) \qquad \gamma \geq 1\%.^7$$

For a given price band around the target price,

$$(3)\quad P_t^* - \delta \leq P_t \leq P_t^* + \delta \qquad \delta \geq 0\%$$

The government can choose the parameters, ω and γ, in order to minimize the expected fiscal costs of enforcing this degree of price stability.

As illustrated in Figure 2, when production is high, the government will purchase supplies from the domestic market in order to prevent the price falling below the price floor. As it purchases supplies, then the government will either increase its stocks, export its purchases, or perform some combination of the two. Conversely, when production is low, the government will reduce its stocks and/or import in order to prevent the domestic price rising through the price ceiling. Stocks cannot, however, fall below zero. We assume (1) that the government's stocks will approach zero asymptotically; (2) that for

Table 1 *Dynamic Stochastic Model of Price Stabilization*

Domestic demand:	$QD_t = A \cdot P_t^{-\alpha}$	$\alpha = 0.3$, $A = SSQ_0 / SSP_0^{-\alpha}$
Domestic supply:	$QS'_t = B.P_t^{*\beta}$	$\beta = 0.5$, $B = SSQ_0 / SSP_0^{\beta}$
	$QS^e{}_t = (QS'{}_t)^{\lambda}.(QS^e{}_{t-1})^{(1-\lambda)}$	$\lambda = 0.2$
	$QS_t = QS^e{}_t.\exp(u_t)$	$u_t = N(0, 10\%)$
Self-sufficiency quantity:	$SSQ_0 = 1750\ 000$ tonnes	
Self-sufficiency price:	$SSP_0 = \$120$/tonne	
	$SSP_t = \left(A / \left(B^{\lambda} \cdot QS^{e}_{t-1}{}^{(1-\lambda)} \right) \right)^{(1/(\alpha + \lambda\beta)}$	$t \geq 1$
World price:	$WP_0 = \$110$/tonne	
	$WP_t = WP_{t-1} \cdot \exp(v_t)$	$t \geq 1$; $v_t = N(0,\ 14.5\%)$
Import parity price:	$MP_t = Wp_t + \text{MCOST}$	MCOST = \$40/tonne
Export parity price:	$XP_t = WP_t +$ White maize Premium – XCOST	Premium = \$20 /tonne; XCOST = \$70/tonne
Government target price:	$P^*{}_t = (1-\omega)\, SSP_t + wMP_{t-1}$	$0 \leq \omega \leq 1$
Government target stock level:	$SK^*{}_t = \gamma \cdot QD(P^*{}_t)$	$\gamma \geq 1\%$
Domestic price:	$P^*{}_t - d \leq P_t \leq P^*{}_t + d$	$\delta \geq 0$
Net government purchases:	$NP_t = 0$	If $\mid P_t - P^*{}_t \mid < \delta$; or
	$NP_t = QS_t - QD_t$	If $\mid P_t - P^*{}_t \mid = \delta$
Government stocks:	$SK_t = (2\, SK^*{}_t) e^{\theta} / (1 + e^{\theta})$	$\theta = (2 / SK^*{}_t)(NP_t + SK_{t-1} - SK^*_t)$
Net exports:	$X_t - M_t = NP_t - (SK_t - SK_{t-1})$	
One-period cost:	$COST_t = (MP_t \cdot M_t) + (P_t \cdot NP_t)$ $+(SKCOST \cdot SK_{t-1})$ $-(XP_t \cdot X_t)$	SKCOST = \$25/tonne
Net present value of cost:	$\sum_{t=1}^{T} \frac{COST_t}{(1+r)^t} - \frac{SSP_0\,(SK_T - SK_0)}{(1+r)^T}$	T= 10 years; $r = 7\%$

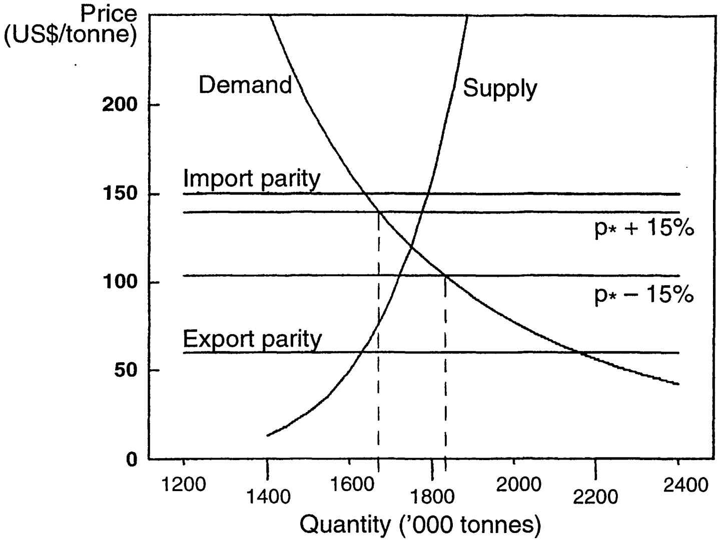

Figure 1

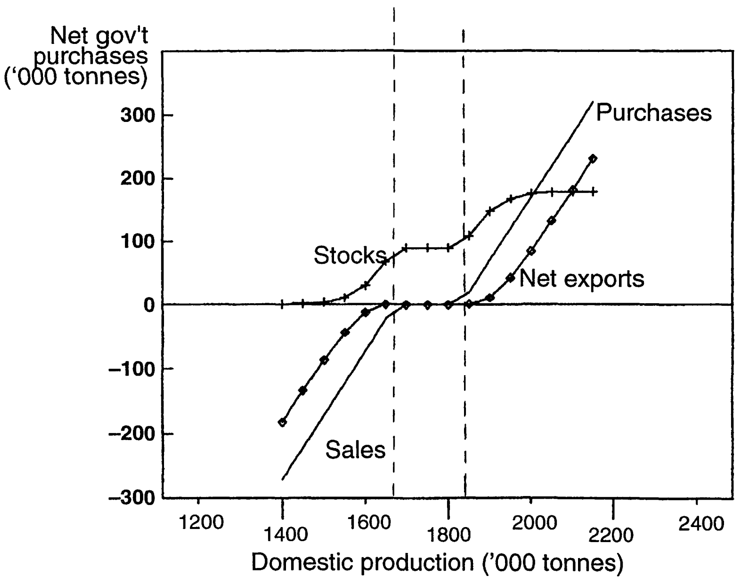

Figure 2

small departures from the target level of stocks, the government neither imports nor exports; and (3) that the government's stock depletion and stock acquisition responses are symmetric around the target level of stocks. As presented in Table 1, the government's stock equation that meets these three criteria is the following:

(4) $SK_t = (2SK_t^*)e^{\theta}/(1+e^{\theta})$, where $\theta = (2/SK_t^*)(NP_t + SK_{t-1} - SK_t^*)$

Net exports are a residual — the difference between net government purchases from the domestic market and the change in government-held stocks.

Less any revenues from exports, the one-period cost of enforcing price stability includes (1) the cost of imports, if necessary; (2) the cost of net purchases from the domestic market if any[8]; and (3) the annual costs of storing government stocks. The net present value of costs is the sum of the discounted one-period costs (over a 10 year simulation period) plus a discounted inventory valuation adjustment between the beginning and ending stocks.

The world price and domestic production are random variables with standard deviations of 14.5 percent and 10 percent respectively[9] For a given set of environmental parameters, in order to determine the optimal target price and target level of stocks that minimizes the expected fiscal costs of enforcing each degree of price stability, we calculated the average cost of 100 replicates for each of 120 different combinations of δ, ω and γ, as follows:

δ = 0, 5%, 10%, 15% and 20%;

ω = 0.00, 0.05, 0.10, 0.15, 0.20 and 0.25; and

γ = 1%, 3%, 5% and 7%.

Then, in order to determine the impact of two environmental parameters — the random variability in domestic production and the export parity price — on the expected fiscal costs, we duplicated the above for each environmental state[10].

THE RESULTS

The overall results are summarized in Figure 3. Each curve corresponds to one combination of the environmental parameters: the standard deviation of domestic production equalling 10 percent or 20 percent, and the white maize premium equaling $10 or $20 a tonne. The numbers in parentheses beside the 20 points on the four curves are the optimal values of ω and γ that minimize the expected fiscal costs of enforcing each degree of price stability.

As expected, for a given set of environmental parameters, there is an inverse relationship between the minimum expected fiscal costs and the degree of price variability allowed. The government must pay a higher cost to achieve a greater degree of price stability. Also, minimum expected costs increase as the random variability in domestic production increases and as the export parity price decreases (because the white maize premium decreases).

As illustrated in Figures 4 to 7, for each set of environmental parameters, the minimum expected cost function is saucer-shaped in ω and γ. For the five degrees of price stability and four environmental states represented in Figure 3, seven are interior solutions, five are corner solutions in which $\omega = 0$, and eight are corner solutions in which $\gamma = 1$ percent[11].

For a given environmental state, as the degree of price variability allowed decreases from 20 percent to 0, the government should generally reduce its target price P_t^* and increase its target level of stocks SK_t^*, in order to minimizes its costs. Also, as the standard deviation of domestic production increases and as the export parity price decreases, the government should reduce its target price and increase its target level of stocks[12].

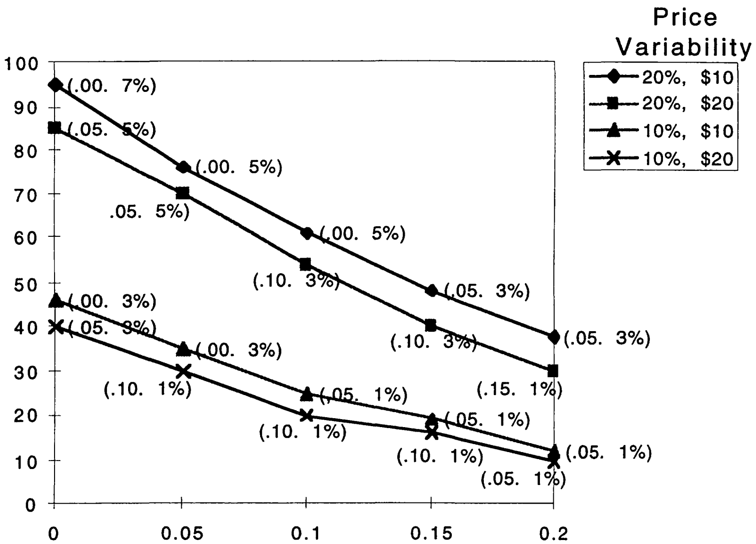

Figure 3 *Minimum Expected Costs*

The government must trade-off two factors that influence the minimum cost of enforcing a given degree of price stability. On the one hand, the target price determines the probability of imports and exports. The higher is the target price, the lower becomes the probability of imports, but the higher probability of exports. On the other hand, the import and export parity prices determine the fiscal cost of importing (at a price above the domestic market price) or exporting (at a price below the domestic market price). The lower is the export parity price the greater becomes the cost of exporting surplus production at a loss, and the more economic becomes a domestic buffer stock.

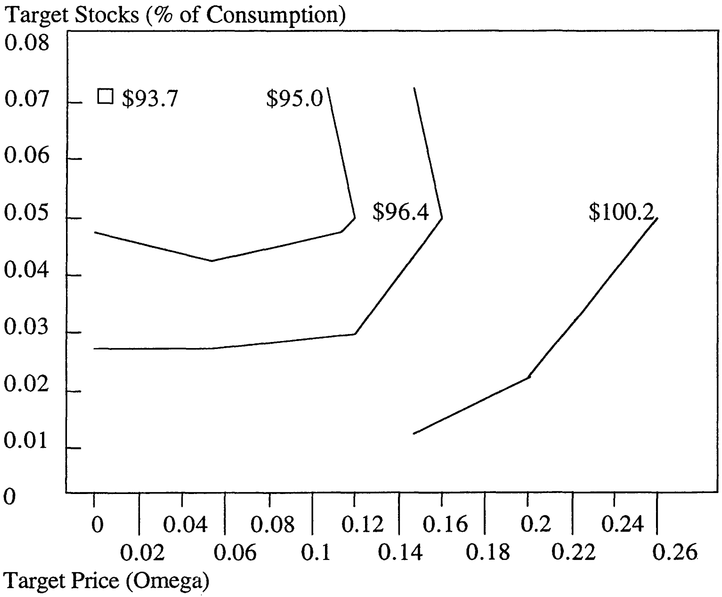

Figure 4 *Price Variability = 0% — St. Dev. = 20%, White Maize Prem. - $10*

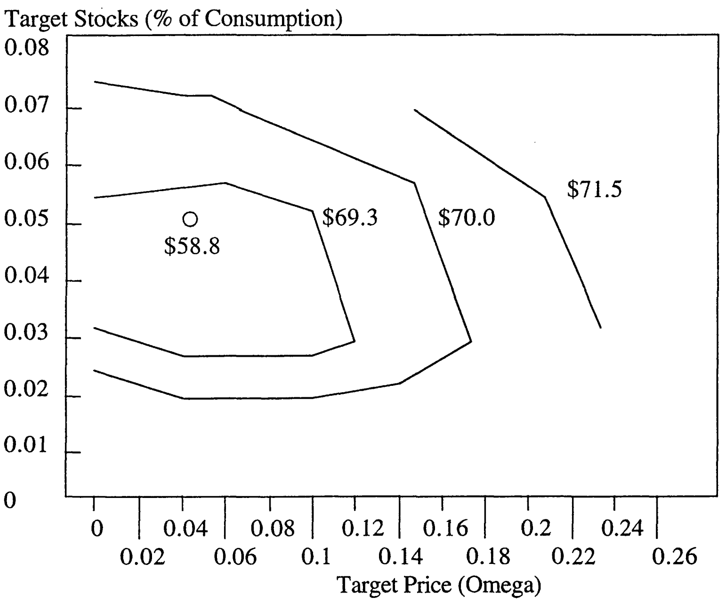

Figure 5 *Price Variability = 5% — St. Dev. = 20%, White Maize Prem. - $20*

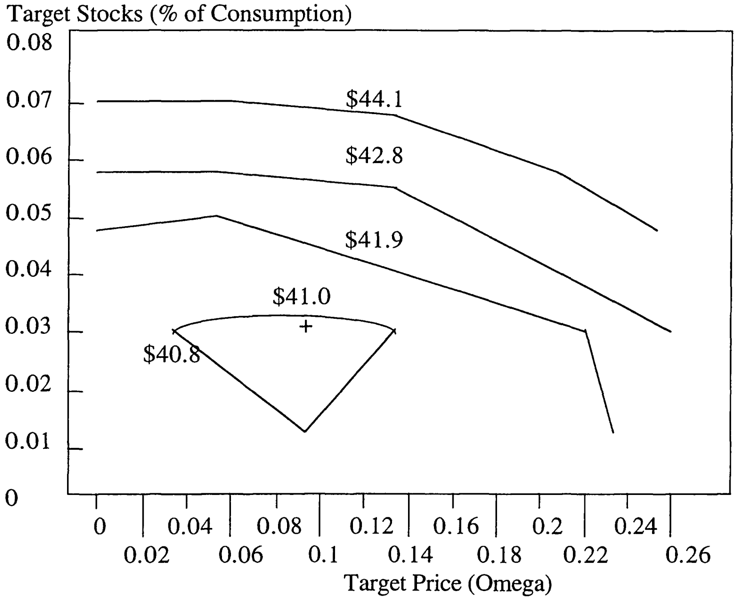

Figure 6 *Price Variability = 15% — St. Dev. = 20%, White Maize Prem. - $20*

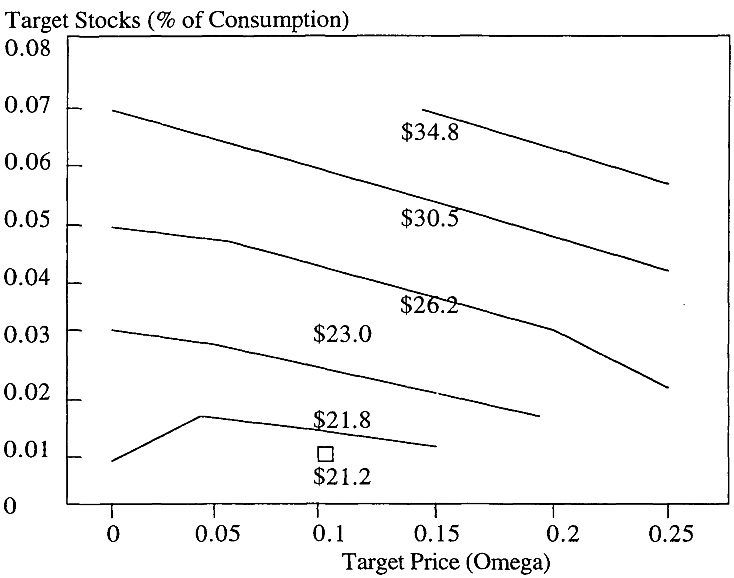

Figure 7 *Price Variability = 10% — St. Dev. = 10%, White Maize Prem. - $20*

CONCLUSION

This paper has presented a dynamic stochastic model of government price stabilization for maize in a typical Eastern of Southern African country. While the environmental constraints and parameters are representative of countries in the region, these could, with relative ease, be more closely calibrated to individual countries. Nonetheless, the basic results will likely continue to hold.

In the future, governments could decrease the cost of their price stabilization programs by allowing somewhat more intra-year price variability than in the past. In the context of random variability in domestic production, a significant divergence between import and export parity prices for maize, and random variability in world maize prices, optimal cost-minimizing policy will generally involve some combination of domestic buffer stocks and international trade. The greater the degree of price stability that the government desires, the closer should be the domestic target price to the expected self-sufficiency price, and the higher should be domestic buffer stocks.

Governments may have other elements in their objective function such as a desire to subsidize domestic consumers (since maize is a wage-good), or a political desire to minimize imports (since imported maize is generally yellow maize rather than white maize). The model could be adapted quite readily to incorporate the cost of these objectives as well.

NOTES

1 According to Blanchard and Fischer (1989, p.44), empirical estimates of the intertemporal elasticity of substitution usually lie around or below unity.

2 As a practical matter, since the establishment of government marketing boards for maize in Eastern Africa started in the 1930s, the establishment of private market alternatives, such as private inter-year stockholding and futures markets, have been hindered. Other institutional constraints include exchange controls and a relatively thin international market for white maize.

3 In Kenya, Pinckney and Gotsch (1987), p.275, estimate annual storage losses to $25 a tonne per year, which equals about 30 percent per year.

4 In the case of Kenya, Pinckney and Gotsch estimate that the cost of preparing maize for export is $70 a tonne, while the cost of importing maize (international plus domestic transportation costs) is $40 a tonne, for a price spread of $110 tonne. While the country may be able to realize a premium of, say, $20 a tonne when exporting white maize, this still leaves a price spread of $90 a tonne, which compares to the average world price of $110 a tonne over the last 20 years.

5 As discussed by Knudsen and Nash (1993), pp.266–268, governments may desire price stability for political and macro economic reasons as well as for the micro economic reasons discussed here.

6 The assumed demand elasticity of –0.3 and long-run supply elasticity of 0.5 are consistent with empirical estimates. See Pinckney and Gotsch (1987), and Gerrard (1983). Like previous authors in this literature, in order to focus on the issue of price instability around a trend, we assume stationarity in production and consumption.

7 The minimum target level of stocks is greater than zero because of the time lag — typically 3 or 4 months — between placing orders for maize and receiving the imports at the border.

8 Net government sales in order to prevent the domestic price from rising through the price ceiling represent, of course, a negative cost.

9 These are the same values assumed by Pinckney and Gotsch (1987).

10 For 48 000 replicates, at approximately 4 seconds a replicate, the computations took approximately 54 hours using EXCEL 4.0.

11 Some of the apparent corner solutions may in fact be interior solutions with a value of ω between 0

and 0.05, or a value of γ between 1 and 3 percent.

[12] The minimum cost combination of ω and γ when price variability equals 20 percent, the standard deviation of domestic production equals 10 percent, and the white maize premium equals $20, is an outlier that does not conform completely to the above relationships.

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DISCUSSION OPENING — Guillermo Flichman *(Institut De Montpellier, France)*

This paper proposes a method to optimize price stabilization policies with a particular application to maize production in Eastern and Southern Africa. In this particular application, domestic production can assure self-sufficiency in an average year, A model is proposed to set the target price (always between the internal self-sufficiency price and the previous period world price), given the preferences of the policy-makers in terms of the target level of stocks (defined as a proportion of domestic demand) and tolerated level of deviations around the target price. The model is simple, rigorous, and may help the decision-making process in a situation in which old rigid price policies, based on a fixed internal price, are going to be abandoned.

The principal critical comment I have concerns the way internal supply is represented in the model. As it is expressed in note 7, the focus is on the issue of price instability about a trend, assuming stationarity in production. The question that arises immediately is; can we reasonably expect that a change from a fixed, guaranteed, price to an uncertain one will not affect the level of supply? If farmers have a production mix integrating different crops, more or less risky, both in terms of natural conditions of production (weather) and expected price variability, a policy change that modifies the security status of maize, may completely change the relative position of this crop in the farmers' strategy.

I believe that the scenarios in which the value of g is bigger, should be associated with a lower level of maize production. The cost of policies allowing higher levels of g is probably higher than is calculated by the model. Complementary research at a micro-economic level, using farm production models, could provide the parameters to improve the model substantially.