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Klaus Abbink^a; Thomas S. Jayne^b; Lars C. Moller^{ac}

^a School of Economics, University of East Anglia, UK ^b International Development, Department of Agricultural Economics, Michigan State University, USA ^c World Bank, Washington, DC, USA

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The Relevance of a Rules-based Maize Marketing Policy: An Experimental Case Study of Zambia

KLAUS ABBINK*, THOMAS S. JAYNE** & LARS C. MOLLER***

*School of Economics, University of East Anglia, UK, **International Development, Department of Agricultural Economics, Michigan State University, USA, ***World Bank, Washington DC, USA

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ABSTRACT *Strategic interaction between public and private actors is increasingly recognised as an important determinant of agricultural market performance in Africa and elsewhere. Trust and consultation tends to positively affect private activity while uncertainty of government behaviour impedes it. This paper reports on a laboratory experiment based on a stylised model of the Zambian maize market. The experiment facilitates a comparison between discretionary interventionism and a rules-based policy in which the government pre-commits itself to a future course of action. A simple precommitment rule can, in theory, overcome the prevailing strategic dilemma by encouraging private sector participation. Although this result is also borne out in the economic experiment, the improvement in private sector activity is surprisingly small and not statistically significant due to irrationally cautious choices by experimental governments. Encouragingly, a rules-based policy promotes a much more stable market outcome thereby substantially reducing the risk of severe food shortages. These results underscore the importance of predictable and transparent rules for the state's involvement in agricultural markets.*

I. Introduction

Food prices and availability are highly politicised issues in the developing world, and there is a widespread view that governments are responsible for ensuring people's access to food (Bratton and Mattes, 2003). Political objectives are often pursued by influencing market outcomes. Yet it is also increasingly recognised that markets must be strengthened to promote farm productivity growth and national food security, and that encouraging private sector activity is crucial to this process. Herein lies the dilemma: if government intervenes too little, it risks price fluctuations and other

Correspondence Address: Professor Klaus Abbink, University of East Anglia, School of Economics, Norwich, NR4 7TJ, UK. E-mail: k.abbink@uea.ac.uk

An Online Appendix is available for this article which can be accessed via the online version of this journal available at www.informaworld.com/fjds

market outcomes that are politically and socially undesirable. If government intervenes too frequently and unpredictably, it risks discouraging traders' participation in markets. Resulting low private sector activity then forces government to intervene in the market in order to achieve its social objectives. To the extent that the private sector is more timely and efficient in its operations, this situation results in an efficiency loss. However, much larger than these short-run efficiency losses are the inhibiting effects of uncertain government behaviour on long-term private investment and the overall development of the marketing system (North, 1987, 1994). Strategic interaction between the public and private sector is therefore an issue that fundamentally affects food security outcomes within these mixed marketing systems.

In this environment, the performance of food markets is greatly affected by the way the private sector and the government interact. In much of Africa, the market liberalisation policies implemented since the late 1980s were marked by ostensible attempts to transfer critical marketing functions from the state to private traders, but in reality governments retained discretionary influence over prices and supplies (Goldsmith, 2002; Jayne et al., 2002). In most cases, the liberalisation process has been marred by lack of trust, cooperation and coordination between the private and public sectors. These problems have contributed to the sluggish rural income growth and frequent food crises witnessed in Africa in recent decades.

Traditional development economics typically analyses the performance of food markets as the impact of shifting demand and supply curves. This approach can be usefully complemented by an investigation of the strategic and behavioural aspects of the economic environment. This paper introduces a novel approach to analyse strategic interaction between government and private traders in food markets, based on the case of Zambia. A strategic market model was designed based on a variation of the Cournot-Stackelberg oligopoly model. Economic parameters and variables were informed by real-world data wherever possible. The strategic and behavioural implications of the model were tested in a controlled laboratory experiment. A specific objective of the experiment was to compare the current government policy of discretionary interventionism with a rules-based policy in which the government precommits itself to a future course of action. The laboratory allows gathering of replicable data under conditions in which these two policy rules can be compared under exactly the same economic conditions – an endeavour that is impossible to carry out in the field. By replicating the same environment the idiosyncratic variance inherent to human behaviour can also be distilled.

The experimental results show that trust and cooperation between government and the private sector are difficult to sustain under a discretionary government policy. Early attempts to cooperate soon break down, leading to low private sector activity. Lack of coordination between the sectors is also prevalent, resulting either in food shortages or losses to the private sector. Surprisingly, private sector supply under the precommitment regime is only slightly and insignificantly higher. This behavioural phenomenon is termed the *paranoia effect*, which, to our knowledge, has not been reported in the experimental economics literature so far. In theory, trust is required only in the ability and willingness of other market participants to act in their own interest. Experimental governments, however, frequently fail to trust the private sector even to that extent, and behave uncooperatively as a result.

The data reveal that this mistrust is unwarranted, hence the term ‘paranoia’ for this type of behaviour. The phenomenon stands in marked contrast to observations in previous trust game experiments (see, for instance, Camerer, 2003), in which experimental participants, contrary to theoretical predictions, achieve high levels of trust.

In the light of the theoretical superiority of the precommitment regime its impact on private sector activity in the trials may seem disappointing. Nevertheless, a rules-based policy still outperforms the discretionary regime on other accounts. Importantly, market outcomes are less erratic than under discretion, making food shortages or ruinous oversupply less likely. Moreover, it is in the government’s hands to which strategy to precommit. The data provide little reason not to go down the cooperative route. In this sense, the results of the maize market experiment underscore the importance of predictable and transparent rules for governing the state’s involvement in markets, and how such operations in the market could reduce the risks of a food crisis and enhance economic efficiency.

The remainder of the paper is structured as follows. Section II introduces the Zambian maize market context and highlights the difficulties of implementing market reforms such as the one advocated in this paper. Section III introduces the model and experimental design. Section IV presents the results of the main experiment with subjects drawn from outside the context of the Zambian maize market. Section V discusses the outcome of the experiment in which Zambian government officials and private sector participants took part. Section VI concludes. As for terminology, ‘rules-based policy’ and ‘precommitment policy’ are used interchangeably.

II. The Political Economy of Maize Market Reform in Zambia

The Government of Zambia adopted maize marketing reforms as part of loan conditionality agreements with the World Bank and IMF in the late 1980s while facing extreme fiscal pressure. However, starting in 1993 the government reversed some of these reforms and progressively re-introduced a number of measures to control food prices and supplies. By 1995, a new parastatal, the Food Reserve Agency (FRA), was formed to hold strategic food stocks. Since the early 2000s, the FRA has taken on many of the activities formerly carried out by the marketing board of the 1980s (Namboard), albeit on a smaller scale. While private trade has developed steadily since the early 1990s, the current market environment is remarkably similar to that of the late 1980s, when external donors were urging the government to curtail the activities of the grain marketing board, open up the borders to regional trade, and reallocate public expenditures toward public goods investments so as to enable the private sector to carry out grain marketing and trade more efficiently. During the past six years, the Mwanawasa and subsequent Banda administrations have progressively introduced greater state intervention in food marketing and trade.

Why have successive governments in Zambia, and elsewhere in the region, tended not to pursue the market reform and liberalisation agenda recommended by international development agencies?¹ There are two possible explanations. The first is that government objectives are varied, inherently political, and vulnerable to

influence and capture by elites. As argued by Lopez (2003), the allocation of public expenditures tends to be biased in favour of private goods, such as input subsidies, that can be captured by politically influential groups and against the provision of public goods that would improve the overall performance of markets and thus have broad-based benefits for the poor. The political landscape in much of Africa can also be described as being dominated by neo-patrimonial relationships, in which government commodity distribution is an important tool by which leaders maintain loyalty and patronage among rural leaders and their constituents (van de Walle, 2001; Bird et al., 2003; Pletcher, 2000).

The second class of explanations, which is focused on in this study, has to do with genuine government concern for the welfare of smallholders as well as urban dwellers. White maize is the strategic political crop in this region of Africa. Maize became the cornerstone of an implicit and sometimes explicit 'social contract' that the post-independence governments made with the African majority to redress the neglect of smallholder agriculture during the colonial period (Jayne and Jones, 1997). The controlled marketing systems inherited by the new African governments at independence were viewed as the ideal vehicle to implement this objective. The benefits of market controls designed to produce rents for European farmers during the colonial period instilled the belief that the same system could also promote the welfare of millions of smallholders if it was simply expanded (Jenkins, 1997). The social contract incorporated the understanding that governments were responsible for ensuring cheap food for the urban population.

While the social contract approach achieved varying levels of success in promoting smallholder incomes and raising consumer welfare, a common result in all cases was an unsustainable drain on the treasury.² The cost of supporting smallholder production – through input subsidies, credit programmes with low repayment rates, commodity pricing policies that subsidised transport costs for smallholders in remote areas, and the export of surpluses at a loss – contributed to fiscal deficits and, in some cases, macroeconomic instability. Under increasing budget pressure, international lenders gained leverage over domestic agricultural policy starting in the 1980s, which culminated in structural adjustment programmes. While structural adjustment is commonly understood to be a decision that international lenders imposed on African governments, a more accurate characterisation of the process is that this adjustment was unavoidable due to the mounting fiscal crises that the social contract policies were imposing on governments (Jayne and Jones, 1997). Continuation of the status quo policies was not an option in countries such as Malawi, Tanzania, Zambia, Zimbabwe, and Kenya, and in some of these countries, the controlled marketing systems had already broken down even prior to 'market liberalisation' as parallel markets swiftly became the preferred channel for most farmers and consumers. Moreover, the erratic performance of the state-led systems, reflected by frequent shortages of basic commodities and late or partial payments to farmers, created support for reform among some domestic constituencies.

The rise of multi-party electoral processes in the early 1990s has, however, made it difficult for governments in these countries to withdraw from 'social contract' policies. Elections can be won or lost through policy tools to reward some farmers with higher prices and reward consumers with lower prices, and this

is hardly unique to developing countries (Bates, 1981; Bates and Krueger, 1993; Bratton and Mattes, 2003; Sahley et al., 2005). Because they provide obvious demonstrations of support for millions of small farmers and consumers, a retreat from the social contract policies exposes leaders to attack from opposition candidates (Sahley et al., 2005). For this reason, it remains difficult for leaders to publicly embrace grain market and trade liberalisation, even as they accepted structural adjustment loans under conditionality agreements from international donors to reform their internal and external markets. And starting in the late 1990s, the transition of the World Bank and other development partners from structural adjustment loans with ex-ante conditionality to direct budget support with ex-post conditionality made it easier for states to reinstate some elements of the social contract policies.

By the early 2000s, grain marketing boards have once again become the dominant players in the market in Kenya, Malawi, Zambia, and Zimbabwe (Jayne et al., 2002). Each of these countries have a highly unpredictable and discretionary approach to grain trade policy, commonly imposing sudden and unanticipated export and import bans, changes in import tariff rates, or issuing government tenders for the importation of subsidised grain. Problems frequently arise due to uncertainty about when and whether governments will alter import duties or import intentions in response to a short crop (for example, Zambia in 2000–2001, 2001–2002, and 2005–2006; Malawi in 2001–2002). Traders otherwise willing to mobilise imports early are likely to incur financial losses if the government later waives the duty and allows competing firms (or the government parastatal) to import more cheaply. When governments create uncertainty over import intentions or tariff rates during a poor crop season, the result is commonly a temporary under-provision of imports, which can produce a situation of acute food shortages and price spikes far above the cost of import (Nijhoff et al., 2003; Mwanauomo et al., 2005; Tschirley and Jayne, 2010). Analysts not familiar with the details of these situations often erroneously interpret them as evidence that markets fail and that the private sector is weak, leading to a rationale for continued direct government involvement in marketing.

The above illustrations highlight the importance of strategic interaction, in determining food security and improving market performance. Many analysts have concluded that predictable and transparent rules governing state involvement in the markets would reduce market risks, allow for greater coordination between private and public decisions in the market, and enable governments to more effectively achieve food security policy objectives (Jayne et al., 2002; Kherallah et al., 2002; Mwanauomo et al., 2005; Byerlee et al., 2006). Generally, the conclusions mentioned above have not been tested in a rigorous manner. In this paper we try to alleviate this deficiency by providing data gathered in a controlled laboratory experiment.

This paper reports the results of the experiment conducted with student subjects under anonymous conditions. The study was embedded in a larger policy advice project, in which the experimental setup developed here was used to provide first-hand experience to policy makers in Zambia. A workshop was convened in March 2007 involving members of the Zambian government, including the minister of agriculture, a permanent secretary, and representatives of farmers, millers and

traders to play the maize market game as the experimental subjects did. This role play was intended for decision makers to gain experience with a policy instrument that may appear counterintuitive to them. Note that the virtue of a precommitment strategy comes from the government's deliberate act of tying its own hands, of reducing its own strategy space in order to improve its own payoff. While game theory provides a plethora of situations in which this is a sensible act, decision makers unfamiliar with the formal analysis of strategic games may find it unnatural. The workshop experiment was therefore a tool for policy advice, not for gathering scientifically meaningful data. For this purpose the number of observations was far too small, moreover the practical constraints (for example lack of anonymity and incentives) prevented us from maintaining the necessary methodological standards in the workshop experiment. The results and policy recommendations of this paper are therefore exclusively based on the outcome of the student experiment. Design and outcome of the workshop are reported in the Online Appendix C for documentary purposes only.

III. The Model and Experimental Design

The design of the experimental model faced a number of challenges. First, the model had to capture the most essential features of the Zambian maize market. It was therefore informed by data from the actual market rather than artificial pay-offs.³ Second, the model had to be sufficiently simple to be playable in a short experimental session. (Note that these two goals are, to some extent, conflicting.) Third, since the game was also designed as a learning tool for Zambian policy makers and traders, it had to be entertaining to play.

The Players

The Zambian maize market has four principal economic agents (on the supply side): farmers, millers, traders and the government. Farmers, who grow and harvest the crop, are mostly small family enterprises, many producing for subsistence. Each farmer's influence on market outcomes is small, so farmers are not modelled as strategic players.⁴ Instead their production level is determined exogenously, predominantly by rainfall. Millers buy the harvest and turn the maize into maize meal. They then sell the meal to consumers, who amongst others use it as the basis for *nshima*, the staple diet in Zambia. Since they do not play a strategic role, millers are also omitted from the game. The omission of farmers and millers does not imply that they are unaffected by maize market policy choices. On the contrary, the policies have a strong effect on market prices, which in turn are a major determinant of farmer profit (and, ultimately household well-being).

The remaining two types of agents, the traders and the government, are the key strategic players in the maize market game. In a shortage year – the main focus of this paper – traders import maize from nearby countries, mainly South Africa, and sell it to millers. The Zambian maize market is composed of about 1,000 small traders accounting for about 60 per cent of the trading volume. A handful of large trading companies, such as AFGRI, Amanita, Zdenakie, and CHC Traders, account for the remaining 40 per cent of the market (Jayne et al., 2007). Their trading volume

is sufficiently high to exert market power, so they can be assumed to make their decisions strategically, taking the actions of the other players into account. Traders are assumed to be profit-maximisers.

Finally, the behaviour of the government, through the Food Reserve Agency (FRA), strongly affects market outcomes. In shortage years, the FRA issues contracts to import maize in competition with the private sector. It can thus be interpreted as an additional big trader on the market. In contrast to the private traders, the government is not a profit-maximiser, but is assumed to pursue a political agenda aimed at re-election. To gain popular support from consumers the government prefers to keep consumer prices low. On the other hand, since many households in Zambia are small maize farmers, the government also has an interest in high producer prices. This set of goals essentially conflicts with that of traders, as discussed later.

The Consumer Market

The core model is a Cournot oligopoly game. In this model suppliers choose their quantities and the price is determined by the market. The model is appropriate for a basic agricultural product with a high degree of product homogeneity. Further, it has very natural predictions for the market outcome. It reacts smoothly to small changes in the traders' behaviour, and changes in the competitive environment leads to the expected change in market outcome (for example an increase in the number of firms results in lower prices and profits). These desirable properties have been reproduced empirically in a plethora of experimental studies (Huck et al., 1999, 2004; Huck et al., 2001; Offerman et al., 2002).

Traders face a downward-sloping demand function, where the consumer price, P , is a decreasing function of the total quantity supplied by the market. For simplicity, a linear demand function is assumed with the inverse form:⁵

$$P = a - b(Q + G + S) \quad (1)$$

where $Q = \sum q_i$ is the total quantity supplied by the n traders, G is the government quantity and S is the baseline supply offered by small traders. Exogenous parameters a and b specify intercept and slope of the demand function, respectively. As mentioned, the suppliers on the consumer market consist of a few big traders and a large number of small traders. The small traders are price takers with a capacity constraint, that is they jointly supply a fixed quantity S , which they sell irrespective of the market price, without strategic considerations.

Each big trader faces constant marginal costs, c . For simplicity, marginal costs are assumed identical to the producer price (the price that the farmers receive), assuming other costs (notably transport costs) to be constant and thus not affecting optimal choices. Note that this assumption implies that traders have the same cost structure, since the producer price is the same for all.⁶

The discretionary policy case. In the discretionary (baseline) model, traders and the government choose their quantities simultaneously after the government has made a non-binding announcement about its supply intention. The total quantity supplied is

given by $\Sigma q_i + G + S$, where q_i is the quantity chosen by trader i . By assumption, the big traders are not capacity constrained, i.e. they can import unlimited supplies.⁷ Trader i 's gross trading margin is given as:

$$\pi_i = (P - c)q_i = (a - b(q_i + Q_{-i} + G + S) - c)q_i \quad (2)$$

where Q_{-i} denotes the total quantity provided by the traders less player i 's supply. This is similar to the profit expression in a standard Cournot model except for government supply, G , and the bulk quantity S supplied by small traders. The market equilibrium can be obtained by maximising trader i 's profit function and solving for q_i . The best response of player i , q_i^* , is then given by the expression:

$$q_i^* = \frac{a - b(S + G^*) - c}{b(n + 1)} \quad (3)$$

Note that Equation (3) contains the government's best response, G^* , which is endogenous. Since the government is not a profit-maximiser, the equilibrium quantity can only be solved once the payoff function of the government has been specified.

The case of policy pre-commitment. In this variant of the game the government chooses its quantity before the traders. The Cournot game of the discretionary case thus turns into a variation of a Stackelberg oligopoly model, with the government as the leader and the n traders as followers. Equilibrium quantities are computed the same way as in the discretionary case. However, since the government's quantity is now known when traders make their decision, the market outcome may be different, as studied in more detail later.

The Demand Function

To increase the relevance of the experimental results, it was important that the model's parameters were not invented, but at least informed by real-world data. Efforts to generate real-life parameters, of course, find their limits in the availability of robust data. In the current framework only very sparse data were available, so the market model developed here cannot claim statistical robustness nor a high level of accuracy. On the other hand, given that the alternative was to assume arbitrary parameter values it was decided to proceed with parameter estimation. As explained in more detail in Online Appendix A, the following demand function for bad weather years (that is a maize production of less than 700 kMT) was derived:

$$P = 436 - 0.99(Q + S) \quad (4)$$

where $Q + S$ is the total quantity supplied jointly by large and small traders (excluding government supply). This demand function was subsequently used as a basis for calculating trader payoffs in the experimental model.

The Government Payoff Function

Government maize trading is not aimed at making a profit. Indeed, due to the comparatively higher operating costs relative to the private sector, it often takes place at a loss. In this paper, the objectives of the government are assumed to be political in nature. Food security and maize price stability are concerns frequently expressed by government officials. Further, because Zambia is a multi-party democracy the ruling party is concerned about its chances of being re-elected, so it aims to increase popular support. As previously discussed, the maize price is a crucial variable for voter satisfaction, because of the vital role maize plays in the staple diet. Virtually all Zambians are consumers of maize. High consumer prices are a likely cause of public dissent, so the government is interested in keeping consumer prices low. At the same time the majority of Zambians are small farmers, where maize is the main crop. These maize farmers benefit from high producer prices, so the government also has an interest in not letting producer prices drop too far. The model abstracts from all other goals the government may have.⁸

Any estimation about the relative weight of the government's two price objectives can naturally only be guesswork, since hard data on governments' payoff functions are inherently absent. The model thus uses a payoff function that is linearly decreasing in the consumer price, P , and linearly increasing in the producer price (that is the marginal cost of traders, c). In lack of qualified data the natural prior, that both goals have equal weight, was used. Finally, to capture the fact that government imports are generally carried out at a higher cost relative to private sector imports, it is assumed that there is a constant cost to each metric ton of maize supplied by the government, k .⁹ Government payoff is thus given by:¹⁰

$$u = c - P^C - kG \quad (5)$$

Note that the government's goals conflict with the interests of the traders, since the difference between producer and consumer prices is essentially the traders' gross margin, see Equation 2.

In reality, the Zambian government has a wide range of maize marketing policy instruments at its disposal. For example, it can influence market outcomes by setting import tariffs, granting export licenses or banning exports altogether. This paper, however, focuses only on direct FRA activity as a buyer and seller of maize. In a shortage year the government's main activity is to import maize from neighbouring countries to ensure adequate domestic supply. It also buys some quantity from the domestic market for the strategic food reserve.

All other things equal, increased government import lowers the consumer price, since it increases total supply. Since the government also buys some maize from the domestic producers, it increases the demand for domestically produced maize, and hence exerts an upward pressure on producer prices. In a shortage year this effect is relatively small, however, since the excess demand must be filled with imports and domestic contributions to the strategic food reserve play a small role. This effect is therefore omitted from the model.

Adaptations of the Model to the Experiment

The real Zambian maize market at the time of the experiment in 2007 had four big traders. However, with four suppliers the game would have been hard to present transparently to experimental participants. Moreover, the principal analytical interest is the strategic interaction between government and traders rather than interaction between traders. For those reasons, the number of traders was reduced to two.¹¹ By reducing the number of active traders the competitiveness of the real market is understated. However, it turns out that the main characteristics of the market, mainly with respect to the strategic environment, remain preserved.

The strategy space was also reduced in order to make the payoffs presentable in tables. Traders therefore have only four options. They can each choose quantities of 20, 40, 60, or 80 kMT. The government's options are reduced even further. It can either supply a low quantity (of zero kMT) or a high quantity (assumed to be 80 kMT). With the reduction of the strategy space of players it is now possible to represent the game using relatively compact payoff tables (see Table 1). The government's payoff depends on its own choice and the aggregate quantity supplied by the two traders. Thus, one table is sufficient to display the government's possible payoffs. Since the government's choices was restricted to two (either a high or a low quantity), the traders have to take two different payoff tables into account, one for each of the government's possible choices.¹²

Finally, the effect of government supply on domestic producer prices also needs to be taken into account. The government must buy its supply from the market first. As mentioned, in a shortage year this effect is not supposed to be large, since most of the maize the government sells is imported. It is therefore assumed that in a high government supply case producer prices are only 10 per cent higher than in the low quantity case. This figure is well within the empirical range of observed prices.

The reduction of the market from a tetrapoly to a duopoly facilitated a presentation of the game in bimatrix form, as it is tradition in game theory. Of course few experimental subjects were trained in game theory and are thus unfamiliar with bimatrix games. The bimatrix representation often looks unintuitive and confusing to game-theoretic laymen. All payoff tables were therefore printed in colour, marking all choices and payoffs for one trader in red and for the other in blue. Colour-coding turns the bimatrix into a more transparent and simpler representation of a game.

Game-theoretic Analysis

The game-theoretic analysis of the two variants is straightforward. Consider the discretionary policy variant. In stage 1, government announces its intended quantity. In stage 2, the government and traders decide simultaneously on the quantity that they supply. Note that the government announcement at stage 1 of the discretionary game is 'cheap talk' and will not affect the game theoretic prediction. From Table 1, it is observed that the government's dominant strategy is to supply a high quantity, as its payoff is always higher regardless of what the traders do. The traders foresee this and only take the payoff table for the government's *high* choice into account. In this case each trader has a dominant strategy to choose the lowest possible quantity

Table 1. The payoff tables

A trader's payoff if the government chooses a <i>LOW</i> quantity								
		<i>The other trader's quantity</i>						
		20	40	60	80			
My own quantity								
20	2763	<i>2763</i>	2367	<i>4733</i>	1971	<i>5912</i>	1575	<i>6299</i>
40	4733	<i>2367</i>	3941	<i>3941</i>	3149	<i>4724</i>	2357	<i>4715</i>
60	5912	<i>1971</i>	4724	<i>3149</i>	3536	<i>3536</i>	2348	<i>3131</i>
80	6299	<i>1575</i>	4715	<i>2357</i>	3131	<i>2348</i>	1547	<i>1547</i>

My own payoff is written in **bold**, the other trader's payoff in *italic*.

A trader's payoff if the government chooses a <i>HIGH</i> quantity								
		<i>The other trader's quantity</i>						
		20	40	60	80			
My own quantity								
20	614	<i>614</i>	218	<i>436</i>	-178	<i>-534</i>	-574	<i>-2296</i>
40	436	<i>218</i>	-356	<i>-356</i>	-1148	<i>-1722</i>	-1940	<i>-3880</i>
60	-534	<i>-178</i>	-1722	<i>-1148</i>	-2910	<i>-2910</i>	-4098	<i>-5464</i>
80	-2296	<i>-574</i>	-3880	<i>-1940</i>	-5464	<i>-4098</i>	-7048	<i>-7048</i>

My own payoff is written in **bold**, the other trader's payoff in *italic*.

The government's payoff							
<i>Government's quantity</i>	<i>The traders' TOTAL quantity</i>						
	40	60	80	100	120	140	160
<i>Low</i>	<i>913</i>	<i>1111</i>	<i>1309</i>	<i>1507</i>	<i>1705</i>	<i>1903</i>	<i>2101</i>
<i>High</i>	<i>1528</i>	<i>1726</i>	<i>1924</i>	<i>2122</i>	<i>2320</i>	<i>2518</i>	<i>2716</i>

of 20. The corresponding Nash equilibrium payoffs are $(u; \pi_1; \pi_2) = (1,528; 614; 614)$ for the government and the two traders.

The Nash equilibrium, however, is a Pareto-inferior allocation. To realise this, suppose that the government can credibly commit itself to choosing a low quantity. The mutual best response occurs if each trader submits a quantity of 60. In this allocation the corresponding payoffs are $(u; \pi_1; \pi_2) = (1,705; 3,536; 3,536)$. This represents a Pareto improvement since both government and private sector are better off. However, in the discretionary variant the government cannot credibly make such a promise, as both traders know that once the decision stage is reached, a rational government will play its dominant strategy of 'high'.

A rules-based policy can overcome this strategic dilemma. In the precommitment treatment the government is a Stackelberg leader and it makes a binding decision before the traders make theirs, thus the traders know what the government will do. The subgame perfect equilibrium of the game, which is now derived by backward induction, is identified as follows. If the government chooses a high quantity, then

the traders choose 20 each, and the government receives 1528 just like in the equilibrium of the discretionary game. If the government chooses a low quantity, then the traders respond with choosing 60 each, which leads to a government payoff of 1705. Thus, the government's best strategy is to commit to a low quantity.

The Conduct of the Main Experiment

The experiment was first conducted with 96 volunteer participants from the University of Amsterdam. It was run as a pen-and-paper experiment in a classroom. A computerised setup was not used to enable a re-run of the exact same set-up in Southern African countries in future studies. In these countries computerised laboratories, which are the norm in most standard university experiments, are virtually non-existent.

Each subject was allowed to participate in one session only, and no subject had participated in experiments similar to the present one. The subjects were undergraduate students from a wide range of disciplines, with a balanced gender distribution. The experiment was conducted in English, which is the language of instruction for most students in Amsterdam. The subject pool was very international, with only a relative majority of Dutch citizens.

In each session between four and six experimental markets were run in parallel. Subjects interacted in fixed groups of three subjects. Subjects were not told who of the other participants were in the same market, but they knew that the composition of the markets did not change during the experiment. Subject roles (government/trader) were also held constant. The subjects were seated distantly from one another in order to ensure that they could not influence each other's behaviour except through their decisions in the game.

The players' decisions were communicated using decision sheets and results sheets. At each stage of the game subjects filled in a decision sheet. If one role was inactive at one stage of the game, the relevant players were given a 'dummy sheet' asking for their expectations of the other players' behaviour. These sheets were administered to avoid revealing the roles of participants which would have been the case if sheets were distributed to a subset of participants only. The dummy sheets were not used to collect any data.

Six rounds of the game were played in each two-hour session, representing six years of the Zambian maize market. This is a slightly longer time horizon than an election term in Zambia where the president is elected for a five-year term. Longer play allows learning and stabilisation of behaviour. However, a length of dozens of rounds, as common in computerised experiments, was not possible in the pen-and-paper set-up and was also unrealistic, given that decision makers in the Zambian government frequently change.¹³

At the outset of the experiment, a capital balance of 2000 *talers* (the experimental currency) was granted to each subject, to account for possible losses. The total earnings of a subject from participating in this experiment were equal to this balance plus the sum of all the profits made during the experiment, minus all losses. A session lasted for about two hours, including the time spent to read the instructions (reproduced in Online Appendix B). At the end of the experiment, subjects were paid their total earnings anonymously in cash, at a conversion rate of one Euro for

1500 talers. A show-up fee of €5 was given to each subject showing up on time. Subjects earned considerably more than students' regular wage in Amsterdam. At the time of the experiment, the exchange rate to other major currencies was approximately US\$1.30 and £0.70 for one Euro.

Three sessions were conducted in each of the two treatments. Since participants did not interact except within their own market, each market can be considered a statistically independent observation. In total, 16 independent observations were gathered in each treatment.

IV. Results of the Experiment

The central purpose of the main experiment was to test different policy options for the Zambian maize market with robust replicable data. The game theoretic analysis of the model suggests the rules-based policy, in which the government precommits to its decisions, to be strongly superior to the discretionary regime. However, whether this advice is empirically valid is another matter. The theoretical inferiority of the discretionary policy stems from the social dilemma, that is the conflict between individual and social rationality, present in the maize market. Numerous experimental studies, however, have shown that subjects are frequently able to overcome such dilemmas and reach stable optimal outcomes through trust and reciprocity (for example, Fehr et al., 1993; Berg et al., 1995; Abbink et al., 2000; Dufwenberg and Gneezy, 2000; Fershtman and Gneezy, 2001; Gächter and Falk, 2002; for an experiment in an African context see Haile et al., 2008).

The Discretionary Treatment

In the discretionary game government players have a strong incentive to choose a high quantity because it is the dominant strategy. In order to reach a Pareto-superior cooperative arrangement, traders must trust that the governments can resist this temptation. At the same time the government also needs to trust the traders. If traders supply low quantities, then the government's payoff is very small if it also chooses *low* – an outcome corresponding to a food shortage situation.

Figure 1 shows the share of *high* choices by the government (left panel) and the average total quantity supplied by the traders (left panel). The graphs show the average values and the standard error corridors. The figure illustrates that cooperation is frequently attempted in early rounds, but it is very short-lived. Over time, *high* choices from the government become increasingly dominant. By the end of the experiment, cooperation collapsed in all but one market. In accordance with the rising frequency of *high* choices, quantities supplied by the traders decrease from the third round onwards. There is some evidence to suggest that it is the governments which first cease to cooperate and that the traders respond to this. In the disaggregated data, however, no predominant response pattern is evident.¹⁴

Before government and traders choose their quantities, the government sends a non-binding signal to the traders, indicating which quantity it intends to choose. The government can use this signal to encourage traders to supply high quantities, if it announces that it will itself choose *low*. However, it can also use the messaging device to send a misleading signal, that is, to lure the traders into believing the government

would choose a low quantity, while it indeed intends to choose a high one. Some observers believe that the Zambian government has occasionally made such misleading announcements, and in fact the strategic environment seems conducive to this behaviour. Table 2 shows the distribution of the four possible combinations of announcement and actual choice. In 36 of 96 rounds (37.5%) the government chooses *high* after announcing *low*. In comparison, a misleading signal in the opposite direction (choosing *low* after indicating *high*) was made only once.

The Precommitment Treatment

In the precommitment treatment, the strategy dilemma between rational own-payoff maximisation and social efficiency concerns is absent. The sub-game perfect equilibrium is for the government to choose the low quantity, since it knows that it is in the traders’ best interest to supply high quantities themselves. It would therefore be expected that precommitment improves market efficiency. Looking at the overall picture, however, the improvement is surprisingly small. Average total trader quantity rises only slightly from 74.4kMT to 79.2kMT. The frequency of government *high* choices decreases from 58.3 per cent to 49.0 per cent, but these differences are statistically insignificant.¹⁵

Two factors explain this phenomenon. First, the aggregate results mask the strong deterioration in cooperative behaviour occurring in the discretionary treatment, but not in the precommitment treatment (see Figure 2). In earlier rounds of the

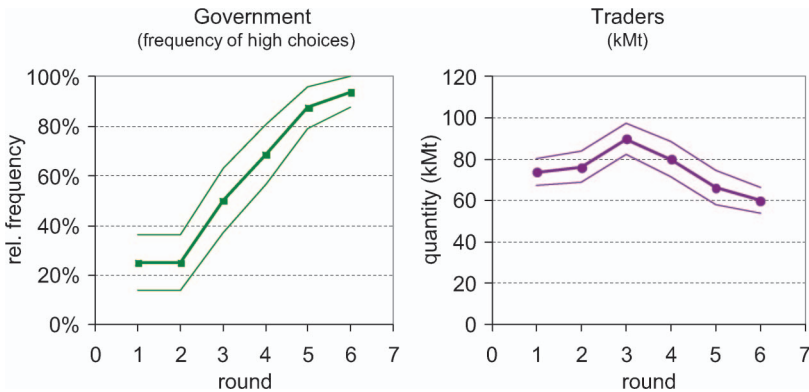


Figure 1. Discretionary policy: trader and government supply.

Table 2. Government quantity: announced versus implemented

Implemented	Announced		Total
	Low	High	
Low	38	1	39
High	36	21	57
Total	74	22	96

discretionary treatment, players establish some level of cooperation, but this eventually breaks down as the game evolves. Considering the second half of the experiment only (the last three rounds), governments behave more cooperatively under the precommitment rule, as reflected by a statistically significant lower frequency of 'high' choices.¹⁶

Second, the unexpectedly poor overall performance of the precommitment regime can be traced back to a phenomenon that is termed the *paranoia effect*. Recall that governments move first and traders second. When governments choose a low quantity, they must rely on the traders responding with high output levels, otherwise governments can be severely hurt by the resulting food shortage. Governments need only to rely on the traders to act in their own best self-interest to achieve the desired outcome for government, thus one would not expect the exposure to this risk to be very high. Nevertheless, Figure 3 shows that in almost half of the rounds government refrained from choosing the efficient quantity (120 kMT), arguably out of fear of being hurt.¹⁷ Such fears could be based in lack of confidence in the rationality of the trader players or fear that these will act spitefully.

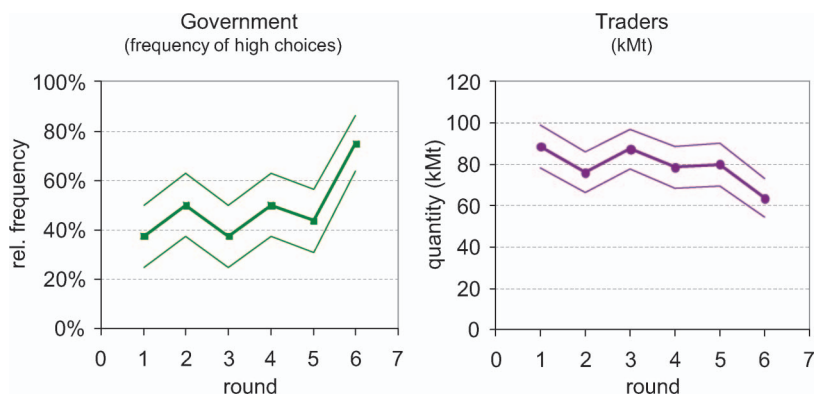


Figure 2. Pre-commitment policy: trader and government supply.

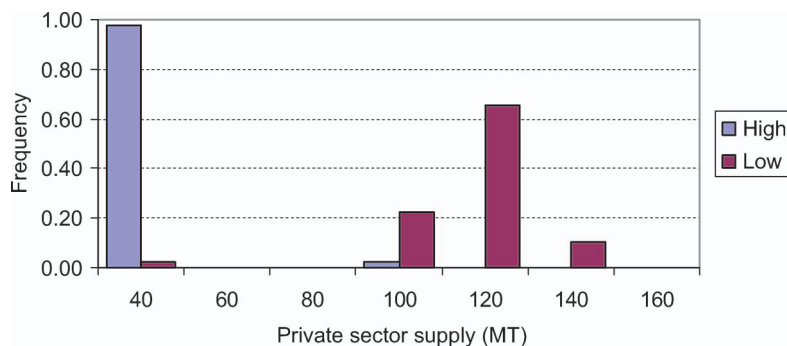


Figure 3. Precommitment policy: private sector supply for alternative government choices (high or low).

The question arises whether the government's fear is warranted. In other words, did the trader players behave irrationally or spitefully in ways that reduced government payoff? The data reveal that this was not the case. Figure 3 shows the distribution of total quantities conditional on the government's choice in the precommitment treatment. In the majority of cases traders responded to a government's *low* quantity choice with the equilibrium quantity of 120 and sometimes even 140 was achieved. These quantities are preferable to the government over the payoff the government obtains when choosing *high* (in which case virtually all traders respond with choosing 20 each). Only in about one-fifth of all rounds did the traders supply a total of 100. This allocation is only marginally worse for the government than the *high* quantity outcome yielding a payoff of 1507 instead of 1528. Thus, the fear of exposure that many experimental governments apparently had was actually unfounded.

Policy Conclusions Arising from the Data

Though the experiment consisted of only two treatments, there are in fact three distinct policy options available to the government. If the government chooses to establish a rules-based regime, it must also specify the rule to follow. In addition to the discretionary regime, therefore, there are two options in the precommitment treatment: commitment to a high quantity and commitment to a low quantity.

One rationale behind the policy of committing to a low government supply is that it may encourage private sector activity and hence raise economic efficiency. Figure 4 illustrates that this goal is largely achieved. The figure shows traders' average total quantity for the three available policy regimes, over the six rounds of the experiment. Precommitment to a low government supply induces the highest supply from the traders. A discretionary policy induces a lower trader supply which declines from round 3 onwards. Finally, precommitment to a high government quantity leads traders to respond with the lowest quantity.

Table 3 shows a range of market performance measures under alternative policy scenarios.¹⁸ An almost complete crowding out of the private sector is observed if the government precommits to a high import quantity compared to when it precommits to a low quantity. Since the private sector is more cost-effective in supplying maize to

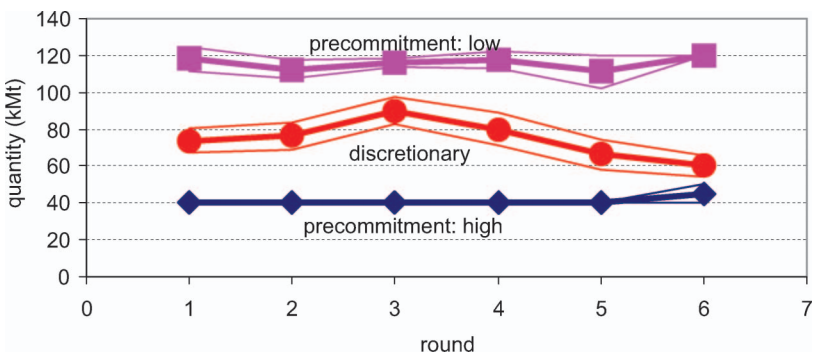


Figure 4. Trader supply under alternative government policy regimes.

the market than government, economic efficiency is highest in the ‘precommitment low’ regime.

Total quantities are, on average, very similar in the three regimes (around 120 kMT), although in this experiment the two government choices are at rather extreme ends of the scale (0 kMT versus 80 kMT). There are, however, substantial differences in the fluctuations around the mean values. The standard deviation of a discretionary policy is twice as large as when governments precommit to a low supply and four times larger than when it precommits to a high supply. These fluctuations reflect the degree to which the two sectors are able to solve the underlying coordination problem.

When governments commit to a high supply this leaves the private sector in little doubt that its best response is to provide relatively low supplies.¹⁹ At the other extreme, under a discretionary policy the private sector is left in limbo concerning government’s course of action. This uncertainty causes frequent occurrences of overshooting where both types of agents supply high quantities simultaneously which drastically reduces trader profit. More importantly, there are also a substantial number of ‘crises years’ where all agents under-supply. This is illustrated in Figure 5.

Table 3. Market outcomes under alternative government policy regimes (averages)

Policy Regime	Government Quantity (kMT)	Trader Quantity (kMT)	Total Quantity (SD)	Trader Profit	Government Payoff
Discretionary	47.5	74.4	121.9 (35.4)	1446	1618
Precommitment Low	0.0	115.5	115.5 (16.5)	2707	1661
Precommitment High	80.0	41.3	121.3 (8.8)	611	1541

SD denotes Standard Deviation.

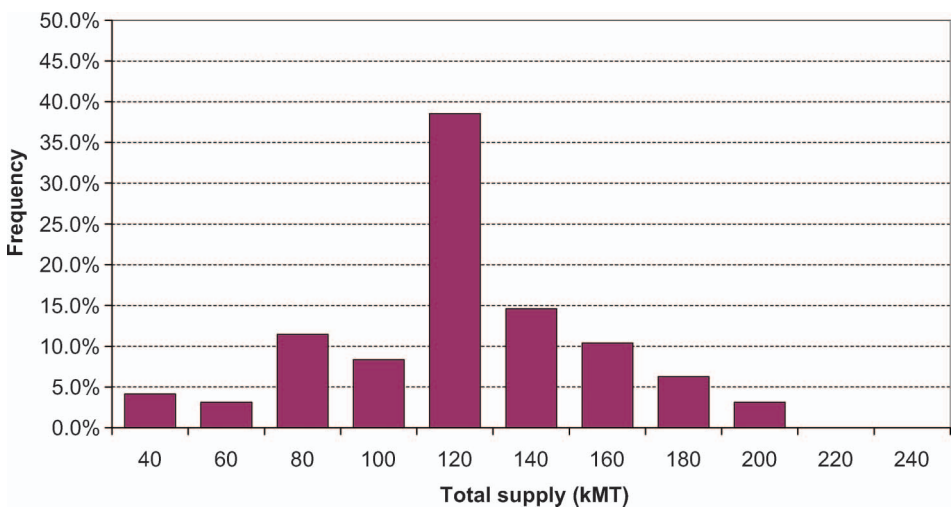


Figure 5. Frequency distribution of total supply (discretionary treatment).

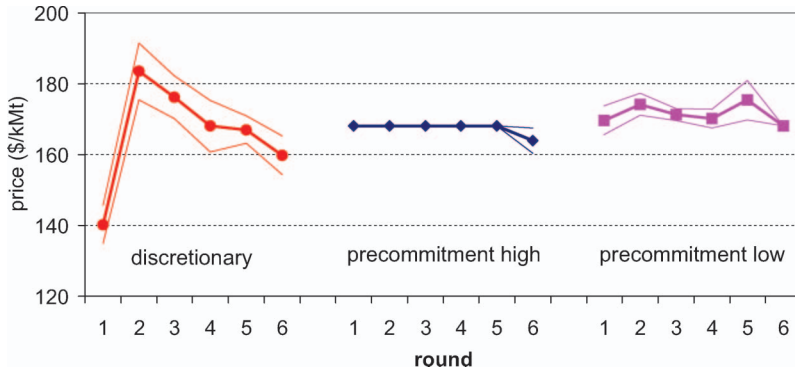


Figure 6. Producer prices under the three alternative policy regimes.

With policy discretion, almost one-fifth of all years result in a total supply of less than 100 kMT – an outcome virtually nonexistent under a policy of precommitment. The intermediate case, precommitment to a low quantity, represents a substantial improvement in reducing market fluctuations, although not as much as ‘precommitment high’ due to the *paranoia effect*. The objective of food security (or food availability, to be precise) is therefore best achieved under a policy of government precommitment.²⁰

In our model we did not explicitly capture the farmers, since they are not strategic players. Nevertheless their well-being is affected by the actions of the government and the traders. For the calibration of the model we used data from total sales quantities, without distinguishing between domestically produced and imported maize (disaggregated data were not available). Further, we lack data on the cost structure of farming operations. Thus we cannot compute farmer profits directly. However, we can compute producer prices from the model we used, which give a strong indication of the effect of the policies on farmers’ revenue. Figure 6 shows the prices as reconstructed from the model. Because of the strong link between quantities and prices they mirror the findings on quantities displayed in Figure 4. Under the discretionary regime producer prices start relatively high but then deteriorate, making farmers worse off than under the precommitment policies. Also, the variance of prices is much higher without government precommitment.

In sum, the most attractive policy regime, across a broad range of objectives, is that of government precommitment to a low quantity. On average, it results in the most efficient market outcome, yields the highest trader profits and government payoffs and represents a substantial reduction in market fluctuations. Nevertheless, a government which places a substantial value on the food security objective over other policy objectives may want to opt for a precommitment to a high quantity.

V. Conclusion

Discretionary and unpredictable government intervention is one of the greatest policy problems plaguing the food marketing systems and food security in the Southern Africa region. This is because actual and potential government

interventions generate private sector uncertainties and inaction leading to the need for additional but unplanned government intervention. This problem has underlain virtually all of the recent food crises in Zambia and Malawi since 2000, where food supplies have dwindled and prices surged above the cost of importing. This study explored how erratic and unpredictable government behaviour arises from a strategic dilemma between the private sector and a government adhering to a social contract whereby it is responsible for ensuring cheap food for the urban population while supporting the welfare of rural smallholders. A laboratory experiment was introduced, testing the strategic and behavioural implications of the present maize market environment, and comparing the current discretionary regime with a rules-based policy recommended by many observers.

The results of the maize market experiment lend support to a policy recommendation of introducing a rules-based policy, taken all aspects of our data together. Effective coordination between the private and public sector would require greater consultation and transparency with regard to changes in parastatal purchase and sale prices, as well as import and export decisions. In this study, a simple pre-commitment rule was found to be superior to discretionary policy making by reducing the risk of food crises and providing appropriate incentives for private actors to participate in the market thereby enhancing economic efficiency. More specifically, it was found that total maize quantities and market prices are quite similar under the two different policy modes. Importantly, however, situations of food shortage (and over-supply) were much more frequent under a discretionary policy because of the risk of poor coordination between the government and the private sector. Government pre-commitment to a low quantity resulted in substantially higher trader profits because of the larger volume traded by them. The Government of Zambia may therefore want to consider mechanisms which can help make maize market policy more predictable or rules-based in the future.

A detailed analysis of the implementing mechanisms for precommitment is beyond the scope of this paper, but a few observations can be offered. Governments can and sometimes have agreed to tie their hands by introducing relevant legislation which explicitly states the policy which will be followed and, importantly, the circumstances under which deviation is permitted, if at all. An important example is that of rules aiming to institutionalise fiscal discipline as introduced by the European Monetary Union and several Latin American countries (Perrotti, 2007). Leaving aside the important question of whether such rules meet their intended macro objectives, the adherence to the rule is often a function of the quality of institutions and the overall policy environment (von Hagen, 2006). While legislative measures are preferable because they are more difficult to reverse and circumvent, the Ministry of Agriculture could, in principle simply adopt a rule as a part of its overall policy. Ultimately, what matters is the credibility of the announcement and such credibility may take several years to establish in the current policy environment. The typical solutions to commitment problems involve third party guarantees, which a regional economic consortium could conceivably play. Regional trade protocols have already been established in the region, for example, through the Southern African Development Community (SADC) and the Common Market for Eastern and Southern Africa (COMESA). Trust between market actors is clearly another crucial ingredient in the establishment of credibility (North, 1994; Schmid and Robison, 1995; Grief et al.,

2004). Regular stakeholder discussions between government and traders could be instituted in an effort to build such trust, by at first coordinating plans informally, sharing market information, and observing over time how the parties behave. In this manner, it may be possible for the parties to learn their way into mutually beneficial relationships, especially if the gains are significant for government.

Finally, it is important to highlight that the policy relevance of our findings should not necessarily be limited to the introduction of a specific policy rule, however desirable. Rather our findings are a practical illustration of the importance of transparency and predictability in policy making. The results therefore also offer additional support for re-considering existing practices of abrupt announcements of changes in import tariffs or introduction or export bans. For the private sector to play a more active role in grain marketing, it is essential that governments provide a predictable and credible market policy environment.

That said, our data suggest that the efficiency gain from the switch to the precommitment treatment was, on average, only slight and insignificant. When changing to a rules-based policy the government must also make sure to choose an effective rule to commit itself to. In the experiment many governments failed to do so, choosing non-cooperative policies that led to suboptimal outcomes. This behaviour can be traced back to what we have coined the *paranoia effect*, which describes irrationally cautious conduct out of fear of being hurt. In the trials this fear has proven to be unwarranted, since traders responded to cooperative moves with own cooperation, which was, after all, in their own best interest and required no sacrifices from them. This paranoia effect is, to our knowledge, a novelty in the experimental economics literature, which boasts a multitude of studies in which people cooperate though rationally they should not. In our data, it is selfishly rational to cooperate, but subjects frequently do not. Thus our experiment, though designed as an application, may be of some interest to experimentalists involved in more fundamental behavioural research. Further work is needed to explore whether the effect observed is specific to the present market environment, or whether it is a more general anomaly that can be identified in other experimental games as well.

The paranoia effect observed in our data underlines how fragile the present environment is with respect to trust and cooperation, and this may partly explain the reluctance risk-averse governments in Zambia and elsewhere have shown to adopt such policies. After all, this would not be the first time that policy makers have been encouraged to reform maize marketing policy by introducing higher degrees of transparency, predictability and cooperation towards the private sector, yet policy makers have thus far been reluctant in adopting such recommendations. An important explanation, as illustrated by the results of our experiments, is that market controls enable governments to adhere to a 'social contract' in which it supports smallholder agriculture while simultaneously ensuring cheap food for the urban population. For those same reasons, the policy recommendations presented in this paper should not be expected to be adopted overnight.

Acknowledgements

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Notes

1. See Jayne and Jones (1997), Mwanaumo et al. (1997), Deininger and Olinto (2000), Jayne et al. (2002), World Bank (2003, 2004, 2006), Del Ninno et al. (2005), Siegel and Alwang (2005), World Bank and IFRPRI (2005).
2. To illustrate, by the late 1980s, Zambia's subsidies to the maize sector reached 17 per cent of the national budget (Howard and Mungoma, 1997).
3. Experiments on games informed by real-world data are surprisingly rare. Some have been carried out in the course of consulting projects for spectrum auctions, but their results are often not published due to confidentiality concerns of the clients (an exception is Abbink et al., 2002). In a different context, Güth et al. (2003) parameterise a bargaining game with data from a case study on the film industry. Abbink et al. (2010) study the conflict between the Central Asian countries sharing the Syr Darya river and estimate payoff functions from real-life data.
4. In surveys conducted in Benin, Madagascar, and Malawi, Fafchamps et al. (2005) have found that market liberalisation even induces less concentrated markets.
5. Empirical estimates often yield a relatively constant demand elasticity over the relevant range of market outcomes. This invites the use of a constant elasticity demand function of the form $p = Q^\eta$. Estimations of such demand functions turned out to have very undesirable properties in a strategic market model. In extreme cases they lead to corner equilibria, in which firms would optimally sell one grain of maize at an infinite price. The reason is that one cannot expect the constant elasticity assumption to hold over the entire price range, including those prices not empirically observed. In a strategic model, however, the unobserved range can affect the equilibria dramatically and this augers against the use of this functional form in the present context.
6. Note that, although intuitive, this model of price determination of the maize market is an approximation. In Zambia, the government announces consumer and producer prices at the start of the season and is at liberty to change this price later in the season or cease purchasing at any time depending on its rate of intake and in light of changes in market conditions. For a recent empirical study on the determination of commodity prices see Fafchamps and Hill (2010) on coffee prices in Uganda.
7. In Zambia, the issue of trader's import capacity is a contentious one with government questioning whether the private sector has sufficient capacity and the private sector eager to demonstrate that it does.
8. Other relevant government objectives in this context include, for example, development and modernisation of the food marketing system, reducing the fiscal outlays of grain marketing operations, and price stabilisation.
9. The assumption $k > 0$ is critical for the results of the paper. It captures the fact that the private sector has a cost advantage over government in importing maize. Economic efficiency therefore increases in private sector imports. This assumption is widely believed to be true for Zambia, according to most market observers.
10. We do not explicitly model a budget constraint to the government's utility function. Surely such a constraint exists since there are limited financial means. However, modelling it would have unnecessarily complicated the approach. As will be seen later, we exogenously restricted the strategy space within the unconstrained range.

11. The calibrations of the demand function continue to assume a four-trader market, since this corresponds to the real-life constellation (see Online Appendix A).
12. It may seem very restrictive to let the government choose only between two rather extreme alternatives (high/low imports). However, the game theoretic analysis will show that the fundamental characteristics of the game are maintained. For the government higher quantities are always better than lower ones, while for the social optimum the lowest government quantity would be preferable.
13. To illustrate, the Zambian Minister of Agriculture, who participated in the workshop, assumed office only six months prior to participating in the workshop experiment.
14. In 13 of the 16 markets *high* frequencies rise from the first to the second half of the game, whereas in the remaining three markets this frequency remains unchanged. The binomial test rejects the null hypothesis of equal likelihood of rising and falling frequencies at $p=0.0001$ (one-sided). Trader quantities fall in 10 of the 12 markets in which there is a change and this fall is significant ($p=0.0193$, one-sided). In the six rounds of play trader quantities do not fully converge to the noncooperative equilibrium, but the trend points toward that outcome. Notably government *high* frequencies rise from the third round on; trader quantities typically follow with a one-round lag.
15. Fisher's two-sample permutation test cannot reject the null hypothesis of equal trader quantities and equal government choices at any conventional significance level.
16. Fisher's two-sample randomisation test rejects the null hypothesis of equal frequencies of government *High* choices at $p=0.015$ (one-sided). The analogous comparison for trader quantities is not significant (one-sided, $p=0.30$).
17. An alternative explanation could be that these subjects have a strong dislike of disadvantageous inequity. In the efficient equilibrium traders earn more than the government, while in the inefficient allocation the government earns more. However, most standard inequity aversion theories (for example Fehr and Schmidt, 1999) assume that individuals dislike inequity even if it is in their favour. The frequent occurrence of paranoid choices in the present experiment is unlikely to be explained by inequality aversion alone.
18. These figures do not include the bulk supply from the small traders, which is held constant.
19. In fact, the entire variance observed in the experiment was due to a single, possibly erroneous, decision.
20. An adequate food supply is a necessary, but not sufficient condition for food security, since the latter depends on appropriate distribution of the total supply between individuals.

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