

Monopsony and Time-Consistency: Sustainable Pricing Policies for Perennial Crops

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Abstract

Since farmers in developing countries must make sunk investments to produce perennial crops, governments, in the guise of state-run marketing boards, face constraints on maximal sustainable price which can be charged by a marketing board assuming that “punishments” involve reversion to subsistence by untrusting farmers. This maximal price balances concerns about revenue extraction against the incentive of governments to cheat by capitalizing on sunk investments.

1. Introduction

State-run monopoly marketing boards have played a significant historical role in the collection and distribution of primary produce in many developing countries. This paper discusses their pricing policies and the difficulties that might arise because of their inability to commit to prices in future. The particular concern is with the fact that they have an incentive to announce generous future prices to persuade farmers to invest in certain cash crops and then to renege on their announcements at some future date. It is with perennials such as coffee, tea, and rubber that such problems are most likely to arise owing to the longevity of such crops.

The paper develops a simple model in which we can characterize the maximal sustainable price of a monopsony marketing board when the effect of cheating on past promises is reversion to subsistence by farmers; i.e. no future planting of the cash crop. The model is simple and stylized, but is able to capture some salient features. Below, I discuss some ways in which broadening the framework can expand the model’s relevance.

Marketing boards have received surprisingly little attention from economists interested in economic development despite their prevalence in developing countries.¹ The issues dealt with here are related to those discussed in relation to taxation of capital in a dynamic world (Kydlund and Prescott, 1977; Fischer, 1980; Chari and Kehoe, 1990).² Pricing policies of perennial crops in developing countries provide a fascinating context in which to study to these issues and history is replete with cases where governments have faced difficult pricing decisions involving the temptation to exploit past investments.³

Analytically, the model here also adds a new dimension, arguing that the time horizon of the investment may make a difference in the kinds of problems faced. In standard models, any investment which is sunk is susceptible to expropriation by a revenue-hungry tax authority. Chari and Kehoe (1990), however, developed a model in which reputational considerations might serve to mitigate such incentives. I carry this

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idea a step further by suggesting that the horizon over which the investment is made may affect what kinds of prices are sustainable by use of reputation.⁴ This differentiates between cases where investments are sunk for only short periods (e.g., where a farmer sows a field anticipating a particular price which is not paid until the end of the season) versus a situation where a crop such as cocoa, which has a 25-year life, is sown. Intuitively, this would seem to make a difference to the prices that can be sustained. I show that this is indeed the case.

Simple models are inevitably stylized and the analysis undertaken here is not meant to serve as a very realistic portrayal of the environment in which marketing boards function. Nonetheless, I do attempt to argue for the relevance of the model. Implications of the model for policies toward parallel markets, political instability and liberalization are discussed.

2. The Model

The model has a monopsony marketing board which buys a crop from a group of farmers and sells it on the world market. There are overlapping generations of farmers, with each generation containing a large number of farmers who may produce the cash crop. The marketing board sets prices, while farmers must make sunk investments in order to produce cash crops. The model evolves over an infinite horizon. At each date there are three significant events, delineated in Figure 1.

At the beginning of the period the marketing board declares a price, and the generation of farmers born at that date decide whether or not to invest. Farmers then produce their crops and the marketing board buys the cash crop.

The Marketing Board

The marketing board has an infinite horizon. Each period it sets a price, p_t , at which it will buy the crop. The crop is sold to the world market at a given world price of q . We refer to its strategy as a *pricing policy*, which we denote by $\omega \equiv \{p_t\}_{t=1}^{\infty}$. Thus any given policy specifies a price for the crop at each date. We use $p_t(\omega)$ to denote the price paid under policy ω at date t .

If we denote the output of the crop at date t by Q_t , the discounted present value of profits earned by the marketing board, viewed from time t , is given by

$$\Pi_t \equiv \sum_{s=0}^{\infty} \delta^{t+s} \{Q_{s+t}(q - p_{s+t})\}, \quad (1)$$

where δ is the discount factor (i.e., one over one plus the discount rate). The marketing board's aim is to maximize (1) through its choice of a pricing policy.

Farmers

Each farmer can produce one of two goods, a subsistence crop whose return is normalized to zero and a cash crop which has a sunk cost of θ . The latter cost varies continuously across farmers on $[0, \bar{\theta}]$. Variation in θ represents the fact that farmers inhabit different agroclimatic zones and/or have different abilities to farm the crop. We suppose that farmers only invest to produce the cash crop at the date at which they are born, and that, if they do so, then they can produce one unit of the crop for T periods, which is the length of their lives.⁵ Thereafter, they die and are replaced on the land by a new generation of identical farmers.

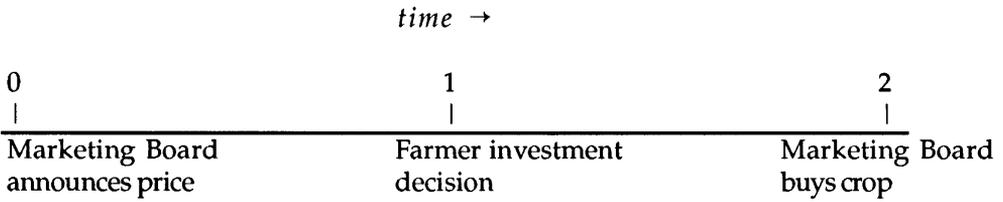


Figure 1. Model Events

A farmer born at time t who is deciding whether to make an investment to produce the cash crop looks at the discounted value of revenues from doing so, given by:

$$R(t, T; \omega) = \sum_{i=0}^{T-1} \delta^i p_{t+i}(\omega). \tag{2}$$

We assume that the farmers and the marketing board use the same discount rate. Farmers will invest if (2) exceeds θ . Using such a rule, the investment decision depends on ω . More formally, the decision to invest at time t based on pricing policy ω , satisfies

$$\sigma(t, \theta; \omega) = \operatorname{argmax}_x \left\{ x [R(t, T; \omega) - \theta] \mid x \in \{0, 1\} \right\}.$$

Thus

$$\sigma(t, \theta; \omega) = \begin{cases} 1 & \text{if } R(t, T; \omega) \geq \theta \\ 0 & \text{otherwise.} \end{cases} \tag{3}$$

This defines a $\hat{\theta}_t \equiv R(t, T; \omega)$, which is the highest cost type who finds it worthwhile to invest at time t , which gives a supply curve of the cash crop from investors born at time t of $F(R(t, T; \omega))$. Thus aggregate output at time $t \geq T$ is given by

$$Q_t = \sum_{i=0}^{T-1} F(R(t-i, T; \omega)). \tag{4}$$

Output at any date depends on the pricing decisions made by the marketing board at future dates.

3. Optimal Pricing with Commitment

The case of up-front price commitment provides a useful benchmark. The optimal policy in this case is stationary and the marketing board chooses a price to extract the maximum surplus from any generation of farmers. This is proved in Proposition 1.

PROPOSITION 1. *Suppose that the marketing board can commit itself to a pricing policy for all time; then it pays farmers a constant price given by*

$$p^m \in \operatorname{argmax}_p \left\{ F(\alpha p) - (q - p) \right\}, \tag{5}$$

where $\alpha \equiv (1 - \delta^T)/(1 - \delta)$.

PROOF. See the Appendix.

Thus the optimal pricing policy with commitment is a constant price. Interpreting $g(p)$ [$\equiv F(\alpha p)$] as the supply curve of a generation of farmers, the optimal policy is precisely the pricing policy chosen by a monopsonist facing $g(p)$.

The problem I wish to focus on here is that the marketing board may have an incentive to deviate from paying p^m after enough farmers have made their investment decision. In doing so, it might lose the confidence of farmers, who respond in turn by failing to invest in future. The next task is to explore when the monopsony pricing policy described in Proposition 1 can be sustained by such “threats” not to invest.

4. Sustainable Pricing Policies

If the marketing board offers a sequence of future prices to farmers, their policy is said to be sustainable if the board would have no incentive to deviate from that policy at any future date, given the investment strategy employed by the farmers. For this to be well-specified, we need to say what happens in the event of a deviation. We assume trigger strategies in which a deviation leads to “reversion to subsistence,” a regime in cash crop production collapses, the government pays nothing ($p_t = 0, t = 1, 2, \dots$) and each farmer runs down his stock of trees to zero. This follows the approach taken in Chari and Kehoe (1990) *inter alia*.

Next, we introduce the value function of the marketing board at each date under a particular pricing policy, ω . Sustainability will require that given the stock of “trees” invested in under the policy, the marketing board will not wish to deviate. The value function from continuing with ω is defined by the recursion

$$\Pi_t(\omega) = \left\{ (q - p_t(\omega))Q_t(\omega) + \delta\Pi_{t+1}(\omega) \right\}, \tag{6}$$

where $Q_t(\omega)$ denotes output under the pricing policy ω , examined in greater detail below.

The value from reverting to subsistence can be obtained by considering the path of output for this case. Output will continue to be positive for some time after the deviation has occurred owing to past investment decisions. Given that a pricing policy, ω , was pursued in the past, output at t after reversion to subsistence is given by

$$\hat{Q}_t(\omega) \equiv \begin{cases} \sum_{i=0}^{T-j-1} F\left(\sum_{j=0}^{T-1} \delta^j p_{t-i+j}(\omega)\right) & \text{for } t \geq T \\ \sum_{i=0}^{t-j} F\left(\sum_{j=0}^{T-1} \delta^j p_{t-i+j}(\omega)\right) & \text{for } t < T. \end{cases} \tag{7}$$

The expression in (7) takes into account the investment rule given in (3). The reason for the two-part expression in (7) is the fact that reversion to subsistence may occur before period T , when not all generations have invested in the crop. Using (7), we define

$$\hat{\Pi}_t(\omega) \equiv q \sum_{r=s}^{T-1+s} \delta^{t-s} \hat{Q}_r(\omega), \text{ for } t = 1, 2, \dots, \tag{8}$$

as the value function after reverting to subsistence.

Calculating the value function for the case where the pricing policy ω is pursued for all time requires an expression for output in period t under the pricing policy. Using (3), this is

$$Q_t(\omega) \equiv \begin{cases} \sum_{i=0}^{T-1} F\left(\sum_{j=0}^{T-1} \delta^j p_{t-i+j}(\omega)\right) & \text{for } t \geq T \\ \sum_{i=0}^t F\left(\sum_{j=0}^{T-1} \delta^j p_{t-i+j}(\omega)\right) & \text{for } t < T. \end{cases} \tag{9}$$

Again, there are two parts to reflect the two phases in the life of the crop. There is an initial *development* phase during which output is growing and more farmers are producing the crop each period. The second is a *mature* (or possibly *steady-state*) phase. This occurs after period T when all generations of farmers have had a chance to invest. After that point the output will be fixed if the pricing policy is stationary. The value function obtained by sticking to the pricing policy ω is thus

$$\Pi_t(\omega) \equiv \sum_{t=s}^{\infty} \delta^{t-s} Q_t(\omega)(q - p_t(\omega)). \tag{10}$$

We will say that a pricing policy, ω , is *sustainable* if

$$\Pi_t(\omega) \geq \hat{\Pi}_t(\omega) \text{ for } t = 1, 2, \dots; \tag{11}$$

that is, it must never be preferable for the marketing board to initiate reversion to subsistence (RTS) at any point in the history of the pricing policy.

To examine the optimal sustainable pricing policy, we make two additional assumptions. First, purely for expositional simplicity, we assume that $\pi(p) \equiv F(\alpha p)(q - p)$ is strictly quasi-concave so that the monopsony price is unique.⁶ Second, we confine attention to *stationary* sustainable pricing policies, those which stipulate that a constant price will be paid through time. Naturally enough, if p^m is sustainable, then it will be paid. Otherwise, the highest price such that deviation to RTS strategies is not worthwhile for the marketing board will be paid for all time. This *maximal* price is provided in Proposition 2.

PROPOSITION 2. *The optimal stationary sustainable price, denoted p^* , satisfies*

$$p^* = \min\{p^m, \beta(T, \delta)q\}, \tag{12}$$

where
$$\beta(T, \delta) = \left[\frac{\delta}{1 - \delta} \cdot \frac{1 - \delta^T}{T} \right].$$

PROOF. See the Appendix.

Viewed as a result about taxes, this has a seemingly paradoxical implication—that taxes have to be sufficiently *high* (or prices low) for the resulting pricing policy to be sustainable.⁷ The reason for this result is, however, plain to see. In order to be sustainable, a pricing policy must not give the marketing board an incentive to choose a lower price once individuals have invested. A low tax rate which induced many individuals to invest would give a larger incentive for the marketing board to deviate in order to capitalize on these investments at some future date.

One way of understanding Proposition 2 is by examining properties of the function $\beta(T, \delta)$. It is straightforward to show that if $\delta < 1$, then the fraction of the world price that can be paid to farmers in any sustainable equilibrium is (strictly) less than one; i.e. $\beta(T, \delta) < 1$. Thus, the maximal sustainable price is a strict fraction of the world price. Furthermore, it is decreasing in T and increasing in δ for all $T \geq 1$.⁸ It also shows that longer-lived investments must have lower sustainable prices since the investment life determines the speed with which the marketing board can be punished for deviating from its announced pricing policy. When this life is increased, then the marketing board has a greater incentive to “cheat,” so the price which it can credibly promise to pay to farmers must be lower. Two extreme cases of the investment life reinforce this:

Case 1: $T = 1$. In this case the investment is least durable. The only time-consistency problem arises because prices are announced before investments are made and paid thereafter. Thus, the marketing board can renege on a pre-announced price but only for one period. In this case, $\beta(1, \delta) = \delta$, and the marketing board can implement a monopsony price which is at most a fraction δ of the world price.

Case 2: $\lim_{T \rightarrow \infty} \beta(T, \delta) = 0$. This says that as the commitment involved in making the investment gets very long, then the only sustainable price is zero. This makes sense. With a very durable investment, the marketing board's temptation to renege on any announced pricing policy is overwhelming. Indeed only by announcing that it will pay zero would the marketing board be believed.

A more patient marketing board may charge a higher sustainable price than an impatient one. Two extreme cases are again relevant:

Case 3: $\lim_{\delta \rightarrow \infty} \beta(T, \delta) = 1$. As the discount rate tends to 1, the marketing board is unconstrained in the price that it can charge up to the world price. This result makes intuitive sense, since the marketing board prefers the long-term gains from sticking with the announced monopsony pricing policy rather than the short-run gains of renegeing to a zero price after everyone has invested.

Case 4: $\beta(T, 0) = 0$. This says that as the discount rate goes to infinity, once again the only sustainable price is zero. The short-term profits from cheating the farmers is overwhelming, and the marketing board will always cheat at some point in the future. Thus the only price which can be sustained from the outset is zero.

PROPOSITION 3. Define the set $\chi(q) \equiv \{(T, \delta) \mid \beta(T, \delta) q = p^m(q)\}$ for all $q > 0$. Then, there exists a $\hat{T} \in [1, \infty)$ and $\hat{\delta} \in (0, 1)$ such that for all $T \geq \hat{T}$ and $\delta \leq \hat{\delta}$, the monopsony price is *not* sustainable, *ceteris paribus*.

Example—A Uniform Distribution of Investment Costs

These results on sustainable pricing are easily illustrated in the following example where $\theta \in [0, 1]$ and is uniformly distributed in the population. In this case, $F(\alpha p) = \alpha p$. It is straightforward to check that $p^m = q/2$ in this case. The monopsony price is sustainable (resp. not sustainable) as $\beta(T, \delta) >$ (resp. $<$) $\frac{1}{2}$. For example, if $\delta = 0.8$, then the monopsony price is sustainable if and only if $T < 6$. Thus investments lasting more than six periods will not be paid the full monopsony price.

In this section we have considered sustainable pricing. We have made precise the idea that policy credibility will put an upper bound on prices that can be promised to farmers. The upper bound is some fraction of the world price which depends on the longevity of the investment decision made by farmers and on the discount rate.

5. Discussion

The aim is to consider the relevance of the above model to understanding some aspects of development experience. In understanding this, we will also be able to consider how some of the assumptions can be relaxed, and to what end. There are three main directions in which the model needs to be extended in order to incorporate these features: (i) the imperfect and incomplete information, (ii) the role of parallel markets,

and (iii) the determinants of the discount rate, in particular in the context of political uncertainty. We will also discuss the advantages of centralized versus decentralized crop collection systems and the role of middlemen.

Uncertainty

The model studied so far has ignored an important and pervasive feature of world commodity prices—the fact that they are highly uncertain. In addition, outputs may also fluctuate owing to weather shocks. There are at least two ways in which such considerations can be important in the model. First, if farmers are risk-averse, then governments may serve an important role in providing insurance, and the simplicity of the above approach will be tainted by such considerations. The analysis of Thomas and Worrall (1989) would be relevant in extending the model in this direction. Many of the main ideas developed here would reappear in any model extended to include a risk-sharing component.

Stochastic commodity prices might also affect the nature of the monopsonist's pricing problem. However it does so appears to be quite sensitive to the exact way in which this is incorporated into the model. If world price shocks are independently and identically distributed and prices perfectly observed by farmers, then the analysis goes through essentially unscathed with q replaced by the average world price. The reason is plain to see. The decision of whether or not to renege depends entirely on the future which, in an *iid* world, has a constant expected value. One could also add a budget constraint to the marketing board's problem, capping the loss (or setting a floor on profit) which it was required to make. In this context, the equilibrium prices would sometimes have to be lowered to meet the budget constraint and the optimal policy would so specify. This would not, however, result in punishments being invoked if farmers could observe the world price and knew the marketing board's budget constraint.

The model becomes more interesting still, however, if the marketing board's budget constraint were not known by the farmers. The model would then require extensions along the lines of Green and Porter (1984) and Abreu et al. (1986). For any given world price, as prices were lowered, ostensibly because of budgetary concerns, it would become more likely that the marketing board was actually attempting to capitalize on the sunk investments. Moreover, repeatedly low prices could trigger a "punishment" phase in which farmers stopped planting.

Parallel Markets and Credibility

The development of parallel markets (illegal markets that may involve smuggling of the goods to other areas with higher prices) has often been a response to state-run monopoly boards who keep prices low. A prime example of this phenomenon is Ghana in the 1970s and 80s. After significantly cutting the price of cocoa paid to growers following a post-independence honeymoon period, farmers increasingly began to sell their cocoa through illegal channels, smuggling to neighboring Togo and Côte D'Ivoire (see Azam and Besley (1989) for some discussion).

Parallel markets can be put into the model used above and may actually serve an *advantageous* function to the marketing board, by putting a floor on the price that the farmer can receive and thereby making it more costly for the marketing board to renege on a pricing policy. Thus, if the marketing board decides to cut prices, farmers may switch to the parallel market. A complete model would involve giving each farmer a reservation price at which he would switch to parallel market trades based

on his location (e.g. nearness to a border) and contacts. We shall, however, only consider the simplest case where all farmers have access to a parallel market which pays a price \underline{p} . In the context of the above model, this implies that if the marketing board deviates from its pricing policy, then it cannot go below the price p . It is straightforward to see that this changes the right-hand side of equation (11), thereby changing the formula for the maximal sustainable price. In particular, we now have a price which satisfies

$$p^* = \min \left[p^m, \beta(T, \delta)q + (1 - \beta(T, \delta))\underline{p} \right]. \quad (13)$$

Thus, the sustainable price is weakly greater, strictly so if $\beta(T, \delta)q < p^m$. The reason is that the gains from renegeing on a pre-announced price of p^m are smaller with a parallel market because of the non-zero price floor. Note also that as the parallel market price approaches the world price, i.e., $\underline{p} \rightarrow q$, then the marketing board can sustain any price up to the world price.

This result parallels some of those in the industrial organization literature on second-sourcing (e.g., Farrell and Gallini, 1988). In effect, a parallel market is a second source of income for farmers selling their produce. *Ex ante*, the marketing board may prefer that such a source exist in order to get around the problem of committing to a pricing policy. Of course, if it does ever renege, then it would prefer to stamp out the parallel market in order to extract as much rent as possible from the farmers who have made sunk investments.

Political Instability

The discount rate was taken to be an exogenous feature of time preference in the above model. More realistically, one can think of the discount rate of the marketing board as being related to the longevity of the regime that sustains the marketing board. Governments come and go in many developing nations with quite high frequency, and there is a danger that some marketing boards, which are essentially run in the interests of the government, will get into “end-game” situations where their discount rate is very high and their incentives to renege on a pricing policy become overwhelming. New generations of farmers who are investing would then only be prepared to believe that prices will be very low in future. The present model would then predict that the ability of a regime to implement an effective investment strategy would depend crucially on the perceived longevity of that regime.

In practice, governments which have in the past lowered prices in a way which undermined confidence, have also attempted to win back the confidence of their citizens. One good example is the Ghanaian government after it instituted the economic recovery program in 1983. The assumption of reversion to subsistence for ever is thus not a good characterization of the result of a “deviation.” To the extent that this is the case, however, the price that a monopsony marketing board can sustain will actually be *lower*, since the punishments for renegeing are less severe. Trying to restore credibility usually involves what would be out-of-equilibrium behavior in this model—making overtures and promises to farmers that the regime has changed in order to move back to the maximal sustainable price. In effect, the government is renegotiating with farmers in order to implement a Pareto superior outcome. (See Fudenberg and Tirole (1991, ch. 5) for discussion of renegotiation in repeated games.) One possibility for the government is to offer investment subsidies to farmers if they will reinvest. The difficulty of this is in actually getting the farmers to use the subsidies for the stated use.

Decentralizing and Credibility

The model has not yet considered the process by which crops are actually picked up and delivered to the marketing board. Implicitly, the marketing board has been collecting the crop from farmers at zero cost. This is unimportant for the analysis above, since we could have just defined the world price net of collection costs if we had wished. It is interesting, however, to focus also on the process of crop collection to investigate whether decentralization of this part of the operation can make a difference to the arguments presented above. This is especially true in the light of recent moves towards liberalization of crop collection systems in recent years, the most famous being the liberalization of Nigeria's cocoa marketing system in the mid 1980s.

There are two sharply contrasting views of the effects of liberalizing the marketing structure. The first view is that the problems discussed in this paper should in fact go away. With competition, the farmer can always sell to another crop purchaser, and if one farmer tries to capitalize on sunk investments by cutting the price, then this purchaser will not be able to buy any of the crop. Only if crop purchasers behave collusively will the effects discussed above remain. The second, contrasting, view is that there is always one monopsonist (the government) and that it can always use taxes in a time-inconsistent way, i.e., by raising taxes after farmers have invested.

We now sketch a story of how it is possible for liberalization to make a difference even when the government is monopsonistic in terms of taxes. Assume that crops must be collected by a middleman, each of which can serve some specified fraction of the farmers from all generations. There is free entry into the sector. We assume that the middlemen make an investment of k at the beginning of each period in order to be able to collect the goods from the farmer. The marketing board pricing policy will now specify a price p which is paid to the farmer and a "margin," m ,⁹ which is for the middleman.

The marketing board is assumed to be able to collect the crop from the farmer by investing an amount $K > k$.¹⁰ Thus the marketing board would always prefer to use the private middleman if possible. Whether the existence of middlemen can help to remove the time-consistency problem depends crucially on what we assume to occur if there is a deviation from a prespecified pricing policy. We again assume that there is reversion to subsistence, but the behavior of middlemen must be specified. A middleman can "punish" the marketing board by refusing to incur the costs to collect the crop immediately and forcing the marketing board to incur the higher cost of K . Let us therefore consider a modified reversion to subsistence regime in which the marketing board sets $m = 0$ and $p = 0$ for all time, but incurs K each period to collect crops. Farmers do no more planting and middlemen collect no more crops. Since $K > k$, the decentralized system can make a difference to the kinds of prices that can be sustained, because it raises the cost to the marketing board of deviating from its proposed policy.

Having this "desirable" effect, however, rests critically on specifying that the middlemen join the farmer in punishing the marketing board. If the marketing board can collude with the middlemen, it may be able to continue to use them to collect the crops after they have cut prices to farmers. In some countries, middlemen come from separate ethnic groups (and even nationalities) from the farmers and are viewed with some suspicion, while in other countries the middlemen come from the same community as farmers. In the latter case, it would seem that we would be most likely to observe some kind of valuable decentralization, whereas in the former case it might make less difference. More generally, this discussion does suggest that the marketing system itself

may make a difference to the kinds of prices that can be sustained in ways apart from purely technological concerns. Moreover, the idea that having a more decentralized system can help to combat the capriciousness of revenue-hungry authorities may have some logical foundation.

Intersectoral Misallocation of Capital

The analysis in this paper can also be used to discuss the possibility of sectoral misallocation of capital in a world of different investment opportunities with different time horizons. To see this, imagine that each farmer has access to two different investment opportunities, denoted by A and B. Cash crop A has an horizon of T and cash crop B has an horizon of $T/2$. If investment in cash crop B is chosen, then an individual gets to make a second investment choice halfway through his life. Thus, he is committed for a shorter period. Each individual has a comparative advantage in producing one or other of the crops, which we still measure as the cost of investment. Thus we characterize each farmer by a pair (θ_A, θ_B) . To illustrate the argument cleanly, assume that $q_A = q_B$ (i.e. both goods have identical world prices) and that the comparative advantages are identically and independently distributed over the population. An individual will choose to invest based on the expected stream of payments to each crop. If they faced an identical fixed price for each crop, then the criterion for choosing between the two cash crops would be $\min\{\theta_1, \theta_2/2\}$. The payoff to investment in each of these cases would then have to be compared with subsistence (which we have normalized at zero).

Using the result of Proposition 2, we would expect equal numbers of investors in either activity if the monopoly price were sustainable. However, it is clear that since cash crop B has a shorter horizon, it may be able to pay a higher price than cash crop A and attract some farmers away from the production of the latter. Hence, concerns about sustainability lead to more investment in the relatively short-lived crops. This is a real cost to the monopsonist.

The tendency towards investment in short-lived projects is a general implication of an analysis of sustainable pricing of investments with differing time-horizons.¹¹ The economy displays a kind of short-termism as a consequence. It would be easy to build in larger costs to this “misallocation” of investment toward short-term opportunities by supposing that technological change is a function of the size of the sector (because of a net work externality). Then, over time, we would get an increase in the comparative advantage of the larger sector driven by the marketing boards inability to commit to a price. The resulting tendency towards mono-cropping would be suboptimal (from the marketing board’s point of view) compared with the case where commitment was possible. Thus commitment problems could feed into the long-run growth and development prospects of the economy via such a mechanism.

6. Concluding Remarks

State-run monopsonistic marketing boards have been and continue to be an important institution in many developing countries. Since many of the investments that farmers must make to grow crops are durable, these institutions provide an important concrete case in which to study problems of time consistency and monopsony. This paper has investigated the sustainable pricing policies of a monopsony marketing board based on reputation. In doing so, it has developed a simple dynamic—as opposed to just repeated—context in which pricing decisions are subject to possibilities of time inconsis-

ency. It has been shown how longevity of investment decisions is an important factor in the analysis. It has also been argued that a model along the lines of that developed here (with appropriate embellishments to increase the realism) provides a lens through which to view some actual development experiences. Trying to take more of these ideas to the real world provides a challenge for further work.

Appendix

PROOF OF PROPOSITION 1. It will pay to write the marketing board’s profits as the sum of profits from each generation. To this end, define

$$\pi_s \equiv \sum_{i=0}^{T-1} \delta^i F(R(s, T))(q - p_{i+s}), \tag{A1}$$

as the profits from generation s , and write the total discounted profits as

$$\Pi = \sum_{s=0}^{\infty} \delta^s \pi_{s+1}. \tag{A2}$$

The key to the proof is showing that the marketing board’s optimization problem is appropriately recursive. We are interested in the price sequence which maximizes equation (A1). Consider p_1 ; then

$$\frac{\partial \Pi}{\partial p_1} = \frac{\partial \pi_1}{\partial p_1} = f(R(1, T)) \left[\frac{1 - \delta^T}{1 - \delta} q - R(1, T) \right] - F(R(1, T)) = 0. \tag{A3}$$

Turning now to p_2 , we have

$$\begin{aligned} \frac{\partial \Pi}{\partial p_2} = \frac{\partial \pi_1}{\partial p_2} + \delta \frac{\partial \pi_2}{\partial p_2} = & \left\{ f(R(1, T)) \left[\frac{1 - \delta^T}{1 - \delta} q - R(1, T) \right] - F(R(1, T)) \right\} \\ & + \delta \left\{ f(R(2, T)) \left[\frac{1 - \delta^T}{1 - \delta} q - R(2, T) \right] - F(R(2, T)) \right\} = 0. \end{aligned} \tag{A4}$$

But since $\partial \Pi / \partial p_1 = 0$, equation (A4) is satisfied if and only if $\partial \pi_2 / \partial p_2 = 0$. More generally, we have that, for $j < T$,

$$\frac{\partial \Pi}{\partial p_j} = \sum_{i=1}^j \delta^i \frac{\partial \pi_i}{\partial p_j}. \tag{A5}$$

A key observation is that $\partial \pi_i / \partial p_j = \delta^{(j-i)} \partial \pi_i / \partial p_i$ if $i \leq j \leq i + T - j$, and zero otherwise. Using this, we can combine equation (A5) with the fact that $\partial \pi_i / \partial p_i = 0$ for $i < j$, to conclude that $\partial \pi_i / \partial p_j = 0$. We now extend this reasoning to $j \geq T$. For j in this range:

$$\frac{\partial \Pi}{\partial p_j} = \sum_{i=j-T+1}^j \delta^i \frac{\partial \pi_i}{\partial p_j}. \tag{A6}$$

Again using $\partial \pi_i / \partial p_j = \delta^{(j-i)} \partial \pi_i / \partial p_i$, we can show that equation (A6) requires that $\partial \pi_i / \partial p_j = 0$, if each $p_i (i < j)$ are all set optimally. Thus we can conclude by induction that a pricing policy is optimal if and only if $\partial \pi_i / \partial p_j = 0$ for $j = 1, \dots$. But this is equivalent to

$$f(R(j, T)) \left[\frac{1 - \delta^T}{1 - \delta} q - R(j, T) \right] - F(R(j, T)) = 0, \tag{A7}$$

which holds only if $R(j, T)$ is independent of j . This can hold only if p_t is independent of t . It is now easy to check that equation (A7) is the first-order condition associated with the maximization in (5). \square

PROOF OF PROPOSITION 2. We begin by characterizing the maximal sustainable price such that reversion to subsistence from the steady state (i.e., after T generations of farmers have invested) is not worthwhile. The value of continuing with a stationary price, p , is $\Pi^s \equiv [T/(1-\delta)(q-p)F(\alpha p)]$, while the value of deviating to $p = 0$, given that reversion to subsistence ensues, is given by $\Pi^d \equiv q \left(\sum_{j=0}^{T-1} (T-j)\delta^j \right) F(\alpha p)$. Formally, we need to find the p which equates these, i.e., satisfies

$$\frac{T}{1-\delta}(q-p)F(\alpha p) = q \left(\sum_{j=0}^{T-1} (T-j)\delta^j \right) F(\alpha p). \tag{A8}$$

A key observation is that

$$\sum_{j=0}^{T-1} (T-j)\delta^j = \frac{T}{1-\delta} [1 - \beta(T, \delta)]. \tag{A9}$$

To verify this, first define $X \equiv \sum_{i=0}^{T-1} i\delta^i$. Nothing that

$$\frac{X}{\delta} = \frac{1}{\delta} \sum_{i=0}^{T-1} \delta^i + \sum_{i=0}^{T-1} (i-1)\delta^{(i-1)},$$

we can solve for X to yield

$$X = -\frac{1}{1-\delta} + \frac{1-\delta^T}{(1-\delta)^2} - \frac{T-1}{1-\delta} \delta^T. \tag{A10}$$

Thus

$$\sum_{i=0}^{T-1} (T-i)\delta^i = \frac{T(1-\delta^T)}{(1-\delta)} + \frac{1}{1+\delta} - \frac{1-\delta^T}{(1-\delta)^2} + \frac{T-1}{1-\delta} \delta^T.$$

It is now straightforward to rearrange this to yield the right-hand side of equation (A9) after noting the definition of $\beta(T, \delta)$. The result then follows by substituting (A9) into (A8) and solving for p .

The proof that the optimal stationary sustainable price is characterized by equation (10) is completed by showing that, if deviation from the steady state is not optimal (i.e. after time T), then deviation before T is not worthwhile either. Hence, suppose that deviation from the proposed price is entertained at some time $s < T$. Profits from that time forward, assuming that a constant price is maintained, are

$$\Pi(s) \equiv \left[\sum_{i=s}^{T-1} i\delta^{s-i} + \delta^{(T-s)} \frac{T}{1-\delta} \right] F(\alpha p)(q-p). \tag{A11}$$

The first term represents profits up to time T , while the second represents profits thereafter. It is straightforward to check that

$$\Pi(s+1) - \Pi(s) = \frac{1}{1-\delta} \left[1 - \delta^{(T-s)} \right] F(\alpha p)(q-p). \tag{A12}$$

Profits from deviating to the RTS pricing policy at date $s < T$ are given by

$$\hat{\Pi}(s) \equiv \left[s \sum_{i=s}^{T-1} \delta^{i-s} + \delta^{(T-s)} \sum_{j=0}^s (s-j) \delta^j \right] F(\alpha p) q. \tag{A13}$$

The first term represents the “grace period” during which output remains fixed because all investments made earlier last up to T . The second term represents the gradual decline in output that occurs after time T because future generations of farmers do not invest. Again, it is straightforward to check that

$$\hat{\Pi}(s+1) - \hat{\Pi}(s) = \frac{1}{1-\delta} \left[1 - \delta^{(T-s)} \right] F(\alpha p) q. \tag{A14}$$

We know that $\Pi(T) = \hat{\Pi}(T)$ at the price specified in Proposition 2 if the latter is less than p^m and sustainable; see equation (A8). We now show that if p satisfies (A8), then $\hat{\Pi}(s) < \Pi(s)$ for all $s < T$. From equations (A.10) and (A.12), we have $[\Pi(s+1) - \Pi(s)] - [\hat{\Pi}(s+1) - \hat{\Pi}(s)] = [1/(1-\delta)][1-\delta^{(T-s)}]F(\alpha p)p < 0$. Suppose now that $\hat{\Pi}(T-1) > \Pi(T-1)$ at the p which satisfies (11); then $[\Pi(T) - \Pi(T-1)] - [\hat{\Pi}(T) - \hat{\Pi}(T-1)] > 0$, which is a contradiction. Thus $\hat{\Pi}(T-1) < \Pi(T-1)$, as required. Repeating this argument establishes the result for all $s < T$. Thus, if the price satisfies (A8), then no deviation at or before T is desirable and the pricing policy is sustainable.

We can also prove that (A9) is necessary by noting that, because $[\Pi(s+1) - \Pi(s)] - [\hat{\Pi}(s+1) - \hat{\Pi}(s)] < 0$ for $s < T$, then if the marketing board were to choose to pay a constant price such that $\Pi(s) = \hat{\Pi}(s)$ for $s < T$, there would exist an s' satisfying $T \geq s' > s$, such that $\Pi(s') < \hat{\Pi}(s')$. But since this contradicts sustainability reversion to subsistence would be preferable after time s . □

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Notes

1. Notable exceptions are Gersovitz (1989) and Krishna and Thursby (1992). For a general discussion of marketing boards in Africa, see Arhin et al. (1985). Bates (1981) discusses their importance in the political dimension.

2. The paper is also related to the literature on durable goods monopoly (Coase, 1971; Bulow, 1982), although with an important difference. In the durable goods monopoly problem, a seller cannot commit to not selling a good at a lower price in the future and thus may engage in intertemporal price discrimination. If expectations are rational, then buyers will wait until the price is lower and buy later. In the model considered here, no price discrimination is allowed. There are many overlapping generations of farmers and the marketing board is assumed to be unable to pay farmers of different generations different prices. This does, however, seem like a reasonable restriction for the type of environment that we have in mind here.

3. A good example is pricing cocoa in Ghana and Côte D'Ivoire. Ghana witnessed a secular decline in real producer prices throughout the 1970s. At the same time, Côte d'Ivoire kept prices high. They were forced to cut prices under a structural adjustment program in the 1980s. This price cut occurred after considerable debate, given the centrality of cocoa in that economy.

4. The ideas are similar to those developed to study reputation and product quality by Klein and Leffler (1981) and others.

5. It is possible to generalize this, but the extra investment in notational complexity does not seem to make it worthwhile.

6. A sufficient condition for this is that $F(\cdot)$ be log concave, a property of many commonly used distribution functions.

7. This is also true in Chari and Kehoe (1990).

8. *Proof:* We first prove that $\beta(T, \delta)$ is decreasing in T . It is straightforward to check that $\beta(T, \delta) < \beta(T-1, \delta)$ for $T \in \{1, 2, \dots\}$ as long as $\Psi(T, \delta) \equiv T\delta^{T-1} - (T-1)\delta^T < 1$. Now note that $\partial\Psi(\cdot)/\partial\delta = (T-1)T\delta^{T-2}(1-\delta) > 0$ and $\Psi(1, T) = 1$, for all T . This proves the required result. The proof that $\beta(T, \delta) < 1$ now follows by induction. Since $\beta(1, \delta) = \delta < 1$, we must have $\beta(T, \delta) < 1$, for all $T > 1$. To prove that $\beta(T, \delta)$ is increasing in δ , for $\delta < 1$, first note that $\partial\beta(\cdot)/\partial\delta = (1 - \delta^T[1 + (1 - \delta)T]) / (1 - \delta)^2 T \equiv (1 - G(\delta, T)) / (1 - \delta)^2 T > 0$. Next observe that $G(1, T) = 1$, $G(0, T) = 0$, and that $\partial G(\cdot)/\partial\delta = -T\delta^{T-1}\{(1 - \delta)(T - 1)\} > 0$, for $\delta < 1$ and $T \geq 1$. Thus $G(\delta, T) < 1$ in the relevant domain and the result follows.

9. Obviously, we need $m \geq k$ for the middleman to participate.

10. The justification for this is that the middleman is assumed to have local knowledge which makes it cheaper for him to collect the crop. While, strictly speaking, this is not too reasonable at the beginning of time, it might be more reasonable after some time has elapsed since the crop was introduced.

11. It would carry over, one imagines, to the Ramsey taxation environment studied by Chari and Kehoe (1990).