Inter-American Development Bank
Office of the Chief Economist
Research Network Document R-335

Oil, Coffee and the Dynamic Commons Problem in Colombia

by

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Inter-American Bank of Development
Office of the Chief Economist
Latin American Research Network
Research Network Document R-335

Agosto 1998

Acknowledgements

This paper has been presented at the 1997 meetings of LACEA, the IDB and Fedesarrollo. We are grateful to Barry Eichengreen, Ricardo Hausmann, Janet Kelly, Roberto Steiner, and Aaron Tornell for valuable comments, to Julio Cesar Alonso for excellent research assistance, and to Carlos J. Rodríguez for help with some of the data processing. This paper is part of a regional research project sponsored by the Inter-American Development Bank. Corresponding author mcardena@fedesarrollo.org.co.

Abstract

The *dynamic commons problem* arises when different groups in society engage in intense re-distributive activity as a result of an export boom. This paper analyzes the role that institutions play in ameliorating that problem in the case of coffee and oil in Colombia. The paper presents a model that rationalizes the existence of a federation of coffee producers that effectively reduces inefficient redistribution to other sectors of society. According to the empirical evidence we find that domestic coffee prices have been unaffected by political factors, so that in practice appropriation of coffee rents does not depend on electoral and partisan cycles. The case of oil is substantially different. Here, rents are claimed by a large number of divided agents. According to the model, one feasible solution to the dynamic commons problem when the fiscal structure is not unitary is to impose a set of rules that restrict appropriations by different groups during windfalls. The major cost of this solution, embodied in the Oil Stabilization Fund, is the total loss of flexibility.

1 Introduction

Colombia's exports are heavily concentrated in oil and coffee. In 1996, oil exports were close to US$ 3 billion (25% of total exports of goods), while coffee exports amounted to US$ 1.7 billion (20% of the total). In addition, due to taxation of export revenues, there is a strong relationship between public finances and export performance. In this context, export revenues can be thought of as an inadequately priced common resource subject to over-utilization. Thus, a "tragedy of the commons" may arise if property rights over those revenues are ill defined or cannot be enforced[1]. In particular, different groups from society would lobby for additional spending programs whose benefits they can internalize. However, the costs of such behavior take the form of under-investment, and are borne by society as a whole. The literature has shown that this form of common access results in over-consumption and lower economic growth[2].

In an inter-temporal setting the commons problem takes other dimensions that are worth mentioning. When the terms of trade improve, or new discoveries are made (as in the case of oil) it is optimal to save part of the boom in order to spread increased consumption over time. This would certainly be the prediction of a representative agent model when the duration of the shock is uncertain. In practice, however, there is a tendency for the additional resources to be consumed immediately, as powerful groups within society attempt to appropriate the windfall. In fact, what is observed is that associated with the boom there is an increase in re-distributive activity. Since groups fear that others will appropriate the windfall, they engage in intense lobbying in order to capture the resources themselves. This is known as the *dynamic commons problem*.

We argue that this problem is more severe in a country highly dependent on state-controlled primary commodity exports, such as oil and coffee. Citizens feel entitled to a share of those revenues, especially during periods of external booms, posing obstacles for the implementation of an inter-

[1] Typical examples are cattle grazing in common pastures or vessels fishing in a lake.
[2] See, for example, Tornell and Velasco (1992).

temporally consistent fiscal policy. In sum, the difficulty to define property rights is compounded by the volatility in export revenues.

The purpose of this paper is to analyze the role that institutions have played in the amelioration of the tragedy of the commons in Colombia. We look at institutions that limit discretionary redistribution by imposing checks and balances on the use of oil and coffee export revenues. In particular, we analyze the National Federation of Coffee Growers (hereafter the Federation) as well as the Oil Stabilization Fund (hereafter the OSF). These are similar institutions in that they both try to limit redistribution and over-consumption of export earnings. However, they differ in their design. The operation of the OSF is defined by rules that leave no room for flexibility. The Federation is an autonomous agency that manages the National Coffee Fund (NCF), a stabilization fund which has been relatively insulated from lobbying by special interests. Contrary to the OSF, the NCF has retained flexibility -which is valuable given the volatility in world coffee markets.

In this sense, the paper can be viewed as an attempt to illustrate the choice between rules and flexibility in the design of institutions. Using a model, we show why rules are preferred to discretion when there are many competing groups, as in the case of oil. When there are fewer agents the opposite may be true. In fact, it may be possible to push-out the frontier of feasible combinations of flexibility and credibility by delegating authority to an autonomous agency[3]. If reputation is acquired throughout time, as in the case of Federation of coffee producers, then discretion is even more favorable.

As we will see in detail, in 1978 the Federation and the NCF became less autonomous from the government. Consequently, the paper also tests for the effects of changes in the degree of autonomy on the ability to prevent redistribution and over-consumption of coffee revenues. In addition, we test for the possibility of political interference on coffee producers' taxation. Interestingly, the evidence suggests that electoral and partisan cycles have played no role in the redistribution of coffee export revenues to other groups. Indeed, the only episode of political interference is associated with an increase in domestic prices,

[3] On the tension between credibility and flexibility, and its implications for institutional design, see Levy and Spiller (1994).

in an effort to gain political support from coffee producers during the last months in power of Rojas-Pinilla´s military regime in the late 1950s.

This paper is structured as follows. Section 2 discusses in detail the institutional design of the Federation, the National Coffee Fund, and the Oil Stabilization Fund. Section 3 presents a model that rationalizes the existence of these institutions. The model captures the nature of the game that leads to a dynamic commons problem, and provides a framework where institutions, such as the Federation and the Oil Stabilization Fund, arise endogenously. Section 4 discusses the empirical evidence for coffee. In particular, we find that political factors have not played a major role in the appropriation of coffee rents by other groups in society. In contrast, Section 5 illustrates the tendency for over-consumption of oil rents. The paper ends with a brief section of conclusions.

2 Institutional Aspects

2.1 Coffee

Production of coffee in Colombia is based on a peasant smallholder economy. Producers are organized around the National Federation of Coffee Growers, a powerful institution created in 1927[4]. Analysts agree that the Federation is not just a producers' association. For instance, Urrutia (1983) argues that the Federation forms a parallel state with its own sources of legitimacy since producers' representatives at all levels are elected by direct vote and for relatively long periods of time (so they deal both with booms and busts and embody the will to stabilize).

[4] The are different views on the origins of the Federation. Bates (1997) has argued that politicians from the coffee regions were instrumental in the creation of the Federation due to their interest in the revenues derived from the coffee industry. In his view, local politicians solved the 'collective action' problem posed by the fact that small peasants have weak incentives to organize. However, large coffee producers –opposed to taxation- were also instrumental in the creation of the Federation. Indeed, the Federation's first general manager came from Cundinamarca, a region characterized by large 'haciendas'.

The creation of the Federation can be thought of as an effort on the part of coffee producers to form a solid block in order to prevent redistribution of coffee revenues to other groups of society[5]. Quarrels between the Federation and the government over coffee taxation and export policies, as well as over exchange rate management have been frequent. For instance, as early as 1935 the government introduced a new tax in order to pay for the war with Peru. The same government wanted to gain control over export policy in order to facilitate collusion with Brazil (the world's largest producer). The Federation, whose views ultimately prevailed, opposed both initiatives. Negotiations came, however, at a cost. Previously, coffee growers had elected all members of the Comité Nacional, the Federation's governing body. This structure changed in 1935: five members of the Comité were to be chosen by the Coffee Congress and five by the government (ties were to be split by the President). In addition, the president of the Republic was granted veto power over the appointment of the Managing Director of the Federation. However, as can be seen in Appendix 1, there have been only three Managing Directors during the last 60 years. Thus, in practice, governments have not exercised that power.

It is difficult to explain the origin of the powers of the Federation. Interpretations where elites mobilize the backing of the industry in defense of their interests do not seem to be valid. The Federation has a democratic structure, where each producer is entitled to one vote favoring the smallholder regions of the country. Bates (1997) has emphasized the dynamics of party competition in Colombia in order to understand the emergence of the Federation as an autonomous agency able to restrain pressures from the government. According to his view, coffee producers in Colombia have been traditionally at the center of the political spectrum. A candidate willing to win office requires the support of this group, which therefore has become pivotal in electoral turnouts. In Bates' words, "[coffee growers] have been able to make or break governments" even without numerical majority.

[5] In addition, the Federation sought to integrate vertically the coffee industry in Colombia by promoting Colombian coffee in world markets while locally providing better infrastructure and easier access to credit. These activities were initially financed with an export tax levied by the government and transferred entirely to the Federation. The Federation was also granted regulatory powers in relation to the quality of coffee.

From a different angle, this might give a clue as to why the economic platforms of political parties (liberal and conservative) have converged in order to capture the representative median voter (i.e. a typical coffee producer). Consequently, liberals and conservatives adopt similar policies in order to stabilize the effects of external shocks that are welfare-reducing for the median voter. Not surprisingly, conservatives and liberals are indistinguishable in regard to economic policies, a point documented by Escobar (1996). Moreover, this political structure explains the dominant role of the technocracy in macroeconomic matters. Technocrats and coffee producers have shared similar objectives and have mutually reinforced their respective powers[6]. In sum, Bates' median voter argument can be useful in explaining the differences in fiscal policies adopted by Colombia relative to other coffee producing countries[7].

History has also played a key role in the consolidation of the Federation. The institutional development of the coffee sector in Colombia has been closely related to its export strategy. In 1940, when the Federation decided to cooperate with Brazil in an effort to control world prices, the National Coffee Fund (NCF) was created. The Fund was provided with some initial capital and the proceeds of coffee taxation in order to purchase and withhold coffee. In a way, the Fund became a tool in order to impose an optimal tax on exports, allowing the country to achieve the first-best outcome.

The Fund explicitly became an instrument for the stabilization of producers' incomes after the collapse in world prices in 1958. In order to smooth out consumption, producers have been willing to make a contribution to the Fund[8]. To avoid free-riding problems, these contributions have taken the form of a tax enforced by the government who, in turn, has the incentive to redirect resources to other groups in

[6] In a recent paper, Junguito (1996) argues that the Federation will lose part of its weight in the formulation of macroeconomic policies as a result of the loss of importance of coffee within the Colombian economy.

[7] Along similar lines, Urrutia (1991) has argued that the absence of populism in Colombia is the result of the checks and balances of the Colombian democracy. In a more recent paper, Urrutia (1996) points out that traditionally the Minister of Finance has not been a politician, but almost always a professional economist. This has been possible because of the highly competitive nature of Colombian democracy. Politicians would rather have a technocrat occupy this ministry than a potential rival, due to the immense power associated with this position.

[8] The NCF has also become an automatic fiscal stabilizer by saving during coffee booms and dissaving during busts. Producers' price stabilization can be completely undermined from a macroeconomic point of view if there there is an incentive for politicians and officials with different preferences than those of the farmers to use the board for redistribution purposes.

society. As we will see in Section 4, the use of the Fund for stabilization purposes has resulted in greater taxation of coffee producers (compared with the period before 1958).

Representatives of producers regained majority over the Comité Nacional, the governing body of the Fund, in 1958. This structure was again changed during the coffee boom of the late 1970s. In fact, since 1978 government officials (led by the Minister of Finance who has veto power over most decisions) and producers have equal representation on the Comité. Negotiations between the two groups are centered on the price paid to domestic producers.

2.2 Oil

In spite of the fact that oil production has a long history in Colombia (the first concession was granted in 1905), exports have been significant only since 1987. Although the level of oil reserves is still low, projections indicate a rapid increase in production (and exports) in the coming years. In fact, the production of oil will increase from an average of 450,000 barrels per day (bpd) during the first half of the 1990s to nearly 900,000 (bpd) by the turn of the century. Oil export revenues will also double, from approximately US$2 billion to US$4 billion. However, it is likely that the increase in oil exports will be of a temporary nature. Recent projections indicate oil exports will fall after 2001, provided that no major new discoveries are made[9].

Fiscal contributions of the oil industry are based on a complex system of royalties and special contributions. According to the most recent legislation, royalties amount to 20% of production and are distributed among the producing departments (47.5%), the producing municipalities (12.5%), the municipalities where exporting harbors are located (8.0%), and the National Royalties Fund (NRF)[10]

[9] See Fedesarrollo-Analdex (1996).

[10] This Fund was created in 1994 and is administered by the National Royalties Commission formed by representatives of the national and the local governments. The Commission, which is presided by the Minister of Energy, allocates the proceeds of the Fund which have amounted to over 0.2% of GDP in 1995 and 1996 (nearly US$200 million). The funds are assigned to regional projects, mainly in mining, environment, and transportation infrastructure.

(32.0%). In addition, the dividends of Ecopetrol (the State owned company) as well as other forms of direct and indirect taxation accrue to the National Government.

In light of the potentially destabilizing effects of an oil boom, the Colombian Congress approved in 1995 the creation of Oil Stabilization Fund (OSF). In contrast to the NCF, which is a tool for private consumption smoothing, the OSF forces saving by all the recipients of oil rents, and invests the proceeds abroad[11].

2.3 Summary

Revenues derived from the production and export of coffee and oil are subject to the *dynamic commons problem*. Oil rents have several powerful shareholders, such as the national government, the local governments, the state-owned oil company, as well as special interest groups. These shareholders behave as if they were more impatient than society, so that excessive appropriation of those rents diminishes economic growth.

In the case of coffee, production takes place in a decentralized fashion by a large number of small growers. They are organized around one institution (i.e. the Federation) which embodies the preferences of the representative producer. Powerful groups within society (including the government) attempt to appropriate and dissipate windfalls. This, again, is an example of the *dynamic commons problem*.

Existing institutions in Colombia try to solve the dynamic commons problem associated with coffee and oil revenues in quite distinct ways[12]. In relation to coffee, the arrangement favors the formation of a unified block of coffee producers. In this case it has been possible to retain flexibility, while the

[11] The saving mechanism is rather complex and starts from the definition of a basic monthly income of US$ 15 million for a production unit (i.e. an oil field). The distribution of that basic revenue is: Ecopetrol (US$9.3 m.); NRF (US$2.1 m.); producing departments (US$2.3 m.); producing municipalities (US$0.5 m.); harbor municipalities (US$0.34 m.); and, non-producing departments (US$0.22 m.). These values are adjusted annually according the U.S. CPI inflation. Two concepts are critical in order to understand the saving mechanism. First, the "additional revenue" (of each recipient), defined as the difference between actual revenues and the basic monthly income. Second, "average additional revenue", defined as the historic average of the additional revenue. In separate accounts for each recipient and for each production unit, the OSF saves the difference between the additional revenue and the average additional revenue. When that difference is negative, the OSF dissaves by reimbursing the difference.

[12] One similarity, however, is that Congress has no role in the management of these institutions.

inability to unify shareholders of oil rents has resulted in an arrangement that favors rules (commitment). Weekly meetings between representatives of coffee producers and government officials determine the management of coffee revenues. In the case of oil, automatic clauses stated in the law leave no room for discretion. In this sense, one could characterize the National Coffee Fund as a flexible instrument were outcomes (the amount of redistribution and the degree of stabilization of domestic prices) are the result of two-player (government vs. producers represented by the Federation) game. On the other hand, the Oil Fund imposes strict rules for mandatory savings by the different recipients of oil rents (Ecopetrol, the Royalties Fund, plus the territorial governments). The cost, of course, is a reduction in the ability of the instrument to accommodate unforeseen circumstances. However, this might be a reasonable price to pay in order to reach a cooperative solution, which otherwise would be difficult to achieve given the large number of players involved.

Indeed, the key in determining the optimal design of the institution is related to the nature of the fiscal process. When there are many heterogeneous agents competing for resources, as in the case of oil, it is difficult retain flexibility. That is probably the reason why the Colombian institutional design favors rules when the problems created by divided fiscal structures become more severe.

In the next section we develop a model where strict rules are optimal when there is a large number of groups. These rules try to replicate the first-best outcome by restricting the appropriation of resources by different groups. Conversely, discretion seems to yield better outcomes than commitment when there are fewer players. In other words, unitary fiscal structures lessen the anomalies associated with the commons problem.

3 The Model

3.1 The Dynamic Commons Problem: Basic Framework

As is well known, a common resource can be accumulated too slowly or appropriated too quickly as competing groups struggle for it. Over-consumption is then sub-optimal from the

point of view of welfare, especially if that common resource is an input into growth. In this section, we illustrate that basic point by presenting a model that follows closely Lane and Tornell (1996). We consider a one-sector growth model where agents have common access to the aggregate capital stock. We can think of this stock as coffee trees or oil reserves. Production takes place through a linear technology that uses that stock as the only productive factor. In turn, production is exported in exchange for a consumption good that can be appropriated by different groups in society. Specifically, the accumulation equation is given by

$$\dot{K}(t) = a\,K(t) - \sum_{j=1}^{n} c_j(t) \tag{1}$$

where *K(t)* is the aggregate capital stock and $c_j(t)$ is the consumption or appropriation by group j (*j = 1,…, n*). α can be thought of as the marginal product of capital or, alternatively, as the terms of trade, i.e. the price of oil (coffee) in terms of the consumption good. Implicitly, equation (1) assumes that groups do not have access to a private accumulation technology. Thus, their appropriation is consumed immediately. The objective function of each group is to maximize overall utility, as given by

$$\int_t^{\infty} \frac{s}{s-1} c_j(s)^{\frac{s-1}{s}} e^{-d\,(s-t)}\,ds \tag{2}$$

where σ is the elasticity of intertemporal substitution, and δ is the rate of time preference or subjective discount rate. We will impose the following restrictions

$$s > 0, \quad n > 1, \quad d > 0, \quad a > 0, \tag{3}$$

$$K(t) \geq 0, \quad t \geq 0 \tag{4}$$

The condition on the value of σ ensures that the second-order conditions are satisfied. The second condition in equation 3 indicates that there are multiple groups. The other restrictions are standard. Equation (4) simply sets the constraint on the capital stock to be nonnegative. A solution is found by postulating that consumption policies are linear functions of the capital stock, $c_j^*(t) = x_j K(t)$, where x_j's

are undetermined coefficients. However, a restriction must be imposed in order to prevent each group from consuming the entire stock of capital at one point in time. This is given by

$$\underline{x}K(t) \le c_h(t) \le \bar{x}K(t), \tag{5}$$

where $\bar{x}K(t)$ is larger than the equilibrium appropriation. This setting captures the main features of the dynamic commons problem. It allows for multiple groups to compete strategically in the redistribution of oil and coffee revenues, while its intertemporal structure assures that each group is concerned with growth (future consumption). In fact, groups save even if that enhances the possibility that other groups increase their appropriation.

One possible solution to this dynamic game among *n* groups is given by the Markov perfect equilibrium (MPE), which is derived in Appendix 2. According to this solution concept, the optimal value of x_i is given by,

$$x_i^* = [a - \sum_{j \neq i} x_i^*][1 - s] + ds \tag{6}$$

To provide some intuition, think of $[a - \sum_{j \neq i} x_i^*]$ as the return on the common asset net of appropriations by the other *n-1* groups. That is, *i*'s rate of return is a negative function of the sum of appropriations by other *n-1* groups. When that sum increases and $\sigma < 1$, the income effect dominates the substitution effect, so that *i*'s appropriation rate falls. The opposite happens when $\sigma > 1$.

Note that (6) forms a system of system of *n* linearly independent equations in *n* unknowns. The unique solution for this system is given by

$$x_i^* = \frac{a[1-s] + ds}{n - s[n-1]}, \quad i = 1, \ldots, n \tag{7}$$

which is simply the solution to $x^* = [a - (n-1)x^*][1-s] + ds$. Consequently, the optimal consumption for every group is

$$c_i^*(t) = \frac{a[1-s] + ds}{n - s[n-1]} K(t), \quad i = 1, \ldots, n \tag{8}$$

so that the equilibrium is symmetric. Substituting (8) in the accumulation equation (1) we get the equilibrium path of aggregate capital[13]

$$K^*(t) = K(s)\exp\left(\frac{s[a - nd]}{n - s[n-1]}[t-s]\right). \quad (9)$$

We now compare this allocation to the first best solution obtained by a central planner that maximizes (2) subject to the accumulation equation $\dot{K}(t) = a\,K(t) - nc_i(t)$ and constraints (3) and (4). This is identical to the Ramsey problem where consumption is given by

$$c_i^{fb}(t) = \frac{a(1-s) + ds}{n} K(t) \quad (10)$$

(*fb* denotes de first best). In turn, the equilibrium path of aggregate capital is given by[14]

$$K^*(t) = K(s)e^{s[a-d][t-s]}. \quad (11)$$

To recapitulate, when there are multiple groups competing for a common capital stock each group's marginal propensity to consume (and appropriate) is too high compared to the case where groups consume only out of their individual capital. That is,

$$x_i^* = \frac{a[1-s] + ds}{n - s[n-1]} > \frac{a(1-s) + ds}{n} = x_{i,fb}^* \quad (12)$$

The amount of over-consumption is reflected in a lower growth rate for the economy (defined as $g = \dot{K}/K$).

$$g^* = \frac{s[a - nd]}{n - s[n-1]} < s(a - d) = g_{fb}^*. \quad (13)$$

[13] Moreover, note that equation (9) implies that $K(t) \geq 0$ ($t \geq 0$), satisfying one of the constraints imposed in (4). Second order conditions must be satisfied for (8) and (9) to be indeed an equilibrium. Given the restrictions imposed in (5), and the linearity (on c_i and K) of the accumulation equation (1), it turns out that second order conditions are ensured as long as the utility function is strictly concave (i.e., as long as $\sigma > 0$).

[14] In this case the transversality condition is ensured if and only if $a(1-s) + ds > 0$.

Thus, the existence of powerful groups leads to a reduction in growth relative to the first best. Note that one can replicate the first best if n=1. Alternatively, the first best solution can be achieved if groups act cooperatively and delegate consumption decisions to a central planner.

3.2 Extensions

As can be readily observed from equation (13) the growth rate of the stock of capital in this economy depends on the number of groups that compete for the common access resources. In particular,

$$\frac{\partial(g^*)}{\partial n} = \frac{s[a(s-1) - \delta s]}{(n - s(n-1))^2} \tag{14}$$

is negative for $\sigma \in (0,1]$. Thus, the rate of growth falls as the number of groups becomes larger, reflecting that total appropriations ($n \times x^*$) are increasing in n. That is, $\frac{\partial(nx^*)}{\partial n} = \frac{as(1-s) + s^2\delta}{(n - s(n-1))^2}$ is positive for $\sigma \in (0,1]$.

The point is clear: Growth falls relative to the first best when there are several groups competing for the common capital stock. In fact, things can be even worse if we assume as is common in the growth literature that each group becomes more impatient to consume (an appropriate) as the number of groups increases. In other words, the risk of other groups increasing their consumption induces greater impatience. In particular, one can think of the disco unt rate as increasing in n (γ>0).

$$\delta = \bar{\delta} + \gamma \ln n . \tag{15}$$

Clearly, in this case increases in n cause a larger contraction in growth than before (and a larger increase in total appropriation). This framework is useful for the analysis of windfalls, such as an increase in the terms of trade or a discovery of new oil reserves. In either case the windfall can be captured by an increase in α, which reflects more consumption opportunities for the same stock of capital. The effect a windfall on appropriations is given by

$$\frac{\partial x^*}{\partial a} = \frac{1-s}{n-(n-1)s} \tag{16}$$

which is positive for $\sigma \in (0,1]$. However, even if appropriations increase, the rate of growth does not necessarily fall. In fact,

$$\frac{\partial g^*}{\partial a} = \frac{s}{n-(n-1)s} = \begin{cases} - \text{ if } s > \frac{n}{n-1} \\ + \text{ if } s < \frac{n}{n-1} \end{cases} \tag{17}$$

Clearly, equation (17) yields positive values if $\sigma \in (0,1]$. However, it is possible that an increase in the raw rate of return (α) results in a perverse effect on growth when there is a more than proportional increase in aggregate redistribution. This case is known in the literature as the *voracity effect* and is associated with $s > \frac{n}{n-1}$. We are ruling out this possibility by assuming $\sigma \in (0,1]$[15].

The voracity effect is in sharp contrast with the results of the first best case (where groups internalize the effects of their appropriations). From (13) it follows that

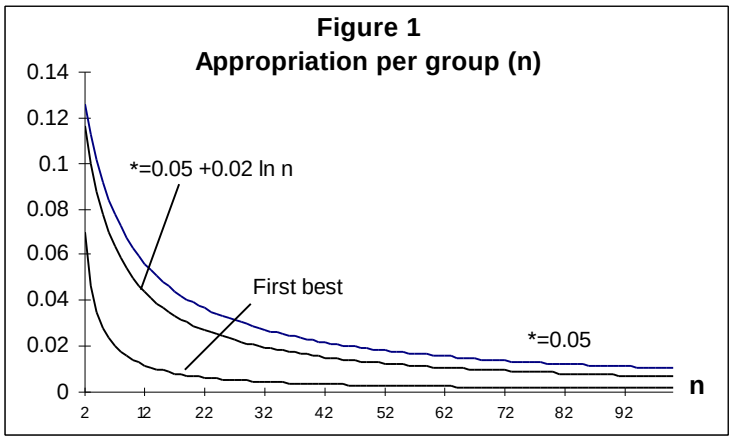
$$\frac{\partial g^*_{fb}}{\partial a} = s > 0, \tag{18}$$

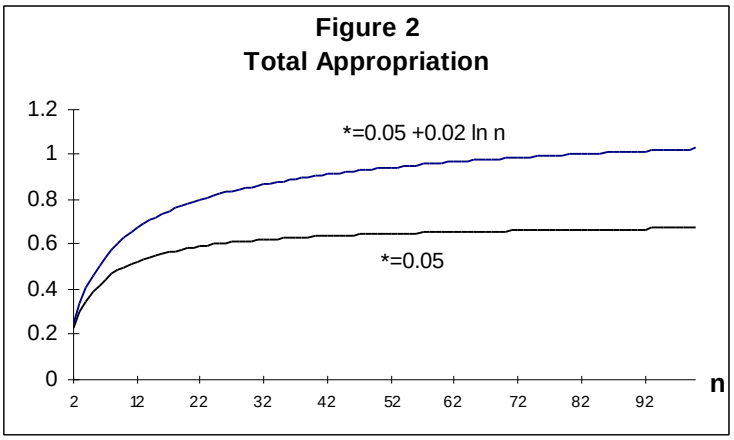
so that the increase in economic growth (after a windfall) is always larger under the first best solution.

3.3 Simulations

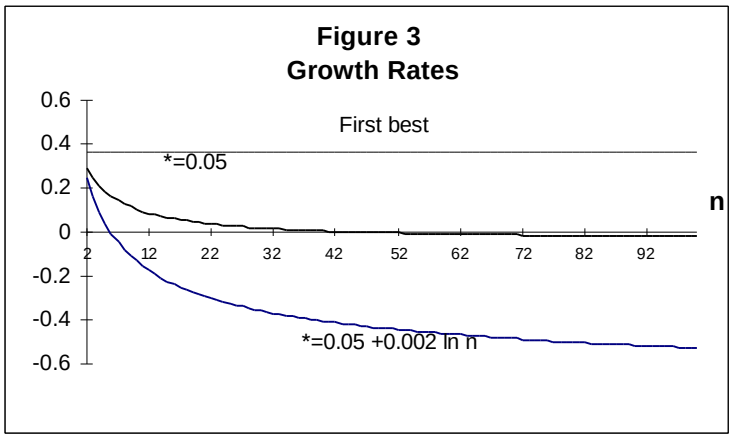
In this section we try to replicate the Colombian economy by assigning some plausible values to the parameters used in the model. Based on estimates by Barrios et al. (1993) for the historical capital-output ratio in Colombia we set $\alpha = 0.5$. We use a value of σ equal to 0.8, which is higher than the estimate (0.588) obtained by Ogaki, Ostry and Reinhart (1996). We arbitrarily set $\delta = 0.05$, in line with the calibrated parameters of Suescún (1996). Figure 1 plots the appropriation rates (x) for $n = 1,....,100$. Clearly, the appropriation rate by each group tends to decrease as the number of competing groups increases. However, the overall appropriation ($n \times x^*$) increases with the number of groups (Figure 2).

That is precisely why the growth rate of the economy decreases with the number of groups (Figure 3). Indeed, the growth rate of the economy becomes negative for *n* sufficiently large. That is, when the number of groups is relatively large, their total appropriations exceed total output (export revenues). The figures also plot the first best case as a benchmark. Clearly, appropriations are higher and growth rates lower as a result of the dynamic commons problem. In addition, the figures include the case where the discount rate depends on the number of groups. In particular we assume that $d = 0.05 + 0.02 \ln n$, so that the discount rate is equal to 0.142 when *n*=100. In this case redistribution increases rapidly in *n* so that economic growth turns negative for $n > 6$.





[15] However, it is possible that individual groups have greater values of σ than the representative agent does, which is the value often used in empirical macroeconomic models. This makes the voracity effect more likely.

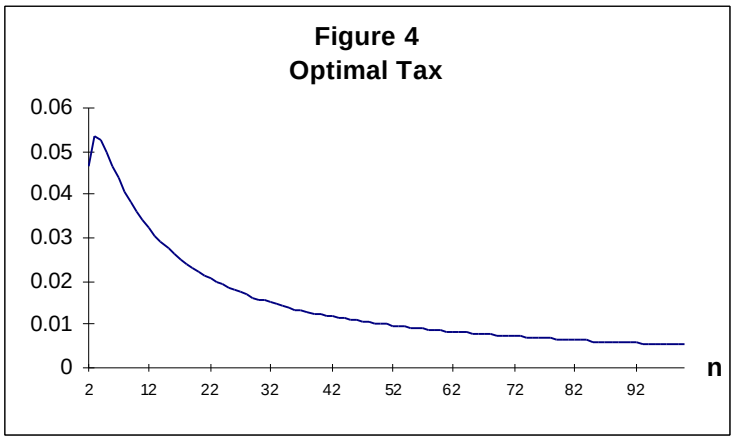


The logical question that arises is how to replicate the first best solution when there are several groups. One possibility is to try to reduce the number of groups that take part in the game. In practice, this may have been the approach implicitly used in the case of coffee in Colombia. By effectively reducing the number of relevant players to two, economic growth has been higher than with more players.

In the case of oil, it has been harder to reduce the number of players. As discussed above, the nature of the political process, combined with the degree of fiscal decentralization, has resulted in a divided fiscal structure. Rather than creating an institution similar to the *Federation*, restrictions have been imposed on the appropriations by all groups that receive oil rents. We can think of this as a case where the central planner limits the amount of consumption, which is equivalent to a forced savings mechanism. Ideally, one would like to restrict appropriations to the point where they mimic the first best allocation. In particular, it would be optimal to design a stabilization fund that has access to the accumulation technology captured by equation (1). The stabilization fund will in turn tax the appropriation by each group to the point where the after-tax appropriation is identical to the first best allocation. Given equation (12) we can express the tax rate (τ) as:

$$x_i^* - x_{i,fb}^* = t = \left[\frac{s(n-1)}{(n-s(n-1))n}\right]\left(a(1-s)+ds\right) \qquad (19)$$

Note that the proceeds of the fund will become part of the common access capital stock. Figure 4 plots the optimal tax rate, which is an increasing function of a windfall (an increase in α results in an increase in the optimal tax). That is, $\frac{\partial t}{\partial a} = (1-s)\left[\frac{s(n-1)}{(n-s(n-1))n}\right] > 0$ for $\sigma \in (0,1]$.



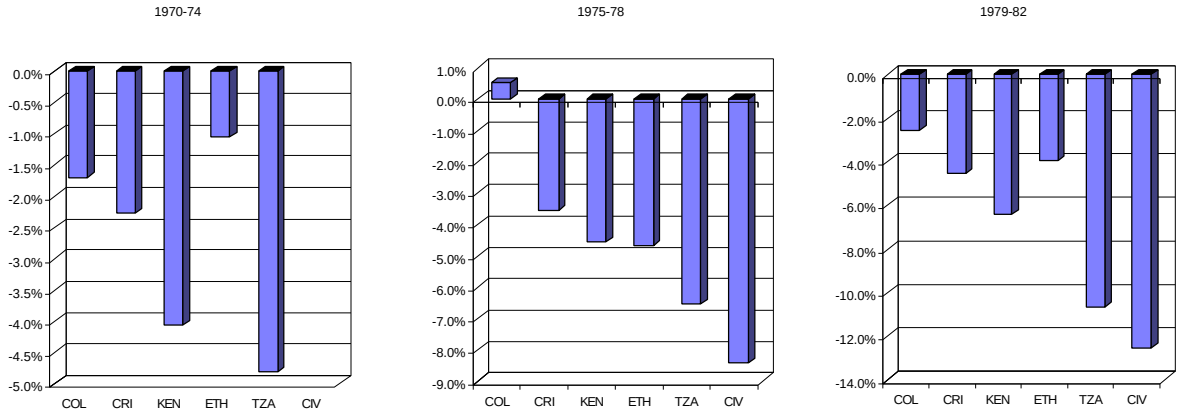
Clearly, commodity booms should generate greater limits on the appropriation by each group[16]. The analysis of this section has shown that the dynamic commons problem can be solved in different ways. One possibility is to reduce the number of groups that compete in society, so that in practice, consumption decisions resemble that of a central planner. Creating strong institutions that embody the preferences of the representative agent can do this. Alternatively, when it is difficult to reduce the number of groups, the government can restrict the appropriation by each group. This is similar to imposing a tax that lowers consumption and increases capital accumulation. Essentially, this framework rationalizes the experience with coffee and oil in Colombia. In the next section, we analyze whether the existence of the *Federation* (of coffee producers) has resulted in lower redistribution and higher growth.

[16] Notice that the change in the tax rate is proportional to the windfall.

4 Empirical Evidence: Coffee

This section tests whether the existence of the Federation has resulted in lower redistribution of coffee revenues to other sectors of society, compared to what is observed in countries where the institution does not exist. This hypothesis is supported by the evidence in Figure 5, which shows the central government's deficit for a group coffee producing nations. Interestingly, Colombia was the only country with a fiscal surplus during the coffee boom of the late 1970s. Cote d'Ivoire, a country with heavy redistribution of coffee rents, experienced the largest deficit[17].

Figure 5
Average Fiscal Deficit (as % of GDP) of Selected Coffee Producing Countries Before, during and after 1975-1978 Coffee boom



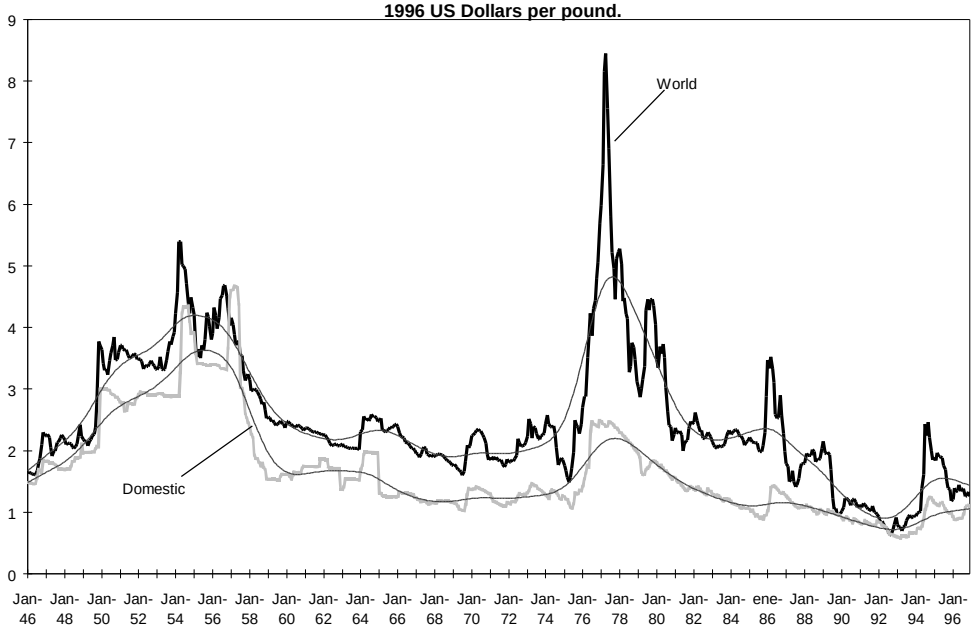
We will also look at the evolution of coffee taxation and redistribution in Colombia throughout time, and test for possible effects of institutional and political variables, such as changes in the composition of the Comité Nacional, the proximity of elections, or changes in the ruling political party. The idea is to evaluate the degree of autonomy of the institution.

[17] As shown in Cárdenas (1994), Côte d'Ivoire is an interesting example where the control of the central government over a similar institution results in a procyclical pattern of fiscal expenditures. In a series of papers about Kenya, Bevan, Collier and Gunning (1987 and 1989) have argued that, in spite of farmers' ability to save, the fiscal sector response to the coffee boom resulted in large macroeconomic fluctuations during the late 1970s.

4.1 Stylized Facts

Figure 6 plots the monthly domestic and world coffee prices (both in constant 1996 US dollars) during the period 1946-1996. A cursory look at the graph indicates that domestic coffee prices have been lower than world coffee prices. In some years, part of the difference between world and domestic prices has been used for the purchase of excess production over exports, so that strictly speaking not all that

Figure 6
World and Domestic coffee Prices
1996 US Dollars per pound.



differential is equivalent to taxation of coffee producers at each point in time.

However, periods of accumulation of stocks are followed by periods of dis-accumulation so that on average the change in inventories has been very small. According to the financial statements of the National Coffee Fund, the cummulated change in coffee stocks from 1968 until 1996 has been equal to 0.14 percentage points of GDP (Appendix 3). In this sense, it is accurate to consider the average

differential between world and domestic prices as the average degree of coffee taxation. The fact that this average differential has been positive implies that there has been on average some form of redistribution.

Figure 7 shows the deviations from the trend values in world and domestic prices[18]. Clearly, since 1958 domestic coffee (producers') prices have been more stable than world prices, reflecting the use of the National Coffee Fund for stabilization purposes. However, the larger degree of stability in domestic prices has resulted in greater taxation. Indeed, as Figure 8 shows, producers' taxation increased permanently after 1958[19]. In other words, stabilization requires more involvement by the government, which has come at a cost for coffee producers. Figure 9 compares the degree of producers' price stabilization among a group of six producing nations (all of them produce similar qualities). The coefficient of variation in domestic prices is lowest for Colombia, while the average taxation is comparable to the other countries. This would suggest that producers' price stabilization in Colombia has been achieved without major costs in terms of redistribution, relative to other countries.

[18] In order to define the 'permanent' level of the variables we used the Hodrick-Prescott filter, which takes out their cyclical or high frequency information and leaves their long-run (low-frequency) properties.

[19] New tools for coffee taxation where introduced in 1958 in order to perform the stabilization objective. However, this measure of coffee taxation is certainly overestimated since marketing costs have not been added to the domestic price.

Figure 7
World and Domestic Coffee Prices
Deviations from Trend

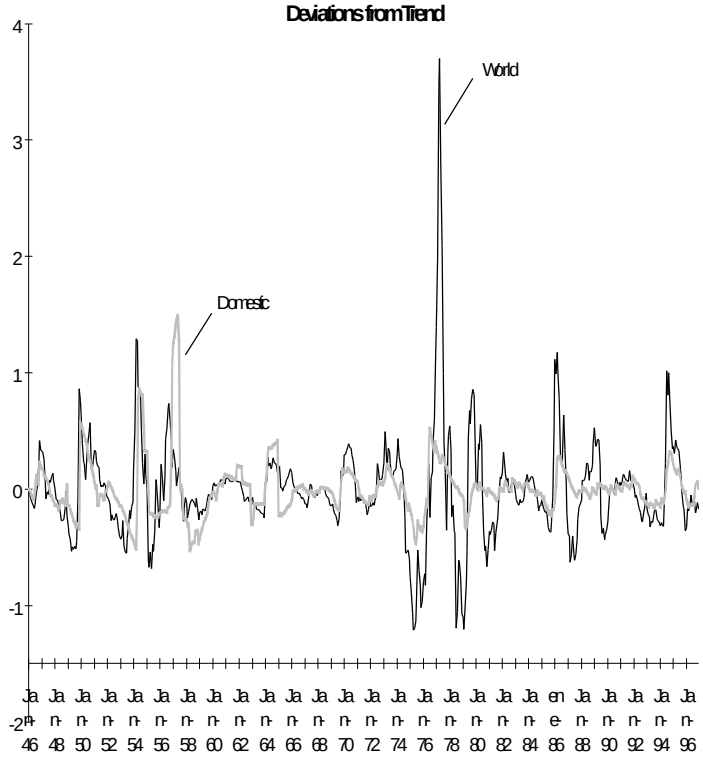


Figure 8
Producers' Taxation

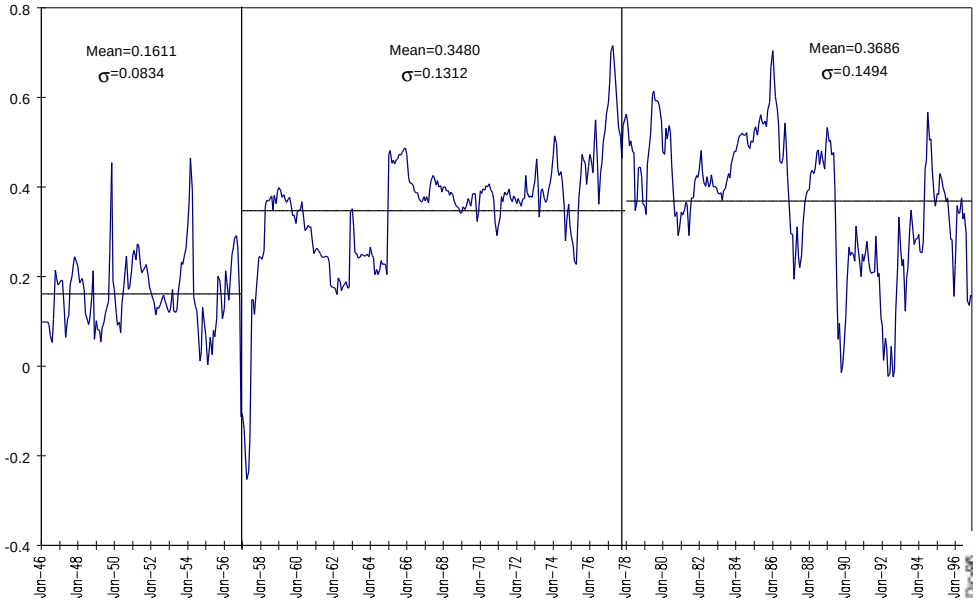
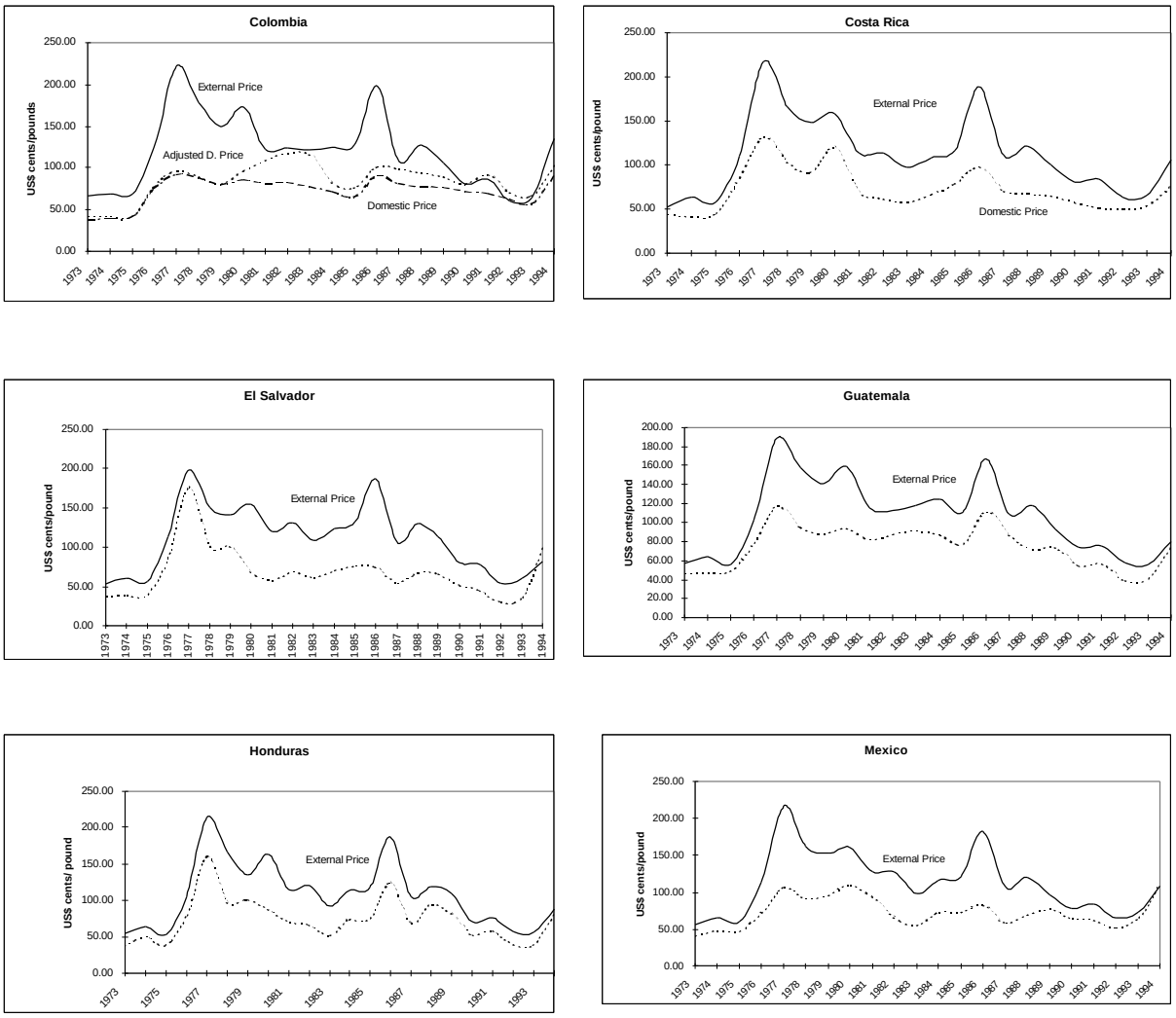


Figure 9
External and Internal Prices in Selected Coffee Producing Countries (Annual Average 1973-1994)



4.2 Econometric Results

To start, it is convenient to state the relationship between world and domestic prices as:

$$P_t^c = a_t \cdot P_t^{*c} \cdot E_t \qquad (20)$$

where P^c is the producers' price in nominal domestic currency, P^{*c} is the nominal world price expressed in dollars, E is the nominal exchange rate ($ per US$), and α is the share of world prices paid to domestic producers. One can think of α as one minus the *ad-valorem* export tax (the discussion generalizes to any form of taxation), which is equivalent to the appropriation of coffee export revenue by coffee producers.

Dividing equation (20) by the domestic country's CPI, and multiplying and dividing by the US CPI, we can write (after differentiating),

$$\hat{p}_t^c = \hat{p}_t^{*c} + \hat{e}_t + \hat{a}_t \qquad (21)$$

where a circumflex denotes percentage rate of change and lowercase letters denote real magnitudes. Therefore, it is possible to express the growth in domestic real coffee prices as the sum of the growth in world real coffee prices plus the rate of real depreciation of the domestic currency, plus the percentage change in the share received by producers. In other words, producers' stabilization can come through changes in the real exchange rate or changes in the share received by producers.

Based on equation (21) we measure the effect of changes in real world coffee prices and changes in the real exchange rate on changes in real domestic prices. In particular, we estimate the following equation,

$$\hat{p}_t^c = c + \sum_{i=0}^{n} a_i \hat{p}_{t-i}^{*c} + \sum_{i=0}^{n} g_i \hat{p}_{t-i}^{*c} d59-96 + b_1 \hat{e}_t + b_2 \hat{e}_t d67-96 + e_t \qquad (22)$$

where *n* is a lag in the response of domestic prices to changes in world prices, *d59-96* is a dummy variable that takes a value of 1 from 1959 to 1996 and *d67-96* takes a value of 1 between 1967 and 1996. These variables capture some of the institutional changes mentioned above. Since the end of 1958 the National Coffee Fund has deliberately pursued a stabilization objective. Therefore, we contend that producers' price stabilization has been more successful since 1959. This would imply that changes in domestic prices are less sensitive to changes in world prices since 1959. The dummy variable that is interacted with the real exchange rate regime captures the fact that before 1967, under a fixed rate system, an exchange rate differential was in place. Coffee exports were paid a lower (i.e. more appreciated) rate[20]. In 1967 exchange rates were unified. Clearly, endogeneity problems may arise if the real exchange rate depends on world and domestic coffee prices. However, according to the Hausman test, exogeneity is not rejected when first differences of the variables are used.

[20] According to Fedesarrollo (1978) an exchange rate differential was adopted during the devaluation of 1951, eliminated in 1955, readopted in 1958, and terminated in 1967.

Table 1

	DEPENDENT VARIABLE : % Changes in Domestic Prices t-statistic in parenthesis	
	Equation 1 1946:01-1996:12 (monthly data) LS	Equation 2 1941-1996 (annual data) LS
constant	0.0003	-0.0013
	(0.17)	(-0.09)
	-	0.5256
		(5.38) ***
	-	-0.0250
		(-0.23)
	0.4479	-
	(7.55) ***	
	-0.3494	-
	(3.22) ***	
	0.1903	-
	(3.25) ***	
	-0.0373	-
	(-0.58)	
	0.0481	-
	(1.98) **	
	0.1467	0.2923
	(3.44) ***	(1.60)
	0.3163	0.9061
	(1.88) *	(3.25) ***
AR(1)	0.1621	-
	(3.88) ***	
R^2	0.2561	0.7052
Durbin Watson	1.9839	2.3969
F-statistic	25.734	30.506
Observations	607	56

(*)significance level : 10%
(**) significance level: 5%
(***) significance level: 1%

Column 1 in Table 1 shows the estimation of equation (22) based on 607 monthly observations for the period 1946:06 to 1996:12. The regression uses a measure of the real exchange rate constructed with the higher nominal exchange rate applicable to imports. Interestingly, the results indicate that a 1% change in real world prices (that lasted more than three months) was associated between 1946 and 1958 with a 0.69% increase in real producers' prices. Since January 1959 the impact on domestic prices (of a similar increase in world prices) has fallen to 0.10%. In regard to the real exchange rate, the regression shows that a 1% real devaluation resulted in a 0.14% increase in domestic prices between 1946 and 1966.

Thus, the use of multiple exchange rates effectively isolated producers' prices from changes in the real (imports) exchange rate during that period. Between 1967 and 1991 the effect increased to 0.46%, so that changes in the real exchange rate had a major impact on producers' prices.

Column 2 in Table 1 presents the results of estimating a similar equation with yearly data for the period 1941-1996. In this regression the lagged dependent variables have been omitted. The estimation indicates that on average a 1% change in real world coffee prices has been reflected in 0.52% change in real domestic prices. The results do not confirm the presence of a significant change in the degree of stabilization after the reform to the National Coffee Fund in 1958.

4.3 Political Influence in Coffee Policy

The analysis of the previous section has identified the fundamental determinants of producers' prices in Colombia. In this section we explore other determinants, possible reflecting political interference in the choice of real domestic coffee prices. First, we test for the impact of the change in the composition of the Comité Nacional in 1978 when producers lost majority. As can be seen in Figure 8 average producers' taxation has been 2 percentage points higher since then. However, the degree of stabilization has remained intact. In fact, when a dummy variable after 1978 interacted with the change in world prices is added to the regressions of Table 1, the estimated coefficient is not statistically significant.

Second, we follow the *political business cycle* literature (e.g., Nordhaus (1975), Lindbeck (1975) and McRae (1977)) in order to argue that elections are preceded by expansionist policies aimed at stimulating the economy and followed by contractions intended to lower inflation. In our particular context, this would imply that real producers' prices are increased prior to elections, in order to boost economic activity. This could happen even in models with rational agents (see Rogoff and Sibert (1988), Rogoff (1987) and Cukierman-Meltzer (1986)). We also test the *partisan cycles* hypothesis, developed by Hibbs (1977, 1987)[21], to see whether liberal and conservative governments have different preferences

[21] Alesina (1988) and Alesina and Sachs (1988) provide models where agents are rational and politicians are ideologically motivated and have partisan objectives.

regarding producers' prices. We define governments as liberal or conservative according to the political affiliation of the President (Appendix 1 shows the list of Colombian Presidents and their political affiliation since 1934).

In order to test for political interference we added the following dummy variables to equation 22. In the case of the partisan cycles hypothesis we included the variable *dumcoli* which takes a value of 1 during liberal governments and –1 during conservative administrations (0 during the military regime between 1953 and 1957[22]). Alternatively, we also used *dumcons* and *dumlib* which take a value of 1 during conservative and liberal administrations, respectively (and 0 otherwise).

In testing for political business cycles we added the variable *dumelect* which takes a unitary value in the six months preceding the presidential elections and 0 otherwise. Also, the variable *dumnord* which takes a value of 1 in the first year of each government and 1 in the last year (0 otherwise) was tested. Finally, other political factors specific to Colombia were taken into account by introducing the variable *drojas* which takes a unitary value during the last six months before the fall in Rojas' military regime in 1957.

Table 2 shows the results when these political variables are added to the basic equation. Interestingly enough, the dummy variable that captures the last-minute populist policies of General Rojas-Pinilla is the only variable that comes out significant in the regressions. Indeed, real coffee prices were increased at a rate of 6.5% per month during his last semester in power. No other political variables seem to have affected the determination of producers' real coffee prices. Controlling for the fundamentals -world prices and the real exchange rate-, domestic prices have not responded to electoral or partisan considerations. Liberal and conservative governments are alike in this regard. In addition, coffee prices

[22] General Gustavo Rojas Pinilla ruled Colombia between June 1953 and May 1957, when a Junta Militar took charge before handing power back to civilians in 1958. Loosing political support, General Rojas tried to gain popularity by expanding the economy during his last months in government.

have not been used to influence elections. In fact, when we perform an F test that nests all the political hypotheses we can safely reject their joint significance[23].

TABLE 2

D E P E N D E N T V A R I A B L E : % Change in Real Domestic Prices t-statistic in parenthesis												
	Equation 1 1946:01-1996:12 LS		Equation 2 1946:01-1996:12 LS		Equation 3 1946:01-1996:12 LS		Equation 4 1946:01-1996:12 LS		Equation 5 1946:01-1996:12 LS		Equation 6 1946:01-1996:12 LS	
constant	-0.0005		-0.0002		0.0004		-0.0012		-0.00013		0.000251	
	(-0.29)		(-0.08)		(0.17)		(-0.59)		(-0.07)		(0.11)	
	0.4681		0.4675		0.4666		0.4692		0.4674		0.4690	
	(7.95)	***	(7.93)	***	(7.90)	***	(7.96)	***	(7.93)	***	(7.95)	***
	-0.3660		-0.3658		-0.3647		-0.3676		-0.3645		-0.3667	
	(-5.60)	***	(-5.59)	***	(-5.57)	***	(-5.62)	***	(-5.57)	***	(-5.60)	***
	0.2089		0.2083		0.2075		0.2098		0.2083		0.2099	
	(3.56)	***	(3.55)	***	(3.53)	***	(3.58)	***	(3.55)	***	(3.58)	***
	-0.0559		-0.0554		-0.0545		-0.0570		-0.0547		-0.0564	
	(-0.87)		(-0.87)		(-0.85)		(-0.89)		(-0.85)		(-0.88)	
	0.0506		0.0502		0.0518		0.0504		0.0509		0.0516	
	(2.11)	**	(2.09)	**	(2.09)	**	(2.10)	**	(2.12)	**	(21,419.00)	***
	0.1564		0.1553		0.1551		0.1561		0.1557		0.1565	
	(3.71)	***	(3.68)	***	(3.67)	***	(3.70)	***	(3.69)	***	(3.71)	***
	0.3247		0.3074		0.3145		0.3059		0.3202		0.3246	
	(1.97)	**	(3.97)	***	(1.90)	*	(1.83)	*	(1.95)	*	(1.97)	**
DRoj	0.0640		0.0636		0.0642		0.0647		0.0636		0.0638	
	(4.00)	***	(4.10)	***	(3.91)	***	(4.03)	***	(3.98)	***	(3.99)	***
AR(1)	0.1336		0.1343		0.1341		0.1343		0.1331		0.1331	
	(3.19)	***	(3.20)	***	(3.20)	***	(3.20)	**	(3.17)	***	(3.17)	***
dumcoli	-		-0.0014		-		-		-		-	
			(-0.65)									
dumlib	-		-		-0.0018		-		-		-	
					(-0.51)							
dumcons	-		-		-		0.0027		-		-	
							(0.67)					
dumelect	-		-		-		-		0.0046		-	
									(-0.74)			
dumnord	-		-		-		-		-		-0.0018	
											(-0.51)	
R^2	0.2750		0.2755		0.2753		0.2755		0.2756		0.275304	
Durbin Watson	1.9841		1.9844		1.9843		1.9844		1.9839		1.9838	
F-statistic	25.159		22.664		22.641		22.666		22.681		22.641	
Observations	607		607		607		607		607		607	
(*)significance level : 10%												
(**) significance level: 5%												
(***) significance level: 1%												

5 Empirical Evidence: Oil

This section illustrates the tendency for over-consumption of oil rents. The data correspond to the 1984-1996 period. The idea is to capture the problems that motivated the introduction of the Oil

[23] In line with the new versions of Partisan theories where agents are rational we also considered dummy variables which take a unitary variable only during the first two years of a liberal or conservative government. The assumption

Stabilization Fund (OSF) in 1995. Unfortunately, the effectiveness of the OSF can not be properly address with the information available.

Table 3 displays the average annual growth in oil net exports, which is equivalent to the revenues available for appropriation. These revenues correspond to the value of exports undertaken by the National Oil Company plus the difference between exports and remittances by private companies operating in Colombia (under the assumption that this difference is used to pay local costs including taxes). Oil rents correspond to the resources appropriated by the different levels of the government though a variety of taxation mechanisms which include the payment of royalties. As can been seen, during the first oil boom (1984-1990) the percentage growth in those rents was higher than for exports. In other words, the income elasticity of oil rents was 1.11, reflecting excessive appropriation of export revenues. This is observation is reinforced by the fact that when oil exports fell (1990-1994) the contraction in oil rents was lower. Recently, the revenues derived from increasing exports have been appropriated by the State Oil Company and have not been redirected to other groups in society. However, this form of appropriation also leads to excessive consumption.

Table 3
Appropriation of Oil Rents

Average Annual Growth:	1984-1990	1990-1994	1994-1996
Oil Net Exports*	120.9%	-91.5%	104.2%
Oil Rents	134.0%	-83.4%	45.6%
1.Taxes and Contributions	131.0%	-86.5%	6.2%
2.Royalties	143.1%	-55.7%	64.7%
-National Government	176.6%	-85.1%	-100.0%
-Departments	132.9%	-54.1%	63.4%
-Municipalities	136.0%	68.2%	85.1%
-Investment Funds and Corporations	146.2%	-71.4%	-16.4%
-National Royalties Fund	-	-	146.2%

* Corresponds to oil exports by Ecopetrol plus (exports - remittances) of foreign companies.

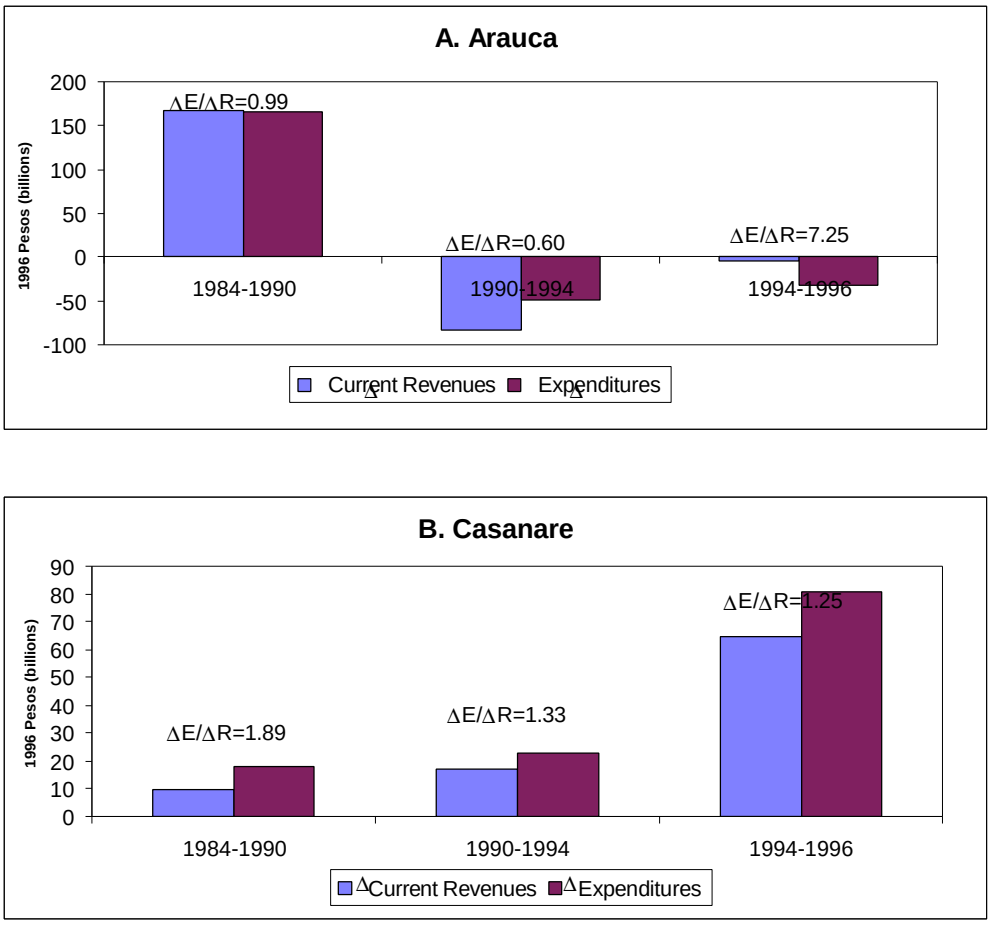
Income Elasticity of*:	1984-1990	1990-1994	1994-1996
Oil Rents	1.11	0.91	0.44
1.Taxes and Contributions	1.08	0.95	0.06
2.Royalties	1.18	0.61	0.62
-National Government	1.46	0.93	-0.96
-Departments	1.10	0.59	0.61
-Municipalities	1.12	-0.75	0.82
-Investment Funds and Corporations	1.21	0.78	-0.16
-National Royalties Fund	-	-	1.40

* Refers to the ratio of the growth rate in oil rents to the growth in oil net exports.

is that agents learn who is in charge an are less likely to be affected by the particular preferences of the government.

Lastly, Figure 10 displays the fiscal accounts of the two largest oil-producing departments in Colombia. The data compare the increase in current revenues, mainly derived from oil rents, with the increase in expenditures. Two points can be made. First, the marginal propensity to spend out of oil rents is higher than one in most episodes. Second, when oil revenues decrease in one single department, the reduction in expenditures is less than proportional. Later, this leads to fiscal adjustment. The final result is a large variability in government expenditures and private consumption. Whether the OSF will prevent this from happening in the future is uncertain. Preliminary evidence suggests that the saving rates established in the law are incapable of reproducing the optimal inter-temporal allocation of resources.

Figure 10
Fiscal Accounts in the two main Oil—producing Departments



The results (not reported) were also not significant.

6 Conclusions

This paper has analyzed the role that institutions play in ameliorating the dynamic commons problem in Colombia. The paper presents a model that rationalizes the existence of a federation of coffee producers that embodies the preferences of the representative producer. The Federation effectively reduces redistribution of coffee revenues to other sectors of society. However, greater involvement by the government in the Federation, has resulted in greater taxation of coffee revenues. For example, the stabilization of prices paid to producers has implied some appropriation of coffee export revenues by other sectors of society. Interestingly, domestic coffee prices have been unaffected by Colombian politics, so that in practice appropriation does not depend on electoral and partisan cycles. However, appropriation of coffee rents has been relatively low. In this sense, the two-player game (between the Federation and the government) has produced efficient outcomes, in part due to the large degree of flexibility.

The case of oil is substantially different. Here, rents are claimed by a large number of divided agents so over-consumption has been limited by imposing a forced saving mechanism. According to the model, this may be the only feasible solution to the dynamic commons problem when the fiscal structure is not unitary. The major cost of this solution, however, is the total loss of flexibility.

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Appendix 1: Political Variables

Table A.1: *Managing Directors of the Federation*

Director	Term	Political Affiliation
Alfredo Cortazar Toledo	Nov. 1927 - Jan. 1930	Liberal
Enrique De Narvaez	Jan. 1930 - Dec. 1930	Liberal
Mariano Ospina Pérez	Dec. 1930 - Jul. 1934	Conservative
Camilo Sáenz	Jul. 1934 - Jan. 1935	Liberal
Alejandro López	Nov. 1935 - Jul. 1937	Liberal
Manuel Mejía Jaramillo	Aug. 1937 - Feb. 1958	Liberal
Arturo Gómez Jaramillo	Feb. 1958 - Dec. 1982	Liberal
Jorge Cárdenas Gutiérrez	Jan. 1983 -	Conservative

Table A.2: *Colombia's Presidents 1900-1994*

President	Political Party	Presidential Term	"Economic" Term
José Manuel Marroquín	Conservative	1900-1904	1901-1904
Rafael Reyes	Conservative	1904-1909	1905-1908
Jorge Holguín	Conservative	1909-1909	1909
Ramón González Valencia	Conservative	1909-1910	1910
Carlos E. Restrepo	Conservative	1910-1914	1911-1914
José Vicente Concha	Conservative	1914-1918	1915-1918
Marco Fidel Suárez	Conservative	1918-1921	1919-1921
Jorge Holguín	Conservative	1921-1922	1921-1922
Pedro Nel Ospina	Conservative	1922-1926	1923-1926
Miguel Abadía Méndez	Conservative	1926-1930	1927-1930
Enrique Olaya Herrera	Liberal	1930-1934	1931-1934
Alfonso López Pumarejo	Liberal	1934-1938	1935-1938
Eduardo Santos	Liberal	1938-1942	1939-1942
Alfonso López Pumarejo	Liberal	1942-1946	1943-1946
Mariano Ospina Pérez	Conservative	1946-1950	1947-1950
Laureano Gómez	Conservative	1950-1952	1951-1952
Gustavo Rojas Pinilla	Military	1953-1957	1953-1956
Junta Militar	Military	1957-1958	1957-1958
Alberto Lleras Camargo*	Liberal	1958-1962	1959-1962
Guillermo León Valencia*	Conservative	1962-1966	1963-1966
Carlos Lleras Restrepo*	Liberal	1966-1970	1967-1970
Misael Pastrana Borrero*	Conservative	1970-1974	1971-1974
Alfonso López Michelsen	Liberal	1974-1978	1975-1978
Julio César Turbay Ayala	Liberal	1978-1982	1979-1982
Belisario Betancur Cuartas	Conservative	1982-1986	1983-1986
Virgilio Barco Vargas	Liberal	1986-1990	1987-1990
César Gaviria Trujillo	Liberal	1990-1994	1991-1994
Ernesto Samper Pizano	Liberal	1994-	1995-

* Presidents during the "Frente Nacional"

Appendix 2: Model Solution

At each point in time, each group chooses a consumption sequence $\{c_i(t)\}$ in order to maximize equation (2) subject to the accumulation equation (1), restrictions (3) through (5), and the strategies followed by the other *n-1* groups. One possible solution to this dynamic game among *n* groups is given the Markov perfect equilibrium (MPE), which restricts strategies to be just functions of payoff relevant state variables. In this solution concept strategies are not allowed to be history dependent.

A Markov strategy for group *i* is a consumption sequence $\{c_i(t)\}$ which is a function only of the payoff relevant state variable: *K(t)*. An *n*-tuple of Markov strategies $\{c_j^*(K(t))\}_{j=1}^n$ forms a MPE if it is a subgame perfect equilibrium for every realization of *K(t)*. That is, if

$$J\left(c_i^*(t), c_{-i}^*(t); K(t)\right) \geq J\left(c_i(t), c_{-i}^*(t); K(t)\right), \quad \forall i, t \tag{A1}$$

where $c_{-i}^* = (c_1, \ldots, c_{i-1}, c_{i+1}, \ldots, c_n)$ and *J(.,.)* is the value taken by the payoff function given by equation (2). Following Lane and Tornell (1996), finding a MPE for the game is identical to finding the solution to a set of *n* Hamiltonian problems (one for each group) of the form (in present value terms):

$$H_i = \frac{s}{s-1} c_i^{\frac{s-1}{s}} + l_i \left[a K - c_i - \sum_{j \neq i} c_j^*(K) \right] + \overline{m}_i \left[\overline{x} K - c_i \right] + \underline{m}_i \left[c_i - \underline{x} K \right] \tag{A2}$$

where c_i is the control variable, K is the state variable, and $\lambda_i e^{-\delta t}$ is the costate variable. In solving for group's *i* problem the consumption policies of the other *n-1* groups $c_j^*(K(t))$ are treated as functions of the state. In turn, these policies correspond to the solution of analogous problems. Therefore, the MPE corresponds to the set of *n* consumption sequences $\{c_j^*(K(t))\}_{j=1}^n$ that simultaneously solve *n* Hamiltonian problems like (A2). A solution is found by postulating that consumption policies are linear functions of the state,

$$c_j^*(t) = x_j K(t), \quad j = 1, \ldots, n \tag{A3}$$

where x_j's are undetermined coefficients. Substituting this guess in (A2) we then find the values of the *n* undetermined coefficients that simultaneously solve the *n* Hamiltonian problems. Thus, we find a set of *n*

strategies that are best responses to one another. As usual, the first order conditions that solve the maximization problem for group *i* are given by (* denotes an optimal value):

$$c_i(t)^* = \left[l_i(t) + \overline{m}_i(t) - \underline{m}_i(t) \right]^{-s} \tag{A4}$$

$$\dot{l}_i(t) = l_i(t)\left[d - a + \sum_{j \neq i} x_j^*(K) \right] \tag{A5}$$

$$\lim_{t \to \infty} K(t)\, l_i(t) e^{-dt^*} = 0 \tag{A6}$$

$$\overline{m}_i(t)\left[\overline{x}K(t) - c_i(t)^* \right] = 0, \quad \overline{m}_i(t) \geq 0 \tag{A7}$$

$$\underline{m}(t)\left[c_i(t)^* - \underline{x}K(t) \right], \qquad \underline{m}(t) \geq 0 \tag{A8}$$

There are three MPE associated with these first order conditions: an interior equilibrium and two extreme equilibria. We will concentrate in the former where appropriations are kept within the bounds defined by equation (5). Since in this equilibrium equation (5) is not binding it follows that $\underline{m}(t) = \overline{m}_j(t) = 0$ for all *i* and *t*. To find and equilibrium candidate we look for the *n* strategies $\{c_1(t), \ldots, c_n(t)\}$ that simultaneously solve the *n* set of equations given by (A4) and (A5). Later we will check that the transversality condition (A6) is indeed satisfied. To derive the unknown coefficients in (A3) note that (A3) and (A4) imply that the optimal consumption policy of each group *i* must satisfy

$$\frac{\dot{K}(t)}{K(t)} = \frac{\dot{c}_i^*(t)}{c_i^*(t)} = -s\, \frac{\dot{l}_i(t)}{l_i^*(t)}, \quad i = 1, \ldots, n \tag{A9}$$

Substituting equations (1) and (A5) in (A9) one gets that the undetermined coefficients must satisfy

$$x_i^* = a\left[1 - s\right] + ds - \sum_{j \neq i} x_i^*\left[1 - s\right], \quad i, j = 1, \ldots, n. \tag{A10}$$

which can be rewritten as equation (6) in the text.

It turns that as long as x_i^* is nonnegative the transversality condition is satisfied. However, not all parameter values result in $x^* = \dfrac{a\left[1 - s\right] + ds}{n - s\left[n - 1\right]} \geq 0$. If σ is restricted to the interval (0,1], as is plausible

for a country like Colombia, then x^* is nonnegative as long as $n > 1$, $\alpha > 0$, and $\delta > 0$ (as stated in equation (3)).

APPENDIX 3. National Coffee Fund (% of GDP)

	Savings	*Change in inventories*	*Superavit (Deficit)*
1968	*0.01*	*0.07*	*-0.07*
1969	*-0.06*	*-0.25*	*0.19*
1970	*0.45*	*0.02*	*0.43*
1971	*0.16*	*0.03*	*0.14*
1972	*0.45*	*-0.45*	*0.90*
1973	*0.13*	*0.34*	*-0.21*
1974	*-0.06*	*-0.71*	*0.65*
1975	*0.06*	*-0.35*	*0.41*
1976	*1.02*	*-0.38*	*1.40*
1977	*1.41*	*1.37*	*0.04*
1978	*-0.01*	*0.80*	*-0.81*
1979	*1.23*	*-0.57*	*1.81*
1980	*0.84*	*-0.22*	*1.07*
1981	*-0.37*	*0.76*	*-1.12*
1982	*0.06*	*0.65*	*-0.58*
1983	*0.20*	*0.52*	*-0.32*
1984	*0.75*	*0.49*	*0.26*
1985	*1.85*	*-0.17*	*2.02*
1986	*3.37*	*-0.56*	*3.94*
1987	*0.30*	*-0.91*	*1.21*
1988	*1.22*	*0.39*	*0.82*
1989	*0.61*	*-0.36*	*0.97*
1990	*0.16*	*-0.48*	*0.64*
1991	*0.26*	*0.24*	*0.02*
1992	*-0.85*	*0.23*	*-1.09*
1993	*-0.05*	*-0.12*	*0.07*
1994	*0.70*	*-0.51*	*1.21*
1995	*0.50*	*0.39*	*0.11*
1996	*0.06*	*-0.09*	*0.15*