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Theory and Applications

A model of rural conflict: violence and land reform policy in Brazil

LEE J. ALSTON
University of Illinois, NBER

GARY D. LIBECAP
University of Arizona, NBER

BERNARDO MUELLER
Universidade de Brasilia, SQN 215 Bloco C Apt. 609, Brasilia DF 70874–070, Brazil
Phone/Fax: 55 61 307–3204, E-mail: bmueller@guarany.cpd.unb.br

ABSTRACT. This paper analyzes the underlying determinants of rural land conflicts in Brazil involving squatters, landowners, the federal government, the courts and INCRA, the land reform agency. A model is presented whereby squatters and landowners strategically choose to engage in violence. Landowners use violence as a means of increasing the likelihood of successful eviction of squatters, and squatters use violence to increase the probability that the farm will be expropriated in their favor as part of the government's land reform program. The model's predictions are tested using state level data for Brazil for 22 states from 1988 through 1995. It is shown that the government's land reform policy, which is based on expropriation and settlement projects, paradoxically may be encouraging both sides to engage in more violence, rather than reducing conflicts.

1. Introduction: land reform and conflict in Brazil

In 1985 the Brazilian government implemented the PNRA (National Plan for Land Reform) in an attempt to redress extremely high levels of land ownership concentration. The main difference between this plan and the many previous failed attempts was that, for the first time, expropriation of private land was to be the main instrument by which land for settlers was to be obtained. Although the Land Statute of 1964 did include expropriations as a major part of the land reform it proposed, until 1985 the basic instrument of land reform policy had been the creation of colonization projects on government land, especially in the Amazon.

The PNRA encountered strong political opposition and was quickly decelerated by the government, with only a small fraction of the target

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expropriations and settlement projects having been implemented.[1] Nevertheless, the expropriations and settlement projects that did go through outlined a new model of land reform that the government would follow up to the present. Those with the most at stake in land reform, squatters and landowners, quickly recognized the pattern within this new policy and reacted to it.

Conceptually, under the new policy, the government's land reform agency, INCRA, was to expropriate private land that was not being put to beneficial use. Once expropriated, the agency was to create a settlement project and enroll families of landless peasants it had previously registered in a cadaster. Families were expected to wait until their time came to be assigned land. In practice, however, landless peasants realized that the pace of implementation was extremely slow and that individual groups could expedite the process in their favor by invading land which met INCRA's criteria as expropriable. These invasions often escalated into a conflict with the landowner, leading INCRA to expropriate the farm and to settle the squatters on it as a means to solve the problem.

During the late 1980s the process of invasion and expropriation evolved slowly and unsystematically, with separate groups invading farms throughout the country, sometimes being successful and sometimes not. During the 1990s, however, the invasions that did work provided a strong demonstration effect, and landless peasants became more organized. The largest and best-organized group was the MST (Landless Peasants Movement) which began in the south of Brazil in 1984 and has since spread throughout the country. The success of this group lay in understanding the formal, as well as the implicit, rules of the game, involving settlers, farmers, INCRA, the government, the courts and public opinion. With this understanding, MST developed a well-thought-out strategy for choosing a farm, invading it, and, most importantly, transforming the invasion into an expropriation by INCRA. In this paper, we use our interpretation of this implicit set of rules to model rural conflicts in Brazil.

Inconsistent property rights institutions regarding land tenure in Brazil underlie land conflicts.[2] The Constitution of 1988, following the example of all previous Constitutions since 1946, states that land must fulfill its 'social function' for title to remain secure. One condition is that land must be made productive according to some clearly specified criteria. If a farm does not fulfill its social function it may be expropriated by INCRA and given to families of landless squatters through a settlement project.

Constitutional rules regarding beneficial use as criteria for maintaining title are designed to address the severe problem of land ownership concentration in Brazil. Formally, the rules do not permit the invasion of private property by squatters since the expropriation is to be done only by INCRA. In practice, however, invasions have become institutionalized as an integral part of land reform. Although the government complains about invasions and threatens not to respond to them, every time it does expro-

[1] See Mueller (1994).

[2] For a more detailed account of the property right institutions for land in Brazil and their effect on rural violence, see: Alston, Libecap, and Mueller (forthcoming).

priate an invaded farm, it implicitly acknowledges that invasions are an avenue for peasants to obtain land.

In themselves, the Constitutional rules are not necessarily the cause of rural conflicts, since they simply give incentives for squatters to invade private farms. If the farmers believed that once they were invaded they would lose their claim to the land, then there would be no point in trying to evict the squatters. It is during evictions that most cases of violence occur. In practice farmers are able to go to the courts and request a warrant for the police to evict the squatters. If the farmer is truly the owner of the land he will almost always be granted such a warrant, even if their farm is completely idle. The courts are aware of the Constitutional requirement that land be used productively, however, they do not treat an invasion as initiating land reform. Rather the courts respond to an invasion in the same way they deal with the taking of any private property. They follow the Civil Code and treat property rights as an absolute concept. If the invasion raises issues of land reform, reason the courts, this is a separate problem for another agency. It is beyond their jurisdiction. Land reform, however, is the specific mandate of the federal agency, INCRA. Uncertainty as to whether or not INCRA will intervene on behalf of squatters provides the necessary condition for violence to occur.

The competing claims for land by peasants and the landowner are such that both can find legal justification for their actions. The Constitution informally legitimizes invasions by squatters, and the Civil Code justifies the resistance by farmers and their efforts for eviction. INCRA acts as advocate of the squatters, and the courts enforce the laws that allow the farmers to evict the squatters. Since there is no institution that determines which of the competing claims should prevail when they clash, the result is rural conflicts.

Table 1 shows the evolution of land conflicts in Brazil by major region from 1987 to 1996. It was during this period that the strategic use of invasion by squatters became established. The number of conflicts is highest in the northeastern and northern regions, however states in all of the regions had problems with rural violence. A similar time pattern of conflicts is followed in all of the regions. In the late 1980s there was a high level of conflicts, followed by a decrease in the first five years of the 1990s. Then, starting in 1994 and accelerating in 1995 and 1996, the number of conflicts increased once again. The fact that all states followed the same

Table 1. *Number of rural conflicts in Brazil 1987–1996, by region*

	1987	*1988*	*1989*	*1990*	*1991*	*1992*	*1993*	*1994*	*1995*	*1996*
Brazil	582	621	500	401	383	361	361	379	569	658
North	160	163	157	198	104	86	109	99	98	104
Northeast	197	199	166	174	157	142	125	157	198	244
Southeast	103	78	58	43	24	49	37	32	121	100
South	41	88	70	36	60	45	40	37	52	78
Mid-west	81	93	49	40	38	39	50	54	100	132

Source: Comissão Pastoral da Terra, *Conflitos no Campo*, Goiânia, yearly issues, 1987–1996.

time pattern indicates that some of the causes of rural conflicts may be nationwide.

In this paper we focus on the effect of government policy as a determinant of land conflicts in Brazil. Our analysis focuses on the land reform program, but includes also other types of government policy such as rural credit. In general terms, the impact of government land reform policy change is evident in the time trends shown in Table 1. During the late 1980s the effects of the PNRA (National Plan for Land Reform) of 1985 were still being felt. The main instrument was the expropriation of private farms. The practice of expropriating farms to settle peasants provided an incentive for squatters to invade those farms in order be settled first. In the period that followed, the new Constitution was passed establishing the rules for expropriations. Because necessary enabling legislation was not enacted until 1993, INCRA spent a period of several years where expropriations were difficult. This condition mitigated the main incentive for squatter invasion, and the number of conflicts fell accordingly. Then, in the mid 1990s, with INCRA once again able to perform expropriations, and with the government's renewed commitment towards land reform, the number of conflicts started to soar. These broad generalizations of the relationship between government policy and conflicts will be examined at the micro level in the sections that follow.

The purpose of this paper is to use a model of rural conflict to analyze the role and effect of the government's land reform policy on rural violence. A model is presented that outlines the incentives of the actors in rural violence. In the section that follows the model, the effect of changes in the government's policy variables will be analyzed using comparative statics and the reaction functions of the chief antagonists, squatters, and landowners. Section 4 presents an empirical test of the model using panel data at state level from 1988 to 1995. The use of data over time allows us to test the effect of changes in the government's commitment towards land reform on the level of violence. In the concluding section the results are used to assess the government's land reform policy and to suggest the links between this policy and several unintended consequences it generates.

2. A model of rural conflict

There is a set of rules within which land conflicts occur in Brazil. These rules involve both formal laws and informal institutions that determine the payoffs to squatters and farmers (as we call landowners) for each possible outcome. The participation of INCRA, the courts, and the federal government is an integral part of the conflicts. Squatters and farmers choose their actions in a strategic manner so as to maximize the net expected value they receive as a payoff. In this section a game theoretic model is presented based on the incentives provided by the institutional setting for squatters and farmers to provide effort towards obtaining the land. Effort by the squatters involves invading a farm, resisting eviction, and lobbying for INCRA to expropriate the land in their favor. Effort by the farmer involves choosing whether and how to evict the squatters. The level of effort by the squatters and farmer are seen as inputs and are denoted by s and v respect-

ively. The model in this section determines the optimal level of inputs for each side. Given that both sides are providing positive levels of these inputs, the outcome is a conflict. The occurrence of a conflict and its severity is not directly determined by the model but can be inferred from the amount of inputs.

The probability that INCRA will expropriate a farm is given by

$$\theta(s, P, G) \quad \text{with } \theta_s \geq 0, \theta_{ss} < 0 \tag{1}$$

where P is the level of tenure security of the farmer's claim and G is the political will of the government towards land reform. INCRA responds to effort from the squatter, s. The weaker the farmer's claim and the higher the government's commitment towards solving the problem the higher will be the probability that INCRA will expropriate the farm.

The model is at the level of an individual conflict, since P refers to the tenure situation of a specific farm. The variable G, on the other hand, is a nationwide variable since it reflects the level of importance given by the government to the issue of land reform and rural conflicts. As with any other issue the government only dedicates attention and resources to land reform when its political calculus deems this to be worthwhile. The level of G in Brazil has varied greatly during past decades.[3] During the 1990s the issue of land reform has acquired renewed political importance, and G has risen accordingly. G is affected by each conflict that occurs in the country since the government is held responsible by public opinion for not bringing peace to the countryside. We assume, however, that the squatters and the farmer in an individual conflict do not view G as being affected by the amount of violence they provide. That is, although G may, in fact, be affected by s and v, we treat it as being exogenous.[4]

After a farm has been invaded, the farmer typically tries to evict the squatters. The farmer may try to negotiate with the squatters to leave the farm by showing his title and by offering to pay for the improvements they may have made to the land. More often, however, the farmer will try to evict the squatters. This can be done through threats and physical action by the farmer, by hiring gunmen, by obtaining a court order, or, more probably, by simultaneous use of all three methods.

The court order, known as a 'reintegration of possession', is requested by the farmer and issued by a local judge, and it directs the police to remove the invaders. In general, judges view a 'reintegration of possession' as necessary to protect private property. Given a high probability of conflict and the social and political nature of the issue, judges may be reluctant to issue the order in some circumstances. Accordingly, we make the probability that a farmer's eviction will be successful a function not only of the level of violence offered by the farmer, but also of the position of the local courts towards land reform

$$\beta\,(v,K) \text{ with } \beta_v \geq 0, \beta_{vv} < 0, \tag{2}$$

[3] See Alston, Libecap, and Mueller (forthcoming).

[4] This is similar to assuming that in a model of perfect competition a firm takes prices as given.

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Table 2. *Farmer's and squatters' valuation of the land*

Outcome	*Squatters' valuation of land*	*Farmer's valuation of land*
I Squatters evicted	0	L
II No eviction – no expropriation	πL	δL
III Land expropriated	L	γL

where a higher K indicates that the local courts are more favorable to the squatters and thus have a lower propensity to order an eviction by the police.

The objective of both the farmer and the squatters in a conflict is ownership of the land. Each side will supply effort so as to maximize the expected value of the land that they will receive. Table 2 presents the value of the land to each party under each possible outcome of the conflict. In order to simplify, it is assumed that both the squatters and the farmer value owning the land at L.

If squatters are evicted, the farmer keeps the land, and they get nothing. Another outcome is neither a successful eviction, nor expropriation. In this case, the squatters remain on the land, but the farmer continues his claim. Eventually this situation will have to be resolved, but it may remain for a long time. The value of the land to the squatters in this case is πL and to the farmer it is δL, where $0 < \pi < 1$ and $0 < \delta < 1$. If INCRA does expropriate the farm, it is given to the squatters and the farmer is compensated. Although the farmer is compensated at a 'fair' price according to the Constitution, the payment is done with Titles of the Agrarian Debt redeemable in five to twenty years depending on the size of the farm. As a consequence, expropriation typically provides the farmer with lower value than ownership.[5] Therefore, it is assumed that $\gamma < \delta < 1$.

The squatters' problem is to choose the amount of effort s to supply so as to maximize their expected payoff minus the costs of doing so. Similarly, the farmer's problem is to choose v in order to maximize his expected payoff minus the costs. It is assumed that all players know the probability functions and the other party's valuation of the land. Additionally it is assumed that the objective functions are twice continuously differentiable in s and v, and strictly concave in their own violence. Given these assumptions the second-order conditions for maximization are satisfied and the first-order conditions are sufficient for a Nash Equilibrium:

Squatters' Problem:

$$\underset{s}{Max}\ (1 - \beta\,(v, K))\,[(1 - \theta\,(s, P, G))\,\pi L + \theta(s, P, G)\,L] - C^{s}(s) \qquad (3)$$

[5] There have been cases where landowners bribed INCRA officials to establish compensation above the market price of the land. Although such cases are highlighted by the media they are the exceptions.

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Farmer's Problem:

$$\underset{v}{Max} \quad \beta(v, K)\, L + (1 - \beta(v, K))[(1 - \theta\,(s, P, G))\, \delta L + \theta\,(s, P, G)\, \gamma L] - C^F(v) \tag{4}$$

Functions (3) and (4) are simply a linear combination of the payoffs for each possible outcome, weighted by the probability of that outcome, minus the costs, where $C^S(s)$ and $C^F(v)$ are the cost of supplying s and v units of effort respectively.

The first-order conditions for maximization are[6]

$$(1 - \beta)\, \theta_s(1 - \pi)L = C_s^S \tag{5}$$

$$\beta_v[\theta L(\delta - \gamma) + L(1 - \delta)] = C_v^F \tag{6}$$

The left-hand side in (5) is the expected marginal benefit for the squatter of supplying an additional unit of s. Doing so increases the probability that INCRA will expropriate the farm in their favor, which moves the squatters from outcome II to outcome III in Table 2, weighted by $(1 - \beta)$ the probability that the squatters are not evicted. At the optimum this marginal benefit must equal the cost of the marginal unit of s.

Analogously the left-hand side in (6) is the expected marginal benefit to the farmer of an additional unit of effort. By adding an additional unit of v the farmer increases the probability of eviction by β_v. This moves the farmer from outcome II to outcome I, thus avoiding a loss of $(1 - \delta)L$, and, were it the case that an expropriation would occur if the eviction were not successful, moves the farmer from outcome III to outcome II, thus avoiding a further loss of $(\delta - \gamma)L$. The right-hand side in (6) is the marginal cost of the farmer's effort.

Given that each side is acting strategically, understands the rules of the game, and possesses all the information regarding the probability functions and valuations, it is reasonable to expect that they will end up in a Nash Equilibrium which is the joint solution to the optimization problem. In such an equilibrium the farmers choose v^* and the squatters choose s^* such that equations (5) and (6) hold simultaneously. For any given level of P, G, and K the probability of expropriation is $\theta(s^*, P, G)$ and the probability of an eviction is $\beta(v^*, K)$.

To visualize the interaction between the farmer and the squatters it is useful to derive the reaction curves for each party. Let λ^s be the objective function of the squatters and λ^F that of the farmers. That is[7]

$$\lambda^S(s, v) = (1 - \beta(v))[(1 - \theta(s))\pi L + \theta L] - C^S(s) \tag{7}$$

and

$$\lambda^F(s, v) = \beta(v)L + (1 - \beta(v))[(1 - \theta(s))\delta L + \theta(s)\gamma L]] - C^F(v) \tag{8}$$

[6] The arguments of the probability functions will be omitted in the first-order conditions. Derivatives are denoted by a subscript, e.g.

$$\frac{\partial \beta(v,K)}{\partial v} \equiv \beta_v.$$

[7] To simplify notation only s and v are included as arguments.

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Let

$$\lambda^S_s(s, v) = \frac{\partial \lambda^S(s, v)}{\partial s} \tag{9}$$

and

$$\lambda^F_v(s, v) = \frac{\partial \lambda^F(s, v)}{\partial v} \tag{10}$$

To find the slopes of the reaction curves define $R^S(v)$ to be the best action that the squatters can take given that the farmer chooses v, and $R^F(s)$ to be the best action that the farmer can take given that the squatters choose s. The first-order condition for the squatter is therefore $\lambda^S_s(R^S(v),v) = 0$ and for the farmer $\lambda^F_v(s, R^F(s)) = 0$. In a Nash Equilibrium the squatters will be playing $s^* = R^S(v^*)$ and the farmer will be playing $v^* = R^F(s^*)$.

The slope of each reaction curve can be obtained by differentiating $\lambda^S_s = 0$ with respect to v and $\lambda^F_v = 0$ with respect to s. For λ^S_s this yields

$$\lambda^S_{sv} + \lambda^S_{ss} \frac{\partial R^S}{\partial v} = 0$$

and for λ^F_v it yields

$$\lambda^F_{vs} + \lambda^F_{vv} \frac{\partial R^F}{\delta s} = 0$$

Rearranging, expressions for the slopes of the reaction curves are obtained

$$\frac{\partial R^S}{\partial v} = -\frac{\lambda^S_{sv}}{\lambda^S_{ss}} \tag{11}$$

and

$$\frac{\partial R^F}{\partial s} = -\frac{\lambda^F_{vs}}{\lambda^F_{vv}} \tag{12}$$

Because the denominator of these expressions is negative, from the second-order condition for maximization, the sign of the reaction curves depends on the signs of λ^S_{sv} and λ^F_{vs}, which are

$$\lambda^S_{sv} = -\beta_v \theta_s (1 - \pi) L \leq 0 \tag{13}$$

$$\lambda^F_{vs} = \beta_v \theta_s (\delta - \gamma) L \geq 0 \tag{14}$$

Therefore the squatters' reaction curve is negatively sloped and that of the farmer is positively sloped. This means that violence is a strategic substitute for the squatters, but a strategic complement for the farmer.[8] That is, the squatters react to more effort from the farmer by offering less effort, and the farmer reacts to more effort from the squatters by offering less.[9]

Figure 1 shows the reaction curves for the squatters and the farmer.[10] At

[8] This classification comes originally from Bulow, Geanakopoles, and Klemperer (1985). See also Tirole (1992).

[9] Note that the reaction curves are only an expositional device since in fact it is a one-shot game and both parties move simultaneously.

[10] The curves have been drawn with slopes that guarantee that the process converges to the equilibrium allocation from the initial position. The condition for this is $\lambda^S_{ss}\,\lambda^F_{vv} > \lambda^S_{sv}\,\lambda^F_{vs}$.

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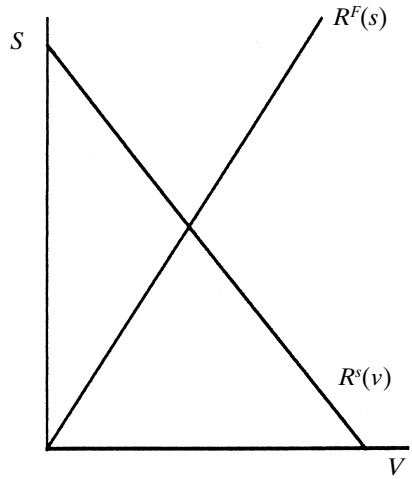

Figure 1. *Farmer and squatters' reaction curves*

the intersection of both curves each side is taking the best response to what the other side is doing, so neither wants to change their action and the point is a Nash Equilibrium.[11]

3. The effect of policy variables on rural conflicts

The model presented in the previous section can be used to examine the effect of government policy on rural violence. Government policy can affect several of the variables in the model: changes in the budget for land reform and changes in personal commitment by the President affect *G*; changes in agricultural policy and availability of credit affect *L*, the price of the land; changes in the rules for land reform and enforcement of property rights can affect *P*; and changes in the courts' attitude towards land reform and conflicts can affect *K*. In this section comparative statics are used to analyze the effects of such changes on rural violence and to show that many of the policies may lead to more rural violence. Some policies are not directly related to land reform, and the incentive they provide for more violence is simply an unforeseen side effect. Other policies, however, are directly aimed at *reducing* violence and promoting land reform. Our analysis suggests that they are having an effect opposite to that intended. In the next section we test these predictions empirically.

To simplify the derivation of testable hypotheses, a few assumptions are made.[12] We assume that $\pi = 0$, $\delta = 1$, and $\gamma = 0$; that is, the squatters'

[11] The model presented in this section is a static one, and land conflicts are obviously dynamic processes. Static assumptions, however, allow us to characterize the relationships between key variables and to derive testable hypotheses.

[12] The possible consequences of these simplifications will be discussed below.

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valuation of the land, if there is neither eviction nor expropriation, is zero and the farmer values the land at its full value, L; additionally, there is no compensation to the farmer if the land is expropriated. These simplifications allow us to focus on the effects of changes in squatter and farmer effort, s and v, on the probabilities of expropriation and eviction. With these simplifications equations (5) and (6), the squatter's and farmer's first-order conditions, respectively become

$$(1-\beta(v, K))\,\theta_s(s, P, G)L - C^S{}_s(s) = 0 \tag{15}$$

$$\beta_v(v, K)\,\theta(s, P, G)L - C^F{}_v(v) = 0 \tag{16}$$

In a Nash Equilibrium equations (15) and (16) hold simultaneously, allowing us to differentiate both equations with respect to an exogenous variable and to solve the resulting system to determine the impact on squatter and farmer violence. Accordingly, we analyze the impact of (a) changes in the government's stand on land reform, G; (b) changes in the level of property rights security, P; (c) changes in land value, L; and (d) changes in the position of the courts, K.

Differentiating equations (15) and (16) with respect to G and rearranging, yields a set of simultaneous equations that we solve to obtain the following expressions for the effect of a change in G on the amount of violence offered by the squatters and by the farmer[13]

$$\begin{bmatrix} (1-\beta)\,\theta_{ss}L - C^s_{ss} & -\beta_v\theta_s L \\ \beta_v\theta_s L & \beta_{vv}\theta L - C^F_{vv} \end{bmatrix} \begin{bmatrix} \dfrac{\partial s}{\partial G} \\ \dfrac{\partial v}{\partial G} \end{bmatrix} = \begin{bmatrix} -(1-\beta)\theta_{sG}L \\ -\beta_v\theta_G L \end{bmatrix} \quad (17) \text{ and } (18)$$

To interpret the comparative static results it is necessary to determine the signs of each term in the above equations. It will be assumed that β_{vv} and θ_{ss}, the second derivatives of the probability functions, are all negative. This assumption seems reasonable because probabilities are bounded between zero and one, so that as effort increases the functions would tend asymptotically to one. Additionally the second derivatives of the cost functions, $C^S{}_{ss}$ and $C^F{}_{vv}$, are reasonably assumed to be positive. The term $|\det|$ is the determinant of the first matrix above. Given that β_{vv} and θ_{ss} are assumed negative and that the terms on the main diagonal are negative due to the second-order condition, $|\det|$ is positive.

Solving (17) and (18) the following expressions are obtained

$$\frac{\delta v}{\delta G} = \frac{[(1-\beta)\,\theta_{ss}L - C^s_{ss}][-\beta_v\theta_G L] - [\beta_v\theta_s L][-(1-\beta)\theta_{sG}L]}{|det|} \tag{19}$$

$$\frac{\delta s}{\delta G} = \frac{[-(1-\beta)\theta_{sG}L][\beta_{vv}\theta L - C^F_{vv}] - [-\beta_v\theta_G L][-\beta_v\theta_s L]}{|det|} \tag{20}$$

$\theta_G > 0$ and $\theta_{sG} > 0$, that is, an increase in the level of government political will towards land reform increases the probability of INCRA

[13] From here on we drop the arguments of β and θ to simplify the presentation.

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intervening in the conflict to expropriate the farm. The term θ_G is the direct effect of the change in the government's position on INCRA's probability of expropriating, and the term θ_{sG} is the indirect effect of INCRA becoming more sensitive to squatter effort in a particular case. The assumption that $\theta_{sG} > 0$ is important for our results and is justified by recalling that government policy toward land reform, G, is national in scope. It may be manifested in higher budgets for INCRA and in more legislation promoting land redistribution. There is a problem of allocation, however. Squatters at any location must attract INCRA's attention, and they compete with squatters elsewhere because INCRA has limited budgets. Squatter effort at a specific site, s, attracts the national media and embarrasses federal politicians. There is a strong national constituency for land redistribution, and politicians are concerned about its reaction. INCRA, in turn, is pressured by those politicians to stop the violence by intervening on behalf of the squatters. Hence, squatter effort can increase the likelihood of expropriation of a particular farm as government will towards land reform increases. Put differently, the marginal impact of squatter effort on the probability of a specific farm being expropriated increases with government action, $\theta_{sG} > 0$. Given these considerations $\frac{\partial v}{\partial G}$ can be shown to be unambiguously non-negative. To understand the logic behind this result it is necessary to look at the farmer's first-order condition (16). The term $\beta_v \theta L$ is the marginal benefit to the farmer from an additional unit of v. That is, by increasing v the probability of an eviction is increased by β_v and thus the potential loss θL, which would result from an expropriation, will occur with a smaller probability. If G increases then θ will be larger and the potential loss will increase. This means that an eviction by the farmer would be avoiding a larger loss and the marginal benefit from v increases. The farmer will thus supply more effort.

The sign of $\frac{\partial s}{\partial G}$ does not have an unambiguous sign. It depends on two effects that can be seen in the squatter's first-order condition (15). The term $(1 - \beta)\ \theta_s L$ is the marginal benefit to the squatter of offering an additional unit of effort. Because the farmer will offer more effort given an increase in G, the term $(1 - \beta)$ will be smaller, implying a smaller marginal benefit, which leads the squatters to choose a lower level of s. On the other hand, the term θ_s will be larger due to the increase in G, since $-\theta_{sG}$ is positive. This increases the marginal benefit and the squatters will prefer to offer more effort. The sign of $\frac{\partial s}{\partial G}$ will therefore depend on which of these effects predominates.

The discussion above can be generalized by noting that the change in an exogenous variable has two effects on the equilibrium levels of s and v. There is a direct effect, which affects both s and v in the same direction, and there is a strategic effect, which moves in the same direction as the direct effect for the farmer and in the opposite direction for the squatters. We

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assume that the strategic effect of the squatters is relatively small, which implies that the squatters' choice of s is not very sensitive to the farmer's choice of v. This assumption is based on the observation that the success of the squatters' strategy relies on them being able to invade a farm and resist the farmer's eviction attempts until INCRA is attracted. That is, they expect and count on the farmer's reaction as a means to further their cause. Therefore, by strategic design the squatters are purposefully little sensitive to the farmer's reaction. Given that the squatter's strategic effect is sufficiently small, the response from both squatters and farmer to a change in an exogenous variable will always be in the same direction, thus allowing us to make clear predictions. In the case of an increase in G, for example, both s and v will increase so that the total level of violence will be higher.[14]

Figure 2 shows the effect on the farmer's reaction curve of an increase in G. The comparative statics indicate that this change should lead to an increase in the amount of v. In the graph this is represented by a downward shift in the farmer's reaction curve as G goes from G_0 to G_1. For a given value of s the farmer now prefers to offer more effort, $v_1 > v_0$. The increase in G also leads to an increase in s along the farmer's reaction curve to s_2, which also leads to a higher v. This is the strategic effect of the increase in G on v through the increase on s.

The change in G also affects the squatter's reaction curve. The direct effect of an increase in G is to make an expropriation more probable, which leads the squatters to offer more effort. In Figure 3 this is depicted as a upward shift of the squatters' reaction curve, so that for any given value of v, the squatters will offer a larger amount of effort, $s_1 > s_0$. The strategic effect comes from the higher amount of v that occurs due to the increase in G. In the graph this strategic effect is represented by a movement along the

[14] The assumption that the squatter's strategic effect is sufficiently small for the effect of G on s to be positive allows us to discuss the implications of the simplification that $\gamma = 0$ (that is, that the farmer is not compensated in case of an expropriation). Note that without this simplification the numerator of equation (20), which determines the sign of $\frac{\partial s}{\partial G}$, becomes $[-(1 - \beta)\theta_{sG}L][\beta_{vv}\theta L(1 - \gamma) - C^F_{vv}] - [-\beta_v\theta_G L(1 - \gamma)][-\beta_v\theta_s L]$. If $\gamma = 1$ then $\frac{\partial s}{\partial G}$ will always be positive because the second product in this numerator will equal zero. Also it would be the case that $\frac{\partial v}{\partial G} = 0$. That is, when the compensation covers the total value of the land the farmer is indifferent between being expropriated or not so he/she sets $v = 0$ and there is no strategic effect on the squatters. For any value of γ less than 1 the farmers will choose $v > 0$. The lower the compensation the stronger will be the incentive for the farmer to provide violence and thus the stronger the strategic effect on the squatters. Thus by assuming that $\gamma = 0$ we are using the case where the strategic effect would be strongest. Using any value of γ greater than zero would only strengthen the case that G affects s positively. In other words, as long as the assumption that the squatter's strategic effect is relatively small holds, the simplification that $\gamma = 0$ does not affect the comparative static results.

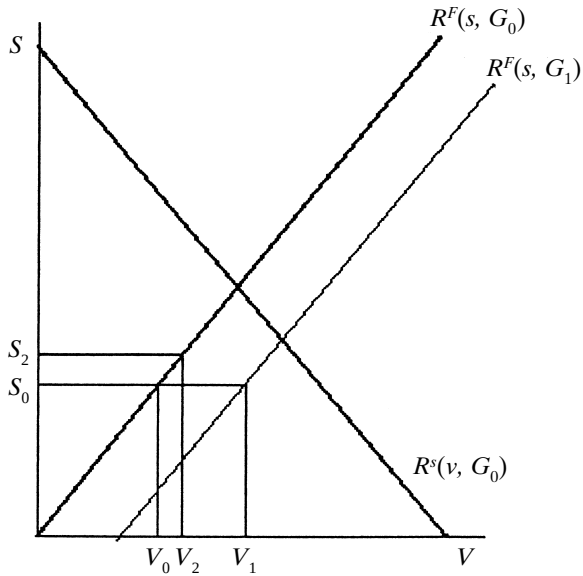

Figure 2. *Effect of a change in* G *on the farmers' reaction curve.*

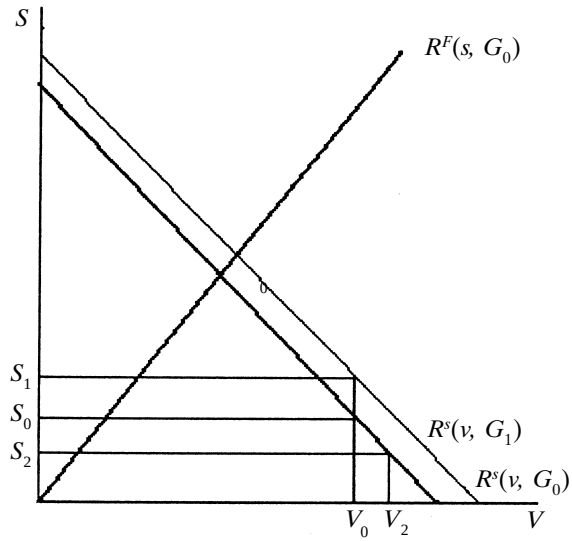

Figure 3. *Effect of a change in* G *on the squatters' reaction curve.*

squatter's reaction curve from v_0 to v_2, leading to a lower s, $s_2 < s_0$. Given our assumption that the strategic effect is relatively small, or equivalently that the squatters' reaction curve is relatively flat, the total effect will be an increase in s. With both s and v increasing due to an increase in G, the prediction that emerges is an increase in violent conflicts.

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The effect of a change of P, the level of tenure security, is analogous to that of a change in G, since G and P enter the farmer and squatters' objective functions in the same way—as an exogenous variable affecting the probability of expropriation.[15] The only difference is that while an increase in G increases the probability of expropriation, an increase in P has the opposite effect. Therefore, the effect of a change in P on the amount of effort supplied by the farmer is unambiguously negative. The effect on the squatters is to decrease s through the direct effect of making INCRA less sensitive to their cause, but to increase s through the strategic effect that comes from the smaller amount of effort from the farmer. Assuming that this latter effect is sufficiently small, the increase in P is predicted to reduce the occurrence of violent conflicts.

In order to determine the effect of an increase in the price of land on the amount of violence, equations (15) and (16) are differentiated with respect to L and the following expressions are obtained

$$\frac{\partial v}{\partial L} = \frac{[(1-\beta)\theta_{ss}L - C^{s}_{ss}][-\beta_{v}\theta] - [\beta_{v}\theta_{s}L][-(1-\beta)\theta_{s}]}{|\det|} \tag{21}$$

$$\frac{\partial s}{\partial L} = \frac{[-(1-\beta)\theta_{s}][\beta_{vv}\theta L - C^{F}_{vv}] - [-\beta_{v}\theta][-\beta_{v}\theta_{s}L]}{|\det|} \tag{22}$$

In equation (21) the first term in brackets is negative; from the second-order condition, the second term in brackets is also negative; the third term is positive; and the fourth term is negative. Thus an increase in the value of land unambiguously leads to an increase in the amount of effort offered by the farmer. This is easily seen in the farmer's first-order condition (16), since an increase in L increases the benefit of offering an additional unit of v.

The sign of (22), as in the previous case, depends on two different effects. The increase in L increases the marginal benefit in the squatter's first-order condition, $(1-\beta)\,\theta_{s}L$, leading the squatters to offer more effort. The increase in land value, however, also leads to a higher value of v and thus a lower value for $(1-\beta)$, which decreases the marginal benefit and prompts a lower value of s. If the positive direct effect of the increase in land value is stronger than the negative effect of a more aggressive farmer, then the increase in land value will lead to a higher choice of effort by the squatters.[16]

The final comparative static result examined is the effect of a change of the position of the courts K on the levels of s and v. These effects can be obtained following the same procedure as above

$$\frac{\partial s}{\partial K} = \frac{[\beta_{K}\theta_{s}L][\beta_{vv}\theta L - C^{F}_{vv}] - [-\beta_{vK}\theta L][-\beta_{v}\theta_{s}L]}{|\det|} \tag{27}$$

[15] To save space the comparative statics for a change in P will be discussed and not shown explicitly.

[16] The effects the change in L and other variables examined below have an analogous effect on the reaction curves to that caused by a change in G. These effects will not be shown graphically here.

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Table 3. *Comparative static results*

Exogenous variable	*Effect on v*		*Effect on s*	
	direct	*strategic*	*direct*	*strategic*
Gov.'s position; G	+	+	+	−
Property rights; P	−	−	−	+
Land value; L	+	+	+	−
Court's position; K	−	+	+	+

$$\frac{\partial v}{\partial K} = \frac{[(1-\beta)\theta_{ss}L - C^{s}_{ss}][-\beta_{vK}\theta L] - [\beta_{v}\theta_{s}L][\beta_{K}\theta_{s}L]}{\det|} \tag{28}$$

The expression in equation (27) is non-negative, which shows that as the courts become more favorable to the squatters they will offer more effort. This happens because $\beta_K \leq 0$, so the increase in K increases the squatters marginal benefit in their first-order condition (15), by making it less likely that they will get evicted by the farmer. The effect of the change by the courts on the farmer's supply of violence is ambiguous. The change in K and the change in s affect the sign of expression (28) in different directions. As can be seen in the farmer's first-order condition (16), an increase in K decreases the farmer's marginal benefit, since $\beta_{vK} \leq 0$, but the accompanying increase in s increases the marginal benefit though θ. The final sign of $\frac{\partial v}{\partial K}$ will depend on which effect predominates.

It is interesting, therefore, that, according to the model, a change that makes the courts more responsive to land reform and squatter's rights, will not only increase the amount of effort from the squatters, but may also lead to more effort from the farmers, leading to an overall increase in violent conflicts. This result is opposite to that intended by the policy change. Table 3 summarizes the comparative static results.

4. Empirical tests of the effect of policy on rural conflicts

The model of rural conflicts presented in the Section 2 and the analysis of the effects of changes in the policy variables in Section 3 provide implications that can be tested in order to determine if the model is a reasonable representation of rural conflicts in Brazil. We present first a panel data regression to explain conflicts as a function of G, P, and L, and then a causality test between rural violence and the governments will towards land reform will be performed in order to test some of the implications derived above.

The model in Section 2 suggests a two equation simultaneous system with squatter effort, s, and farmer effort, v, as endogenous variables. This structural model would be as follows

$$\begin{aligned} s &= f(v,G,P,K,L,X) \\ v &= h(s,G,P,K,L,Y) \end{aligned} \tag{29}$$

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where X is a vector of variables that affect s and not v, thus identifying the second equation, and Y is a vector of variables that affect v and not s, identifying the first equation. Once a stochastic error is added to each of the equations the system could be estimated by the usual econometric techniques for estimating simultaneous systems. This estimation would then allow us to test several hypotheses suggested by the model. Firstly the coefficients of an exogenous variable, say G, in each equation, would provide an estimate for the direct effect of that variable on squatter and farmer effort towards obtaining the land. Additionally the coefficient of v in the first equation and the coefficient of s in the second equation could be used to test the sign of the strategic effects of a change in an exogenous variable against the predictions of the model.

Unfortunately the data available on rural violence are not sufficiently detailed to estimate the system in (29). Ideally we would need data at the level of individual conflicts in a form that would allow us to separate the violence supplied by squatters from that supplied by farmers. Instead, we have more limited data. The solution, therefore, is to estimate a reduced-form equation derived from the structural system, that is, the combined violence of squatters and farmers as a function of G, L, K, P, X, and Y. Using the variables we have available, this equation would be as follows

$$Conflict_{it} = \beta_0 + \beta_1 Settlements_{it-1} + \beta_2 Budget_{t-1} + \beta_3 Price_{it} + \beta_4 Latifundia_i + \beta_5 Farms_i + \epsilon_{it} \quad (30)$$

The panel data include 22 states and the years from 1988 to 1995.[17,18] Timewise these data are particularly well suited to test the model because they involve the late 1980s and the 1990s, the period when the strategic use of violence by squatters became established. The variable *Conflicts* is the total number of conflicts in state i at year t, and it represents the combined effect of s and v. The *Settlement* variable is the number of settlement projects in state i at year $t - 1$. The data on settlement projects is from INCRA and therefore includes all the settlements that INCRA claims as part of its land reform effort. The settlement projects involve mostly farms that have been expropriated or purchased by INCRA and distributed to groups of landless peasants. This variable was lagged one year to avoid problems of

[17] These were the years and states for which all variables were available.

[18] The *Price* data are from Fundação Getúlio Vargas—Centro de Estudos Agrários. The land prices and credit data are values per hectare, are in logs and have been set at December 1993 cruzeiros using the IGP index of FGV. The conflict data are from the CPT—Pastoral Land Commission—Goiânia, yearly reports. The CPT is a NGO associated to the Catholic Church, which monitors the evolution of rural conflicts in Brazil and is the best source for these data. They maintain a file on every rural conflict in the country and publish yearly reports to divulge that information. The settlement data were obtained through personal correspondence with INCRA in Brasil. The *Latifundia* variable is from INCRA, 1992, Indicadores Básicos, Brasil, and is in units of 100,000 hectares. Credit data are from BACEN, Anuário de Crédito Rural, various years. The Incra budget data are from IBDA, Land Reform and Poverty Alleviation Pilot Project, 1997, p.16 and is in millions of US$. The number of farms data are from the 1985 agricultural census by FIBGE and is in units of 1,000 farms.

simultaneity (which will be shown to exist below in the causality tests). Because a settlement project signals to other groups of squatters that INCRA may respond to their demands if they are able to pressure it sufficiently, it is reasonable to assume that the effect of settlements in one year may carry over to the next year. The number of settlements acts as a proxy for the government's effort towards land reform, variable *G*, and it is expected that this variable will have a positive effect on conflicts if the squatters' strategic effect is relatively small.

The variable *Budget* is also a measure of the government's efforts towards land reform. The more politically concerned the government becomes about land reform and rural violence the more resources are allocated for INCRA. The data are for the country as a whole since they are not available at the state level.[19] This variable is also lagged one period to avoid simultaneity issues.

The *Price* variable measures the price of a hectare of land in each state *i* for every year *t*. There are some problems, however, in estimating the effect of land price on conflicts. In cross-sectional data the estimated coefficient may be capturing the fact that the more frontier and less-developed states, where land prices are lower, tend to have more violence than do the older and more central states. In time-series data for a same state this would not happen and the coefficient would capture the dynamic relationship between these variables, which we expect to be positive.

Given that we are using panel data, both forces are at work, but are controlled for through the inclusion of the variable *Latifundia*, which is the total area of agricultural land in state *i* that is classified as a latifundia by INCRA (large and/or unproductive) and thus subject to expropriation.[20] This variable captures the level of property right insecurity in a state and represents variable *P*. The presence of this variable controls for the stage of development of the land in a state and should therefore partially remove that influence from the effect of price on conflict.

Another problem with the land price variable is that it is potentially endogenous because a high incidence of violence in a state may decrease the value of the land. In order to find a consistent estimator if *Price* is in fact endogenous, we estimated *Price* as a function of the amount of rural credit granted in each state,[21] each year, per hectare of agricultural land, together

[19] INCRA's budget in million US$ was 1989: 76, 1990: 393, 1991: 1,209, 1992: 323, 1993: 368, 1994: 443, 1995: 1,314. Source: IBDA, 1997, p.16.

[20] A farm is classified as a latifundium by INCRA if it does not achieve a minimum level of productivity, according to criteria defined by INCRA, and/or if it is above a certain size, which varies from region to region, irrespective of the level of productivity.

[21] Several studies on land prices in Brazil have found that the amount of credit is the variable which best explains price. Other variables that theoretically could explain land prices, such as the returns to agriculture and GNP growth, have only weak explanatory power. The main reason for the strong relationship between credit and land price is the fact that rural credit has long been subsidized in Brazil, so the subsidy naturally gets capitalized into the value of the land. See Rezende (1982) and Brandão, (1992).

Table 4. *Descriptive statistics for the conflict regression*

Variable	*Observs.*	*Mean*	*Std.dev.*	*Minimum*	*Maximum*
Conflict	154	17.88	14.12	0	66
Settlement	154	3.12	3.86	0	19
Price	154	0.538	1.00	−2.18	2.29
Price (estimated)	154	0.538	0.955	−1.49	1.82
Budget	154	412.57	354.13	76	1209
Latifundia	154	98.31	84.57	2.10	313.74
Farms	154	210.32	172.95	2.46	699.13

Table 5. *Regression results for estimation of conflicts*

(Panel data – 22 states – 7 time periods)

Variable	*Coefficient*
Settlements	0.152
	(0.75)
Price	−3.03*
	(−1.77)
Latifundia	0.07***
	(3.38)
Budget	0.003**
	(2.30)
Farms	0.024**
	2.35
Constant	5.06
	(1.55)
N	154
R^2	0.48

Note: Estimated through a random effects model. Ratio of coefficient to its estimated standard error in parentheses (asymptotically distributed as a standard normal). Significance levels: ***1%, **5%, *10%.

with $Budget_{t-1}$, $Settlementes_{t-1}$, and state dummies to capture the fixed effects of each state.[22] The estimated *Price* is then used in the place of the original land price data. Finally, the variable *Farms* is the total number of agricultural units in each state, which controls for the wide variation in the number of farms amongst Brazilian states. Because there are no yearly data available for this variable, this is a time-invariant variable. Descriptive statistics for all of the variables used in the estimation are presented in Table 4

Table 5 shows the results of the estimation of equation (30) through a random effects model.[23] The variable *Settlements* captures the effect of the

[22] The adjusted R^2 in the OLS estimation of *Price* is 0.88.

[23] Given the panel nature of the data, a Hausman test was run to determine whether the state-specific effects are orthogonal to the explanatory variables (Greene, 1998, pp. 320–321). This test did not reject the hypothesis of orthogonality so the estimation was done through a random effects model rather than a fixed effects model. The Wald statistic for the Hausman test (χ^2_3) was 1.96.

variable *G*, the government's political will towards land reform. This variable is positive as predicted but not significant.[24] Another measure for the effort of the government towards land reform is the budget of INCRA, which varied considerably over the period. This coefficient is positive and significant at 5 per cent, providing empirical evidence for an important argument in this paper, that the government's effort may have the effect of increasing the amount of rural violence.

The coefficient on *Price* is negative and significant at 10 per cent. According to the model (see Table 3) an increase in the price of land leads to an increase in the amount of violence from the farmer and to an increase (direct effect) or a decrease (strategic effect) from the squatters. The results of the regression provide empirical evidence that the net effect of the increase in the price of land is negative. As argued above, this is probably due to the fact that there are less invasions and conflicts in states with more developed agriculture, where land prices are higher. In these states the squatters invade less because they realize that the probability of them being successful in getting the land is smaller.

The *Latifundia* variable serves as a proxy for *P*, the level of property rights security. The more farms in latifundia in a state, the higher the chance of INCRA expropriating to create settlement projects. In the model an improvement in P leads to less effort from the farmers and less (direct effect) or more (strategic effect) from the squatters. Since a higher value for *Latifundia* implies a lower *P*, the fact that the coefficient is positive and significant indicates empirically that an improvement in property rights security leads to less violence overall.

Finally, the coefficient on the *Farms* variable is positive and significant at 5 per cent. This result simply confirms that, all else constant, the more farms there are in a state, the more conflicts will occur there.[25]

Despite being a reduced form rather than the preferable structural form, the estimations above provide empirical support for the predictions of the determinants of violence between squatters and farmers as described by the model in Section 2. These findings will be discussed in the concluding section. Before doing so, however, the effect of government policy on conflicts will be further explored through a causality test.

Recall that in Section 2 we modeled squatter violence as increasing the probability that INCRA would expropriate an invaded farm, $\theta_S > 0$. Because expropriations are usually the first step towards a settlement project, this implies causality from conflicts to settlements. On the other hand, in Section 3 we showed that an increased level of governmental effort towards land reform, which can be proxied by the number of settlement projects being implemented, may increase the probability of expropriation and thus provide a demonstration effect which will lead to

[24] Note, however, that in the causality test below, which uses a larger number of states and of years, the effect of the *Settlement* variable on *Conflicts* is statistically significant.

[25] Due to lack of appropriate data the estimation did not include the variable *K* (courts position towards land reform), which, according to the model can have important effects on the amount of violence.

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more invasions. This relationship implies causality from settlements to conflicts. The correlation coefficient between conflicts and settlement projects is 0.26 and provides some empirical support for the view that the net effect of the government's land reform project is to increase violence.[26] The first direction of causality comes from INCRA responding to conflicts by initiating more expropriations and subsequently creating settlement projects.[27] The second direction comes from the reaction of squatters to the increase in the number of settlements. Settlements that result from violence signal to potential squatters that they can increase the probability of an invasion successfully turning into a settlement project by engaging in more violence.

In order to investigate more formally the two-way causality between conflicts and settlement projects, we performed a Granger causality test. The definition of causality used in this test is that variable x causes variable y if taking account of past values of x improves the predictions for y.[28] Table 6 shows the results. In the first column conflicts are regressed against

Table 6. *Granger causality test between settlement projects and conflicts*

Dep. variable	*Conflict*	*Projects*
Conflict_{t-1}	0.455	0.035
	(6.27)	(0.636)
Conflict_{t-2}	−0.161	−0.118
	(2.34)	(2.24)
Projects_{t-1}	0.162	−0.171
	(1.74)	(2.39)
Projects_{t-2}	−0.233	−0.410
	(1.58)	(3.63)
Adjusted R^2	0.69	0.18
F-stat. for H_0	3.46	2.53
p-value	0.03	0.08
H_0	Proj. ⇒ Conf.	Conf. ⇒ Proj.
Decision	Accept**	Accept*

Note: Estimated through a fixed effect model. Panel data of 8 time periods and 27 states. Levels of significance: 1% ***, 5% **, and 10% *. t-ratios in parenthesis.

[26] The correlation is statistically different from zero at a 1 per cent level of confidence.

[27] Note that because the model is at the level of individual conflicts, the squatters and farmer treat G as exogenous. That is, individual agents do not view their own violence as contributing to the level of government effort towards land reform. However, the aggregate level of violence in the country does in fact affect G. This is analogous to producers in a competitive market who do not view their decision to sell as affecting the price level. In the causality test we perform, state level data are being used instead of conflict level data. Although at the level of an individual conflict violence should not affect G, at the state level it is reasonable to expect this to be so.

[28] Harvey (1990, pp. 303–305). More precisely, causality from x to y is inferred to exist when lagged values of x_t have explanatory power in a regression of y_t on lagged values of y_t and x_t.

lagged conflicts and lagged settlement projects.[29] The test rests on the statistical significance of the lagged settlement project variables. If they are statistically different from zero, then we can infer that settlements cause conflicts. Likewise in the second column settlement projects are regressed against lagged projects and lagged conflicts, with the significance of the lagged conflicts variable determining whether conflicts cause settlement projects.[30]

The first column of Table 6 shows that the hypothesis that more settlement projects lead to more violence cannot be rejected a 5 per cent level of significance. This result implies that increases in the government's effort towards land reform may lead to *increases* in the amount of rural violence. This suggests that in order to solve the problem of rural conflicts it is not appropriate for the government simply to dedicate more resources and more effort towards expropriating land and creating settlement projects. A better solution requires adopting a land reform program that does not provide the incentives for violence. This issue is further discussed in the concluding section.

The second column of Table 6 shows that the other direction of causality is also present. The hypothesis that conflicts cause settlement projects is not rejected at a 10 per cent level of significance. This simply reflects the fact that most settlement projects arise as a response to conflict. It should also be noted, however, that these results are affected by the fact that the time-series part of the data is relatively short, not allowing us to try more than two lags, whereas the effect of conflicts may take several years to translate into government action. A longer time series would allow us more degrees of freedom to try to capture the complex dynamic relationships between the variables.

As noted above, the existence of a causal link from settlement projects to conflicts indicates that an increase in the effort by the government towards land reform, within the current land policy parameters of expropriation and settlement, contributes toward an *increase* in the number of conflicts.

[29] Both the conflict and the settlement variables are total numbers for state i in year t. The conflict data are from the Pastoral Land Commission yearly reports and the settlement project data are from INCRA private correspondence. One important issue in a causality test is how to decide the number of lags to use. It is well known that causality tests are very sensitive to the choice of the lag order. We performed the tests with only two lags since with every additional lag we lose an observation and we only have eight time-series observations for each state. Adding more lags would reduce the power of the test significantly. The results were robust to the use of one or two lags. Given the small length of the time series, we could not use unit-root tests to determine if the series are stationary, however, this is mitigated by the panel nature of the data. Given the weak power of such tests the results should be interpreted with care.

[30] A Hausman test (Greene, 1998, pp. 320–321) was performed on each regression to determine whether a fixed effects or a random effects model should be used. The tests rejected the hypothesis of no correlation between the state-specific effects and the regressors, therefore fixed-effects estimation was used. The test statistic for the conflict regression was 16.30 (p-value = 0.003) and for the project regression it was 46.16 (p-value 0.0000), both with 4 degrees of freedom.

This is clearly not the effect intended by the government, which is presumably responding to conflicts in order to reduce the amount of violence. The problem is that for every conflict resolved by an expropriation several other conflicts may arise spurred by the demonstration effect of the success of the earlier invasions. These issues will be further discussed in the concluding section.

5. Concluding remarks

The results in the previous section provide empirical support in favor of the model of rural conflict presented in this paper as a realistic representation of the determinants of rural conflicts in Brazil. The variables *Settlements*, *Budget*, *Price,* and *Latifundia* are reasonable proxies for the variables *G*, *L*, and *P*, for data at the state level. These are key variables in the model and the results show that they affect rural violence in the predicted direction. In the case of *G*, for example, it was found that an increase in government effort towards land reform led to a rise in the number of rural conflicts. Therefore, as far as its goal of reducing the amount of rural violence, the government's land reform policy is having the *opposite* effect to that which is intended. Although the more central goal of land reform is to reduce the extremely high levels of land ownership concentration, this may not be achieved if the efforts in that direction have the unintended consequence of inducing more violence. The government may therefore need to find a new model of land reform that is capable of achieving this goal without providing incentives for more violence.

Although the government now seems to be aware of this unintended consequence of its land reform policy, it has been politically constrained to continue in this same track. Halting the current land reform program or substituting it for another program without expropriations could lead to claims that the government was faltering in its resolve to go through with a land reform. Therefore it has been forced to search for new land reform policies while still persisting with the old land reform model. In 1997 the Ministry of Land reform initiated an experimental program where groups of landless peasants receive credit to purchase land directly from farmers, thus avoiding the contentious expropriations. Additionally, also during 1997, the new land tax law has been put into practice, which is expected to give incentives for large landowners to rent, use or sell their idle land. Another possibility would be to enact legislation to facilitate agricultural contracts (renting and sharecropping) between landowners and landless peasants. In Brazil such contracts are very rare, since landowners fret that entering into these types of relationships may make them prime targets for expropriation by INCRA. As these new policies and others start to take effect the government may be able to reduce the emphasis on expropriations and consequently break the link between its land reform policy and rural conflicts. Doing so will require that the government be able to provide credible commitments that it will not respond to invasions by expropriating the land and settling the group that invaded. Until now, however, it has not been able to do so, since expropriation is often the path of least resistance to solve any given conflict.

Another unintended consequence of the government's land reform

policy that is suggested by the results in this paper is greater deforestation, particularly in the Amazon region where one of the main ways to avoid being invaded is to clear parts of the farm. Our model does not consider deforestation explicitly, however, if, as we argue below, the possibility of invasion and threat of conflict provide incentives for both farmers and squatters to clear the land, then policies which encourage violence will indirectly lead as well to greater deforestation. When the threat of invasion increases, a landowner may opt to clear more than he would if property rights were secure. Therefore, any action by the government that increases the amount of violence, through increases in either G or L or decreases in P, will increase deforestation.

There are numerous incentives for deforestation irrespective of those that arise from the possibility of invasions and rural conflicts. Both large farmers and small settlers will tend to clear the forest off their land in order to secure the income that can be derived from doing so. Clearing is costly and is considered an improvement by landowners of all sizes. Even under secure property rights, it will be undertaken whenever the economic benefits of doing so are larger than the costs. Large landowners in the Amazon have typically cleared large areas of their land, and have often been considered the villains of deforestation. Lately, however, there has arisen the concern that small landowners, including squatters and ex-squatters in settlement projects, are contributing significantly to the deforestation of the Amazon and other forests in Brazil.[31] IBAMA, the government's environmental agency, has recently stated that 40 per cent of the clearing in the Amazon in 1994 and 1995 was done by small rural producers.[32] This number has been strongly denied by INCRA and the Ministry of Land Reform, which put the number at 10 per cent. This controversy between different governmental agencies underscores the incompatibility between the government's social and environmental objectives.

Invasions and conflicts may provide incentives for clearing as a means to assure the possession and ownership of the land. Clearing as a strategy to claim land is engaged in by both the farmer and the squatters. In the Amazon, once a group of squatters has invaded a property they will typically start clearing the forest immediately. This is done, in the first place, in order to plant and assure subsistence. However, it also has the purpose of signaling their intention to stay on the land and their commitment to make it productive and resist any attempt of eviction. The fact that they have made an unproductive latifundia fulfill its social function increases

[31] An interesting study that provides systematic data in this regard is a research project by Embrapa, which has been monitoring the use of the land by small settlers in the state of Rondônia in the Amazon since 1986. Comparing the data from 1986 to that of 1996 they show that the settlers in a sample of 392 properties increased the total explored area from 2,874 to 9,867 hectares, which implies an average increase of 1.78 hectares per farm each year. They state that 'it is difficult to imagine any other region in Brazil where small rural producers can increase their explored area at a rate of almost two hectares per year'. See Embrapa homepage 12/27/97, http://www.nma.embrapa.br/projetos/machadinho/.

[32] Folha de São Paulo, 30 October 1997, p. 8.

the probability that INCRA will expropriate the land in their favor, all else constant. Furthermore, according to both formal and informal institutional arrangements in Brazil, any 'improvement' made by the squatters on the land must be compensated by the landowner in case of an eviction. Therefore the squatter's are not deterred from cutting down the forest, which is a costly activity, due to fear of not having the profits of that effort accrue to themselves.

Farmers also clear their land beyond that level which would be justified economically as a strategy to maintain their possession of the land. Because INCRA considers cleared forest land as unproductive, a farmer who has a substantial part of his/her farm in forest will be subject to expropriation. Knowing this, the squatters will tend to target precisely those farms with their invasions. This naturally leads landowners to substitute their forested areas for pasture as a means to preempt the invasion. Pasture is considered a productive use of the land even if it is not stocked with cattle.

We do not have systematic data in order to measure the extent of these effects on deforestation, but we do have qualitative evidence that the link does exist.[33] We surveyed 69 contested farms in Parauapebas in November 1996. Most of the farmers in this region did not have title but had been on the land for over ten years. Typically only a small fraction of the land had been cleared. INCRA regularized all the farms that had been invaded. Each farmer was allowed to purchase the *cleared area plus 1.5 times* that amount.[34] Squatters were settled in the remaining land or moved to other land if not enough remained. The farmers affected viewed this process favorably, as long as the price of the land was reasonable, because it not only allowed them to finally get title but it solved their problems with the squatters. One consequence of this policy, as we discovered upon surveying both some of the regularized farmers and others that had not been invaded, was to give a strong incentive for clearing. Those which had been regularized admitted to clearing prior to INCRA's visit in order to increase the area they would have titled in their favor, and many who had not been affected stated that they would clear for the same purpose since they also expected to be regularized in the future.

This brief discussion indicates that land reform policies also have an effect on deforestation. The current rules for the ownership and use of land, embodied in the government's land reform and other formal and informal institutions, were shown in this paper to set the stage for invasion and conflicts. If in fact farmers and squatters are led to clear the forest as a strategy in the struggle for land, then a new model for land reform, which removes the incentives to engage in violence, will have the added bonus of contributing to reduce deforestation. This policy change would

[33] A study by the environmental agency of the state of Rondônia in 1997, concluded that one of the major causes of deforestation in that state, in the previous two years, was due to farmers trying to make their land productive in order to avoid being targeted by land reform. Folha de São Paulo, 30 November 1997, p. 14.

[34] This multiple has since fallen to 1, as a reflection of the increased pressure for land by the squatters in the region.

be an important step forward, although unfortunately, there would still remain several other incentives for deforestation unrelated to land tenure issues.

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