A Model of Rural Conflict: Violence and Land Reform Policy in Brazil

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Abstract
This paper analyzes a model of rural conflicts in Brazil involving squatters, landowners, the President, the courts and INCRA, the land reform agency. In this model squatters and landowners strategically choose to engage in violence taking into consideration how this affects the probability that the land will be expropriated in the squatters’ favor as part of the government’s land reform program. The model’s predictions are tested using state level data for Brazil. It is shown that the government’s land reform policy, which is based on expropriation and settlement projects, may be giving incentives for both sides to engage more violence. In addition, the model is used to discuss the link between rural conflicts and deforestation, given that many of these conflicts take place in the Amazon region.
Section 1 - Introduction

In 1985 the Brazilian government implemented the PNRA (National Plan for Land Reform) in an attempt to attack the 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 through which land for landless 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 expropriations and settlement projects having been implemented. Nevertheless, the expropriations and settlement projects which did go through indicated the new model of land reform policy which the government would follow up to the present. The economic agents quickly recognized the pattern behind this new policy and reacted to it.

In theory the new model foresaw INCRA, the government’s land reform agency, expropriating private land that was not being put to beneficial use, creating a settlement project and then calling families of landless peasants it had registered in a cadaster to occupy the plots. The families were expected to wait until their time came to be assigned land. In practice, however, the landless peasants realized that the pace at which the government was implementing the reform was extremely slow and that individual groups of peasants 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 owner of the land, leading INCRA to expropriate the farm and to settle the squatters on it as a means to solve the problem.

During the late eighties this process evolved slowly and unsystematically with separate groups invading farms throughout the country, sometimes being successful and sometimes not. During the nineties, however, the invasions that did work provided a strong demonstration effect and the landless peasants started becoming increasingly organized. The largest and best-organized group was the MST (Landless Peasants Movement) which was born in the south of Brazil in 1984 and has since

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1 See Mueller, B. (1994).
spread throughout the country. The success of this group lay in their understanding of the formal, as well as the implicit, rules of the game, which involved settlers, farmers, INCRA, the government, the courts and public opinion. This understanding led them to develop a well-thought-out strategy for choosing a farm, invading it and, more importantly, transforming the invasion into an expropriation by INCRA. It is precisely this notion that there is a clear implicit set of rules which governs the occurrence of rural conflicts that will be used in this paper to model them.

In order to understand the functioning of rural conflicts in Brazil it is necessary to comprehend the property right institutions that determine land tenure. The Constitution of 1988, following the example of all previous Constitutions since 1946, states that land must fulfill its “social function”, one condition of which being that it 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 in the form of a settlement project. The purpose of these constitutional rules is to allow the severe problem of land ownership concentration to be addressed spontaneously. Formally these rules do not permit the invasion of private property by squatters since the expropriation is to be done only by INCRA, however, in practice the invasions have become institutionalized as a valid part of land reform. Although the government complains about the invasions and threatens not to give in to them, every time it does expropriate 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 have been 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. However, in practice farmers are able to go to the courts after being invaded and request a warrant for the police to evict the squatters. If the farmer is truly the owner of the land he/she 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 bringing up the question of land reform. Rather the courts deal with an invasion in the same way they deal with the taking of any other property from

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2 For a more detailed account of the property right institutions for land in Brazil and their effect on rural violence, see: Alston, L. et. al., (forthcoming).
one individual by another; by following the Civil Code and treating property right as an absolute concept. If the invasion brings up questions of land reform, reason the courts, this is another problem that should be dealt with in a separate instance.

The competing claims for land from the landless peasants and the farmer are such that both can find legal justification for their actions. The Constitution informally legitimized the invasions by the squatters and the Civil Code justifies the resistance of the farmers to having their land invaded. 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 here]

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 1980’s there was a high level of conflicts, followed by a decrease in the first five years of the 1990’s. 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 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 conflicts in Brazil. Our analysis includes mostly policy related to the government’s land reform program, but includes also other types of government policy such as rural credit. In general terms, this effect can be seen in the time trends shown in Table 1. During the late eighties the effects of the PNRA (National Plan for Land Reform) of 1985 were still being felt. As was mentioned above, the main instrument in this plan was the expropriation of private farms. The fact that INCRA was expropriating farms to settle landless peasants provided an incentive for groups of squatters to invade those farms in order to be settled first. In the period that followed, the new Constitution was passed establishing the rules for expropriations. Because the complementary rules were only passed in 1993, INCRA spent a period of several years in which it had much more difficulty in obtaining land through expropriation. During this time one
of the main incentives for invasions was mitigated, and the number of conflicts fell accordingly. Then, in the mid 1990’s, 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, at the macro level, of the relationship between government policy and conflicts will be carefully 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. This model was developed in Alston, Fuller, Libacap and Mueller (1997) where it was used to analyze the determinants of violence in the Amazon. The model presented in section 2 is extended with an examination of the reaction functions for squatters and farmers that arise from the equilibrium conditions. In section 3 the effect of changes in the government’s policy variables will be analyzed using comparative statics and the reaction functions. 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, especially deforestation.

Section 2 - A Model of Rural Conflict

The description of rural conflicts in Brazil in the previous section showed that there is a clear set of rules within which these conflicts occur. These rules involve both formal laws and informal institutions that determine the payoffs to squatters and farmers for each possible outcome. The participation of INCRA, the courts, and the federal and local governments is an integral part of the conflicts. It is clear that squatters and farmers choose their actions in a strategic manner so as to maximize the net expected value they receive as a payoff from the conflict. In this section a game theoretic model is presented based on the incentives provided by the institutional
setting for squatters and farmers to provide violence in a rural conflict. The squatters choose to invade a farm, resist eviction and lobby for INCRA to expropriate the land in their favor. The farmer chooses whether and how to evict the squatters. The level of these actions by the squatters and farmer are broadly defined as violence and are denoted by \( s \) and \( v \) respectively.

The probability that INCRA will expropriate a farm is given by:

\[
\theta(s, P, G) \quad \text{with } \theta_s \geq 0, \theta_{ss} < 0
\]

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 violence 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.

Note that 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. During the 1990’s the issue of land reform has acquired renewed political importance, and \( G \) has risen accordingly. It is clear that \( G \) 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. However, we assume 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.

After a farm has been invaded, the farmer, as we are calling the person who claims to own the land, typically tries to evict the squatters. Many times the farmer will try to negotiate with the squatters for them to leave the farm by showing the title to land and offering to pay for the improvements they may have added to the land. More often, however the farmer will try to evict the squatters. This can be done

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3 This model was developed Alston, Fuller, Libecap and Mueller (1997). In that paper the objective was to analyze the determinants of violence, whereas in this paper the objective is to analyze government policy.

4 See Alston, Libecap and Mueller, (forthcoming).

5 This is similar to assuming that in a model of perfect competition a firm takes prices as given.
through threats and physical action by the farmer himself/herself, by hiring gunmen, by obtaining a court order to engage the police, 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 orders the police to remove the invaders. In general judges view a “reintegration of possession” concerning invaded land as they would the taking of any other private property of one individual by another. However, given the high probability of a conflict and the social and political nature of the issue, judges may be reluctant to concede the orders in some circumstances. Accordingly, we make the probability of 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:

$$\beta(v, K) \quad \text{with } \beta_v \geq 0, \beta_K < 0,$$

(2)

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

The objective of both the farmer and the squatters in a conflict is to end up with the ownership of the land. Each side will supply violence 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 $L$.

[Table 2 here]

If the squatters are evicted, the farmer keeps the land and they get nothing. Another possible outcome is for the farmer to be unable to evict the squatters but there is no expropriation. In this case, the squatters remain on the land but the farmer continues having a claim to it. Eventually this situation will have to be resolved, but it may remain in this state for a long time. The value of the land to the squatters in this case is $\pi L$ and to the farmer it is $\delta L$, where $0 < \pi < 1$ and $0 < \delta < 1$. If INCRA does expropriate the farm from the farmer, 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 5 to 20 years depending on the size of the farm. Therefore being expropriated is generally
valued by the farmer as being worse than keeping the land.\textsuperscript{6} Therefore, it is assumed that
\[ \gamma < \delta < 1. \]

The squatters’ problem is to choose the amount of violence \( s \) to supply so as to maximize their expected payoff minus the cost of doing so. Likewise the farmer’s problem is to choose \( v \) in order to maximize his/her expected payoff minus cost of supplying violence. 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:

\textbf{Squatters’ Problem}

\[
\max_s \quad (1 - \beta(v, K))[(1 - \theta(s, P, G))\pi L + \theta(s, P, G)L] - C^s(s) \tag{3}
\]

\textbf{Farmer’s Problem}

\[
\max_v \quad \beta(v, K)L + (1 - \beta(v, K))[(1 - \theta(s, P, G))\delta L + \theta(s, P, G)\eta L] - C^f(v) \tag{4}
\]

Functions (3) and (4) are simply a linear combination of the payoffs to each type for each possible outcome, weighted by the probability of that outcome, minus the cost of supplying violence, where \( C^s(s) \) and \( C^f(v) \) are the cost of supplying \( s \) and \( v \) units of violence respectively.

The first order conditions for maximization are:\textsuperscript{7}

\[
(1 - \beta)\theta_s(1 - \pi)L = C^s_s \tag{5}
\]

\[
\beta_v[\theta L(\delta - \gamma) + L(1 - \delta)] = C^f_v \tag{6}
\]

The left-hand side in (5) is the expected marginal benefit for the squatter’s of supplying an additional unit of violence. Doing so increases the probability that

\textsuperscript{6} Some times landowners are able to secure a compensation above the market price of the land, either through corruption involving INCRA officials or through the court. Such cases are, however, exceptions.

\textsuperscript{7} The arguments of the probability functions will be omitted in the first order conditions. Derivatives are denoted by a subscript, e.g., \( \frac{\partial \beta(v, K)}{\partial v} \equiv \beta_v \).
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 violence. By adding an additional unit of \(v\) the farmer increases the probability of eviction by \(\beta_v\). 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 violence.

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 \(\beta(v^*,K)\).

In order to visualize the interaction between the farmer and the squatters it is useful to derive the reaction curves for each party. Let \(\lambda^S\) be the objective function of the squatters and \(\lambda^F\) that of the farmers. That is

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

and

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

Let \(\lambda^S_s(s,v) = \frac{\partial \lambda^S(s,v)}{\partial s}\) \(\tag{9}\) and \(\lambda^F_v(s,v) = \frac{\partial \lambda^F(s,v)}{\partial v}\) \(\tag{10}\)

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\(^8\) To simplify notation only \(s\) and \(v\) are included as arguments.
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 $\lambda_v^F = (s, R^F(s)) = 0$.

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 $\lambda_v^F = 0$ with respect to $s$. For $\lambda_s^S$ this yields $\lambda_{sv}^S + \lambda_{ss}^S \frac{\partial R^S}{\partial v} = 0$
and for $\lambda_v^F$ it yields $\lambda_{sv}^F + \lambda_{ss}^F \frac{\partial R^F}{\partial s} = 0$. Rearranging, expressions for the slopes of
the reaction curves are obtained:

$$\frac{\partial R^S}{\partial v} = -\frac{\lambda_{sv}^S}{\lambda_{ss}^S} \quad (11) \quad \text{and} \quad \frac{\partial R^F}{\partial s} = -\frac{\lambda_{sv}^F}{\lambda_{ss}^F} \quad (12)$$

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 $\lambda_{sv}^S$ and $\lambda_{sv}^F$, which are:

$$\lambda_{sv}^S = -\beta_s \theta_s (1 - \pi) L \leq 0 \quad (13) \quad \text{and} \quad \lambda_{sv}^F = \beta_s \theta_s (\delta - \gamma) L \geq 0 \quad (14)$$

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. That is, the squatters react to
more violence from the farmer by offering less violence, and the farmer reacts to
more violence from the squatters by offering more.

Graph 1 shows the reaction curves for the squatters and the farmer. At 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 that point is a Nash-Equilibrium.

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10 Note that the reaction curves are only an expositional device since in fact it is a one-shot game and
both parties move simultaneously.
11 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 $\lambda_{sv}^S \lambda_{sv}^F > \lambda_{ss}^S \lambda_{ss}^F$. 

Before proceeding to the next section a few words should be said about the static nature of the model presented in this section. It is clear from the description of conflicts that they are dynamic phenomena, with squatters invading, then farmers evicting, then squatters deciding whether to resist, then INCRA deciding whether to expropriate or not. In this paper, however, conflicts are modeled as a static game with both squatters and farmers simultaneously choosing the amount of violence to offer and reaching a simple Nash equilibrium. This is a strong simplification that certainly omits some interesting dynamic aspects from the analysis. On the other hand, it does allow us to produce a clear and simple characterization of the relationships between the several variables involved in a conflict, in such a way that yields useful testable hypothesis. All models necessarily abstract from several aspects of reality in order to focus on other aspects. Incorporating explicitly the dynamic nature of the conflicts into the model is a possible avenue for future extensions. For the purposes of this paper, the static model proved to be useful a abstraction that allows us to think clearly about the incentives faced by the players and the effect of government policy on rural violence.

Section 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 show that theoretically many of the policies adopted by the government may lead to more rural violence. Some of these policies are not directly related to land reform and the incentive they give for more violence is simply an unforeseen side effect. Other policies, however, are directly aimed at reducing violence and promoting land reform.
and are having an effect opposite to that which is intended. In the next section we test these predictions empirically.

To simplify the derivation of testable hypotheses, a few assumptions are made. We assume that $\pi=0$, $\delta=1$, and $\gamma=0$; that is, the squatters’ 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 violence, $s$ 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:

\[
\begin{align*}
(1-\beta(v,K))\theta_s(s,P,G)L - C^S_s(s) &= 0 \\
\beta_s(v,K)\theta(s,P,G)L - C^V_s(v) &= 0
\end{align*}
\]

In a Nash Equilibrium equations (15) and (16) hold simultaneously, allowing us to differentiate both equations with respect to an exogenous variable or a parameter 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 which 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:

\[
\begin{align*}
\left[\begin{array}{c}
(1-\beta_\theta)L - C^S_{\theta L} - \beta_\theta L \\
\beta_\theta L - \beta_\theta L - C^F_{\theta v}
\end{array}\right]
\left[\begin{array}{c}
\frac{\partial s}{\partial G} \\
\frac{\partial v}{\partial G}
\end{array}\right]
= \left[\begin{array}{c}
-(1-\beta_\theta)\theta_{L}\theta L \\
-\beta_\theta \theta_{v} L
\end{array}\right]
\end{align*}
\]

In order to interpret the comparative statics results it is necessary to determine the signs of each term in the above equations. It will be assumed that $\beta_{sv}$ and $\theta_{sv}$, the second derivatives of the probability functions, are all negative. This assumption seems reasonable since probabilities are bounded between zero and one, so that it

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12 None of these simplifications alters the basic results obtained below.
13 From here on we drop the arguments of $\beta$ and $\theta$ to simplify the presentation.
should be expected that as violence increases the functions would tend asymptotically to one. Additionally the second derivatives of the cost functions, $C_{ss}$ and $C_{vv}$, are reasonably assumed to be positive. The term $|\det|$ is the determinant of the first matrix above. Given that $\beta_{vv}$ and $\theta_{ss}$ are assumed negative, and that the terms on the main diagonal are negative due to the second order condition to maximization, $|\det|$ is seen to be positive.

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

$$\frac{\partial v}{\partial G} = \frac{[(1-\beta)\theta_{ss}L - C_{ss}^e][-\beta, \theta_{ss}L] - [\beta, \theta_{ss}L][-1-\beta, \theta_{ss}L]}{|\det|}$$ (19)

$$\frac{\partial s}{\partial G} = \frac{[-(1-\beta)\theta_{ss}L][\beta_{vv}, \theta_{vv} - C_{vv}^f] - [-\beta, \theta_{ss}L][-\beta, \theta_{ss}L]}{|\det|}$$ (20)

By definition $\theta_{G} > 0$ and $\theta_{sG} > 0$; an increase in the level of government political will towards land reform increases the probability of INCRA intervening in the conflict. The term $\theta_{G}$ is the direct effect of the change in the government’s position on INCRA’s probability of expropriating and the term $\theta_{sG}$ is the indirect effect of INCRA becoming more sensitive to squatter violence. Given these considerations $\frac{\partial v}{\partial G}$ can be shown to be unambiguously non-decreasing. 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 $\beta_{v}$ and thus the potential loss $\theta_{L}$, that would result from an expropriation, will occur with a smaller probability. If $G$ increases then $\theta$ 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 violence.

The sign of $\frac{\partial s}{\partial G}$ does not have an unambiguous sign. It depends on two effects which can be seen in the squatter’s first order condition (15). The term $(1-\beta)$
θ_s L is the marginal benefit to the squatter of offering an additional unit of violence. Because the farmer will offer more violence given an increase in G, the term (1-β) 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 θ_sG is positive. This increases the marginal benefit and the squatters will prefer to offer more violence. The sign of $\frac{\partial s}{\partial G}$ will therefore depend on which of these effects predominates.

Graph 2 shows the effect on the farmer’s reaction curve of an increase in G. The comparative statics have shown that this change should lead to an increase of 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 violence $v_1 > v_0$. The increase in G also leads to an increase in s along the farmer’s reaction curve to $s_2$, which also lead to a higher v. This is the indirect effect of the increase in G on v through the increase on s.

[Graph 2 here]

The change in G also affects the squatter’s reaction curve. According to the comparative static results, the change in G has two opposing effects on the amount of violence offered by the squatter. The first effect is the direct effect of making an expropriation more probable, which makes the squatters offer more violence. In Graph 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 violence, $s_1 > s_0$. The second effect comes from the higher amount of v that occurs due to the increase in G. In the graph this indirect effect is represented by a movement along the squatter’s reaction curve from $v_0$ to $v_2$, leading to a lower s, $s_2 < s_0$. Depending on which effect is stronger, the final result of the increase in G will be a lower or a higher s, or no change if both effects cancel out.

[Graph 3 here]
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. 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 violence 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 indirect effect that comes from the smaller amount of violence from the farmer.

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:

$$\frac{\partial v}{\partial L} = \frac{[(1-\beta)\theta, L - C_{ss}^F][(-\beta, \theta - [\beta, \theta, L][-(1-\beta)\theta, L] \right]}{\text{det}} \tag{21}$$

$$\frac{\partial s}{\partial L} = \frac{[-(1-\beta)\theta, L][\beta, \theta, L - C_{sp}^s][-\beta, \theta, L][-\beta, \theta, L]}{\text{det}} \tag{22}$$

In equation (21) the first term in brackets is negative, from the second order condition to maximization, 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 violence 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, $(1-\beta)\theta, L$, leading the squatters to offer more violence. However, the increase in land value also led 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,

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14 To save space the comparative statics for a change in $P$ will be discussed and not shown explicitly.
then the increase in land value will lead to a higher supply of violence by the squatters.\textsuperscript{15}

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:

\[
\frac{\partial s}{\partial K} = \frac{[\beta_y \theta_s L][\beta_v \theta L - C_{sv}^F] - [-\beta_v \theta L][-\beta_v \theta L]}{[\text{det}]} \tag{27}
\]

\[
\frac{\partial v}{\partial K} = \frac{[(1 - \beta) \theta_s L - C_{sv}^S][-\beta_v \theta L] - [\beta_v \theta L][\beta_v \theta L]}{[\text{det}]} \tag{28}
\]

The expression in equation (27) is non-decreasing, which shows that as the courts become more favorable to the squatters they will offer more violence. This happens because $\beta_v \leq \theta$, 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 not unambiguous. 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 $\beta_v \leq \theta$, but the accompanying decrease in $s$ increases the marginal benefit though $\theta$. 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 violence from the squatters, but may also lead to more violence from the farmers, leading to an overall increase in violence. This result is opposite to that which was intended by the policy change. Table 3 summarizes the results of the comparative static results.

[Table 3 here]

\textsuperscript{15}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.
Section 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 some implications that can be tested in order to determine if the model is a reasonable representation of rural conflicts in Brazil. Alston et. al. (1997) used data at the municipio level for the state of Pará for 1985 and found strong evidence in favor of the model. In particular it was found that there was a positive relation between changes in land values and conflicts, and a negative relation between both the level of property rights security and the cost of violence and conflicts. Given the cross-sectional nature of the data used in that study and also the fact that the data involved only one state, there was no way to test the effect of the government’s political will towards land reform, variable \( G \), which is a key variable in the model. In this paper we will use data at state level for all Brazil for nine years (1987 to 1996) in order to test the model’s prediction, with special emphasis on the effect of government policy on conflicts.

Timewise those data are particularly well suited to test the model because they involve the late eighties and the nineties, the period when the strategic use of violence by squatters became established, although it is true that a period longer than the nine years we have available would be desirable. The data will be used in two ways; first a panel data regression will be run explaining 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 violence, \( s \), and farmer violence, \( v \), as endogenous variables. This structural model would be as follows:

\[
\begin{align*}
  s &= f(v,G,P,K,L,X) \\
  v &= h(s,G,P,K,L,Y)
\end{align*}
\]  

Whereas that paper was more interested in the issues of property rights and conflicts in the Amazon, this one uses data for the entire country and focuses on the effect of government policy on rural conflicts.
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 on farmer violence. 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 indirect effects of a change in an exogenous variable against the predictions of the model.

Unfortunately the data available on rural violence is 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, the data we have is at state level and measures the number of conflicts in each year from 1987 to 1996. 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 reduced form equation would be as follows:

$$
\text{Conflict}_i = \beta_0 + \beta_1 \text{Settlements}_{i,1} + \beta_2 \text{Budget}_{i,1} + \beta_3 \text{Price}_i + \beta_4 \text{Latifundia}_i + \varepsilon_i
$$

(30)

The panel data includes 22 states and the years from 1988 to 1995.\textsuperscript{17} The variable $\text{Conflicts}$ is the number of conflicts per hectare of agricultural land in state $i$ at year $t$, and it represents the combined effect of $s$ and $v$. The $\text{Settlement}$ variable is

\textsuperscript{17} These were the years and states for which all variables were available.

\textsuperscript{18} The area of agricultural land is taken from the 1985 agricultural census by IBGE and is used to transform $\text{Conflict}$, $\text{Settlements}$ and $\text{Credit}$ (to be discussed below) into per hectare values, since there is no yearly area data available. In order to make the units of the $\text{Conflict}$, $\text{Settlement}$ and $\text{Price}$ data more manageable they were, respectively, multiplied by 100,000, multiplied by 100,000 and divided by 100,000. The $\text{Price}$ data is from Fundação Getúlio Vargas - Centro de Estudos Agrários. The land prices and credit data are values per hectare and have been set at December 1993 Cr$ using the IGP index of FGV. The conflict data is from the CPT - Pastoral Land Commission - Goiânia, yearly reports. The settlement data was obtained through personal correspondence with INCRA in Brasília. The $\text{Latifundia}$ variable is from INCRA, 1992, Indicadores Básicos, Brasília. Credit data is from BACEN, Anuário de Crédito Rural, various years. The Incra budget data is from IBDA, Land Reform and Poverty Alleviation Pilot Project, 1997, p.16 and is in millions of US$. 
the number of settlement projects per hectare in state $i$ at year $t-1$. This variable was lagged one year to avoid problems of 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 as long as the direct effect on squatters is larger than the indirect effect.

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 state level. This variable also is lagged one period to avoid simultaneity issues.

The effect of land prices on conflicts should also be positive if the direct effect on squatters outweighs the indirect effect. There are 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 in two ways: The first is the fact that we use a fixed effects estimation procedure which accounts for the varying level of violence in different states. The second is the inclusion of the variable $Latifundia$, which is the percent of the agricultural land in state $i$ that is classified as a latifundia by INCRA and thus subject to expropriation. $^{19}$ This variable captures the level of property right insecurity in a state and represents variable $P$. The presence of this variables 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.

$^{19}$ 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.
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, each year, per hectare of agricultural land, together with $Budget_{t-1}$, $Settlementes_{t-1}$, and state dummies to capture the fixed effects of each state.\textsuperscript{20} \textsuperscript{21} The estimated Price is then used in the place of the original land price data.

[Table 4 here]
[Table 5 here]

Descriptive statistics for the variables used in the estimation are presented in Table 4 and the regression results are shown in Table 5. Two different estimating procedures were used for the conflict equation. Column I presents the results of a fixed effect model and column II those of a random effect model. It is generally not easy to determine whether a fixed or random effect model should be used (Hsiao, 1986, pg.41), especially in a case such as this where there is a small number of time-series and a larger number of cross-sections. The fact the observations are of states that cannot be regarded as a random sample of the population of Brazilian states, would indicate that the fixed effect model is preferable. However, the relative sizes of T and N suggest that the use of the random effect model is appropriate (Judge et. al., 1988, pg.489-90). The estimation of the fixed effect model has the disadvantage that the variable $Latifundia$ cannot be included since it does not vary over time (due to data constraints) and would thus lead to perfect collinearity with the state dummies.

The variable Settlements captures the effect of the variable G, the government’s political will towards land reform. This variable is positive but not significant in either type of estimation.\textsuperscript{22} Another measure for the effort of the government towards land reform is the budget of INCRA, which varied considerably

\textsuperscript{20} 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, G.C. (1982) and Brandão, A.S. (1992).

\textsuperscript{21} The adjusted $R^2$ in the OLS estimation of Price is 0.80.

\textsuperscript{22} 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 and positive.
over the period. This variable is positive and significant in column I and positive and weakly significant in column II. This provides 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.

*Price* is positive and significant in both types of estimation though the coefficient is three times larger with random effects. 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 (indirect 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 positive, that is, the indirect effect on the squatters does not outweigh the sum of the direct effect plus the violence from the farmer. As land becomes more valuable the likelihood of violence between farmers and squatters increases.

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 violence from the farmers and less (direct effect) or more (indirect effect) from the squatters. Since a higher value for *Latifundia* implies a lower $P$, the fact that the coefficient in the random component model is positive and significant indicates empirically a that an improvement in property rights security leads to less violence overall.\(^{23}\)

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, section 3 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 more invasions. This relationship implies causality from settlements to conflicts. The positive correlation coefficient between conflicts and settlement projects is 0.31 and provides some empirical support for the view that the net effect of the government’s land reform project is to increase violence.\textsuperscript{24} The first direction of causality comes from INCRA responding to conflicts by initiating more expropriations and subsequently creating settlement projects.\textsuperscript{25} 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 $y$.\textsuperscript{26} Table 6 shows the results. In the first column conflicts are regressed against lagged conflicts and lagged settlement projects.\textsuperscript{27} \textsuperscript{28} The test rests on the statistical significance of the lagged settlement

\textsuperscript{23} 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.

\textsuperscript{24} The correlation is statistically different from zero at a 1\% level of confidence.

\textsuperscript{25} 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 is 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.

\textsuperscript{26} Harvey (1990, p.303-305). More precisely, causality from $x$ to $y$ is inferred to exist when lagged values of $x$, have explanatory power in a regression of $y$, on lagged values of $y$, and $x$,.

\textsuperscript{27} Both the conflict and the settlement variables are in per hectare terms. Ideally we would like to divide the absolute values by the area of land in the state where conflicts and projects can occur. Much of the land in each state is either beyond the economic frontier or in very well developed areas. In either of these cases there is very little probability of a conflict occurring, since in the first property rights are irrelevant and in the second they are very secure. It is in the intermediate region that the conditions for conflict exist. Due to lack of such specific data, the area of farmland in each state was used. The conflict data is from the Pastoral Land Commission yearly reports and the settlement project data is from INCRA private correspondence. The data was multiplied by 100,000 to make the units more manageable.

\textsuperscript{28} One important issue in a causality test is how to decide the number of lags to use. We performed the tests with only two lags since with every additional lag we lose an observation and we only have 9 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.
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. Columns I and II perform the estimations without using fixed effects dummies for the states while columns III and IV include the fixed effects.

Columns I and III show that the hypothesis that more settlement projects lead to more violence cannot be rejected at a 1% 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 result 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.

Columns II and IV, on the other hand, reject the hypothesis that the number of conflicts causes the numbers of settlement projects. This is an odd result given the fact that during most of the period in the sample, most settlement project arose from instances of conflicts. That is, that conflicts lead to settlement projects is directly observable and is not controversial. The fact that the estimation does not confirm this causality may be due to the fact that the data are at state level, whereas in practice the government may react to violence in one state by increasing its level of effort in land reform not necessarily in the states where violence has occurred, but rather in those states where it expects the higher potential for other conflicts to occur. For example, after the massacre in the state of Pará in April of 1996, the government reacted by increasing the number of settlement projects not only in Pará, but in several other states as well. It should also be noted 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

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29 The coefficients were estimated using a pooling technique that takes into consideration the possibly cross-sectionally heteroskedastic and timewise autoregressive nature of the data Kmenta (1986, Section 12.2, pp.616-625). In essence the method performs a double transformation of the variables in order to correct first for autoregression, and then for heteroskedasticity. The estimation in columns II and IV was done using a fixed effects model which includes a dummy for each state so as to account for the effects of omitted variables specific to each state but constant over time.

30 Note that the other direction of causality is not so much affected by this nature of the data. The fact that several projects are being implemented in a given state does provide a strong signal for squatters in that state that an invasion will have a higher chance of being successful.
government action. A longer time-series would allow us more degrees of freedom to try to capture the complex dynamic relationships between the variables

[Table 6 here]

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. 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 and settlement project, several other conflicts may arise spurred by the demonstration effect of the success of the earlier invasions. 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. 

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, Price and Latifundia and Budget are reasonable proxies for the variables G, L and P, for data at state level. These are key variables in the model and the results not only show that they do affect rural violence, but also that the direction of their influence is such that the direct effect of a change in each of these variables outweighs the indirect effect. In the case of G, for example, this implies that, for our sample, a shift in government policy towards land reform led: (1) to more violence from the farmers, and (2) either

31 In May of 1997 the government put together a committee of land policy specialists from various sectors of society to elaborate new guidelines for its land reform and supposedly correct some of the problems the current program is facing. There is a clear search for a new model of land reform which avoids the problems of the current one. 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
to more violence from the squatters or to less violence but not enough to counter the increase in farmer violence. 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.

The results also suggest another way in which the government’s agricultural policy inadvertently leads to rural violence. Since subsidized rural credit leads to an increase in land prices (see footnote 23) and an increase in land prices leads to more violence, this policy may be having an unwanted effect on rural violence. It is intuitively clear that the potential for rural conflict is higher when the possession and ownership of the land is a necessary condition for access to subsidized rural credit. Note that the fact that the credit is subsidized may make it attractive even for those who do not intend to use the land and will chose to leave the property idle and thus subject to invasion. This is not to say that rural credit may not be a useful instrument for agricultural policy, an issue which we do not address here, but it does imply that when considering the use of subsidized credit, the effect on rural violence should be explicitly considered, and if possible, mechanisms should be introduced to break the link between credit, land values and violence.

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/she 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.

put into practice, which is expected to give incentives for large landowners to rent, use or sell their idle land.
It is clear that 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.\textsuperscript{32} IBAMA, the government’s environmental agency, has recently stated that 40 percent of the clearing in the Amazon in 1994 and 1995 was done by small rural producers.\textsuperscript{33} This number has been strongly denied by INCRA and the Ministry of Land Reform, which put the number at 10 percent. This controversy between different governmental agencies underscores the incompatibility between the government’s social and environmental objectives.

According to a special commission created by the Brazilian Congress in 1997 to investigate the deforestation of the Amazon, 76.15 percent of the area of all settlements created from 1994 to 1997, and 64.34 percent of the settled families, are in the Amazon. This involves an area of 5.55 million hectares of which 2.27 million are estimated by the commission to have already been cleared.\textsuperscript{34} Land in the Amazon is cheaper and easier to expropriate since farms there are large and often not productive; thus it is natural for a government which has high land reform targets to reach to concentrate in that region. The Commission estimates further that of the 10

\textsuperscript{32} 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/.

\textsuperscript{33} Folha de São Paulo, October 30, 1997, pg.8.

\textsuperscript{34} Folha de São Paulo, December 21, 1997, pg.1. These estimates have also been attacked by INCRA, which insists that the deforestation is done mostly by large cattle ranches, logging companies and miners.
percent of total deforestation of the Amazon since 1964, land reform has contributed 30 percent.\textsuperscript{35}

Experience has shown that both large landowners and small settlers, including squatters, will tend to clear the land they claim, even when there is secure tenure. We do not know of any study that measures whether one type will do so at a faster rate than the other, an issue that would lead to important policy implications. There is however a critical lesson from the past that can help in this regard. Both large landowners and small settlers have tended to engage in more deforestation when subsidized by the government to do so, either directly or indirectly. These subsidies include those in the 1970s and 1980s for the creation of large cattle ranches, subsidized credit, and now the special credit and advantages provided to settlers in land reform settlements.

In this paper, however, we are not concerned with this economically driven tendency for deforestation. Our focus here is in the way through which invasions and conflicts provide additional 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 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 squatters 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.

\textsuperscript{35} Deforestation from squatters is not only a problem in the Amazon. In Paraná, in southern Brazil, the MST (Landless Peasant Movement) invaded in 1997 a farm of over 30 thousand hectares mostly covered by natural forest. This has been the largest invasion to date involving 10 thousand squatters. Large areas of forest have been burnt and it is believed that most of what remains will follow shortly. O Estado de São Paulo, September 14, 1997, pg. 5. Another example is the land bordering the Una Biological reserve in Bahia, northeast Brazil, covered in Atlantic forest. Landless peasants have invaded 5000 hectares of this land in 1997 and are in the process of having the land expropriated in their favor. Veja, \textit{Amazônia: Um Tesouro Ameaçado}, edição especial, Dezembro 1997, pg.85.
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.

When we surveyed farmers in Parauapebas in November 1996, INCRA staff was present in the region to “regularize” several farms, that is, straightened out their tenure situation. Most of the farmers in this region did not have title but had been on the land for over 10 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. 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 affect stated that they would clear for the same purpose since they also expected to be regularized in the future.

In an attempt to neutralize the perverse incentives that the rules for land reform provide for farmers to engage in deforestation, the government allows farmers to register the covered part of their farm as a natural reserve. This reserve is then not considered unproductive, both for purposes of land reform and land tax. In practice, however, few farmers have adopted this possibility since it not only requires a project, developed by a licensed agronomer, involving considerable bureaucracy and

36 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, November 30, 1997, pg.14.
expenses, but more importantly, once the land is made into a natural reserve the farmer looses his/her discretion to one day clear the land. Registered forest is officially recognized and the farmer can be held responsible for its clearing, whereas the clearing of unregistered forest is easily done. Furthermore, the fact that few farmers have registered their reserves also indicates a disbelief on their part that the squatters will be deterred from invading such an area. That is, INCRA is unable to make a credible commitment to not respond to an invasion in a farm which has its forest registered. Although INCRA cannot legally expropriate the farm, because it is not considered unproductive, it can purchase the farm or settle the squatters elsewhere.

This brief discussion of the relationship between rural conflicts and deforestation indicates that policies that reduce the former will have an effect of reducing the latter. 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 be an important step forward, although unfortunately, there would still remain several other incentives for deforestation unrelated to land tenure issues.

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


______________. (forthcoming), Titles, Conflict, and Land Use in the Brazilian Amazon, University of Michigan Press.


O Estado de São Paulo, September 14, 1997, pg. 5.


INCRA (1992), Relatório Anual de Atividades, INCRA, Brasilia.

INCRA (1996), Relatório sobre Projetos de Assentamento, INCRA, Brasilia.


Table 1 - Number of Rural Conflicts in Brazil 1987-1996 by Region

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>582</td>
<td>621</td>
<td>500</td>
<td>401</td>
<td>383</td>
<td>361</td>
<td>361</td>
<td>379</td>
<td>569</td>
<td>658</td>
</tr>
<tr>
<td>North</td>
<td>160</td>
<td>163</td>
<td>157</td>
<td>108</td>
<td>104</td>
<td>86</td>
<td>109</td>
<td>99</td>
<td>98</td>
<td>104</td>
</tr>
<tr>
<td>Northeast</td>
<td>197</td>
<td>199</td>
<td>166</td>
<td>174</td>
<td>157</td>
<td>142</td>
<td>125</td>
<td>157</td>
<td>198</td>
<td>244</td>
</tr>
<tr>
<td>Southeast</td>
<td>103</td>
<td>78</td>
<td>58</td>
<td>43</td>
<td>24</td>
<td>49</td>
<td>37</td>
<td>32</td>
<td>121</td>
<td>100</td>
</tr>
<tr>
<td>South</td>
<td>41</td>
<td>88</td>
<td>70</td>
<td>36</td>
<td>60</td>
<td>45</td>
<td>40</td>
<td>37</td>
<td>52</td>
<td>78</td>
</tr>
<tr>
<td>Mid-west</td>
<td>81</td>
<td>93</td>
<td>49</td>
<td>40</td>
<td>38</td>
<td>39</td>
<td>50</td>
<td>54</td>
<td>100</td>
<td>132</td>
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</tbody>
</table>

Table 2 - Farmer’s and Squatters’ valuation of the land.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Squatters' valuation of Land</th>
<th>Farmer’s Valuation of Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>I  Squatters Evicted</td>
<td>0</td>
<td>$L$</td>
</tr>
<tr>
<td>II  No Eviction - No Expropriation</td>
<td>$\pi L$</td>
<td>$\delta L$</td>
</tr>
<tr>
<td>III  Land Expropriated</td>
<td>$L$</td>
<td>$\gamma L$</td>
</tr>
</tbody>
</table>
Graph 1 - Farmer and Squatters Reaction Curves
Graph 2 - Effect of a Change in P on the Farmer's Reaction Curve
Graph 3 - Effect of a Change in $P$ on the Squatters Reaction Curve.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effect on violence by the farmer</th>
<th>Effect on violence by the squatter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property Rights; P</td>
<td>-</td>
<td>+ or -</td>
</tr>
<tr>
<td>Gov.’s Position; G</td>
<td>+</td>
<td>+ or -</td>
</tr>
<tr>
<td>Land Value; L</td>
<td>+</td>
<td>+ or -</td>
</tr>
<tr>
<td>Court’s Position; K</td>
<td>+ or -</td>
<td>+</td>
</tr>
</tbody>
</table>
### Table 4 - Descriptive Statistics for the Conflict Regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>Observs.</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conflict</td>
<td>154</td>
<td>0.181</td>
<td>0.252</td>
<td>0</td>
<td>2.231</td>
</tr>
<tr>
<td>Settlement</td>
<td>154</td>
<td>0.031</td>
<td>0.043</td>
<td>0</td>
<td>0.313</td>
</tr>
<tr>
<td>Price</td>
<td>154</td>
<td>2.57</td>
<td>2.065</td>
<td>0.113</td>
<td>9.949</td>
</tr>
<tr>
<td>Price (Estimated)</td>
<td>154</td>
<td>2.57</td>
<td>1.857</td>
<td>0.239</td>
<td>6.075</td>
</tr>
<tr>
<td>Budget</td>
<td>154</td>
<td>412.57</td>
<td>354.13</td>
<td>76</td>
<td>1209</td>
</tr>
<tr>
<td>Concentration</td>
<td>154</td>
<td>0.605</td>
<td>0.147</td>
<td>0.300</td>
<td>0.840</td>
</tr>
</tbody>
</table>
### Table 5- Regression Results for Estimation of Conflicts per Hectare

**Estimation of Number of Conflicts per hectare**  
**Panel Data - 22 states - 7 Time Periods**

<table>
<thead>
<tr>
<th>Variable</th>
<th>I Fixed Effects</th>
<th>I Random Effects</th>
<th>II Fixed Effects</th>
<th>II Random Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Settlements</td>
<td>0.263 (0.52)</td>
<td>0.328 (0.68)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Price</td>
<td>0.241 (2.96)</td>
<td>0.07 (2.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latifundia</td>
<td></td>
<td>0.32 (1.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Budget</td>
<td>0.0002 (2.81)</td>
<td>0.0001 (1.63)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>-0.200 (1.21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>154</td>
<td>154</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.44</td>
<td>0.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

`t-statistics in parenthesis.`
### Table 6 - Granger Causality Test

**Granger Causality Test between Settlement Projects and Conflicts**

<table>
<thead>
<tr>
<th>Dep. Variable</th>
<th>No Fixed Effects</th>
<th>Fixed Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>Conflict&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.707</td>
<td>-0.009</td>
</tr>
<tr>
<td></td>
<td>(10.86)</td>
<td>(0.96)</td>
</tr>
<tr>
<td>Conflict&lt;sub&gt;t-2&lt;/sub&gt;</td>
<td>0.123</td>
<td>0.107</td>
</tr>
<tr>
<td></td>
<td>(1.96)</td>
<td>(0.89)</td>
</tr>
<tr>
<td>Projects&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>0.272</td>
<td>0.154</td>
</tr>
<tr>
<td></td>
<td>(4.10)</td>
<td>(2.34)</td>
</tr>
<tr>
<td>Projects&lt;sub&gt;t-2&lt;/sub&gt;</td>
<td>-0.212</td>
<td>0.212</td>
</tr>
<tr>
<td></td>
<td>(2.443)</td>
<td>(3.31)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.013</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>(3.183)</td>
<td>(4.55)</td>
</tr>
<tr>
<td>N</td>
<td>216</td>
<td>216</td>
</tr>
<tr>
<td>Cross-sections</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Time-periods</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>311.478</td>
<td>451.108</td>
</tr>
<tr>
<td>F-stat. for H&lt;sub&gt;0&lt;/sub&gt;</td>
<td>10.181</td>
<td>0.506</td>
</tr>
<tr>
<td>p-value</td>
<td>0.00006</td>
<td>0.603</td>
</tr>
<tr>
<td>Decision</td>
<td>Accept***</td>
<td>Reject</td>
</tr>
</tbody>
</table>

Estimated as a pooled cross-section time-series of 27 states from 1987 to 1996.

Levels of significance: 1% ***, 5% ** and 10% *. t-ratios in parenthesis.