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The dual policy in the dual economy—The political economy of urban bias in dictatorial regimes

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ABSTRACT

In many developing countries, public resource allocation is often biased against the rural population. Since a vast majority of the poor live in rural areas, the bias is highlighted as one of the most important institutional factors contributing to poverty. This paper develops a political economy model of urban bias in a dictatorial regime. A novel result of the model is that urban bias can emerge in predominantly agrarian economies even if there is *no* bias in political power toward urban residents. The empirical evidence from a recently compiled country-level panel dataset on agricultural taxes/subsidies is consistent with the prediction of the model.

1. Introduction

One of the major policy features that characterize many developing countries is a heavy bias against the rural population. This bias is highlighted as one of the most important policy obstacles to poverty reduction as a vast majority of the poorest households depend on farming for their livelihood. According to the Rural Poverty Report (2011), "1.4 billion people continue to live in extreme poverty, struggling to survive on less than US $1.25 a day. More than two thirds of them reside in rural areas of developing countries." The bias was first articulated by Lipton and he coined the term "urban bias" in his influential book *Why Poor PeopleStay Poor: Urban Bias in World Development* (Lipton, 1977). Lipton identified such a systematic bias against rural residents as the single most important source of deprivation for the majority of the poor across the world. Moreover, Bates (1984) provides extensive accounts of various tax instruments that governments use to extract resources from the rural sector. For example, government-owned marketing boards with monopsony power buy export products from peasants at administratively set low prices, sell those products at prevailing world prices, and pocket the surplus. Bates (1984) also shows how governments in Sub-Saharan Africa manipulated exchange rates against exportable farm products and used other domestic policies to suppress the prices of agricultural products (particularly food) in the domestic market. More recently, Bezemer and Headey (2008) single out urban bias as "the largest institutional impediment to growth and poverty reduction in the world's poorest countries."

This paper presents a model to shed some light on the political economy mechanism driving the bias. It also provides empirical support for the main prediction of the model. As previous studies of urban bias have shown that the bias is primarily a feature of non-democratic regimes (e.g., see Ades and Glaeser, 1995), the focus in this paper is on dictatorial regimes. One of the main regime features that characterize a dictatorial regime is the role of intra-elite conflict in power transfer (Lizzeri and Persico, 2004). In many dictatorial regimes, conflicts within the ruling elite are major sources of threat to political power. Citizens may also play a role in those conflicts. For example, citizens can support certain factions within the ruling circle. On the other hand, regime insiders may use popular sentiments against the current leader to come into power. It is not unusual for regime insiders to capitalize on citizens' dissatisfaction to justify coups d'état against leaders (Bates, 1984, pp. 30–35; Wiseman, 1986). The model combines these features in a dynamic setting.

I derive a testable prediction regarding political incentives and economic structure as defined by the relative size of different sectors in the economy. A novel result of the model is that anti-agricultural biases can emerge in predominantly agrarian economies even if there is no bias in political power between urban and rural citizens. In the political game, it is assumed that the insider can stage a coup and take over power with the support of either the rural or the urban residents. To

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avert a coup, the leader has two options: either to bribe the insider or to lower the taxes to citizens so that they do not provide any support for the insider. Urban residents are said to be politically more powerful the higher is the probability that the insider needs their support to overthrow the leader. Urban bias is then defined as the expected tax rate on the rural residents relative to the expected tax rate on urban residents. I show that relative tax rate becomes higher when the share of output by the rural sector is larger. The reason is that, as the relative size of agriculture increases, appeasing the rural population may require giving up a large amount of rent. And the leader reverts to bribing the insider whenever the insider needs the support of the rural residents. On the other hand, whenever the insider needs the support of the urban residents, the leader prefers to lower taxes on urban residents rather than bribing the insider. Using a recently compiled country-level panel dataset on taxation of the agricultural sector (see Anderson and Valenzuela, 2008), I show that the empirical evidence is consistent with the prediction of the model.

Previous literature on the political economy of urban bias emphasizes the role of disproportionate political power by urban residents as a driving force of urban bias.[1] A common explanation follows the "collective action logic" forwarded by Olson (1971), where a larger size of the agricultural labor force is argued to weaken farmers' lobbying ability by worsening the free-riding problem (Olson, 1986). This explanation is motivated by what appears to be a general pattern that poorer countries, which tend have a larger share of their labor force in the agricultural sector, tend to tax agriculture while rich countries subsidize agriculture (Bale and Lutz, 1981; Honma and Hayami, 1986; Krueger et al., 1988). The informational advantage for urban residents is argued to be an alternative explanation for urban bias. Using a voting model with imperfect information, Majumdar et al. (2004) show how an informational advantage for urban residents can lead to a disproportionate political influence of urban residents. Ades and Glaeser (1995) emphasize differences in regime types as a source of differences in political power between urban and rural residents. They argue that dictatorships favor urban residents since urban residents are assumed to have a higher political power in dictatorships than in democracies. In this paper, I expand on this idea. Specifically, I show that the extent to which dictatorships are biased towardthe urban sector varies substantially depending on the relative size of the rural economy. A key finding of the paper is that dictatorship may feature urban bias in predominantly agrarian economies even if there is no bias in political power between urban and rural residents.

The remainder of this paper proceeds as follows. The model is presented in Section 2. This is followed by an analysis of the equilibrium outcomes in Section 3. Section 4 looks at correlates of agricultural policies and economic structure under different regime types to examine the major prediction of the model. The final section presents concluding remarks.

2. The model

2.1. Setup: players, strategies and timing

Consider a dynamic game among various groups within a society. Specifically, assume that there are four groups of players: an incumbent leader (denoted by L), a regime insider (denoted by I), a continuum of urban citizens (denoted by U) and a continuum of rural citizens (denoted by R).

Political influences are carried out through non-democratic means. The leader's objective is to maximize his rent (taxes collected) from the output produced by the citizens. While doing so, however, he faces certain constraints depending on the relative political strength of each group within society. The main constraint is the threat that he faces from his own insider.

There are two states of the world, denoted by $q \in \{q_u, q_r\}$. In order to overthrow the leader, the insider needs the support of R if the state is q_r. He needs the support of U if the state is q_u.[2]

If the leader is overthrown, there is uncertainty regarding the relative political power of each group in the future (i.e. the state of the world may change). Such uncertainties are typically the case following political uprisings in weakly institutionalized states. Following Besley and Kudamatsu (2007) and Padro-I-Miquel (2007), the uncertainty is captured by random changes in the state variable q whenever there is a change in power (i.e. leader overthrow). In each period, assume that y_u and y_r quantities of output are produced by the urban and rural sectors, respectively.

The timing of the game and the strategies by each player are as follows:

Step 1 At time $t = 0$ (the initial period), nature randomly selects a leader and an insider from the citizens, and determines the type of the state $q_t \in \{q_u, q_r\}$ according to the probability distribution $p(q_u) = p_u > 0$ and $p(q_r) = p_r = 1 - p_u > 0$.

Step 2 All players observe the state of the world q_t.

Step 3 The leader announces tax rates on both sectors $\tau'_{u,t}, \tau'_{r,t} \in [0, \overline{\tau}]$ for some $\overline{\tau} \in [0, 1)$, and the share of the rent to be given to the insider $\delta'_t(\tau'_{u,t} y'_u + \tau'_{r,t} y_r)$, with $\delta'_t \in [0, 1]$.[3]

Step 4 The insider proposes whether to overthrow the leader and, if so, whether to do it with the support of U or R. Denote the insider's strategy by $\psi_t = (\psi_{u,t}, \psi_{r,t}) \in \Psi \equiv \{0,1\} \times \{0,1\}$. We have $\psi_u = 1$ ($\psi_r = 1$) if the insider calls for support from the urban (rural) citizens; otherwise, $\psi_u = 0$ ($\psi_r = 0$).

Step 5 Citizens decide whether to offer support for the insider's call: $z_{u,t}, z_{r,t} \in \{0,1\}$. Following Acemoglu and Robinson (2006), I assume that participating in a revolution to overthrow an incumbent is a costly activity. Hence, if $z_{s,t} = 1$ for $s \in \{u,r\}$ (i.e. if citizens participate in an overthrow), it costs them γy_s for some $\gamma > 0$.[4]

Step 6 If the leader is not overthrown, $q_{t+1} = q_t, \tau'_{u,t} = \tau_{u,t}, \tau'_{r,t} = \tau_{r,t}$ and $\delta_t = \delta'_t$; and the game continues from Step 2 in period $t + 1$.

Step 7 If the leader is overthrown, $\tau_{u,t} = \tau_{r,t} = 0$. The leader gets 0 in the future.[5] q_{t+1} takes either of the values with probabilities p_u and p_r. In period $t + 1$, the game continues from Step 2 with the insider as a new leader and a randomly selected citizen as an insider. This assumption implies that an insider who overthrows a leader and takes over power will face similar rivalry from his own insider. Leaders change, but the political regime remains the same.

The payoffs for player j, denoted by V^j, are the discounted sum of instantaneous consumptions C^j_t:

$$V^j = \sum_{t=0}^{\infty} \beta^t C^j_t$$

[1] Swinnen (2010) provides a detailed review of the literature.

[2] The main results do not change if more states are allowed for. For example, we can consider two additional states—the insider can overthrow the leader by himself (with no support) and the insider can overthrow the leader with the support of *either* U or R.

[3] The assumption that $\overline{\tau} < 1$ is a reduced form for non-political constraints faced by the leader. One such constraint is what is called the "dead-weight loss" where the actual revenue for the leader from a tax rate of τ will be $\tau - \alpha\frac{\tau^2}{2}$ for some $\alpha > 0$; see Meltzer and Richard (1981). The other constraint is what Acemoglu (2005) calls "economic power" of citizens where citizens can hide their output and evade taxes albeit at certain costs (such as resorting to informal activities which may give them lower returns) if the taxes are too high.

[4] The sequence between Steps 4 and 5 is not necessary for the conclusion on tax rates. The equilibrium tax rates will still be the same even if we interchange Step 5 and Step 4.

[5] An interpretation could be that he loses everything after having been purged.

where

$$C_t^j = \begin{cases} (1-\delta_t)\left(\tau_{u,t}y_u + \tau_{r,t}y_r\right), & \text{if } j \text{ is a leader in period } t. \\ \delta_t\left(\tau_{u,t}y_u + \tau_{r,t}y_r\right), & \text{if } j \text{ is an insider in period } t. \\ \left(1-\tau_{s,t}-z_{s,t}\gamma\right)y_s, s\in\{u,r\}, & \text{if } j \text{ is an ordinary citizen.} \end{cases}$$

The difference between probabilities p_u and p_r reflects the relative power of the two groups, U and R. A higher p_u, for example, implies that it is more likely that urban residents become important political constituencies for rival groups within the ruling circle (i.e. the leader and the insider). The opposite is true for a higher p_r.[6]

Finally, note that the distinction between urban versus rural groups is based on two main assumptions: the leader can impose separate tax rates on each sector and he needs to lower the taxes for the whole group in order to win the support of the group. Thus, to the extent that these two assumptions are realistic, the implications of the model can be relevant for analyzing policy biases among other types of groups as well.

2.2. Equilibrium

The equilibrium concept used in this analysis is a pure strategy Markov Perfect Equilibrium (henceforth MPE). The appealing feature of MPE is its analytical simplicity. Within each period, players play a sub-game perfect equilibrium. Along the equilibrium path, equilibrium strategies are functions of the state variable q. The following definition presents a precise equilibrium concept used in this analysis.

Definition. The MPE of this game is a set of the value functions $\{V_i(q) : i \in \{U,R,I,L\}\}$; strategy by the leader $(\tau_u,\tau_r,\delta)(q)$; strategy by citizens $z_u(q)$ and $z_r(q)$; and strategy by the current insider $\psi(q)$ such that:

- Given $(z_r,z_u,\psi)(q)$, $(\tau_u,\tau_r,\delta)(q)$ and $V_L(q)$ solve

$$V_L(q) = \max_{\tau_u,\tau_r\in[0,\overline{\tau}];\delta\in[0,1]} \left\{C_L(\tau_u,\tau_u,\delta,(z_u,z_r,\psi)(q),q) + \beta\mathbb{E}V_L(q')\right\}$$

- Given $(z_r,\tau_u,\tau_r,\delta,\psi)(q)$, $z_u(q)$ and $V_U(q)$ solve

$$V_U(q) = \max_{z_u\in\{0,1\}} \left\{C_U(z_u,(z_r,\tau_u,\tau_r,\delta,\psi)(q),q) + \beta\mathbb{E}V_U(q')\right\}$$

- Given $(z_u,\tau_u,\tau_r,\delta,\psi)(q)$, $z_r(q)$ and $V_R(q)$ solve

$$V_R(q) = \max_{z_r\in\{0,1\}} \left\{C_R(z_r,(z_u,\tau_u,\tau_r,\delta,\psi)(q),q) + \beta EV_R(q')\right\}$$

- Given $(z_u,z_r,\tau_u,\tau_r,\delta)(q)$, $\psi(q)$ and $V_I(q)$ solve

$$V_I(q) = \max_{\psi\in\Psi}\left\{C_I(\psi,(z_r,z_u,\tau_u,\tau_r,\delta)(q),q) + \beta EV_I(q')\right\}$$

The political constraint faced by the leader is binding only when $\gamma<\overline{\tau}$, and we assume this throughout the analysis.[7] Depending on the parameter values of the model, we will see that there are four cases with unique equilibrium tax rates in each case. These cases correspond to the leader's decision with regard to the group he wants to appease. The leader adopts one of the following four strategies:

Case 1 Irrespective of the state of the world, impose the maximum tax rate $\overline{\tau}$ on both U and R, and rely on the insider's support for survival.

Case 2 Lower τ_u if $q = q_u$ and lower τ_r if $q = q_r$, i.e. rely on the support of either U or R that can provide support for the insider.

Case 3 Lower τ_u when $q = q_u$ but impose $\tau_r = \overline{\tau}$ when $q = q_r$, i.e. rely on the support of U when $q = q_u$ and on the insider's support when $q = q_r$.

Case 4 Lower τ_r when $q = q_r$ but impose $\tau_u = \overline{\tau}$ when $q = q_u$, i.e. rely on the support of R when $q = q_r$ and on the insider's support when $q = q_u$.

What factors affect the leader's choice among the above four strategies? The following proposition states the assumptions needed to sustain each of the above four cases as the MPE outcome of the game.

Proposition 1. *Assume that, for $n, m \in \{r,u\}$ and $n \neq m$, either of the four sets of assumptions (A1–A4) is satisfied.*

$$\frac{\overline{\tau}}{1+\beta}\left(1-\beta\frac{y_m}{y_n}\right) \geq \gamma \tag{A1}$$

$$(1-\beta)\overline{\tau}-\overline{\tau}\beta\frac{y_m}{y_n} \leq \tau_m^* \tag{A2}$$

$$c_u - b_u\frac{y_r}{y_u} \leq \tau_u^* \leq a_u\frac{y_r}{y_u} - \overline{\tau} \tag{A3}$$

$$c_r - b_r\frac{y_u}{y_r} \leq \tau_r^* \leq a_r\frac{y_u}{y_r} - \overline{\tau} \tag{A4}$$

where

$$a_n = \left(\frac{1+\beta p_m}{p_n\beta}(\overline{\tau}-\gamma) - 2\overline{\tau}\right)$$

$$b_n = \frac{\beta(1-\beta)\overline{\tau}}{1-\beta^2 p_m} \tag{1}$$

$$c_n = \frac{\overline{\tau}[1-\beta(1-\beta p_m)]}{1-\beta^2 p_m}$$

$$\tau_m^* = \frac{1}{1-\beta p_m}(\gamma - \gamma\beta + \beta\overline{\tau} - \beta p_m\overline{\tau}) \tag{2}$$

Then, the leader's MPE strategy is such that Case 1 prevails if assumption A1 is satisfied. Similarly, either of Cases 2,3 or 4 prevail if either of the assumptions A2, A3 or A4, respectively, is satisfied.

An important factor that determines the leader's strategy is the relative size of the sectors. Note that Case 3 features urban bias in the sense that the leader lowers the urban tax rate whenever urban support is relevant (i.e. when $q = q_u$) but he does not lower the rural tax rate when rural support is relevant (i.e. $q = q_r$). Case 3 is likely to occur when the relative size of agriculture becomes larger. This is captured by assumption A3 that is needed to sustain Case 3 as an MPE outcome. Note that b_u (on the LHS of A3) is always positive. Moreover, if $a_u > 0$, assumption A3 can always be satisfied for a large enough y_r/y_u. The main intuition behind this result is that, when the relative size of agriculture increases, appeasing the rural population may require giving up a large amount of rent. Instead of lowering the taxes on the rural population to win their support, the leader prefers imposing the maximum tax rate on the rural population and rely on the insider's support.

Fig. 1 illustrates the relationship between the relative size of agriculture and the leader's strategy. When the two sectors are relatively equal

[6] Although γ is assumed to be the same for both U and R, in reality, it could also vary across U and R depending on the political tools available to the groups. Among many others, Ades and Glaeser (1995) and Bates (1984), for example, argue that urban residents tend to have better access to influence due to factors such as physical proximity to power centers, better access to information, and better ability to organize. In this model, the purpose of assuming a similar γ for U and R is to focus on the impact of economic structure on urban bias in spite of similar γ s for urban and rural residents.

[7] If $\gamma \geq \overline{\tau}$, the political constraint becomes irrelevant and the equilibrium tax rates are always equal to $\overline{\tau}$.

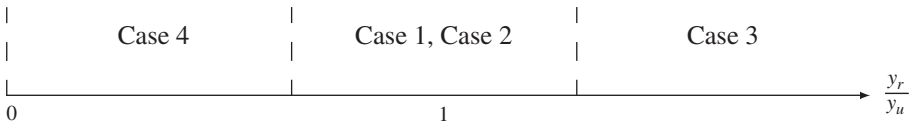

Fig. 1. Size of the agricultural sector and the leader's strategy.

(i.e., when y_r/y_u is in the neighborhood of 1), we are more likely to have Case 1 and/orCase 2. Case 3 is more likely to occur for higher values of y_r/y_u whereas the oppose holds for Case 4.

We now turn to the equilibrium tax rates, the insider's share of the rent and the strategies by all players. Lets define V_3 and V_4 as follows.

$$V_3 \equiv p_u(\tau_u^* y_u + \overline{\tau} y_r) + p_r \overline{\tau}(y_u + y_r)$$
$$V_4 \equiv p_u \overline{\tau}(y_u + y_r) + p_r(\overline{\tau} y_u + \tau_r^* y_r)$$

where τ_u^* and τ_r^* are given by (2). We will that V_3 and V_4 denote the expected total amount of rents (before the states are realized) collected by the leader under Cases 3 and 4, respectively.

Proposition 2. *Assume that either of the sets of assumptions (A1–A4) is satisfied. Then,*

- *the MPE urban tax rate $\tau_u(q)$ is given by*

$$\tau_u(q) = \begin{cases} \dfrac{\gamma - \gamma\beta + \beta\overline{\tau} - \beta p_u \overline{\tau}}{1 - \beta p_u} & \text{if either A2 or A3 holds and } q = q_u. \\ \overline{\tau} \quad \text{otherwise.} \end{cases}$$

- *the MPE rural tax rate $\tau_r(q)$ is given by*

$$\tau_r(q) = \begin{cases} \dfrac{\gamma - \gamma\beta + \beta\overline{\tau} - \beta p_r \overline{\tau}}{1 - \beta p_r} & \text{if either A2 or A4 holds and } q = q_r. \\ \overline{\tau} \quad \text{otherwise.} \end{cases}$$

- *the MPE insider's share $\delta(q)$ is given by*

$$\delta(q) = \begin{cases} \dfrac{\beta}{1+\beta} & \text{if A1 holds.} \\ \dfrac{\beta}{(1+\beta p_r)} \dfrac{V_3}{\overline{\tau}(y_u + y_r)} & \text{if A3 holds and } q = q_r. \\ \dfrac{\beta}{(1+\beta p_u)} \dfrac{V_4}{\overline{\tau}(y_u + y_r)} & \text{if A4 holds and } q = q_u. \\ 0 \quad \text{otherwise.} \end{cases}$$

- $\psi_i(q) = z_i(q) = 0$ for $i \in \{u,r\}$ and for all q.

Proof. See the appendix. □

When the leader prefers to lower taxes to the group of citizens that provide support to the insider needs, he lowers the tax rates to $\tau_u(q_u)$ and $\tau_r(q_r)$—lower than the maximum level $\overline{\tau}$. Both $\tau_u(q_u)$ and $\tau_r(q_r)$ are increasing in γ.[8] This happens because, as the cost of providing support increases, citizens are less willing to overthrow the leader even if the leader imposes high taxes.

$\tau_u(q_u)$ is decreasing in p_u. This outcome is driven by the uncertainty following a change in the leader—captured by the probabilities p_u and p_r. The group that has political power today may lose its power in the aftermath of the overthrow of a leader. For example, a higher p_u implies that urban residents are less concerned about losing power in the event of the overthrow of a leader (i.e., there is a higher likelihood that the next state will remain to be q_u in the event of the overthrow of a leader). Thus, they will be less willing to accept higher taxes. Knowing this, the leader imposes a lower tax rate. Similarly, $\tau_r(q_r)$ is decreasing in p_r. $\tau_u(q_u)$ and $\tau_r(q_r)$ are also increasing in β. The more forward-looking citizens are, the more they worry that future political power may slip out of their hands if they overthrow the current leader—a fear upon which the leader can capitalize to impose higher taxes.[9]

In the cases where the leader bribes the insider, the insider's share δ is increasing in two factors: (i) the amount of expected total rent if he were to seize power and (ii) the discount factor. The former sets the value of the outside option for the insider (i.e., overthrowing the leader). A more forward-looking insider would put more weight on future rents if he were to seize power. Thus, he requires a higher share of the current rent not to stage an overthrow.

3. Urban bias, political power and dominance of agriculture

The impact of political power (as measured by the probability distribution) depends on which of the four cases prevail and, for a given case, which state of the world we are in. For example, under *Case 1*, a change in p_u has no effect on the equilibrium τ_u. However, under *Case 3*, an increase in p_u decreases the equilibrium τ_u if the state is q_u. Thus, we will consider the expected equilibrium tax rates in order to have a more tractable and comprehensive measure of urban bias. Let $\mathbb{E}\tau_u$ and $\mathbb{E}\tau_r$ be given by

$$\mathbb{E}\tau_u = p_u \tau_u(q_u) + p_r \tau_u(q_r)$$
$$\mathbb{E}\tau_r = p_u \tau_r(q_u) + p_r \tau_r(q_r)$$

$\mathbb{E}\tau_u$ and $\mathbb{E}\tau_u$ are more comprehensive because they do not depend on the actual state.

An increase in p_u decreases $\mathbb{E}\tau_u$ in those cases where urban support is relevant (i.e., Cases 2 and 3). This happens for two reasons. First, $\tau_u(q_u)$ decreases as p_u increases. $\mathbb{E}\tau_u$ also decreases in p_u since $\tau_u(q_u)$ enters additively in the expression for $\mathbb{E}\tau_u$. Second, note that $\tau_u(q_u) \leq \tau_u(q_r)$. An increase in p_u decreases $\mathbb{E}\tau_u$ since a higher p_u means a larger weight for the smaller term in the expression for $\mathbb{E}\tau_u$ and a smaller weight for the larger term. Similarly, an increase in p_r decreases $\mathbb{E}\tau_r$ in the cases where rural support could be relevant (i.e., Cases 2 and 4). The following corollary summarizes these effects.

Corollary 1. *$\mathbb{E}\tau_u$ is decreasing in p_u if either of assumptions A2 and A3 holds. Similarly, $\mathbb{E}\tau_r$ is decreasing in p_r if either of assumptions A2 and A4 holds.*

Proof. See the appendix. □

This proposition is consistent with previous claims that urban bias, among other factors, is driven by disproportionate political power by urban residents (Ades and Glaeser, 1995). According to Corollary 1, the group with a higher p is likely to get relatively favorable tax rates.

Disproportionate political power by urban residents, however, is not a necessary condition for urban bias to emerge. Urban residents could be more likely to get favorable tax rates if the urban sector is small relative to the rural sector, as we saw in Proposition 1. Such a bias against agriculture can occur *despite* the relative political power of the rural residents (as measured by p_u and p_r). Consider the relative expected tax rates $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ as a measure of bias against agriculture. There is no bias

[8] Taking the derivatives, $\frac{\partial \tau_{r1}}{\partial p_r} = \frac{-\beta(\overline{\tau}-\gamma)(1-\beta)}{[1-\beta(p_r+p_{ur})]^2} < 0$, $\frac{\partial \tau_{u1}}{\partial p_u} = \frac{-\beta(\overline{\tau}-\gamma)(1-\beta)}{[1-beta(p_u+p_{ur})]^2} < 0$, $\frac{\partial \tau_{u1}}{\partial \gamma} = \frac{1-\beta}{[1-\beta(p_u+p_{ur})]^2} > 0$, $\frac{\partial \tau_{r1}}{\partial \gamma} = \frac{1-\beta}{[1-\beta(p_r+p_{ur})]^2} > 0$, $\frac{\partial \tau_{r1}}{\partial \beta} = \frac{(\overline{\tau}-\gamma)(1-(p_r+p_{ur}))}{[1-\beta(p_r+p_{ur})]^2} > 0$, $\frac{\partial \tau_{u1}}{\partial \beta} = \frac{(\overline{\tau}-\gamma)(1-(p_u+p_{ur}))}{[1-\beta(p_u+p_{ur})]^2} > 0$.

[9] Such a fear of losing political power is the main mechanism in what Padro-I-Miquel (2007) calls "the politics of fear" where leaders capitalize on citizens' fear of losing power in ethnically divided societies.

if $\mathbb{E}\tau_r/\mathbb{E}\tau_u = 1$, the bias is against agriculture if $\mathbb{E}\tau_r/\mathbb{E}\tau_u > 1$, and the bias is against the urban sector if $\mathbb{E}\tau_r/\mathbb{E}\tau_u < 1$. We have the following proposition stating the bias that is driven by the mere dominance of agriculture in the economy.

Proposition 3. *Assume that $p_u = p_r = 0.5$, i.e. there is no bias in political power. For large enough y_r/y_u, $\mathbb{E}\tau_r/\mathbb{E}\tau_u \geq 1$. Moreover, for a large enough y_r/y_u, $\mathbb{E}\tau_r/\mathbb{E}\tau_u > 1$ if $(1+\beta p_r)(\bar{\tau}-\gamma)/(p_u\beta) - 2\bar{\tau} > 0$.*

Proof. See the appendix. □

The condition in this proposition is more likely to be satisfied as $(\bar{\tau}-\gamma)$ becomes larger. γ is the citizens' cost for providing support for the insider, imposing an upper bound on the tax rate that the leader can set without inciting the citizen's support for the insider. $\bar{\tau}$ is the maximum feasible tax rate if the leader reverts to bribing the insider (instead of lowering the taxes for the citizens). Hence, the extra amount of rent that the leader collects if he reverts to relying on the insider's support is increasing in $(\bar{\tau}-\gamma)$. The condition in this proposition implies that the extra rent must be large enough so that the leader chooses to rely on the insider's support when the share of agriculture increases.

Fig. 2 distinguishes the impact of political power and agriculture on urban bias. We have the relative expected tax rate on the vertical axis and the relative size of agriculture on the horizontal axis. In Panel A, it is assumed that there is no bias in political power ($p_u = p_r$). $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ equals one (i.e. there is no urban bias in policy) if the urban and rural sectors are of a relatively equal size (i.e. if y_r/y_u are in the neighborhood of 1). However, as the share of the rural sector increases, $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ shifts to a level above one (i.e. an urban bias will emerge).

Panel B illustrates the impact of political power on urban bias. As p_u increases, $\mathbb{E}\tau_r/\mathbb{E}\tau_u$ shifts upward.

4. Empirical evidence

This section takes a look at the data to verify whether the statistical correlates between the share of agriculture in the national economy and observed policies are consistent with Proposition 3. I will first discuss the main variables in the analysis and the data source. Then, I will proceed to the regression analysis.

4.1. Data

4.1.1. Rates of assistance

The two key variables in the analysis are the nominal rate of assistance (NRA) and the relative rates of assistance (RRA) to agriculture. The estimates for NRA and RRA are compiled by a team of researchers under the auspices of the World Bank. The data source is Anderson and Valenzuela (2008).

NRAs measure the subsidies (or taxations) that the agricultural sector receives (or pays) as a result of mainly government-imposed measures. Details of the measurement steps are described in Anderson et al. (2008). For each country in the sample, NRAs are estimated for a variety of agricultural commodities. Then, a weighted average of NRAs for each commodity is taken to estimate overall NRA to the agricultural sector in the country. The nominal rate of assistance that a particular agricultural product i receives, denoted by NRA_i is defined as

$$NRA_i = \frac{D_i}{R_i} - 1 \tag{3}$$

where D_i denotes the actual return that a producer of agricultural product i receives while R_i denotes the return that would have prevailed under a free market condition. An agricultural commodity i is said to be subsidized (or taxed) if $NRA_i > 0$ (or $NRA_i < 0$). The subsidies/taxes take various forms such as tariffs on competing imported items, export subsidies/taxes, direct production subsidies/taxes to farmers, exchange rate manipulations, and subsidies/taxes on inputs for production. The overall NRA that the agricultural sector receives is computed as a weighted average of NRAs offered to each commodity.

$$NRA = \sum_i \alpha_i NRA_i \tag{4}$$

where α_i is the ratio of the value of commodity i to the value of the country's total agricultural produce. Hence, α_i measures the relative economic importance of commodity i in the country's agricultural sector. For each country included in the sample, the annual time series of NRAs are estimated spanning from 1955 to 2007. For some countries, the time series may not cover the entire period of 1955–2007. A total of 75 countries are included in the estimation. According to Anderson and Valenzuela (2008), the countries together account for 92% of the world population and agricultural GDP and 95% of total GDP. They also account for more than 85% of farm production and employment in each of Africa, Asia, Latin America and the transition economies of Europe and Central Asia.

RRA, on the other hand, measures the net assistance offered to agriculture *relative* to other sectors. It is computed using the formula

$$RRA = \frac{1 + NRA}{1 + NRA_{nonagri}} - 1 \tag{5}$$

where $NRA_{nonagri}$ measures the nominal rate of assistance offered to non-agricultural sectors.

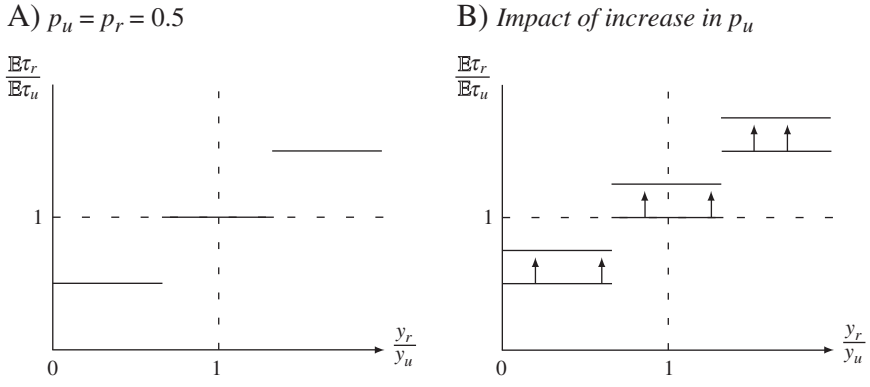

Fig. 2. Size of the agricultural sector, political power and urban bias.

4.1.2. Other variables

As a measure of the relative importance (or extent of dominance) of agriculture in the national economy, I use the ratio of value-added by the agricultural sector to total value-added in the whole economy (i.e. the sum of value added by all sectors). The correlation between the share of agricultural value-added in the national economy and the NRA/RRA will be used to study the statistical relationship between agricultural dominance and anti-agricultural policy. Other variables included in the statistical analysis are the ratio of agricultural to non-agricultural population, income from resource extraction, number of conflicts, number of anti-government demonstrations, and government consumption (as a percentage of GDP). The data on conflicts, anti-government demonstrations, and government consumption are from Teorell et al. (2011), Banks (2001) and Heston et al. (2011), respectively. The data source for the other viarlables is World Development Indicators (2010).

Since the model focuses on dictatorial regimes, a measure of political freedom is needed to distinguish regimes that are dictatorial from those that are not. I use the Freedom in the World (2010) data that ranks countries as *free*, *partially free* or *not free*.

4.2. Estimation results

Tables 1 and 2 present fixed-effect panel regression estimates to examine the relationship between the output share of agriculture in the national economy (defined as the ratio of value added by agriculture to total value added in the economy) and rate of assistance. An advantage of the fixed-effect estimate is that it controls for time-invariant factors such as geography and historical legacies. As the mechanisms outlined in the model pertain to non-democratic regimes, the estimations in Tables 1 and 2 are carried out for non-democratic regimes (labeled *not free* or *partially free* in the Freedom House category). In Table 1, the dependent variable is NRA. The dependent variablein Table 2 is RRA.

Column (A) in Table 1 includes the share of value added in agriculture as the only right-hand-side variable. The theoretical model predicts that, in dictatorial regimes, the expected agricultural tax rates are higher in economies with a greater share of agricultural GDP. The estimated coefficient is negative. As the output share of agriculture in the economy increases, countries tend to impose higher tax rates on the agricultural sector, which is consistent with the prediction of the model. A unit increase in the share of agriculture decreases the NRA by almost a proportional amount (0.92).

Columns (B) to (E) verify whether the correlation between the share of agricultural output and NRA disappears if we control for alternative explanations. One such explanation follows from Olson (1971) where, due to a free-riding problem, smaller groups may be more effective at lobbying than larger groups. Applied to agricultural policies, this argument implies that by reducing the lobbying incentive of farmers, an increase in the relative size of the agricultural population may thus have a negative effect on NRA (Anderson, 1995; Olson, 1986). If the agricultural population share is correlated with the agricultural output share (which is true in the data), the observed negative correlation between the agricultural output share and NRAs may also be due to farmers' weaker incentive to lobby. Note that the collective action logic is a different mechanism to that outlined by the model in this paper. According to the collective action logic, a larger agricultural population share leads to lower NRAs by reducing the political power of farmers (by changing the farmers' incentive to lobby). According to the model in this paper, however, a larger agricultural output share leads to lower NRAs by changing the leader's incentive despite the political power of the agricultural population (see Proposition 3). If the observed negative correlation between agricultural output share and NRAs is driven by the collective action logic, the correlation should become insignificant when we control for the agricultural population share. Column (B) in Table 1 thus controls for the ratio of agricultural to non-agricultural population. The estimated coefficient is negative and significant, suggesting that the collective action logic is indeed empirically valid. However, the coefficient on the value added share of agriculture is still significantly negative.

Another potential explanation is related to the fiscal capacity of the state (i.e. the ability of the state to mobilize fiscal resources). At the early stage of development, countries may have a lower capacity to collect taxes (see, e.g., Acemoglu, 2005; Besley and Persson, 2010). Such countries may thus have to rely on few agricultural products (particularly tradeable commodities) to raise revenue. Moreover, countries with a higher share of agricultural output may have lower state

Table 1
Share of agriculture and NRA in non-democracies.

	(A)	(B)	(C).	(D)	(E)
Agri. value added	−0.92***	−0.67**	−0.77**	−0.93***	−0.93***
	(0.26)	(0.31)	(0.30)	(0.33)	(0.32)
Agri/non-Agri pop.		−0.08***	−0.05**	−0.04*	−0.04*
		(0.03)	(0.02)	(0.02)	(0.02)
Energy (% of GNI)			−0.00	−0.00	−0.00
			(0.00)	(0.00)	(0.00)
Mineral(% of GNI)			−0.01***	−0.01***	−0.01***
			(0.00)	(0.00)	(0.00)
Government share			1.14**	1.05**	1.11**
			(0.49)	(0.46)	(0.45)
Manuf. value added				0.54	0.57
				(1.21)	(1.20)
Manuf. square				−3.45	−3.52
				(2.53)	(2.51)
Armed conflicts					−0.02
					(0.02)
Observations	953	789	719	719	719
Countries	44	38	36	36	36
R-Square	0.073	0.122	0.156	0.200	0.204

The dependent variable is the nominal rate of assistance to agriculture. Country-fixed effects are included in all of the regressions. Robust standard errors clustered by country are in parentheses.
* significant at the 10% level.
** significant at the 5% level.
*** significant at the 1% level.

Table 2
Share of agriculture and RRA in non-democracies.

	(A)	(B)	(C)	(D)	(E)
Agri. value added	−1.61***	−0.97***	−1.05***	−1.19***	−1.19***
	(0.31)	(0.34)	(0.34)	(0.42)	(0.42)
Agri/non-Agri pop.		−0.10***	−0.08***	−0.08***	−0.08***
		(0.02)	(0.02)	(0.03)	(0.03)
Energy (% of GNI)			−0.01	−0.01**	−0.01**
			(0.00)	(0.00)	(0.00)
Mineral(% of GNI)			−0.01***	−0.01***	−0.01***
			(0.00)	(0.00)	(0.00)
Government share			1.05**	0.93**	0.93**
			(0.41)	(0.39)	(0.40)
Manuf. value added				1.00	1.00
				(1.33)	(1.33)
Manuf. square				−4.71	−4.71
				(2.83)	(2.84)
Armed conflicts					0.00
					(0.02)
Observations	798	780	712	712	712
Countries	36	35	33	33	33
R-Square	0.163	0.200	0.243	0.289	0.289

The dependent variable is the relative rate of assistance to agriculture. Country-fixed effects are included in all of the regressions. Robust standard errors clustered by country are in parentheses.
* significant at the 10% level.
** significant at the 5% level.
*** significant at the 1% level.

capacity, since typically, as the economy grows along with higher state capacity, the economy passes through a structural change where the share of agricultural output falls. In order to control for this channel, I make use of two observations in the recent literature onstate capacity—(i) countries with a higher fiscal capacity tend to have a larger government share of GDP, and (ii) resource rich countries tend to have a lower fiscal capacity (see [Acemoglu, 2005; Besley and Persson, 2010, 2011; Sachs and Warner, 1995). Thus, Column (C) controls for two sets of variables: the share of government consumption in GDP and resource income as a percentage of GNI. The estimated effect of the control variables is consistent with this view. Resource availability, as captured by the two variables Energy Income (% of GNI) and Mineral Income (% of GNI), decreases NRA. The government share of GDP (as a proxy for state capacity) has a positive and significant effect. The coefficient on the output share of agriculture still remains significantly negative.

A third potential explanation relates to the role of ideology. In countries with a lower level of industrialization, governments' ambition to develop their manufacturing sector through resource transfer from the agricultural sector is often mentioned as areason for anti-agricultural policies in many developing countries (Krueger, 1996; Schiff and Valdés, 2002). To control for such an effect, column (D) includes the share of the manufacturing sector in the total value added of the country. Dueto the potential non-linearity of this effect, partly because of the non-linearity in the share of the manufacturing sector in the stage of economic transformation, the square term is also included. Consistent with this view, the estimated coefficients show that NRAs increase as the share of the manufacturing sector increases (before reaching a maximum). The coefficient on the agricultural output share largely remains unaltered.

Ades and Glaeser (1995) argue that unstable governments tax the rural sector more. The last column (E) accounts for instability by controlling for the number of armed conflicts. The coefficient has the expected sign (is negative), although it is insignificant[10].

Finally, Table 2 reports estimation results with RRA as the dependent variable. NRA and RRA are highly correlated (with a correlation coefficient of 0.97). The estimation results show the positive effect of a higher agricultural output share on relative agricultural tax rates. The coefficient also remains significant when we control for the alternative explanation (columns (B) through (E)).

Corresponding regressions are also carried out for democratic regimes, i.e. regimes that are categorized as *free* by Freedom House. The results are reported in Table 3. For democratic regimes, the share of agricultural value added does not have a significant effect on NRA.[11] This finding suggests that the relationship between the agricultural output share and anti-agricultural policies is primarily driven by political forces that are typical for non-democratic regimes. The model in this paper provides such a mechanism.

To summarize, the correlation between the output share of agriculture and anti-agricultural policies is consistent with the prediction of the model. Moreover, alternative specifications to verify whether the observed correlation is driven by alternative explanations show that those explanations are relevant and need to be controlled for. However, controlling for those explanations does not nullify the initial result.

Table 3
Share of agriculture and NRA.

	(A)	(B)	(C)	(D)	(E)
Agri. value added (ratio)	0.53	0.05	−0.11	−0.28	−0.28
	(0.69)	(0.59)	(0.57)	(0.64)	(0.64)
Agri/non-Agri pop.		−0.30**	−0.18	−0.16	−0.17
		(0.11)	(0.15)	(0.25)	(0.28)
Energy income (% of GNI)			−0.02	−0.03	−0.03
			(0.03)	(0.03)	(0.03)
Mineral income (% of GNI)			−0.04**	−0.05**	−0.05**
			(0.02)	(0.02)	(0.02)
Government share			2.82	1.54	1.54
			(1.78)	(1.54)	(1.55)
Manuf. value added (ratio)				12.70**	12.69**
				(5.16)	(5.21)
Manuf. square				−29.35***	−29.33**
				(10.82)	(10.92)
Number of armed conflicts					−0.00
					(0.01)
Observations	998	848	844	844	844
Countries	50	45	44	44	44
R-Square	0.002	0.008	0.026	0.084	0.084

The dependent variable is the nominal rate of assistance to agriculture. Country-fixed effects are included in all of the regressions. Robust standard errors clustered by country are in parentheses.
* significant at the 10% level.
** significant at the 5% level.
*** significant at the 1% level.

5. Conclusion

A heavy systematic bias against the rural population, which constitutes the majority of the poor, still remains one of the major policy features that characterize many developing countries. As argued by Bezemer and Headey (2008), the bias remains to be "the largest institutional impediment to growth and poverty reduction in the world's poorest countries."

One may expect the political incentives that perpetuate anti-agricultural policies to respond to changes in economic structure, and the incentives to respond differently in different political environments. This paper develops a formal political economy model to explain urban bias in dictatorial regimes. By identifying the mechanisms that link economic structure with political incentives under dictatorial regimes, the model sheds some light on the impact of economic structure and policy outcomes. In economies with a larger share of agricultural output, the model shows that dictatorial regimes have the incentive to impose higher agricultural tax rates even if there is no bias in political power. The empirical evidence is consistent with the prediction of the model. Alternative empirical specifications suggest that the mechanism outlined in the model complements existing theories of urban bias.

This paper examines the implication of differences in economic structure among dictatorial regimes. Given that urban bias is primarily a feature of dictatorial regimes, and that there is a large heterogeneity among dictatorships with respect to political structures, an important avenue for future research may be to examine the policy implications of such heterogeneity within dictatorships. Besley and Kudamatsu (2007), for example, emphasize the importance of differences between party and autocratic dictatorships. Future research may examine the implication for urban bias of differences in political structure within dictatorial regimes. The large dataset on agricultural taxes and subsidies made available by Anderson and Valenzuela (2008) also provides an opportunity to empirically test alternative theories.

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[10] The result is similar when an alternative measure of instability, namely, the number of anti-government demonstrations from Banks (2001), is controlled for.
[11] This result still holds if we have RRA (instead of NRA) as the dependent variable.

Appendix A. Proof of Propositions 7 and 2

We follow the usual procedure where we first conjecture that the set of strategies are MPE strategies and then verify the claim.[12]

A.1. MPE—Case 1

Note that, when $q = q_u$, urban residents are indifferent between paying the current tax τ_u and participating in an overthrow of the leader (upon the insider's call to do so) if

$$\frac{\beta(1-\tau_u(q_u))}{1-\beta} + 1-\tau_u = 1-\gamma + \frac{\beta}{1-\beta}(p_u(1-\tau_u(q_u)) + p_r(1-\overline{\tau}))$$

Under the conjecture, $\tau_i(q_s) = \overline{\tau}$ for all $i, s \in \{r,u\}$. So the above condition becomes

$$\frac{\beta(1-\overline{\tau})}{1-\beta} + 1-\tau_u = 1-\gamma + \frac{\beta}{1-\beta}(p_u(1-\overline{\tau}) + p_r(1-\overline{\tau}))$$
$$\tau_u = \gamma$$

By assumption A1, however, the leader is better off increasing the taxes to $\overline{\tau}$ and sharing the rent with the insider. Since the insider gets V_1 in each period, he does not have the incentive to call for an overthrow of the leader.

The insider's expected pay-off if he seizes the leadership is

$$\beta\frac{(1-\delta)\overline{\tau}(y_u + y_r)}{1-\beta}$$

The insider's pay-off if he continues to be an insider is

$$\frac{\delta\overline{\tau}(y_u + y_r)}{1-\beta}$$

When $\delta = \beta/(1+\beta)$, the above two pay-offs are equal. Hence, the insider does not have an incentive to stage an overthrow of the leader.

We also need to verify that the leader does not have the incentive to lower taxes to the citizens instead of bribing the insider:

$$(1-\delta)\overline{\tau}(y_u + y_r) \geq \gamma y_u + \overline{\tau}y_r$$
$$\geq \overline{\tau}y_u + \gamma y_r$$

This condition will be satisfied under assumption A1.

A.2. MPE—Cases 2, 3 and 4

Given the conjecture under Cases 2 and 3, and when $q = q_u$, urban residents are indifferent between paying the current tax τ_u and participating in an overthrow of the leader (upon the insider's call to do so) if

$$\frac{\beta(1-\tau_u(q_u))}{1-\beta} + 1-\tau_u = 1-\gamma + \frac{\beta}{1-\beta}(p_u(1-\tau_u(q_u)) + p_r(1-\overline{\tau}))$$
$$\tau_u = \gamma - \frac{\beta}{1-\beta}(p_r(1-\overline{\tau}) - (1-p_u)(1-\tau_u(q_u)))$$
$$\tau_u = \gamma + \frac{\beta}{1-\beta}((1-p_u)(\overline{\tau} - \tau_u(q_u)))$$

In equilibrium, $\tau_u = \tau_u(q)$, which implies that $\tau_u = \tau_u^*$ (given by Eq. (2)).

[12] See, for example, Hassler et al. (2003).

Similarly, under Cases 2 and 4, and when $q = q_r$, rural citizens are indifferent between paying the current tax τ_r and protesting if

$$\frac{\beta(1-\tau_r(q_r))}{1-\beta} + 1-\tau_r = 1-\gamma + \frac{\beta}{1-\beta}(p_u(1-\overline{\tau}) + p_r(1-\tau_r(q_r)))$$
$$\tau_r = \gamma + \frac{\beta}{1-\beta}((1-p_r)(\overline{\tau} - \tau_r(q_r)))$$

In equilibrium $\tau_r = \tau_r(q)$, which implies that $\tau_r = \tau_r^*$ (given by Eq. (2)).

The leader does not have the incentive to decrease taxes below what is required to keep the urban and rural residents just indifferent between protesting or not (i.e. τ_u^* and τ_r^*).

If the leader increases the tax rates beyond τ_u^* and τ_r^*, he must appease the insider as citizens will support the insider's call for leader change. We verify that either of the assumptions A2, A3 or A4 imply that increasing taxes to $\overline{\tau}$ and sharing the rent with the insider is not optimal for the leader.

Case 2

Given the conjecture under Case 2, the discounted value of the expected future pay-off from remaining an insider is zero. The expected pay-off for the insider from seizing the leadership is:

$$\frac{\beta}{1-\beta}\left[p_u(\tau_u^* y_u + \overline{\tau}y_r) + p_r(\overline{\tau}y_u + \tau_r^* y_r)\right]$$

If the leader decides to rely on the insider's support, the insider's share has to be large enough so that he does not stage an overthrow of the leader:

$$\delta\overline{\tau}(y_u + y_r) = \frac{\beta}{1-\beta}\left[p_u(\tau_u^* y_u + \overline{\tau}y_r) + p_r(\overline{\tau}y_u + \tau_r^* y_r)\right]$$
$$\Rightarrow \delta = \frac{\beta}{1-\beta}\frac{1}{\overline{\tau}(y_u + y_r)}\left[p_u(\tau_u^* y_u + \overline{\tau}y_r) + p_r(\overline{\tau}y_u + \tau_r^* y_r)\right]$$

For the leader to prefer lowering the taxes to the citizens (instead of bribing the insider), we should have:

$$\tau_u^* y_u + \overline{\tau}y_r, \overline{\tau}y_u + \tau_r^* y_r \geq (1-\delta)\overline{\tau}(y_u + y_r)$$

This is satisfied by assumption A2.

Thus, the leader proposes τ_u^* and τ_r^* as his optimal strategy. And knowing that he will not get the support from the citizens, the insider does not have the incentive to call for an overthrow of the leader.

Case 3

The value of seizing power equals

$$\frac{\beta}{1-\beta}\left[p_u(\tau_u^* y_u + \overline{\tau}y_r) + p_r(1-\delta)\overline{\tau}(y_u + y_r)\right]$$

Given the conjecture, when $q = q_r$, the discounted value of expected pay-offs from remaining an insider is

$$\frac{\delta\overline{\tau}(y_u + y_r)}{1-\beta}$$

where, according to Proposition 2,

$$\delta = \frac{\beta}{(1+\beta p_r)\overline{\tau}(y_u + y_r)}\left[p_u(\tau_u^* y_u + \overline{\tau}y_r) + p_r\overline{\tau}(y_u + y_r)\right]$$

Thus, when $q = q_r$, the insider does not have the incentive to overthrow the leader.

Given the conjecture, when $q = q_u$, the discounted value of expected future pay-offs from remaining an insider is zero. If the leader decides to bribe the insider, the leader's offer, denoted by δ_u below,

must be large enough to make the insider indifferent between seizing power and receiving the rent today:

$$\delta_u\overline{\tau}(y_u+y_r)\geq\frac{\beta}{1-\beta}\left[p_u(\tau_u^*y_u+\overline{\tau}y_r)+p_r(1-\delta)\overline{\tau}(y_u+y_r)\right]$$
$$\Rightarrow\delta_u\geq\frac{\beta}{1-\beta}\frac{1}{\overline{\tau}(y_u+y_r)}\left[p_u(\tau_u^*y_u+\overline{\tau}y_r)+p_r(1-\delta)\overline{\tau}(y_u+y_r)\right]$$

Assumption A3 means that: (i) when $q=q_r$ the leader prefers to offer δ to the insider rather than lowering the rural tax rate to τ_r^* and (ii) when $q=q_u$, the leader prefers lowering the urban tax rate to τ_u^* to offering the insider δ_u.

Case 4

Proving Case 4 follows similar steps as Case 3.

Appendix B. Proof of Corollary 1

We take the derivatives of $\mathbb{E}\tau_u$ with respect to the probabilities and see whether they are negative or positive.

$$\begin{aligned}1\mathbb{E}\tau_u&=p_u\tau_u(q_u)+p_r\tau_u(q_r)\\&=p_u\tau_u(q_u)+(1-p_u)\tau_u(q_r)\\\Rightarrow\frac{dE\tau_u}{dp_u}&=\tau_u(q_u)+p_u\frac{\partial\tau_u(q_u)}{\partial p_u}-\tau_u(q_r)+(1-p_u)\frac{\partial\tau_u(q_r)}{\partial p_u}\end{aligned}$$

Under Cases 2 and 3, $\tau_u(q_u)=\tau_u^*$ and $\tau_u(q_r)=\overline{\tau}$. Thus,

$$\frac{d\mathbb{E}\tau_u}{dp_u}=\tau_u^*+p_u\frac{\partial\tau_u^*}{\partial p_u}-\overline{\tau}+(1-p_u)\times0$$

Since $\partial\tau_u^*/\partial p_u=-(1-\beta)\beta(\overline{\tau}-\gamma)/(1-\beta p_u)^2<0$,

$$\frac{d\mathbb{E}\tau_u}{dp_u}=p_u\frac{\partial\tau_u^*}{\partial p_u}-2\overline{\tau}<0.$$

Similar steps can be followed to prove that $\mathbb{E}\tau_r$ is decreasing in p_r if either of assumptions A2 and A4 holds.

Appendix C. Proof of Proposition 3

First, note that if $p_u=p_r$, then $\mathbb{E}\tau_r/\mathbb{E}\tau_u=1$ under Case 1 and 2. Under Case 3, $\mathbb{E}\tau_r/\mathbb{E}\tau_u>1$. Under Case 4, $\mathbb{E}\tau_r/\mathbb{E}\tau_u<1$. So we prove this proposition by proving that given that the condition $(1+\beta p_r)(\overline{\tau}-\gamma)/(p_u\beta)-2\overline{\tau}>0$ is satisfied, then assumption A3 is satisfied for a large enough y_r/y_u. This is true because, as y_r/y_u gets arbitrarily large, the LHS of A3 approaches minus infinity and the RHS of A3 approaches positive infinity.

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