CORRUPTION, TAX EVASION AND ECONOMIC DEVELOPMENT IN ECONOMIES WITH HIERARCHIAL TAX ADMINISTRATIVE SYSTEM

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ABSTRACT

The paper looks into joint determination of corruption and development where there is hierarchial bureaucratic setup; tier one-bureaucrat and tier two bureaucrats. Corruption happens at two level once when tier one bureaucrat collude with households for tax evasion and another when tier one and tier two bureaucrats collude to hide corruption.. The paper determines that at high level of corruption, there is low development and at low incidence of corruption, there is high development.

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1. Introduction

In the last decade, there has been consistent focus on the effect of the corruption on economic growth and development. The literature has been trying to identify the theoretical and empirical proof of what exactly is happening in economies. So far, there has been certain progress for theoretical studies show that the presence of corruption in an economy is hindrance for the economic growth and economic development. The evidence in these papers shows that there is a negative relationship between corruption and growth through multiple channels, (Shleifer & Vishny, 1993; Barreto & Alm, 2003; and Wadho, 2013). The empirical literature shows that economies with high corruption have low economic growth and development figures, (Mauro, 1995; Mo, 2001). The paper adds to the growing literature in the direction of describing joint determination of corruption and economic growth and development. There has been lack of theoretical work, which hampers the statistical work in this direction. In this paper, I study corruption in the tax compliance problem under hierarchical bureaucratic setup where tax collectors can collude with tier two bureaucrats and taxpayers, and its repercussion for economic growth and development.

Corruption is defined as misuse of public office for private gains, (Barreto, 2000; Banerjee, Mullainathan & Hanna, 2012). According to Barreto and Alm (2003), these public officials are repeatedly found self seeking, and they abuse their public position for personal gain. Their actions like demanding bribe to issue license, for exchange of money awarding contracts, industrialists who contribute extend their subsidies, stealing from public treasury and selling government-owned commodities at black market prices.

Among economists, there are ambiguous beliefs about the impact of corruption on economic growth. One strand of literature supports that the presence of corruption in an economy with institutional inefficiency that appears in the form of weak legislative and judicial systems and bureaucratic red tape tend to enhance economic growth, (Mo, 2001; Aidt, 2009). The alternative strand of literature is much stronger and has provided with sufficient theoretical and empirical justification for negative relation between economic growth and corruption. Corruption through the misallocation of resources and unequal distribution of wealth in economy not only slowdowns the economic growth but also reduces the standard of living in an economy, (Blackburn, Bose & Haque, 2010).

In theoretical literature, Shleifer and Vishny (1993) elaborates that corruption is expensive for distortions involved require secrecy for corruption. The demand of secrecy shifts the country's investment away from highest value projects (health and education) into potentially useless projects (defense and infrastructure). This is proved by empirical readings where Mauro (1995) finds that corruption lowers private investment, thereby reducing economic growth. In his paper, Mo (2001) established that economic growth decreases by 0.72% when corruption increases by 1%. Aidt (2009) in his paper establishes that corruption reduces the growth rate of genuine wealth substantially, thus corruption proves a hindrance for sustainable development.

Economies with corruption tend to have tax evasion problem. The revenue generation of any economy is done through tax collection. Barro (1991) through endogenous growth model show that tax financed government services effect production or utility. Which simply states that revenue collected through taxation of households is utilized either to provide utility services in the economy or used in production process to enhance growth.

The revenue collected through taxes is used for investment in public services and physical capital. In an economy, the presence of physical capital not only shows the existence of resources but also the ability to convert the raw resources into output. Romer (1994) in his article elaborates that as the level of the physical capital in economy increases the economy tends to move towards high growth. In addition, the investment in physical capital accelerates the spillover in economy. According to Solow growth model as investment in capital increases the output produced in economy also increases which translates as the economic growth and later economic development, (Solow, 1994).

The theoretical literature has been focusing on the problem of tax evasion and economic growth. According to the literature on corruption, tax evasion is a form of corruption. The problem of tax evasion seems to have varied impact on the economic growth. Lin and Yang (2001) study static as well as dynamic model of tax evasion. In the analysis of the static model, it is seen that at low level of taxes, the extent of tax evasion was small and the growth was decreasing. Intuitively at a particular time, the income of individuals is same and they consume and save a certain portion of their income along with being taxed. If the income is not changing then their saving remains same as of which change in investment would be either zero or negative. Furthermore, the dynamic model shows that increase in the level of taxes in a continuous time allows tax evasion to take place because of which saving increases, investment goes up and there is growth in economy.

In an endogenous growth model with tax evasion and economic growth, Eichhorn (2004) show that tax evasion is beneficial for growth as households evade taxes only if it is profitable such that it leaves higher amount of income for saving. The poor provision of public goods does not have impact on growth, as it is considered for consumptive purpose alone.

In recent macroeconomic studies, the relationship between economic growth and fiscal decentralization and its impact on corruption has been of debate. Fiscal decentralization classifies the government into tiers where the local government acts as a subordinate tier in a multi-tiered system, the principle defining the roles and responsibility of each tier are clearly specified, (Shah & Shah, 2007). Fiscal decentralization is defined as division of government into sub-national government units with autonomy over provision of public goods and services, (Bjedov & Madies, 2010). According to the article by Amagoh and Amin (2012) such classification of the government body into tiers improves the efficiency level along with economy's output which leads to economic growth. Hierarchical tax administrative system is a form of fiscal decentralization. Separate government department, the federal bureau of revenue, collects taxes. In the department, there is delegation of power. The superiors delegate authority to tax inspectors, which certainly does not mean there is no check on the performance of tax collectors or on collected revenue.

The benefit of multi-tier government is seen in economies with no corruption but in economies where corruption is prevalent, the benefits are overshadowed by disadvantages, which mainly include poor accountability and poor efficiency level. In an argument against the multi-tier government system, Shleifer and Vishny (1993) points out that delegation of power results in dispersion of the government decision making, as of which lack of coordination among bureaucrats result in excess rent extraction.

In an empirical paper Enikolopov and Zhuravskaya (2003) analyze data of 95 countries for 25 years find that strong party system is essential for the decentralization to be beneficial for the less developed countries in terms of better economic growth, quality of government and provision of public goods. In another study by Fan, Lin and Triesman (2009) where 80 countries were considered it is seen that as tiers in the government increases, the frequency of bribery for government contracts, connection to public utilities and customs also increases. Furthermore, this relationship was strongest for the business licenses and tax collection.

Blackburn, Bose and Haque (2010) (hereafter BBH) analyzed neo classical growth model where bureaucrats are employed as agents of government for tax collection. Corruption in the paper is represented through bribery that takes place between households and tax collectors. The revenue generated is used for the purpose of investment in economy by the government. Public officials not adequately paid tend to involve in corruption to make their ends meet. Also how easily individuals can hide the illegal income without being caught is another reason that people get involved in illegal activity.

The basic framework of my model stems from Wadho (2009) model (hereafter W-model) with changes. In W-model the endogenous monitoring of the tax collectors is being done so that corruption can be caught. As per the W-model corruption will only take place when corrupt tax collector meets with corrupt household.

My model combines various aspects of the BBH-model and the W-model. From W-model it takes the basic setup of the population with addition, external effective monitoring. The BBH-model and W-model essentially have the same setup for the tax collectors and the households, but my model introduces another player in the environment that is tier two bureaucrats. The tax administration department is a two-tier government body. Tier one bureaucrats are tax collectors that are responsible for collecting the taxes, these agents are hired by government. The government for monitoring of tax collectors has appointed second tier bureaucrats known as effective auditors. These bureaucrats are responsible for overseeing the tax collection process along with maintaining a corrupt free setup. The taxes are collected from household who belong to high-income bracket; the government itself has determined the rate of taxes corresponding to the income bracket. Various theoretical and empirical papers have elaborated the importance of the decentralized government but such concept has not been related to the sole purpose of tax collection in a developing economy.

Both tier one and tier two bureaucrats have the opportunity to be corrupt. There are two level at which corruption takes place; 1) corruption in the form of bribery that tier one bureaucrats take from households such that they are reported as low income households, 2) corruption that appears in the form of paying-off tier two bureaucrats by tier one bureaucrats so that during the audit they are not caught.

The payoffs of tier two bureaucrats and tax collectors would be demonstrated through Nash bargaining. Cerqueti and Coppier (2009) use the Nash bargaining to explain the payoff of inspector and the entrepreneur. Similarly, my paper will first establish Nash bargaining set up between tier two bureaucrats and keeping the bribe share in mind tax collectors will ask for bribe from the households.

The focus of my model is not just tax collection but it relates to the savings of the economy that is the catalyst of economic growth and development. My model through various manipulations will show that investment in equilibrium with corruption is less than that of the investment in equilibrium with no corruption. In addition, my model while defining the public good takes the definition that is close to reality such that public good is rival and non-excludable. Furthermore, the agents in my economy live for two-time period and two generations.

The remaining paper is organized in the following manner in section 2, I give a detailed description of the economy along with basic model set-up. In section 3, I analyze the incentive to be corrupt for the agents in the society. In the next section, I will elaborate on the equilibriums that are clear through my model. Then in section 5, I demonstrate through my finding the two-way relationship between corruption and economic growth and development. In section 6, I give comparative statics. In the last section, I conclude my finding with suggestions for further research.

2. Framework

2.1. The Environment- Economy

There is overlapping generation model where each generation consists of constant population N, who lives for two time periods and are risk neutral. A proportion $\theta \in (0,1)$ of agents are corruptible, i.e. they will be corrupt if it pays them to be corrupt and the remaining fraction $(1-\theta)$ is not corruptible, who irrespective of the monetary gains will stay honest. Agents of each generation, are divided into three sets; private individuals referred to as *households* of which there is a fixed measure n, for the purpose of collecting taxes there is a fixed mass of m tax collectors classified as *tier one bureaucrats* and overseeing of the tier one bureaucrats is done by a fixed mass s of *tier two bureaucrats* (known as super auditors) where $n>m>s$ and $n+m+s=N$. In the economy, households are differentiated on the basis of their labor endowment, which determines their relative income and their propensity to be taxed. A fraction $\mu \in (0,1)$, of households are endowed with $\varepsilon >1$ units of labor (high income bracket) who are liable to pay a proportional tax $\tau \in (0,1)$ which is decided by the government, while the remaining fraction $(1-\mu)$ have labor endowment $\varepsilon =1$(low income bracket) and they are not liable to pay any taxes. The government is aware of the total μ without knowing the individual taxes due by households. I assume that both tier one and tier two bureaucrats are not liable to pay taxes, i.e. they are low type, whereas tier two gets a premium $\upsilon < \varepsilon$.[1] Taxes are collected by tier one bureaucrats and each one of them collect taxes from $\frac{2n}{2m}$ households. At the first level, corruption takes place when tax collector conspires with households to conceal their information about their true income. In this scenario, the tax collector expects a gain in the form of bribe and households expect gains in the form of tax evasion. There is a fraction $\lambda \in (0, 1)$ of tax collectors, which are corrupt in this way and the remaining fraction $(1- \lambda)$ are honest (non-corrupt). At the second level, corruption happens when during the audit this misreporting is revealed to tier two bureaucrat. I assume that when tier two bureaucrat is honest, then, corrupt tier one bureaucrat is reported and punished. When corrupt tier one bureaucrat matches with corruptible tier two bureaucrat, then, later does not reveal this misreporting, and former pays him share out of total bribes determined through Nash bargaining.

All agents in the society work in both time periods, they save their entire 1st time period income and consume in the 2nd time period. The firms are responsible for the output production, of which there is continuum of unit mass. The household provide the labor for hiring to the firms and the firms hire the rent capital from all agents of the society. All markets are perfectly competitive.

2.2. Households

Households of generation *i=1,2* at time period *t* earn income $I_{i,t}$ by supplying their labor to firms in the private market and earn wages, $w_{i,t}$. Each household faces a linear utility function of its expected income. Households with labor endowment ε =1 earns labor income w_i in each time period and are exempt from taxes. Households with labor endowment ε >1 earn labor

[1] *This is to simplify the model and I believe it does not affect the qualitative results of this model. .*

income εw_i and pay proportional tax τ to the government. Both the high income and the low-income households save their current wages at the prevailing market interest rate for the next time period r_{t+1}, which, is received in the next period to be consumed with the next period wages. For the time period *t+1* the income for the household is $I_{i,t+1}$ and the wages are $w_{i,t+1}$, as I will show in the steady state where $w_{i,t} = w_{i,t+1}$. From here onwards, I focus only on high-income households, as they are the ones who are liable for taxes and could collude with the tax collectors (tier one bureaucrats) for tax evasion. Honest households do not evade taxes such that their net income equal to $\varepsilon w_{i,t}\ (1-\tau) +\ r_{t+1}\varepsilon w_{i,t}(1-\tau) + \varepsilon w_{i,t+1}(1-\tau)$. Since in the steady state $w_{i,t} = w_{i,t+1}$, for the next section onwards I use *w* without the subscript. For corruptible households, there income is uncertain and depends on the bribe that they pay to bureaucrat and the probability of being caught. With probability p their corruption is detected through audit. I assume that the effective probability depends on the type of tier two bureaucrats. With probability *θ*, tax collector matches with a corruptible tier two bureaucrat. In this case, tier two bureaucrat does not reveal this corruption and they bargain on the share of bribes that each of them receive. Given this the effective probability of being caught is $p(1-\theta)\ \epsilon\ (0{,}1)$. I assume that when detected, a corrupt household is asked to pay its taxes. Given this, the net income of corruptible household is

$$E(I;b,r) = \begin{cases} \varepsilon w(1-\tau)(2+r_{t+1}), & if\ \ b=0 \\ \varepsilon w(2+r_{t+1})(1-b_t-p(1-\theta)\tau), & if b>0 \end{cases} \tag{1}$$

Where *b* >0 implies that the household is involved in corruption.

2.3. Tax Collectors- Tier One Bureaucrats

Tax collectors differ in their behavior in public offices. They supply inelastically their unit endowment of labor to government and earn wages equal to, w_g in each time period. Any bureaucrat (corruptible or non corruptible) working for a firm while supplying one labor unit will receive non-taxable wage equal to wage paid to households. Therefore, any bureaucrat who is agreeable to accept wages less than stated wage must be expecting to receive recompense through bribery hence is identified as being corrupt[2]. Each bureaucrat has $\frac{2\mu n}{2m}$ households under his jurisdiction. Honest bureaucrat do not indulge in corruption and earn a lifetime income, $w_g(2+r_{t+1})$. Whereas, corruptible tax inspectors can be corrupt if it pays them to be corrupt. There are $\frac{2\mu n}{2m}$ households under the jurisdiction of each bureaucrat. Further, I assume that an honest household even when he encounters corrupt bureaucrat, he refuses to collude and declares his true income. Thus, with probability θ, a corruptible tax collector matches with a corruptible household who pays him bribe (b) and collude to hide his true income.

There is a fraction $\lambda \epsilon (0,1)$ of corruptible tax collectors who are corrupt and demand bribes to conceal information about households income. For corrupt bureaucrats, their income is uncertain and depends on chances of being caught, bribe they receive, penalty associated with being corrupt, and the return they get on their investment from bribe income. They face a effective probability $p(1-\theta)$ of being caught through audit. Particularly, with probability *(1-θ)* tax inspector matches with honest tier two bureaucrats who report his corruption. With probability θ tax inspector matches with corruptible tier two bureaucrats, who demands a share $\varphi \epsilon (0,1)$ from bribe income to conceal his corruption. I assume that tax inspector is willing to pay this share and its value is determined through Nash bargaining. Since, corruption is illegal, tax inspector invests bribe income differently from wage income, i.e. he invests it in black market. I assume that black market rate of return is smaller and is equal to $r_{t+1}-\rho$, where $\rho > 0$.

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[2] *See Blackburn, Bose and Haque, 2010 for more discussion.*

I assume that when tax inspectors are caught through the audit, their entire income is confiscated which constitute of their earnings along with the bribe they have received form household. Given this the expected net income of a corruptible tax inspector is[3]

$$E(I;b,r) = \begin{cases} w_g(2+r_{t+1}) & b=0 \\ [1-p(1-\theta)]\left\{w_g(2+\ r_{t+1}) + (2+r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon w b(1-\varphi)\right\}, & b>0 \end{cases} \quad (2)$$

2.4. Super Auditors- Tier Two Bureaucrats

Tier two bureaucrats supply their labor to government and earn wage equal to υw_g, where 1< $\upsilon < \varepsilon$. This implies that tier two bureaucrats' are paid a higher wage than tier one bureaucrats whereas for simplicity I are assuming that they do not pay taxes. Honest tier two bureaucrats do not collude with tax inspectors and they earn only wage income, whereas corruptible tier two bureaucrats collude with corrupt tax inspectors and their income is uncertain. The bribe income of tier two bureaucrats depends upon the bribe paid by the corrupt households and the corrupt tax collectors $\left(\frac{2\theta\mu n}{2m}\right)\left(\frac{2m}{2s}\right)$ since $m < s$ there would $\frac{m}{s}$ tax collectors under tier two bureaucrats. Symmetric to tier one bureaucrat, I assume that when tier two bureaucrats are caught being corrupt, their entire income is confiscated, and they invest their bribe income in black market that earns smaller return. Given this, the expected net income of tier two bureaucrats is

$$E(I;b,r) = \begin{cases} \upsilon w_g(2+r_{t+1}), & \varphi\ = 0, b=0 \\ \left[\upsilon w_g(2+r_{t+1}) + (2+r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon w b_t \varphi\right], & \varphi > 0, b > 0 \end{cases} \quad (3)$$

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[3] *See Appendix B*

2.5. Government

Government collects taxes and provides public goods that are used as input in final goods production. Revenues are collected through levying a proportional tax on high-income households, along with the fine that is collected from tier one and tier two bureaucrats when they are caught being corrupt. Government audits the conduct of bureaucrats that costs it resources. For simplicity, I assume that cost of auditing is equal to revenues collected through successful auditing. Government assigns a fixed proportion, $\Phi \in (0, 1)$ of tax revenue generated on public goods, G_t and the remaining portion to the payment of wages to tier one and tier two bureaucrats. As in the Blackburn et.al (2010) I assume any bureaucrat (corruptible or non corruptible) working for a firm while supplying one labor unit will receive non-taxable wage equal to wage paid to households. Therefore, any bureaucrat who is agreeable to accept wages less than stated wage must be expecting to receive recompense through bribery hence is identified as being corrupt. Given this, then no corruptible bureaucrat would ever reveal himself in the way described above. Therefore, to minimize the labor costs the government set the wages of all bureaucrats equal to the wages households receive from the private firms to ensure complete bureaucratic participation, (Blackburn et.al, 2010).

2.6. Firms

The representative firm produces output according to following Cobb-Douglas production function

$$Y_t = AL_t^{\beta} K_t^{1-\beta} G_t^{\alpha} \tag{4}$$

When there is congestion of the public services (Barro & Sala-I-Martin, 1992), such that $G_t = {}^{G}/_{K}$, where G is the quantity of the public services and K is the private capital available to the private firms. I assume that public good are non-excludable but rival i.e. there is congestion.

Public capital has strong impact on private capital. According to Fisher and Turnovsky, (1997) use of public good is congested only by the use of private capital. Government investment has a smaller impact on private capital formulation in the presence of congestion. Congestion is important in assessing the relationship between public and private capital formulation, as congestion and economic growth are intimate economic variables (Eicher & Turnovsky, 2000). Furthermore, Eicher and Turnovsky (2000) relate that congestion has negative impact on labor productivity of the economy[4]. Given there is congestion of public good the production function becomes

$$Y = AL_t^{\beta} K_t^{1-\beta} \left(\frac{G_t}{K_t}\right)^{\alpha} \tag{5}$$

Where A>0, α ,β ϵ (0, 1), α+ β < 1. Also L_t is the labor of the economy and K_t is the capital of the economy. Firms hire labor from households at competitive wage rate w_t and rents capital at competitive rental rate r_t. Profit maximization implies that

$$w_t = \beta AL_t^{\beta-1} K_t^{1-\alpha-\beta} G_t^{\alpha} \tag{6}$$

$$r_t = (1-\alpha-\beta) AL_t^{\beta} K_t^{-\alpha-\beta} G_t^{\alpha} \tag{7}$$

3. The Incentive to be Corrupt

In my model, corruption is happening at two levels; 1) a corruptible tax collector meets up with corruptible high-income household to declare the household as low income and 2) during the audit tax collectors are caught by tier two bureaucrats who conspire with corrupt tax collectors to conceal the information of audit from the government. In the following analysis, I look into the behavior of households, tax collectors and tier two bureaucrats in the environment

[4] *Relative congestion: you benefit from the public good if you utilize it; otherwise, there is no impact on the non-user utility.*

of tax evasion and bribery[5].

In the analysis of corruption tax collectors, decide on the minimum bribe that is acceptable to them while considering the share φ that they would have to give to tier two bureaucrats in order to evade being caught. The share of bribe φ is decided between tax collector and tier two bureaucrats through the Nash bargaining. The point where they will both agree will decide the share.

I have two-dimensional problem where tier one bureaucrats decide wither to be corrupt or not and second if he is corrupt, what share he is willing to give to tier two bureaucrats. I solve the model through backward induction, where first he decides the share that he gives to tier two bureaucrats by taking the bribe and corruption. The share φ that he gives to tier two bureaucrats is decided through Nash bargaining. By including in this bargaining, a tax collector maximizes the net benefits from this collusion. If he colludes, the effective probability of being caught is smaller. It is equal to $p(1-\theta)$ because his corruption can only be revealed if he matches with honest auditor. However, he will have to share bribe income with corrupt auditor. Moreover, if he does not collude, he is going to be caught with probability (p) irrespective of who is the auditor. Given this the net gains of colluding for tax collector with tier two bureaucrat are

$$\Delta B_1 = \Big\{[1-p(1-\theta)]\left[w(2+\ r_{t+1}) + (2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb(1-\varphi)\right] - (1-p)\left[w(2+\ r_{t+1}) + (2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\right]\Big\}^{0_1}$$

$$\Delta B_1 = \left\{\left[p\theta w(2+\ r_{t+1}) + (2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb([1-p(1-\theta)]-[1-p])\right]\right\}^{0_1} \quad (8)$$

Similarly, net gains of tier two bureaucrats from this collusion is

[5] *My model looks at the economy in equilibrium such that $w_g = w$ as stated wage to private and public agents is same.*

$$\Delta B_2 = \left\{\left[\upsilon w(2+\ r_{t+1}) + (2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi\right] - \upsilon w(2+\ r_{t+1})\right\}^{O_2} \quad (9)$$

$$\varphi^{NB} = \Delta B_2 . \Delta B_1$$

Keeping this in mind following share of bribe is given as [6]

$$\varphi^{NB} = \left[\frac{O_2}{0_1 + O_2}\right].\left[\frac{p\theta}{[1-p(1-\theta)]}\right]\left[1 + \frac{(2+\ \ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon b}\right] \quad (12)$$

From the above expression, I establish the share of bribe tier two bureaucrats demand of the tax collectors. The comparative statics $\frac{\partial(\varphi^{NB})}{\partial O_2} > 0$, which explains that increase in bargaining power of tier two bureaucrats, increases the share in bribe, by $\frac{\partial(\varphi^{NB})}{\partial 0_1} < 0$ I see that if the bargaining power of the tax collectors increases the share in bribe of tier two collectors would decrease. The increase in the rate of interest, the bribe and the proportion of corruptible agents have a negative impact on the share of tier two bureaucrats in bribe, ($\frac{\partial(\varphi^{NB})}{\partial\ r_{t+1}} < 0$, $\frac{\partial(\varphi^{NB})}{\partial b_t} < 0$, $\frac{\partial(\varphi^{NB})}{\partial\theta} < 0$). If the probability of being caught were to increase the share would also increases to cover the risk associated with it $\frac{\partial(\varphi^{NB})}{\partial p} > 0$.

Given this share the tax collectors receives from Nash bargaining he decide to be corrupt or not. Tax collectors are corrupt only when the expected utility from getting bribe leaves them no worse than not getting a bribe. The tax collectors would demand a bribe that would cover the risk they are taking for covering the households from the government along with the share φ they have to give to tier two bureaucrats. The bribe would vary with the degree of risk, if the risk of being caught were high then the bribe demanded would be high and vice versa. From the

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[6] *See Appendix E*

equation (2) I find that corruptible tax collector will be corrupt if

$$b_t^* \geq \frac{p(1-\theta)(2+\mathrm{r}_{\mathrm{t+1}})}{[1 - p(1-\theta)](2+\mathrm{r}_{\mathrm{t+1}}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon(1-\varphi)} \tag{13}$$

The second incidence of the corruption happens when the tax collectors and the households collude together to hide the true extent of household's income. The corrupt high-income households will be willing to pay a bribe as long as it is feasible for them, such that the expected utility of from paying the bribe and the expected utility from not paying is at least equal. Keeping this in mind the optimum bribe rate for the households is calculated through equation (1) and is estimated to be

$$b_t^* = [1 - p(1-\theta)]\tau_t \tag{14}$$

Intuitively equation 14 states that the households will not pay the tax collectors more than they expect to save from tax evasion. In my model incidence of corruption happens only when the tax collectors and the households concur on the same bribe such that they are simultaneously satisfy one another, this is seen when equation (13) and (14) are solved together

$$[1 - p(1-\theta)]\tau_t \geq \frac{p(1-\theta)(2+\mathrm{r}_{\mathrm{t+1}})}{[1 - p(1-\theta)](2+\mathrm{r}_{\mathrm{t+1}}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon(1-\varphi)} \tag{15}$$

The above condition relies on the economy wide variable τ and r_{t+1}. The current tax rate and the future market interest rate that is of interest; determined by the current economic situation in the economy. The prevalent economic condition in the economy accounts for corruption in my model. The current statics show that the presence of corruption will provide incentive to the upcoming bureaucrats both tax collectors and tier two bureaucrats to be involved in illegal activity. The current time period t corruption will determine future corruption, which in return determines the future market interest rate.

The behavior of the economy is analyzed under two scenarios 1) equilibrium where there is no corruption, 2) equilibrium where there is corruption, the purpose of the analysis is to look into the behavior of the capital accumulation and its impact on development in both the scenarios. Furthermore, the model looks into the behavior of capital in steady state alone such that $Y_{1,t} = Y_{1,t+1}$ *and* $Y_{2,t} = Y_{2,t+1}$ *and* $Y_{1,t} = Y_{1,t+1} = Y_{2,t} = Y_{2,t+1} = Y$ and $K_{1,t} = K_{1,t+1}$ *and* $K_{2,t} = K_{2,t+1}$ *and* $K_{1,t} = K_{1,t+1} = K_{2,t} = K_{2,t+1} = K$. From here onwards, I do not use subscript. Solving the equation (3), (4) and (5) I find the current market interest rate and the current wage in the market. Where $w = \beta L^{-1} \Psi K^{\chi}$ and $r = (1 - \alpha - \beta) \Psi K^{\chi - 1}$this shows that economy wide variable rely on the labor force in the market along with the labor and capital share in the output function. Furthermore, the presence of K shows that the current level of capital in economy plays a dominant role for the determination of current wage, current market interest rate. Seeing this relation, I can conclude that the presence of future capital K_{t+1} would determine the future market interest rate r_{t+1} that would be accounted as the investment of economy for economic growth. In my model there is fixed proportion for the government services such that $G_t = \Phi Y_t$, thus when in equilibrium I see that that the total labor supply $L = [(1 - \mu) + \varepsilon \mu] n$, which is the sum of total labor supply of high income households $\varepsilon \mu n$ and labor supply of low income households $(1 - \mu) n$.[7] I find the government share in the economy through $G = \Psi K^{\chi} \Phi$ where $\Psi = \left[A(\Phi)^{\alpha} L^{\beta}\right]^{1/1-\alpha}$ and $\chi = \frac{1-\alpha-\beta}{1-\alpha}$[8].

[7] *This holds true when there is equilibrium in the labor market.*
[8] *See Appendix D*

Government expenditure are covered by tax revenues. These expenditures include the provision of public services and the salaries of both bureaucrats. Seeing this the economy follows balanced budget i.e. *tax revenues = G+ mw+svw* as I have calculated the values of *G* and *w* replacing it I get the following relation

$$Tax\ revenue = \Psi[\Phi + \beta(m + s\upsilon)]K^{\chi}$$

According to growth theory, the presence of physical capital translates into investment of the economy; accumulations of physical capital are the savings of the agents in economy. The savings of an economy comes from low-income households $(1-\mu)nw$ and the high-income honest and dishonest households $\mu n\varepsilon w(1-\theta)(1-\tau),\ \theta\lambda\mu n\varepsilon w(1-b-p(1-\theta)\tau) + (1-\lambda)\theta\mu n\varepsilon w(1-\tau)$ respectively. The saving of tier one bureaucrats are $[(1-\theta) + \theta(1-\lambda)]mw$ and $\theta\lambda\mu mw\left\{[1-p(1-\theta)][w(2+\ r_{t+1}) + (2+r_{t+1}-\rho)(\frac{\theta\mu n}{m})\varepsilon wb(1-\varphi)]\right\}$ and savings of tier two bureaucrats constitute of $(1-\theta)s\upsilon w, \theta(1-\lambda)s\upsilon w\ and\ \lambda\theta s\left\{(1-p)\left[\upsilon w + \left(\frac{\mu n}{s}\right)\theta\varepsilon wb\varphi\right]\right\}$. Where savings equals future capital

$$s_t = K_{t+1}$$

4. General Equilibrium

4.1. Equilibrium with No Corruption

In equilibrium with no corruption, total tax revenue collected in the economy is $\hat{\tau}\mu n\varepsilon w$. As already stated the government utilizes the revenue to cover the expenditure to cover the wages of the tier one and tier two bureaucrats mw and $s\upsilon w$ respectively, and to provide public good and services G, which is utilized by private firms. Given that government runs a balanced budget, the tax rate without corruption is[9]

$$\hat{\tau}_t = \frac{G + \mathrm{w}(m + s\upsilon)}{\mu n \varepsilon w} \tag{16}$$

$$\hat{\tau}_t = \left[\frac{L\Phi + \beta(m + s\upsilon)}{\beta \mu n \varepsilon}\right] \equiv \hat{\tau} \tag{17}$$

Looking at this tax level the optimum tax rate, household's willingness to pay the bribe would be $\widehat{b_t} = [1 - p(1 - \theta)]\hat{\tau}_t$ (from equation (14)).

In equilibrium with no corruption *λ=0* total savings of the economy come from the honest low-income individuals $(1 - \mu)nw$ and honest high-income households $\mu n \varepsilon w(1 - \hat{\tau})$.The savings of tier one and tier two bureaucrats is mw and svw respectively. Combining all these expressions together, I get the following relation

$$(1 - \mu)nw + \mu n \varepsilon w(1 - \hat{\tau}) + mw + svw = \widehat{K}_{t+1}$$

Replacing value of $\hat{\tau}$ and manipulation yield the following relation

$$wL - G = \widehat{K}_{t+1} \tag{18}$$

Manipulating equation (18) by replacing $G = \Psi K^{\chi}\Phi$, and $w = \beta L^{-1}\Psi K^{\chi}$, I get the following expression for the future accumulation of the physical capital

$$\widehat{K}_{t+1} = \Psi K_t^{\chi}[\beta - \Phi] \equiv \widehat{K}(K_t) \tag{19}$$

As already established that $\hat{r}_t = (1 - \alpha - \beta)\Psi \widehat{K}_t^{\chi - 1}$, then from this I can conclude $\hat{r}_{t+1} = (1 - \alpha - \beta)\Psi \widehat{K}_{t+1}^{\chi - 1}$, combing this relationship with equation (19) I get the following relation

[9] *See Appendix G*

$$\hat{R}_{t+1} = (1-\alpha-\beta)\Psi\,[\beta-\Phi]^{\chi-1}.\hat{K}_{t+1}^{\chi(\chi-1)} \;\equiv \hat{R}(K) \tag{20}$$

$$\hat{R}(K_t) \geq \frac{2\bar{Z}-(2-\rho)\hat{\tau}}{(\hat{\tau}-\bar{Z})} \equiv \widehat{W}^{10} \tag{21}$$

4.2. Equilibrium with Corruption

For complete analysis my model I now consider equilibrium where there is corruption, $\lambda=1$. The total tax receipts should come from all households, however that is not the case, only honest high-income households pay the taxes and honest tax collectors submit the true taxes to the government. In my model corruption happens when corrupt household meet with a corrupt tax collector. With probability $(1-\theta)[(1-\theta)+\theta(1-\lambda)]$ honest households meet up with honest tax collectors, with probability $(1-\theta)\lambda\theta$ honest households meet up with corrupt tax collectors, corrupt households match with honest tax collector with probability $\theta[(1-\theta)+\theta(1-\lambda)]$. Combing all these three cases the total tax receipts submitted to the government equals $\tilde{\tau}\mu n\varepsilon w((1-\theta^2)$. When a corrupt household meets with corrupt tax collector with probability θ^2 and no tax receipt are submitted.

A corrupt tax collector is caught with probability *p(1-θ)* he loses his corrupt income and is fined the amount that he has gained as illegal income. Once caught the corrupt tax collector has to pay the tax difference. Thus the revenues for the government coming from tax collector being caught is $p\tilde{\tau}\mu n\theta^2\lambda$ and $(p(1-\theta))[w(2+\,r_{t+1})+(2+r_{t+1}-\rho)(\frac{\mu n}{m})\theta\varepsilon wb]$. Once this revenue is collected, it is utilized by the government to finance the public services and goods G and the wages of the tier and tier two bureaucrats mw and sυw respectively. The cost of the effective audit is $c\eta\tilde{\tau}\mu n$ and for external audit is $c\sigma\tilde{\tau}\mu n$. The cost borne by the government is

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[10] *See Appendix H*

financed through the fine that is collected from the tax collectors. For the purpose of my analyses, I take the total cost and the fine to be equal such that the government spends no extra. Keeping all this in view, I find the following expression[11]

$$\tilde{\tau}_t = \frac{G + \mathrm{w}(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon w} \tag{22}$$

$$\tilde{\tau}_t = \left[\frac{\Phi L + \beta(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon\beta}\right] \equiv \tilde{\tau} \tag{23}$$

The optimum level of bribe that households are willing to pay and the tax collectors are willing to accept is $\tilde{b}_t = [1 - p(1-\theta)]\tilde{\tau}_t$ (from equation (14)). The total saving in such economy comes from the corrupt as well as the honest agents.

Households

1) Low-income HH $=(1-\mu)nw$
2) High-income HH (honest) $=\mu n\varepsilon w(1-\tilde{\tau}_t)(1-\theta)$
3) High-income HH (dishonest) $=\theta\lambda\mu n\varepsilon w\left(1-\tilde{b}_t - p(1-\theta)\tilde{\tau}_t\right)$,

Tax collectors

1) B_1 Honest = $(1-\theta)mw$
2) B_1 Dishonest/corruptible $=\theta\mu m\left\{[1-p(1-\theta)][w + (\frac{\theta\mu n}{m})\varepsilon w\tilde{b}_t(1-\varphi)]\right\}$

Tier-two bureaucrats

1) B_2 Honest = $(1-\theta)s\upsilon w$
2) B_2 Dishonest/corruptible = $(1-\lambda)s\upsilon w + \theta s\left\{(1-p)\left[\upsilon w + \left(\frac{\theta\mu n}{s}\right)\varepsilon w\tilde{b}_t\varphi\right]\right\}$

Combing all these expression together, I get the following relation

$$(1-\mu)nw + \mu n\varepsilon w(1-\tilde{\tau}_t)(1-\theta) + \theta\mu n\varepsilon w\left(1-\tilde{b}_t - p(1-\theta)\tilde{\tau}_t\right) + (1-\theta)\,mw + \theta m\left\{[1-p(1-\theta)]\left[w + \left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}\tilde{b}_t(1-\varphi)\right]\right\} + (1-\theta)s\upsilon w + \theta s(1-p)\left[\upsilon w + \left(\frac{\theta\mu n}{s}\right)\varepsilon \mathrm{w}\tilde{b}_t\varphi\right] = \widetilde{K}_{t+1}$$

[11] *See Appendix I*

Replacing value of $\tilde{\tau}$ and manipulation yields the following relation

$$Lw + mw[1-\theta p(1-\theta)] + s\upsilon w - \frac{(1-\theta)}{(1-\theta^2)}[G + \mathrm{w}(m + s\upsilon)][1+\theta p] - \theta\mu n\varepsilon \mathrm{w}\tilde{b}_t\{1-\theta\varphi - [1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\} = \widetilde{K}_{t+1} \quad (24)$$

Manipulating equation (24) by replacing $G = \Psi K^{\chi}\Phi$, $w = \beta L^{-1}\Psi K^{\chi}$ and $\tilde{b}_t = [1 - p(1-\theta)]\tilde{\tau}$ I get the following capital accumulation relation that is currently working in equilibrium with corruption

$$\widetilde{K}_{t+1} = \Psi K_t^{\chi}\left[\beta + \frac{\beta}{L}m[1-\theta p(1-\theta)] + \frac{\beta}{L}s\upsilon - \frac{(1-\theta)}{(1-\theta^2)}\left[\Phi + \frac{\beta}{L}(m+s\upsilon)\right][1+\theta p] - \frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\}\right] \quad (25)$$

I know that $\tilde{r}_t = (1-\alpha-\beta)\Psi\widetilde{K}_t^{\chi-1}$, then from this I can conclude $\tilde{r}_{t+1} = (1-\alpha-\beta)\Psi\widetilde{K}_{t+1}^{\chi-1}$, combing this relationship with equation (25) I get the following relation

$$\tilde{R}_{t+1} = (1-\alpha-\beta)\Psi\left[\Psi\left[\beta + \frac{\beta}{L}m[1-\theta p(1-\theta)] + \frac{\beta}{L}s\upsilon - \frac{(1-\theta)}{\left(1-\theta^2\right)}\left[\Phi + \frac{\beta}{L}(m+s\upsilon)\right][1+\theta p] - \frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1} . K_{t+1}^{\chi(\chi-1)} \equiv \tilde{R}(K_t) \quad (26)$$

$$\tilde{R}(K_t) \geq \frac{2\bar{Z} - (2-\rho)\tilde{\tau}}{(\tilde{\tau} - \bar{Z})} \equiv \widetilde{W}^{12} \quad (27)$$

[12] *See Appendix J*

5. Corruption and Development

5.1. From Low Development to Corruption

The above analysis has laid groundwork for further analysis that at which level of physical capital there is corruption or not. My model solidifies the relationship of corruption, capital accumulation and economic development that has already been discussed above in the literature. What now is of interest is to see whether at the equilibrium level there is corruption or not, at what level of capital there is high growth and what level there is low growth in economy and if these level are same for both the equilibrium with corruption and with no corruption.

From the equations (21 and 27) I find the relationship such that $\tilde{R}(K)$ and $\hat{R}(K)$ have monotonically downward function with respect to K. From equation (20), (21), (26) and (27) I establish that $\tilde{R}(K_t) > \hat{R}(K_t)$ and $\widetilde{W} < \widehat{W}$ for all values of K_t. From these inequalities, I find the optimum level of K_t would define a point in economy there is high growth. I define $K_1^c$and K_2^c around which I can define K_t at which where they may be growth, low growth or multiple growth level. For all $K_t < K_1^c$, $\hat{R}(K_t) > \widehat{W}$ and for all $K_t > K_1^c$, $\hat{R}(K_t) < \widehat{W}$. Similarly, for all $K_t < K_2^c$, $\tilde{R}(K_t) > \widetilde{W}$ and for all $K_t > K_2^c$, $\tilde{R}(K_t) < \widetilde{W}$. Where $K_1^c < K_2^c$.

Proposition 1: *For $\forall\, K_t < K_1^c$, there is a unique equilibrium where all corruptible bureaucrat is corrupt. For $\forall\, K_t > K_2^c$, there is a unique equilibrium where no corruptible bureaucrat is corrupt. For $\forall\, K_1^c < K_t \leq K_2^c$ there is multiple equilibrium.*

Proof: See Appendix K

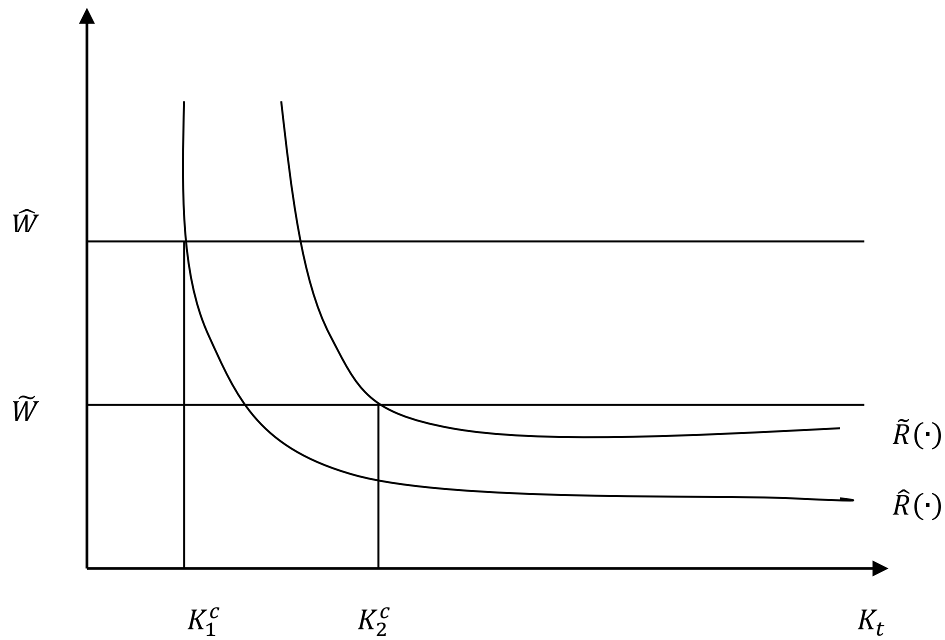

FIGURE 1: Corruption Equilibrium

Where

$$K_1^c \geq \left[\frac{\bar{\mathrm{S}}(\hat{\tau}_t - \bar{Z})}{2\bar{Z} - (2-\rho)\hat{\tau}_t}\right]^{\chi(\chi-1)}$$

$$K_2^c \geq \left[\frac{\bar{\mathrm{V}}(\tilde{\tau}_t - \bar{Z})}{2\bar{Z} - (2-\rho)\tilde{\tau}_t}\right]^{\chi(\chi-1)}$$

5.2. From Corruption to Low Development

Two paths capital accumulation has been identified one for equilibrium where there is no corruption and one for there is corruption, $\widehat{K}^*$ and $\widetilde{K}^*$. In equilibrium where there is no corruption, the economy moves on higher development path $K(\cdot)$ and thus has a high level of steady state equilibrium $\widehat{K}_H = \{\Psi[\beta - \Phi]\}^{1-\chi}$ (from equation19). Whereas in equilibrium where there is corruption the economy moves on lower development path $K(\cdot)$ so there is low level of steady state $\widetilde{K}_L = \left[\Psi\left[\beta + \frac{\beta}{L} m[1 - p\theta(1-\theta)] + \frac{\beta}{L} s\upsilon - \frac{(1-\theta)}{(1-\theta^2)}\left[\Phi + \frac{\beta}{L}(m + s\upsilon)\right][1 + \theta p] - \frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}\left[1 - p(1-\theta)\right]\{1 - \theta\varphi - [1 - p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{1-\chi}$ (from equation 25).

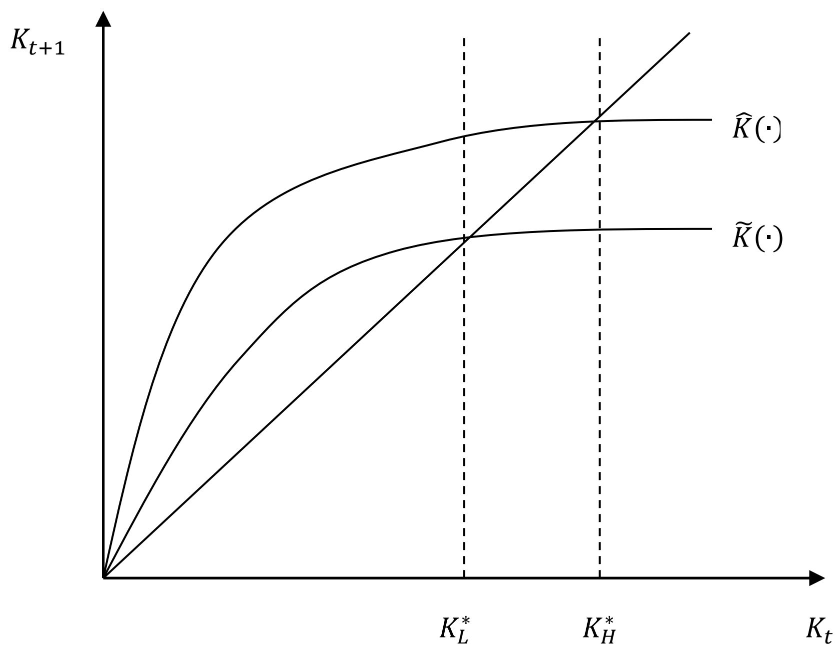

FIGURE 2: Capital Accumulation

Intuition

In an economy with equilibrium with corruption $\frac{\partial \widetilde{K}_L}{\partial p} > 0$, and $\frac{\partial \widetilde{K}_L}{\partial \theta} < 0$, which intuitively tells me that as the probability of being caught increases capital accumulation increases. As the proportion of the corrupt individual increases, capital accumulation in a corrupt economy decreases.

6. Comparative Statics

For a given level of physical capital K_t in an equilibrium with or without corruption satisfy $\tilde{\tau}_t > \hat{\tau}_t, \tilde{r}_{t+1} > \hat{r}_{t+1}$.What I see is that for a given level of physical capital K_t the optimum tax rate of the corrupt economy is higher than that of the equilibrium with no corruption, $\tilde{\tau}_t > \hat{\tau}_t$ as easily seen from equation (17) and (23), as of which $\tilde{b}_t > \hat{b}_t$. Intuitively, this holds true for government need to run a balanced budget, the revenues collected in equilibrium with corruption are lower than the expenditure. The government raises the taxes to overcome the shortage.

Similarly from equation (19) and (25) I see that $\widetilde{K}_{t+1} < \widehat{K}_{t+1}$ and equation (20) and (26) clearly show that $\tilde{r}_{t+1} > \hat{r}_{t+1}$. Together this establishes that in equilibrium with corruption the level of taxes are high as of which the cost of concealment in the shape of bribe is also high, furthermore the accumulation of the physical capital is less as compared to the equilibrium with no corruption and the rate of interest is also high. What all this entails that in equilibrium with corruption the level of taxes is high due to which households pay a large bribe to evade taxes, which leads to low saving and capital accumulation. In equilibrium with no corruption, the taxes are not high such that all households pay the taxes. Their saving is high enough for the capital accumulation and economic growth. When the rate of capital accumulation is high the rate of interest associated with is low, this is due diminishing marginal returns to capital.

7. Conclusion

In the last decade there have been concern that how corruption that is prevalent in the government seem to have a negative impact on economic growth and development. Economist throughout the world have been working on justifying the relation that how corruption affect growth through various channels. There has been abundant empirical literature on that but now theoretical strand of literature focuses on how corrupt government affects the growth through different channels.

Corruption creates unfavorable conditions for investment in physical capital and thus growth. I have modelled this by treating legal income differently from the corruption income. Corruption income is illegal and can only be invested in black market which offers smaller returns. FDI can help in diluting negative effect of corruption on investment. In my model corruption negatively affects savings that in turn affect investment, since FDI is savings of foreigners in a foreign country, corruption of destination country cannot affect the saving decisions of FDI of host countries. In this case if FDI is a bigger share of total investment then corruption might have negligible effect on investment. However, literature on FDI and corruption highlights that corrupt economies are not attractive destinations for FDI.

According to Wei (2000) the international investors do not find it worthwhile to invest in economies where the corruption index is high for then there is poor contractual enforcement, making it difficult for them to make profits. Country's investment environment is measured through the institutional quality, which is an indicator of political institutions, rule of law, property rights, non-transparency and instable economic policies, if these are poor in quality then FDI in that country would be low for it creates operational inefficiencies, (Globerman & Shapiro, 2002; Habib & Zurawicki, 2002). Corruption lowers the productivity of the public inputs as already shown in the model, this leads to decrease in the country's locational attractiveness which is important factor for foreign investors, (Egger & Winner, 2005). The location plays an important role when the investor are deciding on the host countries from investment point of view.

Blackburn et.al (2010) and Wadho (2009) look at a single public office tier. My model is further extension of these model with two government tiers, which implies that the share of the bureaucrats have decreased for the proportion of the illegal income is same. There is fixed value of bribe that is shared among the bureaucrats. If the number of bureaucrats were to increase the each bureaucrat share would decrease for now the bribe would have to be split into more shares. This can easily be explained that if a pie was to be distributed among two individuals the share would more than if the same pie were to be distributed among large number of individuals. Increase in the number of the bureaucrats could lead to two effects; negative and positive. Taking the multiple tiers may also increase the size of the bribe (pie) this could be done when the tier two bureaucrats ask a particular percentage of bribe from tax collectors who in return will ask for higher bribe from households by framing them. If there were *'n'* number of tiers the negative effect will appear in the form of small share in bribe, the positive affect will appear for when there are more corrupt bureaucrats there would be framing and extortion. There might be optimal level of *'n'*. My paper does not focus on the number of tiers as I am not interested in so many tiers of government but rather on the how corruption effects economic development through savings and physical capital investment.

This paper adds to the growing literature of how corrupt government through tax evasion and capital accumulation effect economic growth and development. The basic setup for the corrupt bureaucrat is same but my model introduces the multi-level tax administrative system. Where, tier two bureaucrats and the tax collectors are both involved in double incidence of corruption. Furthermore, my model shows that the households bribe the tax collector and then they in return offer bribe to their tier two bureaucrats. There is transfer of resources as of which illegal income is created that cannot be included in savings, which results in lower capital investment of economy. Low investment in capital becomes visible as low economic growth and development. My paper has explained how corruption accompanies low growth and development and how low development accompanies high corruption. My paper tries to explain the corruption and economic growth duos relationship through theoretical model but there remains scope for further research.

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APPENDIX A

In this appendix, I give detail calculation for expected income of the households.

SETTING

All individuals save in first period, invest it and consume in the second period. The individuals live for two periods only.

There are two generation 1 and 2 with time t and t+1, where $w_{1t} = w_{1,t+1} = w_{2t} = w_{2,t+1} = w$

Only high-income households pay taxes

HOUSEHOLDS (honest, bribe=0)

1) Wage earned in first period =εw
2) Proportion of wage invested in the 1 period= $r_{t+1}\varepsilon w$
3) Wage earned in second period= εw
4) Proportional tax payable on the wage in the 1 period= εw τ
5) Proportional tax payable on the wage in the 2 period= εw τ

I_{HH}= $(\varepsilon w - \varepsilon w\tau) + r_{t+1}(\varepsilon w - \varepsilon w\tau) + (\varepsilon w - \varepsilon w\tau)$

= $\varepsilon w - \varepsilon w\tau + r_{t+1}\varepsilon w - r_{t+1}\varepsilon w\tau + \varepsilon w - \varepsilon w\tau$

= $2\varepsilon w - 2\varepsilon w\tau + r_{t+1}\varepsilon w - r_t\varepsilon w\tau$

=$\varepsilon w(2 + r_{t+1}) - \varepsilon w\tau(2 + r_{t+1})$

=$(\varepsilon w - \varepsilon w\tau)(2 + r_{t+1})$

=$\varepsilon w(1 - \tau)(2 + r_{t+1})$

HOUSEHOLDS (dishonest/ corrupt, bribe >0)

1) Wage earned in first period =εw
2) Bribe paid to the $B_1$to be classified as low income in 1 period= $b_t = b$
3) Proportion of income paid as bribe 1 period =bεw
4) Probability of being caught through effective auditing,(in 1 period) result in payment of τ= *p(1-θ)*τ
5) Proportion of wage invested in the 1st period= $r_{t+1}(\varepsilon w - b\varepsilon w - p(1-\theta)\tau\varepsilon w)$
6) Wage earned in second period= εw
7) Bribe paid to the $B_1$to be classified as low income in 2 period=b
8) Proportion of income paid as bribe 2 period =bεw
9) Probability of being caught through the internal and external audit,(in 2 period) result in payment of τ= *p(1-θ)*τ

I_{HH}= $(\varepsilon w - b\varepsilon w - p(1-\theta)\tau\tau\varepsilon w) + r_t(\varepsilon w - b\varepsilon w - p(1-\theta)\tau\varepsilon w) + (\varepsilon w - b\varepsilon w - p(1 - \theta)\tau\varepsilon w)$

= $\varepsilon w - b\varepsilon w - p(1-\theta)\tau\tau\varepsilon w + r_{t+1}\varepsilon w - r_{t+1}b_t\varepsilon w - r_{t+1}p(1-\theta)\tau\tau\varepsilon w + \varepsilon w - b_t\varepsilon w - p(1-\theta)\tau\tau\varepsilon w$

= $2\varepsilon w + r_{t+1}\varepsilon w - 2b\varepsilon w_t - r_{t+1}b\varepsilon w - 2p(1-\theta)\tau\varepsilon w - r_{t+1}p(1-\theta)\tau\varepsilon w$

=$\varepsilon w(2 + r_{t+1}) - b\varepsilon w(2 + r_{t+1}) - p(1-\theta)\tau\varepsilon w(2 + r_{t+1})$

=$\varepsilon w(2 + r_{t+1})(1 - b - p(1-\theta)\tau)$

APPENDIX B

In this appendix, I give detailed calculation for expected income of the tax collectors that has been classified as the bureaucrats'B_1.

TAX INSPECTORS (honest, b=0)

1) Wage earned in first period =w
2) Proportion of wage invested in the 1st and consume in 2nd period= $\mathrm{r}_{t+1}\mathrm{w}$
3) Wage earned in second period= w

I_{B1}= $\mathrm{w} + \mathrm{r}_{t+1}\mathrm{w} + \mathrm{w}$

= $2\mathrm{w} + \mathrm{r}_{t+1}\mathrm{w}$

= $\mathrm{w}(2 + \mathrm{r}_{t+1})$

TAX INSPECTORS (dishonest/ corruptible, b>0)

1) Wage earned in first period =w
2) Proportion of wage invested in the 1st period= $\mathrm{r}_{t+1}\mathrm{w}$
3) The bribe income = $(\frac{\theta\mu n}{m})\varepsilon \mathrm{w} b$
4) The bribe income left after searching for black market investment= $(\mathrm{r}_{t+1} - \rho)(\frac{\theta\mu n}{m})\varepsilon \mathrm{w} b$
5) Wage earned in second period= w
6) Bribe income in the 2 period = $(\frac{\theta\mu n}{m})\varepsilon \mathrm{w} b$
7) If $B_2$are also corrupt then the tax collectors share their bribe= φ
8) All of this is received with the probability of success in hiding bribe through effective auditing= *(1- p(1-θ))*

$$I_{B1}=[1 - p(1-\theta)] \left[w + \left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi) + w\mathrm{r}_{t+1} + (\mathrm{r}_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi) + w + \left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi)\right]$$

$$=[1 - p(1-\theta)] \left[w + w\mathrm{r}_{t+1} + w + (\mathrm{r}_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi) + \left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi) + \left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi)\right]$$

$$=[1 - p(1-\theta)] \left[2w + w\mathrm{r}_{t+1} + (2 + \mathrm{r}_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi)\right]$$

$$=[1 - p(1-\theta)] \left[w(2 + \mathrm{r}_{t+1}) + (2 + \mathrm{r}_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right) \varepsilon \mathrm{w} b(1-\varphi)\right]$$

APPENDIX C

In this appendix, I give detail calculation for expected income of the superior that's have been classified as the bureaucrats B_2

TIER TWO BUREAUCRATS (honest, φ=0)

1) Wage earned in first period =υw
2) Proportion of wage invested in the 1st and consume in 2nd period= $r_{t+1}\upsilon w$
3) Wage earned in second period= υw

$I_{B2}=\upsilon\text{ w} + r_{t+1}\upsilon w_t + \upsilon w$

$= 2\upsilon w + r_{t+1}\upsilon w$

$= \upsilon w(2 + r_{t+1})$

TIER TWO BUREAUCRATS (dishonest/corruptible, φ>0)

1) Wage earned in first period =υw
2) Proportion of wage invested in the 1st period= $r_{t+1}\upsilon w$
3) The bribe income = $(\frac{\theta\mu n}{m})(\frac{m}{s})\varepsilon wb\varphi$
4) Proportion of illegal income received from $B_1$to protect them from internal audit= $(r_{t+1} - \rho)(\frac{\theta\mu n}{s})\varepsilon wb\varphi$
5) Wage earned in second period= υw
6) Bribe income in the 2 period=$(\frac{\theta\mu n}{s})\varepsilon wb\varphi$

$I_{B2}=\left[\upsilon\text{ w} + \left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi + r_{t+1}\upsilon w + (r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi + \upsilon w + (\frac{\theta\mu n}{s})\varepsilon wb\varphi\right]$

$=\left[\upsilon\text{ w} + r_{t+1}\upsilon w + \upsilon w + (2 + r_{t+1} - \rho)(\frac{\theta\mu n}{s})\varepsilon wb\varphi\right]$

$=\left[2\upsilon w + r_{t+1}\upsilon w + (2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi\right]$

$= \left[\upsilon w(2 + r_{t+1}) + (2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi\right]$

APPENDIX D

In the appendix, I give detail calculation for the firm's problem. I calculate the $w_t$and $r_t$which is later utilized in problem solving.

FIRMS

Cobb-Douglas production function

$$Y_t = AL_t^{\beta} K_t^{1-\beta} G_t^{\alpha}$$

Where by the congestion model the Cobb-Douglas production function becomes

$$Y = AL_t^{\beta} K_t^{1-\beta} \left(\frac{G_t}{K_t}\right)^{\alpha}$$

$$Y = AL_t^{\beta} K_t^{1-\alpha-\beta} G_t^{\alpha}$$

$$\frac{\partial Y}{\partial L_t} = \beta AL_t^{\beta-1} K_t^{1-\alpha-\beta} G_t^{\alpha} = w_t = MPL$$

$$\frac{\partial Y}{\partial K_t} = (1-\alpha-\beta) AL_t^{\beta} K_t^{-\alpha-\beta} G_t^{\alpha} = r_t = MPK$$

Where G is the fixed proportion Φ of Y

$$G_t = \Phi Y_t$$

Replace G in Y such that

$$Y = AL_t^{\beta} K_t^{1-\alpha-\beta} (\Phi Y_t)^{\alpha}$$

Isolate the value of Y_t

$$\frac{Y}{Y^{\alpha}} = AL_t^{\beta} K_t^{1-\alpha-\beta} (\Phi)^{\alpha}$$

$$Y^{1-\alpha} = AL_t^{\beta}K_t^{1-\alpha-\beta}(\Phi)^{\alpha}$$

Divide by the power $1 - \alpha$ on both sides (removing power of Y

$$Y = \left[AL_t^{\beta}K_t^{1-\alpha-\beta}(\Phi)^{\alpha}\right]^{1/_{1-\alpha}}$$

$$Y = \left[AL_t^{\beta}(\Phi)^{\alpha}\right]^{1/_{1-\alpha}}.[K_t^{1-\alpha-\beta}]^{1/_{1-\alpha}}$$

Let $\left[AL_t^{\beta}(\Phi)^{\alpha}\right]^{1/_{1-\alpha}} = \Psi$

$\frac{1-\alpha-\beta}{1-\alpha} = \chi$

Such that

$$Y = \Psi K^{\chi}$$

As

$$G = \Phi Y$$

$$Y = \frac{G}{\Phi}$$

Then

$$\frac{G}{\Phi} = \Psi K^{\chi}$$

$$G = \Psi K^{\chi}\Phi$$

As

$$w = \beta AL^{\beta-1}K^{1-\alpha-\beta}G^{\alpha}$$

and

$$Y = AL^{\beta}K^{1-\alpha-\beta}G^{\alpha}$$

$$w = \beta L^{-1}Y$$

$$\therefore Y = \frac{G}{\Phi} = \Psi K^{\chi}$$

Replace in w_t which becomes

$$w = \beta L^{-1}\Psi K^{\chi}$$

As

$$r = (1-\alpha-\beta)AL^{\beta}K^{\alpha-\beta}G^{\alpha}$$

$$Y = AL^{\beta}K^{1-\alpha-\beta}G^{\alpha}$$

$$r = (1-\alpha-\beta)YK^{-1}$$

$$\therefore Y = \frac{G}{\Phi} = \Psi K^{\chi}$$

Replace in r_t which becomes

$$r = (1-\alpha-\beta)\Psi K^{\chi}K^{-1}$$

$$r = (1-\alpha-\beta)\Psi K^{\chi-1}$$

APPENDIX E

In this appendix, I calculate the share φ of the bribe for tier two bureaucrats through Nash bargaining. This gives the minimum share that tier two bureaucrats are willing to accept in order to overlook the corruption that is taking place among the tax collectors and the households. Also comparative statics are calculated.

NASH BARGAINING

B_1 Payoff during Nash bargaining

B_1 and B_2 are both corrupt, $\varphi > 0$,

$$[1-p(1-\theta)]\left[w(2+\ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\text{wb}(1-\varphi)\right]$$

B_1 corrupt, B_2 honest, φ=0

$$(1-p)\left[w(2+\ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\right]$$

$$\varphi^{NB} = \Delta B_2 . \Delta B_1$$

$$\Delta B_2 = \left\{\left[\upsilon w(2+\ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi\right]-\upsilon w(2+\ r_{t+1})\right\}^{O_2}$$

$$\Delta B_2 = \left\{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi\right\}^{O_2}$$

$$\Delta B_1 = \left\{[1-p(1-\theta)]\left[w(2+\ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\text{w}b(1-\varphi)\right] - (1-p)\left[w(2+\ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\text{w}b\right]\right\}^{0_1}$$

$$\Delta B_1 = \left\{\left[[1-p(1-\theta)]w(2+\ r_{t+1})+[1-p(1-\theta)](2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\text{w}b(1-\varphi)\right] - \left[(1-p)w(2+\ r_{t+1})+(1-p)(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\text{w}b\right]\right\}^{0_1}$$

Cancel out $w(2+\ r_{t+1})$

$$\Delta B_1 = \left\{p\theta w(2 + \ r_{t+1}) + (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1 - p(1-\theta)](1-\varphi) - (1-p)\}\right\}^{0_1}$$

$$\varphi^{NB} = \ \Delta B_2 . \Delta B_1$$

Derivate w.r.t φ

$$O_2[\Delta B_2]^{O_2 - 1} . (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb . \Delta B_1^{\ 0_1} + [\Delta B_2]^{O_2} . O_1\left(-[1 - p(1-\theta)](2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\right)[\Delta B_1]^{0_1 - 1} = 0$$

Take minus sign common and take the second term to the other side

$$O_2[\Delta B_2]^{O_2 - 1} . (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb . \Delta B_1^{\ 0_1} = [\Delta B_2]^{O_2} . O_1\left([1 - p(1-\theta)](2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\right)[\Delta B_1]^{0_1 - 1}$$

Divide both sides by $\Delta B_2{}^{O_2} . \Delta B_1{}^{0_1}$, $(2 + \ r_{t+1} - \rho)\theta\mu n\varepsilon wb$

$$\frac{O_2}{s}[\Delta B_2]^{-1} = \frac{O_1}{m}[1 - p(1-\theta)][\Delta B_1]^{-1}$$

$$\frac{O_2}{s}\Delta B_1 = \frac{O_1}{m}\Delta B_2[1 - p(1-\theta)]$$

As

$$\Delta B_1 = p\theta w(2 + \ r_{t+1}) + (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1 - p(1-\theta)](1-\varphi) - (1-p)\}$$

$$\Delta B_2 = \ (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi$$

Replacing values

$$\frac{O_2}{s}\left[p\theta w(2 + \ r_{t+1}) + (2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1 - p(1-\theta)](1-\varphi) - (1-p)\}\right] = \frac{O_1}{m}(2 + \ r_{t+1} - \rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi[1 - p(1-\theta)]$$

Opening brackets to simplify

$$\left[\frac{O_2}{s} p\theta w(2+ \ r_{t+1}) + \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1-p(1-\theta)] - \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb[1-p(1-\theta)]\varphi - \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb(1-p)\}\right] = \frac{O_1}{m}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi[1-p(1-\theta)]$$

Isolating φ

$$\frac{O_2}{s} p\theta w(2+ \ r_{t+1}) + \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1-p(1-\theta)] - \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb(1-p) = \frac{O_1}{m}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{s}\right)\varepsilon wb\varphi[1-p(1-\theta)] + \frac{O_2}{s}(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb[1-p(1-\theta)]\varphi$$

$$\varphi(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb[1-p(1-\theta)]\left[\frac{O_2}{s}+\frac{O_1}{s}\right] = \frac{O_2}{s}\left[p\theta w(2+ \ r_{t+1}) + (2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1-p(1-\theta)](1-\varphi)-(1-p)\}\right]$$

Cancel out s

$$\varphi(2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb[1-p(1-\theta)][O_1+O_2] = O_2\left[p\theta w(2+ \ r_{t+1}) + (2+ \ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon wb\{[1-p(1-\theta)](1-\varphi)-(1-p)\}\right]$$

Simplify

$$[1-p(1-\theta)](1-\varphi)-(1-p) = 1-p+p\theta-1+p = p\theta$$

$$\varphi(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}b[1-p(1-\theta)][O_1+O_2]$$
$$=O_2\left[p\theta w(2+\ \ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}bp\theta\right]$$

$$\varphi^{NB}=\frac{O_2\left[p\theta w(2+\ \ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}bp\theta\right]}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}b[1-p(1-\theta)][O_1+O_2]}$$

$$\varphi^{NB}=\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{[\mathrm{w}(2+\ r_{t+1})]}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{wb}}+1\right]$$

Taking w common from denominator and numerator, it cancels out leaving only the expression

$$\varphi^{NB}=\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}+1\right]$$

CPMPARATIVE STATICS

$$\frac{\partial(\varphi^{NB})}{\partial O_2}=\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}+1\right]\frac{(O_1+O_2)-O_2}{(O_1+O_2)^2}$$

$$\frac{\partial(\varphi^{NB})}{\partial O_2}=\ \frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}+1\right]\frac{O_1}{(O_1+O_2)^2}$$

$$\frac{\partial(\varphi^{NB})}{\partial O_2}>0$$

$$\frac{\partial(\varphi^{NB})}{\partial 0_1}=\ \frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}+1\right]\frac{0-O_2}{(O_1+O_2)^2}$$

$$\frac{\partial(\varphi^{NB})}{\partial 0_1}=\ \frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}+1\right]\frac{-O_2}{(O_1+O_2)^2}$$

$$\frac{\partial(\varphi^{NB})}{\partial 0_1} < 0$$

$$\frac{\partial(\varphi^{NB})}{\partial\, r_{t+1}} = \left[\frac{O_2}{O_1 + O_2}\right] . \frac{p\theta}{[1 - p(1-\theta)]} . \left[\frac{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b} - (2 + r_{t+1})\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}{\left\{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}\right\}^2}\right]$$

$$\frac{\partial(\varphi^{NB})}{\partial\, r_{t+1}} = \left[\frac{O_2}{O_1 + O_2}\right] . \frac{p\theta}{[1 - p(1-\theta)]} . \left[\frac{(-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}}{\left\{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}\right\}^2}\right]$$

$$\frac{\partial(\varphi^{NB})}{\partial\, r_{t+1}} < 0$$

$$\frac{\partial(\varphi^{NB})}{\partial b_t} = \left[\frac{O_2}{O_1 + O_2}\right] . \frac{p\theta}{[1 - p(1-\theta)]} . \left[\frac{-(2 + r_{t+1})}{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}^2}\right]$$

$$\frac{\partial(\varphi^{NB})}{\partial b_t} < 0$$

$$\frac{\partial(\varphi^{NB})}{\partial\theta} = \left[\frac{O_2}{O_1 + O_2}\right] . \frac{p(1-p)}{[1 - p(1-\theta)]^2} . \left[\frac{-(2 + r_{t+1})}{(2 + r_{t+1} - \rho)\left(\frac{\theta^2\mu n}{m}\right)\varepsilon\mathrm{b}}\right]$$

$$\frac{\partial(\varphi^{NB})}{\partial\theta} < 0$$

$$\frac{\partial(\varphi^{NB})}{\partial p} = \left[\frac{O_2}{O_1 + O_2}\right]\left[\frac{\theta[1 - 2p(1-p)]}{[1 - p(1-\theta)]^2}\right]\left[\frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{b}} + 1\right]$$

$$\frac{\partial(\varphi^{NB})}{\partial p} > 0$$

APPENDIX F

In this appendix, I calculate the minimum level of the bribe $b_t$share at, which both the households and the tax collectors are willing to agree during corruption.

CLACULATING BRIBE b^*

HOUSEHOLDS

$$\varepsilon w(1-\tau)(2+\ r_{t+1})=\varepsilon w(2+\ r_{t+1})(1-b-p(1-\theta)\tau)$$

εw and $(2+\ r_{t+1})$cancels out

$$(1-\tau)=(1-b-p(1-\theta)\tau)$$

1 cancels out

$$-\tau=(-b-\ p(1-\theta)\tau)$$

Take τ common

$$b^*=(\tau-\ p(1-\theta)\tau)$$

$$b^*=[1-p(1-\theta)]\tau$$

$$[1-p(1-\theta)]\left[w(2+\ \ r_{t+1})+(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon w b(1-\varphi)\right]\geq w(2+\ r_{t+1})$$

Let

$a=w(2+\ r_{t+1})$

$X=(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon w$

$$[1-p(1-\theta)][a+Xb(1-\varphi)]\geq a$$

$$[1-p(1-\theta)]a+[1-p(1-\theta)]Xb(1-\varphi)\geq a$$

$$[1-p(1-\theta)]Xb(1-\varphi)\geq a-[1-p(1-\theta)]a$$

$$[1-p(1-\theta)]Xb(1-\varphi)\geq a-a+pa(1-\theta)$$

a Cancels out

$$(1-pq)Xb(1-\varphi)\geq pa(1-\theta)$$

$$b^* \geq \frac{pa(1-\theta)}{[1-p(1-\theta)]X(1-\varphi)}$$

As

$a = \mathrm{w}(2 + r_{t+1})$

$\mathrm{X}{=}(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{w}$

Replacing values

$$b^* \geq \frac{p(1-\theta)\mathrm{w}(2 + r_{t+1})}{[1-p(1-\theta)](2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\mathrm{w}(1-\varphi)}$$

Taking w common from denominator and numerator, it cancels out leaving only the expression

$$b^* \geq \frac{p(1-\theta)(2 + r_{t+1})}{[1-p(1-\theta)](2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon(1-\varphi^{NB})}$$

APPENDIX G

In this appendix, I give detail proof for the equilibrium with no corruption. I calculate the revenues of the government through tax receipts, then I calculate the total savings of economy from which I calculate future rate of interest that will lead to economic growth.

GOVERNMENT

TAX RECEIPTS, NO CORRUPTION

Tax revenue = $\hat{\tau}\mu n\varepsilon w$

EXPENDITURES

a) Wages = $mw + s\upsilon$w= w$(m + s\upsilon)$
b) Government services = G

REVENUE=EXPENDITURE

$$\hat{\tau}\mu n\varepsilon w = G + \mathrm{w}(m + s\upsilon)$$

$$\hat{\tau}_t = \frac{G + \mathrm{w}(m + s\upsilon)}{\mu n\varepsilon w}$$

Replace

$$G = \Psi K^{\chi}\Phi$$

$$w = \beta L^{-1}\Psi K^{\chi}$$

$\hat{\tau}$ becomes

$$\hat{\tau}_t = \frac{\Psi K^{\chi}\Phi + \beta L^{-1}\Psi K^{\chi}(m + s\upsilon)}{\mu n\varepsilon\beta L^{-1}\Psi K^{\chi}}$$

$$\hat{\tau}_t = \frac{\Psi K^{\chi}\Phi}{\mu n\varepsilon\beta L^{-1}\Psi K^{\chi}} + \frac{\beta L^{-1}\Psi K^{\chi}(m + s\upsilon)}{\mu n\varepsilon\beta L^{-1}\Psi K^{\chi}}$$

$$\hat{\tau}_t = \frac{L\Psi K^{\chi}\Phi + \beta\Psi K^{\chi}(m + s\upsilon)}{\mu n\varepsilon\beta\Psi K^{\chi}}$$

Take ΨK_t^{χ} common such that

$$\hat{\tau}_t = \Psi\left[\frac{\Phi L + \beta(m + s\upsilon)}{\mu n\varepsilon\beta\Psi K^{\chi}}\right]K^{\chi}$$

$$\hat{\tau}_t = \left[\frac{L\Phi + \alpha(m + s\upsilon)}{\mu n\varepsilon\beta}\right] \equiv \hat{\tau}$$

TOTAL SAVINGS, NO CORRUPTION

1) Low-income HH $=(1-\mu)nw$
2) High-income HH $=\mu n\varepsilon w(1-\hat{\tau})$
3) B_1 savings = mw
4) B_2 savings = $s\upsilon w$

$$(1-\mu)nw+\mu n\varepsilon w(1-\hat{\tau})+mw+s\upsilon w=\ \widehat{K}_{t+1}$$

Replace

$$\hat{\tau}=\frac{G+\mathrm{w}(m+s\upsilon)}{\mu n\varepsilon w}$$

Such that

$$(1-\mu)nw+\mu n\varepsilon w\left(1-\left[\frac{G+\mathrm{w}(m+s\upsilon)}{\mu n\varepsilon w}\right]\right)+mw+s\upsilon w=\ \widehat{K}_{t+1}$$

Take L.C.M

$$(1-\mu)nw+\mu n\varepsilon w\left[\frac{\mu n\varepsilon w-[G+\mathrm{w}(m+s\upsilon)]}{\mu n\varepsilon w}\right]+mw+s\upsilon w=\ \widehat{K}_{t+1}$$

$\mu n\varepsilon w$ cancels out

$$(1-\mu)nw+\mu n\varepsilon w-[G+\mathrm{w}(m+s\upsilon)]+mw+s\upsilon w=\ \widehat{K}_{t+1}$$

Simplifying the expression gives

$$(1-\mu)nw+\mu n\varepsilon w-G-mw-s\upsilon w+mw+s\upsilon w=\ \widehat{K}_{t+1}$$

$s\upsilon w\ and\ mw$ cancels out

$$n\big((1-\mu)+\mu\varepsilon\big)w-G=\ \widehat{K}_{t+1}$$

Total labor supply= fraction low income and high income

Low endowment HH= $(1-\mu)n$

High endowment HH = $\varepsilon\mu n$

$$(1-\mu)n+\varepsilon\mu n=\ L$$

$$[(1-\mu)+\varepsilon\mu]n=\ L$$

Replace L in $\widehat{K}_{t+1}$ such that

$$Lw-G=\ \widehat{K}_{t+1}$$

Replace

$$G=\Psi K^{\chi}\Phi$$

$$w=\beta L^{-1}\Psi K^{\chi}$$

$$L\beta L^{-1}\Psi K^{\chi}-\Psi K^{\chi}\Phi=\ \widehat{K}_{t+1}$$

L cancels out

$$\beta\Psi K^{\chi} - \Psi K^{\chi}\Phi = \widehat{K}_{t+1}$$

Take ΨK^{χ}common

$$\Psi K^{\chi}(\beta - \Phi) = \widehat{K}_{t+1}$$

As

$$r = (1 - \alpha - \beta)\Psi K^{\chi - 1}$$

Then

$$\hat{r}_t = (1 - \alpha - \beta)\Psi \widehat{K}_t^{\chi - 1}$$

$$\hat{r}_{t+1} = (1 - \alpha - \beta)\Psi \widehat{K}_{t+1}^{\chi - 1}$$

Replace $\widehat{K}_{t+1}$ in $\hat{r}_{t+1}$

$$\hat{r}_{t+1} = (1 - \alpha - \beta)\Psi[\Psi K^{\chi}(\beta - \Phi)]^{\chi - 1}$$

$$\hat{r}_{t+1} = (1 - \alpha - \beta)\Psi[\Psi(\beta - \Phi)]^{\chi - 1}. K^{\chi(\chi - 1)} = \hat{R}_{t+1}$$

$$\hat{R}_{t+1} = (1 - \alpha - \beta)\Psi[\Psi(\beta - \Phi)]^{\chi - 1}. K^{\chi(\chi - 1)} \equiv \hat{R}(K_t)$$

COMPARATIVE STATICS

Derivate w.r.t K

$$\frac{\partial \hat{R}(K)}{\partial K} = \chi(\chi - 1)(1 - \alpha - \beta)\Psi[\Psi(\beta - \Phi)]^{\chi - 1}. K^{\chi(\chi - 1) - 1}$$

$$\frac{\partial \hat{R}(K)}{\partial K} = 0$$

$$\chi \in (0,1)$$

$$\chi - 1 < 0$$

$$\chi(\chi-1)<0$$

$$(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}>0$$

$$K^{\chi(\chi-1)-1}>0$$

$$\chi(\chi-1)(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}.K^{\chi(\chi-1)-1}<0$$

Therefore, the first derivative is negative

Taking the second derivative

$$\frac{\partial\left(\frac{\partial\hat{R}(K)}{\partial K}\right)}{(\partial K)^2}=\frac{\partial\left(\chi(\chi-1)(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}.K^{\chi(\chi-1)-1}\right)}{(\partial K)^2}$$

$$\frac{\partial\left(\frac{\partial\hat{R}(K)}{\partial K}\right)}{(\partial K)^2}=(\chi(\chi-1)-1)\chi(\chi-1)(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}.K^{\chi(\chi-1)-2}$$

As

$$\chi\in(0,1)$$

So as of which

$$\chi-1<0,\chi(\chi-1)<0,\chi(\chi-1)-1<0,$$

Because of which I can say

$$\chi(\chi-1)(\chi(\chi-1)-1)$$

$$(-)*(-)>0$$

$$(\chi(\chi-1)-1)\chi(\chi-1)(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}.K^{\chi(\chi-1)-2}>0$$

$$\frac{\partial\left(\frac{\partial\hat{R}(K)}{\partial K}\right)}{(\partial K)^2}>0$$

Therefore, the second derivative is positive

$\hat{R}(K)$ is decreasing in K.

APPENDIX H

In this appendix, I check the ICC constraint for the equilibrium with no corruption.
In addition, I check the comparative statics with respect to K_t
ICC CONSTRAINT

EQUILIBRIUM WITH NO CORRUPTION

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)](2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon(1-\varphi^{NB})}$$

$$b^* = [1-p(1-\theta)]\hat{\tau}_t$$

$$\varphi^{NB} = \left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon b}+1\right]$$

Replacing φ^{NB} in b

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)](2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon b}+1\right]\right)}$$

Let

$$(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon = \overline{X}$$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{\overline{X}b}+1\right]\right)}$$

Take L.C.M $\overline{X}b$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})+\overline{X}b}{\overline{X}b}\right]\right)}$$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(\frac{\overline{X}b-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{X}b]}{\overline{X}b}\right)}$$

Cancel out $\overline{\mathrm{X}}$

$$b^{*} \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\left(\dfrac{\overline{\mathrm{X}}\mathrm{b}-\left[\dfrac{O_2}{O_1+O_2}\right].\dfrac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]}{\mathrm{b}}\right)}$$

$$b^{*} \geq \frac{p(1-\theta)(2+\ r_{t+1})\mathrm{b}}{[1-p(1-\theta)]\left(\overline{\mathrm{X}}\mathrm{b}-\left[\dfrac{O_2}{O_1+O_2}\right].\dfrac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]\right)}$$

Cancel out b

$$\left(\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

Simplifying the expressions

$$\left(\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta(2+\ r_{t+1})}{[1-p(1-\theta)]}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\overline{\mathrm{X}}\mathrm{b}\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

$$\overline{\mathrm{X}}\mathrm{b}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}+\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

$$\overline{\mathrm{X}}\mathrm{b}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right) \geq \frac{p(2+\ r_{t+1})}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

$$\mathrm{b} \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\dfrac{O_2}{O_1+O_2}\right].\dfrac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

As

$$b^{*} = [1-p(1-\theta)]\hat{\tau}_t$$

Replace

$$[1-p(1-\theta)]\hat{\tau}_t \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\dfrac{O_2}{O_1+O_2}\right].\dfrac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

$$\hat{\tau}_t \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\dfrac{O_2}{O_1+O_2}\right].\dfrac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]^2}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

As

$$\overline{\mathrm{X}} = (2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon$$

Replace

$$\hat{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right]$$

$$\hat{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)}.\frac{1}{\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right]$$

Let

$$\frac{1}{\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right] = \bar{Z}$$

$$\hat{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)}.\bar{Z}$$

$$(2 + r_{t+1} - \rho)\hat{\tau}_t \geq \bar{Z}(2 + r_{t+1})$$

$$(2 - \rho)\hat{\tau}_t + \hat{\tau}_t\, r_{t+1} \geq 2\bar{Z} + r_{t+1}\bar{Z}$$

$$\hat{\tau}_t\, r_{t+1} - r_{t+1}\bar{Z} \geq 2\bar{Z} - (2 - \rho)\hat{\tau}_t$$

$$r_{t+1}(\hat{\tau}_t - \bar{Z}) \geq 2\bar{Z} - (2 - \rho)\hat{\tau}_t$$

$$r_{t+1} \geq \frac{2\bar{Z} - (2 - \rho)\hat{\tau}_t}{(\hat{\tau}_t - \bar{Z})}$$

$$\bar{Z} \neq f(K_t)$$

As

$$\hat{\tau}_t = \hat{\tau}$$

Where

$$\hat{r}_t = \hat{r}_{t+1} = \hat{R}_{t+1} = \hat{R}(K_t)$$

So above expression becomes

$$\hat{R}(K_t) \geq \frac{2\bar{Z} - (2-\rho)\hat{\tau}}{(\hat{\tau} - \bar{Z})} \equiv \widehat{W}$$

Derivate w.r.t K

$$\frac{\partial \widehat{W}}{\partial K} = 0$$

W is not a function of K, W is independent of K.

APPENDIX I

In this appendix, I give a detail proof for the equilibrium with corruption. I calculate the revenues of the government through tax receipts, then I calculate the total savings of economy from which I calculate future rate of interest that will lead to economic growth in a corrupt society.

TAX RECEIPTS, WITH CORRUPTION

Tax revenue = $\mu n \varepsilon w \tilde{\tau}_t$

1) Honest HH, Honest B_1= $(1-\theta)[(1-\theta)+\theta(1-\lambda)]$
2) Honest HH, Corrupt B_1=$(1-\theta)\theta\,\lambda$
3) Corrupt HH, Honest B_1=$\theta[(1-\theta)+\theta(1-\lambda)]$
4) Corrupt HH, Corrupt B_1= $\theta^2\,\lambda$

RVENUES

1) Mismatch

$$\mu n \varepsilon w \tilde{\tau}_t(1-\theta)[(1-\theta)+\theta(1-\lambda)] + \mu n \varepsilon w \tilde{\tau}_t(1-\theta)\theta\,\lambda + \mu n \varepsilon w \tilde{\tau}_t\theta[(1-\theta)+\theta(1-\lambda)]$$

$$\mu n \varepsilon w \tilde{\tau}_t(1+\theta^2-2\theta+\theta-\theta^2-\theta(1-\lambda)+\theta(1-\lambda)+\theta-\theta^2+\theta^2-\theta^2\,\lambda)$$

$\theta, \theta(1-\lambda)\ and\ \theta^2$Cancel out

$$(1-\theta^2\lambda)\mu n \varepsilon w \tilde{\tau}_t$$

2) B_1 are corrupt

$$p\mu n \varepsilon w \tilde{\tau}_t\theta^2\lambda$$

3) B_1 are caught and fined

$$(p(1-\theta))[w(2+\ r_{t+1})+(2+r_{t+1}-\rho)(\frac{\theta\mu n}{m})\varepsilon w b]$$

EXPENDITURES

c) Wages = $mw + s\upsilon$w= w$(m + s\upsilon)$
d) Government services = G
e) Cost of auditing = internal + external

$$c\eta\tilde{\tau}\mu n + c\sigma\tilde{\tau}\mu n$$

What $B_1$are finned is equal to the cost of auditing to the government such that

$$(p(1-\theta))\left[w(2+\ r_{t+1})+(2+r_{t+1}-\rho)\left(\frac{\mu n}{m}\right)\theta\varepsilon w b\right]+p\mu n\varepsilon w\tilde{\tau}_t\theta^2\lambda = c\eta\tilde{\tau}\mu n + c\sigma\tilde{\tau}\mu n$$

REVENUE=EXPENDITURE

$$\lambda = 1$$

$$(1-\theta^2)\mu n\varepsilon w\tilde{\tau}_t = G + \mathrm{w}(m + s\upsilon)$$

Isolate $\tilde{\tau}_t$

$$\tilde{\tau}_t = \frac{G + \mathrm{w}(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon w}$$

Replace

$$G = \Psi K^{\chi}\Phi$$

$$w = \beta L^{-1}\Psi K^{\chi}$$

$$\tilde{\tau}_t = \frac{\Psi K^{\chi}\Phi + \beta L^{-1}\Psi K^{\chi}(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon\beta L^{-1}\Psi K^{\chi}}$$

$$\tilde{\tau}_t = \frac{\mathrm{L}\Psi K^{\chi}\Phi + \beta\Psi K^{\chi}(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon\beta\Psi K^{\chi}}$$

L cancels out

Take ΨK^{χ} common and cancel it

$$\tilde{\tau}_t = \left[\frac{\mathrm{L}\Phi + \beta(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon\beta\Psi K^{\chi}}\right]\Psi K^{\chi}$$

$$\tilde{\tau}_t = \frac{\mathrm{L}\Phi + \beta(m + s\upsilon)}{(1-\theta^2)\mu n\varepsilon\beta} \equiv \tilde{\tau}$$

TOTAL SAVINGS, WITH CORRUPTION

HOUSEHOLDS

4) Low-income HH =$(1-\mu)nw$
5) High-income HH (honest) =$\mu n\varepsilon w(1-\tilde{\tau}_t)(1-\theta)$
6) High-income HH (dishonest) =$\theta\lambda\mu n\varepsilon w\left(1-\tilde{b}_t - p(1-\theta)\tilde{\tau}_t\right)$, $(1-\lambda)\theta\mu n\varepsilon w(1-\tau)$

TAX COLLECTORS

B_1 Honest = $[(1-\theta)+\theta(1-\lambda)]mw$

B_1 Dishonest/corruptible =$\theta\lambda\mu mw\left\{[1-p(1-\theta)][w + (\frac{\theta\mu n}{m})\varepsilon w\tilde{b}_t(1-\varphi)]\right\}$

TIER TWO BUREAUCRATS

B_2 Honest = $(1-\theta)s\upsilon w$

B_2 Dishonest/corruptible = $(1-\lambda)s\upsilon w, \lambda\theta s\left\{\left[\upsilon w+\left(\frac{\theta\mu n}{s}\right)\varepsilon w\tilde{b}_t\varphi\right]\right\}$

$$\lambda = 1$$

$$(1-\mu)nw+\ \mu n\varepsilon w(1-\tilde{\tau}_t)(1-\theta)+\ \theta\mu n\varepsilon w\left(1-\tilde{b}_t-p(1-\theta)\tilde{\tau}_t\right)+\ (1-\theta)\ mw$$
$$+\theta m\left\{[1-p(1-\theta)]\left[w+\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}\tilde{b}_t(1-\varphi)\right]\right\}+(1-\theta)s\upsilon w$$
$$+\theta s\left[\upsilon w+\left(\frac{\theta\mu n}{s}\right)\varepsilon \mathrm{w}\tilde{b}_t\varphi\right]=\widetilde{K}_{t+1}$$

Replace

$$\tilde{\tau}_t=\frac{G+\mathrm{w}(m+s\upsilon)}{(1-\theta^2)\mu n\varepsilon w}$$

$$(1-\mu)nw+\ \mu n\varepsilon w(1-\left[\frac{G+\mathrm{w}(m+s\upsilon)}{(1-\theta^2)\mu n\varepsilon w}\right])(1-\theta)$$
$$+\ \theta\mu n\varepsilon w\left(1-\tilde{b}_t-p(1-\theta)\left[\frac{G+\mathrm{w}(m+s\upsilon)}{(1-\theta^2)\mu n\varepsilon w}\right]\right)+\ (1-\theta)\ mw$$
$$+\theta m\left\{[1-p(1-\theta)]\left[w+\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}\tilde{b}_t(1-\varphi)\right]\right\}+(1-\theta)s\upsilon w$$
$$+\theta s\left[\upsilon w+\left(\frac{\theta\mu n}{s}\right)\varepsilon \mathrm{w}\tilde{b}_t\varphi\right]=\widetilde{K}_{t+1}$$

Opening brackets and taking L.C.M

$$(1-\mu)nw+\ \mu n\varepsilon w\left(\frac{(1-\theta^2)\mu n\varepsilon w-[G+\mathrm{w}(m+s\upsilon)]}{(1-\theta^2)\mu n\varepsilon w}\right)(1-\theta)$$
$$+\ \theta\mu n\varepsilon w\left(\frac{(1-\theta^2)\mu n\varepsilon w-(1-\theta^2)\mu n\varepsilon w\tilde{b}_t-p(1-\theta)G+\mathrm{w}(m+s\upsilon)}{(1-\theta^2)\mu n\varepsilon w}\right)$$
$$+\ (1-\theta)\ mw+\theta mw[1-p(1-\theta)]+\theta m[1-p(1-\theta)]\left(\frac{\theta\mu n}{m}\right)\varepsilon \mathrm{w}\tilde{b}_t(1-\varphi)$$
$$+(1-\theta)s\upsilon w+\theta s\upsilon w+\theta s\left(\frac{\theta\mu n}{s}\right)\varepsilon \mathrm{w}\tilde{b}_t\varphi=\widetilde{K}_{t+1}$$

Simplifying the expressions

$$(1-\mu)nw+\mu n\varepsilon w(1-\theta)-\left(\frac{[G+\mathrm{w}(m+s\upsilon)]}{(1-\theta^2)}\right)(1-\theta)+\ \theta\mu n\varepsilon w-\theta\mu n\varepsilon w\tilde{b}_t$$
$$-\left(\frac{p(1-\theta)[G+\mathrm{w}(m+s\upsilon)]}{(1-\theta^2)}\right)+\ (1-\theta)\,mw+\theta mw[1-p(1-\theta)]$$
$$+\,\theta[1-p(1-\theta)]\theta\mu n\varepsilon\mathrm{w}\tilde{b}_t(1-\varphi)+(1-\theta)s\upsilon w+\theta s\upsilon w$$
$$+\,\theta(1-p)\theta\mu n\varepsilon\mathrm{w}\tilde{b}_t\varphi=\widetilde{K}_{t+1}$$

$$n\big((1-\mu)+\mu\varepsilon\big)w+mw[1-p\theta(1-\theta)]+s\upsilon w-\frac{(1-\theta)}{(1-\theta^2)}[G+\mathrm{w}(m+s\upsilon)][1+\theta p]$$
$$-\,\theta\mu n\varepsilon\mathrm{w}\tilde{b}_t\{1-\theta\varphi-[1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\}=\widetilde{K}_{t+1}$$

Total labor supply= fraction low income and high income
Low endowment HH= $(1-\mu)n$
High endowment HH = $\varepsilon\mu n$

$$(1-\mu)n+\varepsilon\mu n=\ L$$
$$[(1-\mu)+\varepsilon\mu]n=\ L$$

Replace L in $\widetilde{K}_{t+1}$ such that

$$Lw+mw[1-p\theta(1-\theta)]+s\upsilon w-\frac{(1-\theta)}{(1-\theta^2)}[G+\mathrm{w}(m+s\upsilon)][1+\theta p]$$
$$-\,\theta\mu n\varepsilon\mathrm{w}\tilde{b}_t\{1-\theta\varphi-[1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\}=\widetilde{K}_{t+1}$$

Replace

$$G=\Psi K^{\chi}\Phi$$

$$w=\beta L^{-1}\Psi K^{\chi}$$

$$\tilde{b}_t=[1-p(1-\theta)]\tilde{\tau}$$

$$L\beta L^{-1}\Psi K^{\chi}+m\beta L^{-1}\Psi K^{\chi}[1-p\theta(1-\theta)]+s\upsilon\beta L^{-1}\Psi K^{\chi}$$
$$-\frac{(1-\theta)}{(1-\theta^2)}[\Psi K^{\chi}\Phi+\beta L^{-1}\Psi K^{\chi}(m+s\upsilon)][1+\theta p]$$
$$-\,\theta\mu n\varepsilon\beta L^{-1}\Psi K^{\chi}[1-p(1-\theta)]\tilde{\tau}\{1-\theta\varphi-[1-\mathrm{p}(1-\theta)]\theta(1-\varphi)\}=\widetilde{K}_{t+1}$$

L cancels out

Take ΨK^{χ} common

$$\Psi K^{\chi}\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}s\upsilon-\frac{(1-\theta)}{(1-\theta^{2})}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]\right.$$
$$\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]=\widetilde{K}_{t+1}$$

As

$$r=(1-\alpha-\beta)\Psi K^{\chi-1}$$

Then

$$\widetilde{r_{t}}=(1-\alpha-\beta)\Psi\widetilde{K}_{t}^{\chi-1}$$

$$\tilde{r}_{t+1}=(1-\alpha-\beta)\Psi\widetilde{K}_{t+1}^{\chi-1}$$

Replace $\widetilde{K}_{t+1}$ in $\tilde{r}_{t+1}$

$$\tilde{r}_{t+1}=(1-\alpha-\beta)\Psi\left\{\Psi K^{\chi}\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}s\upsilon\right.\right.$$
$$-\frac{(1-\theta)}{(1-\theta^{2})}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]$$
$$\left.\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right\}^{\chi-1}$$

$$\tilde{r}_{t+1}=(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}s\upsilon\right.\right.$$
$$-\frac{(1-\theta)}{(1-\theta^{2})}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]$$
$$\left.\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K^{\chi(\chi-1)}$$
$$=\tilde{R}_{t+1}$$

$$\tilde{R}_{t+1} = (1-\alpha$$

$$-\beta)\Psi\left[\Psi\left[\beta + \frac{\beta}{L}m[1-p\theta(1-\theta)] + \frac{\beta}{L}s\upsilon\right.\right.$$

$$-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi + \frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]$$

$$\left.\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K_{t+1}^{\chi(\chi-1)}$$

$$\equiv \tilde{R}(K)$$

COMPARATIVE STATICS

Derivate w.r.t K

$$\frac{\partial\tilde{R}(K)}{\partial K} = \chi(\chi-1)(1-\alpha$$

$$-\beta)\Psi\left[\Psi\left[\beta + \frac{\beta}{L}m[1-p\theta(1-\theta)] + \frac{\beta}{L}s\upsilon\right.\right.$$

$$-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi + \frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]$$

$$\left.\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K^{\chi(\chi-1)-1}$$

$$\frac{\partial\tilde{R}(K)}{\partial K} = 0$$

$$\chi \in (0,1)$$

$$\chi - 1 < 0$$

$$\chi(\chi-1) < 0$$

$$(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}sv-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]\right.\right.$$
$$\left.\left.-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}>0$$

$$K^{\chi(\chi-1)-1}>0$$

$$\chi(\chi-1)(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}sv-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K^{\chi(\chi-1)-1}<0$$

Therefore, the first derivative is negative

Taking the second derivative

$$\frac{\partial\left(\frac{\partial\tilde{R}(K)}{\partial K}\right)}{(\partial K)^2}=\frac{\partial\left(\chi(\chi-1)(1-\alpha-\beta)\Psi\left[\Psi\left[\begin{array}{c}\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}sv-\\ \frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]-\\ \frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\end{array}\right]\right]^{\chi-1}.K^{\chi(\chi-1)-1}\right)}{(\partial K)^2}$$

$$\frac{\partial\left(\frac{\partial\tilde{R}(K)}{\partial K}\right)}{(\partial K)^2}=(\chi(\chi-1)-1)\chi(\chi-1)(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}sv-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K^{\chi(\chi-1)-2}$$

As

$$\chi\in(0,1)$$

So as of which

$$\chi - 1 < 0, \chi(\chi - 1) < 0, \chi(\chi - 1) - 1 < 0,$$

Because of which I can say

$$\chi(\chi - 1)(\chi(\chi - 1) - 1)$$

$$(-) * (-) > 0$$

$$(\chi(\chi - 1) - 1)\chi(\chi - 1)(1 - \alpha - \beta)\Psi\left[\Psi\left[\beta + \frac{\beta}{L}m[1 - p\theta(1 - \theta)] + \frac{\beta}{L}s\upsilon - \frac{(1 - \theta)}{(1 - \theta^2)}\left[\Phi + \frac{\beta}{L}(m + s\upsilon)\right][1 + \theta p] - \frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1 - p(1 - \theta)]\{1 - \theta\varphi - [1 - p(1 - \theta)]\theta(1 - \varphi)\}\right]\right]^{\chi - 1} . K^{\chi(\chi - 1) - 2} > 0$$

$$\frac{\partial\left(\frac{\partial\tilde{R}(K)}{\partial K}\right)}{(\partial K)^2} > 0$$

Therefore, the second derivative is positive

$\tilde{R}(K)$ is decreasing in K.

APPENDIX J

In this appendix, I check the ICC constraint for the equilibrium with corruption.
In addition, I check the comparative statics with respect to K
EQUILIBRIUM WITH CORRUPTION

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)](2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon(1-\varphi^{NB})}$$

$$b^* = [1-p(1-\theta)]\tilde{\tau}_t$$

$$\varphi^{NB} = \left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon b}+1\right]$$

Replacing φ^{NB} in b

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)](2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon b}+1\right]\right)}$$

Let

$$(2+\ r_{t+1}-\rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon = \overline{X}$$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})}{\overline{X}b}+1\right]\right)}$$

Take L.C.M $\overline{X}b$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.\left[\frac{(2+\ r_{t+1})+\overline{X}b}{\overline{X}b}\right]\right)}$$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\overline{X}\left(\frac{\overline{X}b-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{X}b]}{\overline{X}b}\right)}$$

Cancel out $\overline{\mathrm{X}}$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]\left(\frac{\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]}{\mathrm{b}}\right)}$$

$$b^* \geq \frac{p(1-\theta)(2+\ r_{t+1})\mathrm{b}}{[1-p(1-\theta)]\left(\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]\right)}$$

Cancel out b

$$\left(\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}.[(2+\ r_{t+1})+\overline{\mathrm{X}}\mathrm{b}]\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

Simplifying the expressions

$$\left(\overline{\mathrm{X}}\mathrm{b}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta(2+\ r_{t+1})}{[1-p(1-\theta)]}-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\overline{\mathrm{X}}\mathrm{b}\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

$$\overline{\mathrm{X}}\mathrm{b}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right) \geq \frac{p(1-\theta)(2+\ r_{t+1})}{[1-p(1-\theta)]}+\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta(2+\ r_{t+1})}{[1-p(1-\theta)]}$$

$$\overline{\mathrm{X}}\mathrm{b}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right) \geq \frac{p(2+\ r_{t+1})}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

$$\mathrm{b} \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

As

$$b^* = [1-p(1-\theta)]\tilde{\tau}_t$$

Replace

$$[1-p(1-\theta)]\tilde{\tau}_t \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

$$\tilde{\tau}_t \geq \frac{(2+\ r_{t+1})}{\overline{\mathrm{X}}\left(1-\left[\frac{O_2}{O_1+O_2}\right].\frac{p\theta}{[1-p(1-\theta)]}\right)}.\frac{p}{[1-p(1-\theta)]^2}\left[(1-\theta)+\left[\frac{O_2}{O_1+O_2}\right]\theta\right]$$

As

$$\overline{X} = (2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon$$

Replace

$$\tilde{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right]$$

$$\tilde{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)}.\frac{1}{\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right]$$

Let

$$\frac{1}{\left(\frac{\theta\mu n}{m}\right)\varepsilon\left(1 - \left[\frac{O_2}{O_1 + O_2}\right].\frac{p\theta}{[1 - p(1-\theta)]}\right)}.\frac{p}{[1 - p(1-\theta)]^2}\left[(1-\theta) + \left[\frac{O_2}{O_1 + O_2}\right]\theta\right] = \bar{Z}$$

$$\tilde{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)}.\bar{Z}$$

$$(2 + r_{t+1} - \rho)\tilde{\tau}_t \geq \bar{Z}(2 + r_{t+1})$$

$$(2 - \rho)\tilde{\tau}_t + \tilde{\tau}_t\, r_{t+1} \geq 2\bar{Z} + r_{t+1}\bar{Z}$$

$$\tilde{\tau}_t\, r_{t+1} - r_{t+1}\bar{Z} \geq 2\bar{Z} - (2 - \rho)\tilde{\tau}_t$$

$$r_{t+1}(\tilde{\tau}_t - \bar{Z}) \geq 2\bar{Z} - (2 - \rho)\tilde{\tau}_t$$

$$r_{t+1} \geq \frac{2\bar{Z} - (2 - \rho)\tilde{\tau}_t}{(\tilde{\tau}_t - \bar{Z})}$$

$$\bar{Z} \neq f(K_t)$$

As

$$\tilde{\tau}_t = \tilde{\tau}$$

Where

$$\tilde{r}_t = \tilde{r}_{t+1} = \tilde{R}_{t+1} = \tilde{R}(K_t)$$

So above expression becomes

$$\tilde{R}(K_t) \geq \frac{2\bar{Z} - (2-\rho)\tilde{\tau}}{(\tilde{\tau} - \bar{Z})} \equiv \widetilde{W}$$

Derivate w.r.t K

$$\frac{\partial \widetilde{W}}{\partial K} = 0$$

W is not a function of K, W is independent of K.

APPENDIX K

In this appendix, I take the ICC constraint for the economy to calculate the value of K for equilibrium with corruption and equilibrium with no corruption.

EQUILIBRIUM WITH NO CORRUPTION

From Appendix H

$$\hat{\tau}_t \geq \frac{(2+\ r_{t+1})}{(2+\ r_{t+1}-\rho)}.\bar{Z}$$

As

$(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}.K^{\chi(\chi-1)}=\hat{r}_{t+1}$

Let

$$(1-\alpha-\beta)\Psi[\Psi(\beta-\Phi)]^{\chi-1}=\bar{S}$$

$$\hat{r}_{t+1}=\bar{S}K^{\chi(\chi-1)}$$

Replace $\hat{r}_{t+1}$

$$\hat{\tau}_t \geq \frac{\left(2+\bar{S}K^{\chi(\chi-1)}\right)}{(2+\bar{S}K^{\chi(\chi-1)}-\rho)}.\bar{Z}$$

Isolating K

$$\left(2+\bar{S}K^{\chi(\chi-1)}-\rho\right)\hat{\tau}_t \geq \left(2+\bar{S}K^{\chi(\chi-1)}\right)\bar{Z}$$

$$(2-\rho)\hat{\tau}_t+\bar{S}K^{\chi(\chi-1)}\hat{\tau}_t \geq \left(2\bar{Z}+\bar{S}K^{\chi(\chi-1)}\bar{Z}\right)$$

$$\bar{S}K^{\chi(\chi-1)}\hat{\tau}_t-\bar{S}K^{\chi(\chi-1)}\bar{Z} \geq 2\bar{Z}-(2-\rho)\hat{\tau}_t$$

$$\bar{S}K^{\chi(\chi-1)}(\hat{\tau}_t-\bar{Z}) \geq 2\bar{Z}-(2-\rho)\hat{\tau}_t$$

$$K^{\chi(\chi-1)} \geq \frac{2\bar{Z}-(2-\rho)\hat{\tau}_t}{\bar{S}(\hat{\tau}_t-\bar{Z})}$$

$$K \geq \left[\frac{2\bar{Z}-(2-\rho)\hat{\tau}_t}{\bar{S}(\hat{\tau}_t-\bar{Z})}\right]^{1/\chi(\chi-1)}$$

$$K_1^c \geq \left[\frac{\bar{S}(\hat{\tau}_t-\bar{Z})}{2\bar{Z}-(2-\rho)\hat{\tau}_t}\right]^{\chi(\chi-1)}$$

EQUILIBRIUM WITH CORRUPTION
From Appendix I

$$\tilde{\tau}_t \geq \frac{(2 + r_{t+1})}{(2 + r_{t+1} - \rho)}.\bar{Z}$$

As

$$(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}s\upsilon-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}\left[1-p(1-\theta)\right]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}.K^{\chi(\chi-1)}=\tilde{r}_{t+1}$$

Let

$$(1-\alpha-\beta)\Psi\left[\Psi\left[\beta+\frac{\beta}{L}m[1-p\theta(1-\theta)]+\frac{\beta}{L}s\upsilon-\frac{(1-\theta)}{(1-\theta^2)}\left[\Phi+\frac{\beta}{L}(m+s\upsilon)\right][1+\theta p]-\frac{\theta\mu n\varepsilon\beta\tilde{\tau}}{L}[1-p(1-\theta)]\{1-\theta\varphi-[1-p(1-\theta)]\theta(1-\varphi)\}\right]\right]^{\chi-1}=\overline{\nabla}$$

$$\tilde{r}_{t+1}=\overline{\nabla}K^{\chi(\chi-1)}$$

Replace $\tilde{r}_{t+1}$

$$\tilde{\tau}_t \geq \frac{\left(2+\overline{\nabla}K^{\chi(\chi-1)}\right)}{(2+\overline{\nabla}K^{\chi(\chi-1)}-\rho)}.\bar{Z}$$

Isolating K

$$\left(2+\overline{\nabla}K^{\chi(\chi-1)}-\rho\right)\tilde{\tau}_t \geq \left(2+\overline{\nabla}K^{\chi(\chi-1)}\right)\bar{Z}$$

$$(2-\rho)\tilde{\tau}_t+\overline{\nabla}K^{\chi(\chi-1)}\tilde{\tau}_t \geq \left(2\bar{Z}+\overline{\nabla}K^{\chi(\chi-1)}\bar{Z}\right)$$

$$\overline{\nabla}K^{\chi(\chi-1)}\tilde{\tau}_t-\overline{\nabla}K^{\chi(\chi-1)}\bar{Z} \geq 2\bar{Z}-(2-\rho)\tilde{\tau}_t$$

$$\overline{\nabla}K^{\chi(\chi-1)}(\tilde{\tau}_t-\bar{Z}) \geq 2\bar{Z}-(2-\rho)\tilde{\tau}_t$$

$$K^{\chi(\chi-1)} \geq \frac{2\bar{Z}-(2-\rho)\tilde{\tau}_t}{\overline{\nabla}(\tilde{\tau}_t-\bar{Z})}$$

$$K \geq \left[\frac{2\bar{Z} - (2-\rho)\tilde{\tau}_t}{\overline{\mathrm{V}}(\tilde{\tau}_t - \bar{Z})}\right]^{1/\chi(\chi-1)}$$

$$K_2^c \geq \left[\frac{\overline{\mathrm{V}}(\tilde{\tau}_t - \bar{Z})}{2\bar{Z} - (2-\rho)\tilde{\tau}_t}\right]^{\chi(\chi-1)}$$

Where

$$\overline{\mathrm{V}} > \overline{\mathrm{S}}$$

$$\tilde{\tau}_t > \hat{\tau}_t$$

$$K_2^c > K_1^c$$