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# Country output and financial black holes: public–private partnerships and the Laffer curve, fiscal corruption risk, and bailout rate of non-performing loans

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## ABSTRACT

This study develops the link between output and fiscal corruption risk in public–private partnership (PPP) schemes and the government bailout rate of non-performing loans (NPLs). The model assumes that corruption is widespread in such public investment programs. The objective functions of the government and PPP firms include fiscal corruption risk, given that the PPP firm and tax inspector can ‘effectively’ negotiate bribes. The model solves for the optimal country output (i.e., aggregate productivity) according to the Lagrange method. Long-term prospects are introduced to solve the problem with commercial banks, as most PPPs borrow from commercial banks. The results reaffirm that tax policy can exacerbate the country’s output loss. Although the equilibria between aggregate productivity and the Laffer curve lack a direct link to fiscal corruption risk, their magnitude does and depends on the number of PPPs. The PPP transfer from the government in period 2 and the number of PPPs rather than government expenditure in period 1 and the Laffer curve (tax revenues) mainly determines the bailout rate of PPPs’ NPLs. The article concludes with suggestions to prevent tax evasion and fiscal corruption risk in PPP schemes by using a cluster of cooperation, and recommends further research into cultural aspects.

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public–private partnership (PPP); government rescue rate of non-performing loans (NPL); aggregate productivity; fiscal corruption risk; cluster of cooperation

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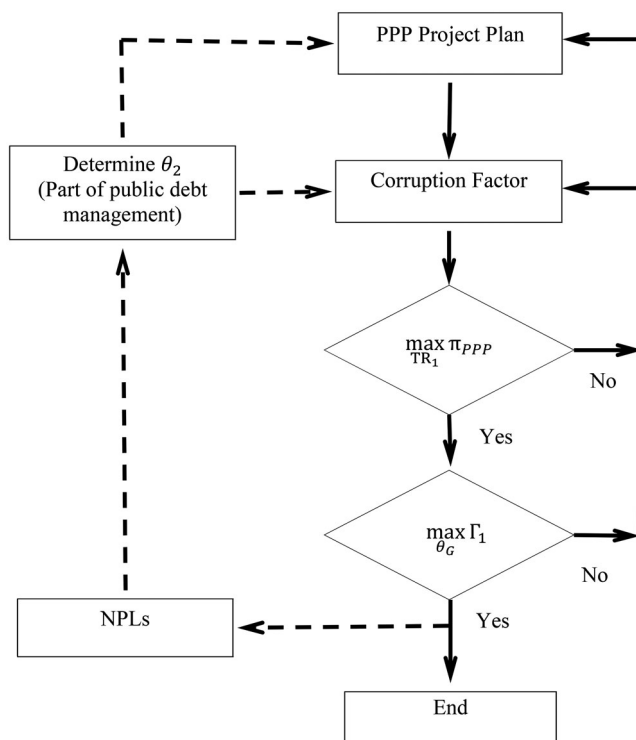
## 1. Introduction

The recent literature on fiscal policy demonstrates the role of fiscal corruption on tax evasion in quantifying its effects on state tax revenues. Camous and Gimber (2018) determine the effect of fiscal austerity and emphasise that the austerity measure can be based on aggregate productivity and the Laffer curve if an endogenous decrease in government spending is in the retrenchment process (Korpi & Palme, 2003) and the government implements fiscal austerity (Sau, 2018). However, as many countries justify their expenses on the grounds of tax collection and debt issuance, it would be practical to focus on public debt management and fiscal corruption. Consequently,

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**Figure 1.** The flow chart stimulated by our model.

this study looks at public debt management, specifically the bailout rate of non-performing loans (NPLs) and the aggregate productivity in countries forging public–private partnerships (PPPs) when tax evasion is subject to fiscal corruption risk (or constraint) and when these countries consider the PPPs as an alternative for reducing public debt (Engel, Fischer, & Galetovic, 2013); (National Assembly, 2018). We assume that these countries launch a series of fiscal policy tools in period 1 (i.e., a short-term tactic), and implement the policy statement in period 2 (the long-term prospects).

NPLs due to corruption in PPP projects<sup>1</sup> make public debt management more difficult, so the model introduces the government bailout rate of NPLs ( $\theta_2$ ) in period 2 to solve the problem with commercial banks, as most PPP projects borrow money from commercial banks, as in the Lao People’s Democratic Republic, where its central bank proposes  $\theta_2 = 0.65 - 0.7$  (Lao Prime Minister, 2014). This study then examines whether a common device to implement fiscal austerity (i.e.,  $\theta_2$ ) that restricts monetary supply to stabilise inflation based on supply side economics (Xi, 2017) can meet the height of the Laffer curve or a certain level of government expenditure ( $G_1$ ) in period 1 (Camous & Gimber, 2018; Prati & Tressel, 2006). We provide motivation to the study in Figure 1.

The results confirm the existence of a procyclical tax policy in the model. Tax policy can exacerbate the output loss (i.e., low aggregate productivity), both in the short and long run, as the higher number PPP projects is, the lower the aggregate productivity is. We also find that  $\theta_2$  is determined by the PPP transfer from a government

(public debt) in period 2 and the total number of PPP projects rather than government expenditure ( $G_1$ ) in period 1 or the Laffer curve (tax revenues). Moreover, in terms of tax evasion, other PPP firms could be free riders on the punishment for discovered and evaded taxes, and thus a cluster of cooperation is necessary (Luo & Zhao, 2013). The authors extend the model accordingly and find that if the punishment rate for tax inspectors is characterised by the high and low amount of discovered and evaded taxes, then the reverting punishment rate for the PPP firm describes the steady state of the fiscal policy.

This study is based on the work of Camous and Gimber (2018), who focus on the cyclical nature of tax policy and public debt management in the absence of fiscal corruption.<sup>2</sup> The main contribution of this study is that it emphasises the role of fiscal corruption risk in a more realistic context of public debt management in countries encouraging PPPs. This study also offers a new perspective on 'legal tax avoidance' (Mankiw (2007) rather than tax evasion, as firm can employ tax lawyers and accountants to handle tax avoidance (see Definition 3).

This study extends Vasin's (1999) model, which explores the interaction of tax inspectors and taxpayers using a monetary punishment for poor quality audits under complete information. A key difference between the model in the present study and Vasin's (1999) model is in terms of fiscal corruption. The present study focuses on bargaining outcomes, as Svensson (2005) and Cerqueti and Coppier (2016) note that taxpayers and tax inspectors can 'effectively' negotiate bribes in the absence of contracts. Vasin's (1999) model includes the punishment rate for PPP firms for dishonest behaviour in the evaded taxes. The model in this study instead assumes that both the punishment rates for PPP firms and tax inspectors are embedded in fiscal policy and fiscal corruption risk, as Definition 3 explains in detail.

In prior studies, Cerqueti and Coppier (2016) build a theoretical game model to investigate tax collection in a multiethnic country with incomplete information. Under specific circumstances, taxpayers (i.e., PPP firms) and tax inspectors seem unconcerned about punishments for tax evasion. However, the results in the present study indicate partial support for that study's Propositions concerning the relationship between tax revenue (fiscal policy) and the punishment rate for tax inspectors based on an evolutionary game (i.e., concerning free riders). Specifically, when the cluster of cooperation is formed by the payoff distribution (Luo & Zhao, 2013), the fiscal policy can define an equilibrium.

This study is related to the extensive literature on corruption. Few game theorists examine the negative impact of corruption on specific functions. Zhang, Bao, and Skitmore (2015) examine land hoarding issues in China with real estate developers and land inspectors representing the players of the game. Verma, Nandi, and Sengupta (2017) focus on social conflict between government servants and citizens in an asymmetric game. Given anti-corruption measures, Mishra (2006) finds that corruption is persistent and may be the social norm. Verma and Sengupta (2015) investigate harassment corruption when citizens pay bribes to officers. However, these researchers compare the asymmetric penalty on corrupt officers to the symmetric penalty programs, regardless of bargaining outcomes. Although this study applies a bargaining game based on Cerqueti and Coppier (2016), it explores the relationship

between progressive taxation and the punishment rate for tax inspectors when complete information and symmetric bribe conditions prevail. Notably, game theoretical applications for tax corruption are still immature, as this study is one of the first to apply the model to understand some unsolved problems regarding corruption, such as the bailout rate of NPLs.

Finally, in a more economics-focused paper, Shi (2019) defines intolerance as backing corruption and slowing economic growth. However, the present study focuses on public debt management (i.e., determining the bailout rate of NPLs) in countries promoting PPP projects, for which both the punishment rates for the PPP firm and tax inspector are embedded in fiscal policy and the fiscal corruption risk. Notably, corruption limits economic growth (Svensson, 2005); Therefore, solving this issue potentially benefits the PPP firm, government, and ordinary citizens.

The rest of the article proceeds as follows. Section 2 develops the model, describes the government and PPP firm's optimisation problem, and states the solution method. Section 3 discusses public debt management, defines fiscal corruption risk, suggests a strategy to prevent tax evasion and corruption in PPP scheme by applying a cluster of cooperation, and offers policy recommendations on public debt management. The final section concludes.

## 2. Model

The model focuses on PPPs (Iossa & Martimort, 2015) in a small open economy (Camous & Gimber, 2018), expressed in discrete time between periods 1 and 2. The late period covers the long-term commitment.

### 2.1. Firm's objective function

The representative private sector's general objective function is an extension of a model of the PPP transfer from the government based on Prati and Tressel (2006) model, which maximises the expected discounted profit in period 2. Let  $\pi_{PPP}$  and  $\pi_1$  be the private sector's expected profits from the PPP project and in period 1, respectively. Let  $TR_1$  and  $TR_2$  be the transfer from the government in periods 1 and 2, respectively (Prati & Tressel, 2006). The PPP firm prefers the transfer to the bribery and corruption risk ( $b^*$ ). Following previous work on profit functions in PPPs, the PPP firm's problem is:

$$\max_{TR_1} \pi_{PPP} = \pi_1 - b^* + TR_1, \quad (1)$$

subject to:

$$(1-r)\theta_2 TR_1 = TR_2 - A_2.$$

The optimal bribe  $b^*$  is provided (see Section 4.2).  $r$  is the nominal interest rate. Notably,  $\theta_2 \in (0,1)$  is the bailout rate of the PPP's NPLs proposed by the

government, as commercial banks receive a guarantee of  $TR_1$  from a (local) government.  $A_2$  is foreign aid such as official development assistance (Prati & Tressel, 2006).

## 2.2. Government's maximisation problem

This study analyses two forms of the model, each related to a unique set of fiscal instruments and fiscal disciplines. In the first form, the government attempts to prevent fiscal corruption by employing a punishment rate for the PPP firm and tax inspector in the amount of the discovered and evaded taxes (see Section 4.2). In the second form, as in Laos, a government protects the affected domestic commercial banks by introducing  $\theta_2$  in period 2. Let  $\tau_1$  and  $z_1$  be the profit tax rate and the contemporaneous productivity<sup>3</sup> in period 1, respectively. Let  $\Gamma_1$  be provided by the Laffer curve  $\tau_1 z_1 \Gamma_1$ . Thus, the optimisation problem of the government, as an extension of equations 5 to 7 of Camous and Gimber (2018), and equation 28 of Cerqueti and Coppier (2016), is:

$$\max_{\theta_G} \Gamma_1 - N_b b^* + N_{PPP} TR_2, \quad (2)$$

subject to the government's budget constraints, as follows:

$$TR_1 + G_1 \leq \tau_1 z_1 \Gamma_1 + \frac{TR_2}{R_G}$$

$$TR_2 \leq \bar{B}_2,$$

where  $N_{PPP}$  is the total number of PPP projects;  $N_b$  is the number of failed PPP projects; that is, the PPP projects alleged to engage in fiscal corruption or tax evasion in the country;  $G_1$  is the short-run public expenditure;  $R_G$  is the government's risk-free (interest) rate at which it lends between periods 1 and 2; and  $\bar{B}_2$  is the borrowing limitation (i.e., public debt ceiling).

## 2.3. Solution method

This study uses an optimisation method to resolve the model for a nonlinear relationship. The optimised solution is typically composed of maximising or minimising an objective function. The analysis here uses input values and computes the optimal values for the function by using the first- and second-order derivatives of the objective function. The optimisation condition is often an abstract concept. In mathematics, it is possible to visualise an optimal point as the highest place on a hilltop or the lowest point in a valley, or 'the quest for the best' (Chiang & Wainwright, 2005). Moreover, the optimal point on a hilltop or in a valley is called the 'local maximum or local minimum', respectively. However, another definition exists, called the 'absolute (or global) extremum'. The model first contains fiscal corruption risk and the Laffer curve<sup>4</sup> to solve for the optimal aggregate productivity according to the Lagrange method. Please see Chiang and Wainwright (2005) for more detail on the solution method. The authors propose an algorithm to refine the model, as shown in Figure 1.

### 3. Result

This section provides the technical details of the comprehensive solution that focuses on fiscal corruption risk. In public debt management, a sudden decrease in  $\theta_2$  makes the PPP firm face financial difficulties, especially in period 2, as their profits tend to decrease. This is a common device in the literature to implement the fiscal austerity and can restrict the monetary supply to stabilise inflation based on supply side economics and the Laffer curve (Xi, 2017).

**Theorem.** *In a PPP, the aggregate productivity ( $z_1$ ) in period 1 based on the Laffer curve is:*

$$z_1 = \frac{TR_1}{\tau_1 R_G N_{PPP}} \tag{3}$$

**Proof.** Given an initial level of public debt in period 1, or  $TR_1$ , which represents the PPP transfer from the government (Iossa & Martimort, 2015) and the Laffer curve  $\Gamma_1$ , then an equilibrium of this economy consists of  $\{b^*, \theta_2, G_1, r, z_1\}$  such that:

- i.  $\{b^*, \theta_2\}$  solves the PPP firm’s problem, and
- ii.  $\{G_1, z_1\}$  solves the government’s problem.

It is straightforward to show that an equilibrium can be characterised by

$$\{\pi_{PPP}, \ell_1, b^*, \theta_2, G_1, r, z_1\}$$

satisfying the following equation:

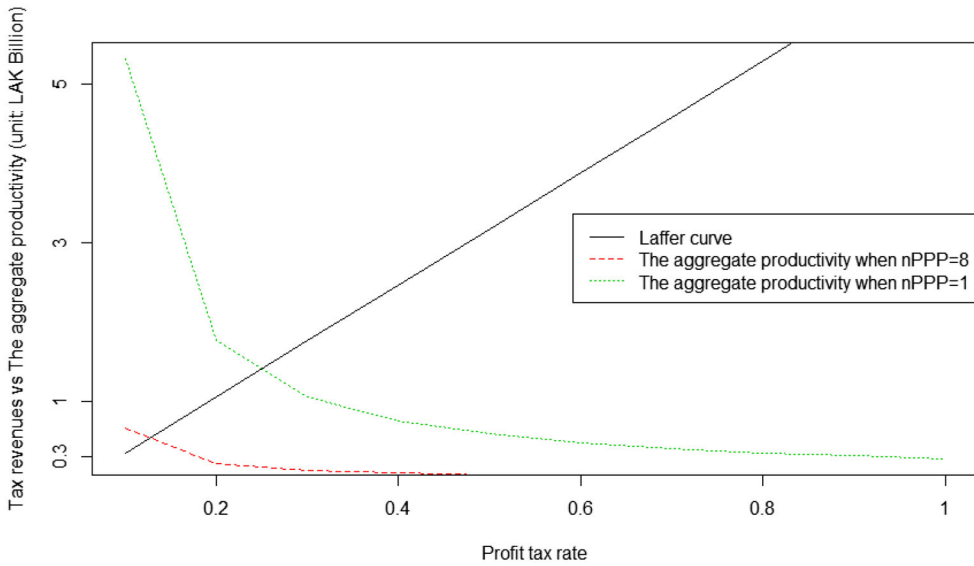
$$\frac{(1-r)\theta_2 TR_1 + A_2}{R_G} + \tau_1 z_1 \Gamma_1 - (TR_1 + G_1) \geq 0. \tag{4}$$

Provided that  $TR_2 = (1-r)\theta_2 TR_1 + A_2$ , which is the constraint of [equation \(1\)](#), then  $\ell_1$  is the Lagrange function characterising the implementable equilibrium in period 1 in the form:

$$\begin{aligned} \ell_1 = & \Gamma_1 - N_b b^* + N_{PPP}((1-r)\theta_2 TR_1 + A_2) \\ & + \lambda_1 \left( \frac{(1-r)\theta_2 TR_1 + A_2}{R_G} + \tau_1 z_1 \Gamma_1 - (TR_1 + G_1) \right) + \lambda_2 b^* . \end{aligned} \tag{5}$$

Given the vector of Lagrange multipliers (i.e.,  $\lambda_1$  and  $\lambda_2$ ) and [equation \(5\)](#), the aggregate productivity satisfying the first-order necessary conditions is:

$$\left\{ \begin{array}{l} \frac{\partial \ell_1}{\partial \Gamma_1} = \Gamma'_1 + \lambda_1 \tau_1 z_1 \Gamma'_1 = 0 \\ \frac{\partial \ell_1}{\partial b^*} = -N_b b' + \lambda_2 b' = 0 \\ \frac{\partial \ell_1}{\partial TR_1} = N_{PPP}(1-r)\theta_2 + \lambda_1 \frac{(1-r)\theta_2 TR_1}{R_G} = 0 \end{array} \right. .$$



**Figure 2.** Procyclicality of tax policy. The R-code is provided in appendix A.

The second-order derivative is used to check if an optimal solution is achievable, and results in  $\partial^2 \ell_1 / \partial \Gamma_1^2 = 1 + \lambda_1 \tau_1 z_1 > 0$ . This is a sufficient condition for the minimum  $\Gamma_1$ . Consequently, the following is obtained:

$$\frac{1}{\tau_1 z_1} = \frac{R_G N_{PPP}}{TR_1}.$$

The result is proved □

The theorem reaffirms the procyclicality of tax policy (see Figure 2 and its parameter in Table 1). Specifically, tax policy can exacerbate output as the higher the number of PPP projects is, the lower the aggregate productivity is.

## 4. Discussion

### 4.1. The bailout rate of NPLs and financial black holes

Given the constraints of equations (1) and (3) :

$$\theta_2 = \frac{TR_2 - A_2}{(1-r)\tau_1 z_1 R_G N_{PPP}}. \tag{6}$$

If  $\theta_2 \geq \frac{R_G(TR_1 + G_1 - \tau_1 z_1 \Gamma_1) - A_2}{(1-r)TR_1}$ , then from the constraints of equations (1) and (2) versus that from equation (6), Definition 1 provides a policy recommendation.

**Definition 1.** In a PPP, the bailout rate of NPLs ( $\theta_2$ ) is mainly determined by the PPP transfer from the government ( $TR_2$ ) and the total number of PPP projects ( $N_{PPP}$ ) in a country with long-term prospects rather than short-term government expenditure ( $G_1$ ) as a tactic or the Laffer curve ( $\tau_1 z_1 \Gamma_1$ ).



**Table 1.** Parameterisation.

Parameter	Description	Parameter value	Source
$TR_1$	The transfer from a government in period 1 (i.e., public debt)	9,300 bil.	<a href="http://vientianetimes.org.la/">http://vientianetimes.org.la/</a>
$TR_2$	The transfer from a government in period 2 (i.e., government bonds)		<a href="https://laoedaily.com.la">https://laoedaily.com.la</a>
GDP	Gross Domestic Product	140,749 bil.	Lao National assembly
$\Gamma_1$	Tax revenues (16.7% of GDP) in 2018 which is as period 1.	23505 bil.	Lao National assembly
$z_1$	The aggregate productivity in period 1	300	
$\tau_1$	Profit tax rate	0.05-1.0	
$N_{PPP}$	The total number of PPP projects	1,225	<a href="http://vientianetimes.org.la/">http://vientianetimes.org.la/</a>
$\rho_{lo}, \alpha_{lo}$	Low punishment rate for PPP firm and tax inspector, respectively, on the amount of discovered and evaded taxes ( $D_H$ )	0.1	
$\rho_{hi}, \alpha_{hi}$	High punishment rate for PPP firm and tax inspector, respectively, on the amount of discovered and evaded taxes ( $D_H$ )	0.9	
$D_H$	The higher level of the basis discount of annual profit tax	15 Mil.	Laos's Tax law
$D_L$	The lower level of the basis discount of annual profit tax	10 Mil	Laos's Tax law
$\pi_1$	PPP firm's expected profit in period 1	50% of $TR_1$	

In other words, although the main motivation of this study is to understand the mathematical model assumptions and background in countries promoting PPPs,<sup>5</sup> determining the value for  $\theta_2$  is subject to debate and a vote in a National Assembly; that is, to enact law and regulations rather than to seek a short-term solution.

However,  $\theta_2$ , a revised version of 'helicopter drop' for a PPP, can contravene financial regulation and cause financial black holes, as negative NPV projects are publicly financed (Ranciere & Tornell, 2011).

#### 4.2. Financial black holes and bargained corruption

As fiscal corruption can cause financial black holes, this study also addresses several related research questions. Should the fiscal corruption risk between the PPP firm and the tax inspector find a corresponding discrepancy between the PPP firm and the government, or between the tax inspector and itself? Should the optimal solutions be an immediate practical alternative? First, note that  $b$  is the value for the unique bribe for tax evasion.

**Definition 2.** In a progressive tax system, let  $D_H$  and  $D_L$  be the higher and lower levels of the basis discount on the annual profit tax, respectively. The optimal bribe ( $b^*$ ) can be calculated as:

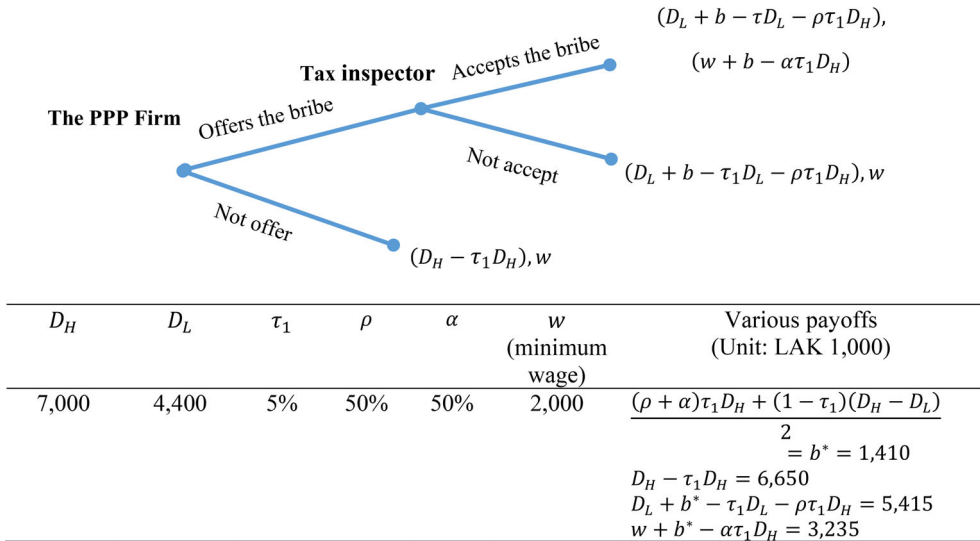
$$b^* = \frac{(\rho + \alpha)\tau_1 D_H + (1 - \tau_1)(D_H - D_L)}{2}, \tag{7}$$

where  $\rho$  and  $\alpha$  are the punishment rates for the PPP firm and tax inspector, respectively, on the amount of discovered and evaded taxes ( $D_H$ ).

**Proof.** Let  $w$  denote the fixed wage of a tax inspector, and  $w > 0$ . Table 2 provides an example. In Laos, if a firm's real profit ranks between 3,600,001 and 8,000,000 Kip<sup>6</sup> per year (row 3), the basis discount stipulated in the tax law is 4,400,000 Kip. In

**Table 2.** Annual Taxable Profit in Laos (Unit: LAK).

Annual Taxable Profit	Basis Discount ( $D_H$ vs. $D_L$ )	Tax Rate ( $\tau_1$ )	Profit Tax
Equal or less than 3,600,000	3,600,000	0%	0
3,600,001 to 8,000,000	4,400,000	5%	220,000
8,000,001 to 15,000,000	7,000,000	10%	700,000
15,000,001 to 25,000,000	10,000,000	15%	1,500,000
25,000,001 to 40,000,000	15,000,000	20%	3,000,000
Equal or more than 40,000,001	...	24%	...



**Figure 3.** Bargaining the bribe and various payoffs based on Table 2.

this profit rank, if the firm reports its real profit, then the basis discount is the higher one; that is,  $D_H = 4,400,000$ . However, if the firm underreports profit by referring to the lower basis discount (i.e.,  $D_L = 3,600,000$ ), then it successfully evades profit tax. This practice is ‘legal tax avoidance’ according to Mankiw (2007) because the PPP firm can employ tax lawyers and accountants to handle these affairs (i.e., seeking to convert  $D_H$  to  $D_L$ ). However, this study takes the behaviour toward illegal tax evasion as an offered and accepted bribe ( $b$ ).

Figure 3 depicts the PPP firm and the tax inspector as in a two-person bargaining game. The firm moves first and offers the bribe ( $b$ ). In this case, the PPP firm tends to underreport its profit ( $D_L$ ) and has the game outcome of  $D_L + b - \tau_1 D_L - \rho \tau_1 D_H$ . The payoff for the tax inspector is  $w + b - \alpha \tau_1 D_H$ . In Laos,  $\tau_1 = \{0, 0.05, 0.1, 0.15, 0.2, 0.24\}$  (column 3 of Table 2). Note that the tax inspector’s decision can influence the outcome of the game based on backward induction.

Clearly, the game can be solved by the subgame perfect equilibrium, which signifies the Nash bargaining solution for the symmetric bribe. As a game with complete information, the solution to the game is to obtain the payoff vector  $[(D_L + b - \tau_1 D_L - \rho \tau_1 D_H), (w + b - \alpha \tau_1 D_H)]$ . Note that first and second payoffs belong to the PPP firm and tax inspector, respectively. The disagreement point is the payoff

vector  $[(D_H - \tau D_H), w]$ . In short, the solution is to find an optimal bribe ( $b^*$ ) resulting from Nash bargaining  $f_{Nash}$ ; therefore:

$$\begin{aligned} \text{maximize } f_{Nash} &= [(D_L + b - \tau D_L - \rho \tau_1 D_H) - (D_H - \tau_1 D_H)] [(w + b - \alpha \tau_1 D_H) - w] \\ \text{maximize } f_{Nash} &= [(b - \rho \tau_1 D_H) + (1 - \tau_1) D_L - (1 - \tau_1) D_H] (b - \alpha \tau_1 D_H) \\ \text{maximize } f_{Nash} &= [b - \rho \tau_1 D_H - (1 - \tau_1)(D_H - D_L)] (b - \alpha \tau_1 D_H) \end{aligned} \tag{8}$$

Next, the first-order derivative of equation (8) with respect to  $b$  in period 1 produces:

$$\begin{aligned} \frac{\partial f}{\partial b} &= b - \rho \tau_1 D_H - (1 - \tau_1)(D_H - D_L) + b - \alpha \tau_1 D_H \\ \frac{\partial f}{\partial b} &= 2b - (\rho + \alpha) \tau_1 D_H - (1 - \tau_1)(D_H - D_L) \end{aligned}$$

Based on the second-order derivative,  $\partial^2 f / \partial b^2 = 2 > 0$ . This is the minimum  $b$ . Next, the optimal answer is obtained from  $\partial f / \partial b = 0$ . Specifically:

$$2b^* = (\rho + \alpha) \tau_1 D_H + (1 - \tau_1)(D_H - D_L)$$

□

### 4.3. The cluster of cooperation to prevent tax evasion, fiscal corruption, and financial black holes in PPP projects

Failed PPP projects can be prevented by a cluster of co-operators (Luo & Zhao, 2013) when the punishment rates for discovered evaded taxes are applied. Accordingly, the higher the punishment rates are, the higher the cooperation level is.

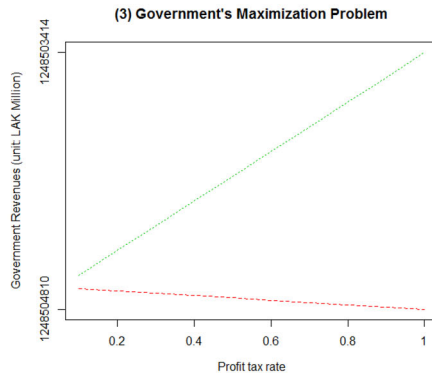
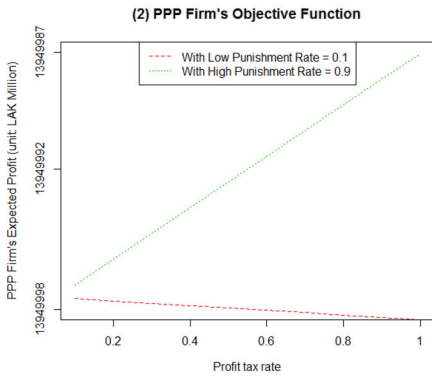
**Definition 3.** With the PPP’s cluster of cooperation (Luo & Zhao, 2013), let  $\rho_{hi}$  and  $\rho_{lo}$  be the punishment rate for the PPP firm on the high and low amount of discovered and evaded taxes, respectively; let  $\alpha_{hi}$  and  $\alpha_{lo}$  be the punishment rate for the tax inspector on the high and low amount of discovered and evaded taxes, respectively. For all  $\rho_{lo} < 1 - \alpha_{lo}$ , there exist a unique equilibrium.

**Proof.** Tax evasion in PPP projects can be prevented by solving the game in Figure 4. The arrows on the left and right pointing up (Figure 4 [1]) show that the PPP firm prefers a high punishment to reduce its cost of doing business by lowering the bribes it pays to the tax inspector as much as possible (Figure 4 [2] and Table 1). Likewise, the arrows at the top pointing to the left indicate that the government prefers high punishment for the tax inspector as an indicator of its good governance (Figure 4, Manshaei et al. 2013). However, in this case, the arrows point in both directions; that is, the PPP firm and government seek high punishment (Figure 4 [1]). From the PPP firm’s perspective<sup>7</sup>, this is a Nash equilibrium satisfying:

$$\pi_{PPP}(\rho_{lo}, \alpha_{lo}) < \pi_{PPP}(\rho_{hi}, \alpha_{hi}). \tag{9}$$

(1) The strategic form of game

		A government's tax revenue	
		High punishment	Low punishment
The PPP Firm's profit	High punishment	$\pi_{PPP}(\rho_{hi}, \alpha_{hi}), \Gamma_1(\rho_{hi}, \alpha_{hi})$	$\pi_{PPP}(\rho_{hi}, \alpha_{lo}), \Gamma_1(\rho_{hi}, \alpha_{lo})$
	Low punishment	$\pi_{PPP}(\rho_{lo}, \alpha_{hi}), \Gamma_1(\rho_{lo}, \alpha_{hi})$	$\pi_{PPP}(\rho_{lo}, \alpha_{lo}), \Gamma_1(\rho_{lo}, \alpha_{lo})$



**Figure 4.** The Nash equilibrium based on the cluster of cooperation and the fiscal corruption. The R-code is provided in appendix B.

Using equation (1) yields:

$$\pi_1 - b^*(\rho_{lo}, \alpha_{lo}) + TR_1 < \pi_1 - b^*(\rho_{hi}, \alpha_{hi}) + TR_1 - b^*(\rho_{lo}, \alpha_{lo}) < -b^*(\rho_{hi}, \alpha_{hi}).$$

Given equation (7):

$$-(\rho_{lo} + \alpha_{lo}) < -(\rho_{hi} + \alpha_{hi}).$$

Finally, since  $\rho, \alpha \in [0, 1]$ ,  $\rho_{hi} = 1 - \rho_{lo}$  and  $\alpha_{hi} = 1 - \alpha_{lo}$  are assumed and become:

$$\begin{aligned} -(\rho_{lo} + \alpha_{lo}) &< -(2 - (\rho_{lo} + \alpha_{lo})) \\ -2(\rho_{lo} + \alpha_{lo}) &< -2. \end{aligned}$$

Dividing by -2:

$$\rho_{lo} + \alpha_{lo} < 1$$

□

However, a previous experiment demonstrates that monetary incentives and harsh punishments (e.g., the higher punishment rate for the tax inspector) may not strengthen tax compliance (Bitzenis, Vlachos, & Kontakos, 2015). In addition, Cerqueti and Coppier (2016) confirm that most taxpayers and tax inspectors are not worried about the punishment rate if fiscal corruption and discrimination among ethnic groups are prevalent. Thus, future research is needed to examine the effects of the

many various cultures of corruption such as the relationship between corruption and social attitudes (Yingying & Min, 2018).

## 5. Conclusion

This study develops a theory linking the cyclicity of tax policy based on the Laffer curve to solve public debt problems, aggregate productivity, and fiscal corruption. This study differs from those in the existing literature by focusing on public debt management (i.e., determining the bailout rate of NPLs) in countries promoting PPP projects. The results indicate that tax policy can exacerbate the country's output, as the higher the number of PPP projects is, the lower the aggregate productivity is. In other words, the patterns of the equilibria, which are between the aggregate productivity and the Laffer curve, lack a direct link to fiscal corruption risk, though their magnitude does. To illustrate, when the number of PPP projects in Laos jumped to 1,225 projects, the aggregate productivity dropped to near zero (see Figure 2). In addition, the results indicate that applying a cluster of cooperation is a valid strategy to prevent tax evasion and corruption in PPP schemes. Specifically, it is recommended that sustainable sources of tax revenues should be based on the tax inspector's capacity rather than the punishment rate, particularly in the least developed countries (L.D.C.s), which have less efficient tax systems. It would therefore be useful to examine the implications of cultural aspects in future research. Thus, policymakers designing a tax system in the L.D.C.s could prioritise small deadweight losses over small administrative burdens. For example, in many L.D.C.s, including Laos, the government has begun to expand its electronic (e-tax) system nationwide this year in the hope of reducing administrative costs and improving tax efficiency. The goal is to solve fiscal corruption risk and tax evasion in Laos. This study examines the government's optimisation problem by abandoning the labour utility assumption of Camous and Gimber (2018), thus introducing fiscal corruption risk into the model. In addition, this study incorporates the PPP firm's optimisation problem. However, there is a limitation to using game theory to solve public policy problems. As Bitzenis et al. (2015) observe, there is doubt about the accuracy of the players' payoffs.

## Notes

1. As in Laos, the State inspection authority found that many submitted PPP projects overreport investment costs. For a seven-metre-wide double-deck asphalt pavement, some projects cost as much as \$1.8 million per kilometre, whereas others cost as much as \$1.5 million. All of these exceed the standard unit price of between \$600,000 and \$750,000 per kilometre (<https://mp.weixin.qq.com/s/5VUm-dN7ekqi-Vk0d5fG1w>).
2. Bribery and corruption can be widespread in public investment programs (Svensson, 2005).
3. Aggregate productivity refers to output per efficiency unit of labour in the economy (Heathcote, Storesletten, & Violante, 2017).
4. In the form of  $\tau_1 z_1 \Gamma_1 \geq TR_1 + G_1 - \frac{TR_2}{R_G}$ .
5. We consider PPPs an alternative to solve economic problems (Engel et al., 2013), and public debt management as in Laos (National Assembly, 2018).
6. Kip is Lao currency or LAK. Its exchange rate is roughly 8,200 LAK per US\$1.
7. We view similar result from the perspective of a government involved.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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## Appendix A. The R-code of Figure 2

---

```
#the aggregate productivity
tau_1 = seq(0.05,1,0.1)
nPPP = 8
TR1 = 9300
RG = 0.035
Z1 = TR1/(tau_1*RG*nPPP)
Z1

plot(Z1,type="l",col="2",lty = 2, ylim = c(279698,5314286),xlab="Profit tax rate",
ylab="Tax revenues vs The aggregate productivity (unit: LAK Billion)", axes = F)

##
box()
axis(side = 1, at = c(2, 4, 6, 8, 10),
labels = c(0.2, 0.4, 0.6, 0.8, 1))
axis(side = 2, at = c(300000,1000000,3000000,5000000),
labels = c(0.3, 1, 3, 5))

##
Z2 = TR1/(tau_1*RG*1)
Z2
lines(Z2,type="l",col="3",lty = 3)

##
Z0 = 300
Gamma_1 = 23505
Laffer = tau_1*Z0*Gamma_1
Laffer
lines(Laffer,type="l",col="1",lty = 1)

##
legend("right",legend = c("Laffer curve",
"The aggregate productivity when nPPP = 8",
"The aggregate productivity when nPPP = 1"),
col = c("1","2","3","4"), lty = 1:4)
```

---

## Appendix B. The R-code of Figure 4

---

```

##the cluster of cooperation
par(mfrow = c(1,2))

###
tau_1 = seq(0.05,1,0.1)
DH = 15
DL = 10
p1 = 0.1
alpha1 = 0.1
TR1 = 9300000
pi_1 = TR1*0.5
b = ((p1 + alpha1)*tau_1*DH + (1-tau_1)*(DH-DL))/2
b
pi_PPP = pi_1 - b + TR1
pi_PPP
plot(pi_PPP,type="l",col="2",lty = 2, ylim = c(13949998,13949987),xlab="Profit tax rate",
ylab="PPP Firm's Expected Profit (unit: LAK Million)",
main="(2) PPP Firm's Objective Function", axes = F)

##
box()
axis(side = 1, at = c(2, 4, 6, 8, 10),
labels = c(0.2, 0.4, 0.6, 0.8, 1))
axis(side = 2, at = c(13949998,13949992, 13949987),
labels = c(13949998,13949992, 13949987))

##
p2 = 0.9
alpha2 = 0.9
b2 = ((p2 + alpha2)*tau_1*DH + (1-tau_1)*(DH-DL))/2
pi_PPP2 = pi_1 - b2 + TR1
pi_PPP2
lines(pi_PPP2,type="l",col="3",lty = 3)

##
legend("top",legend = c("With Low Punishment Rate = 0.1",
"With High Punishment Rate = 0.9"), col = c("2","3"), lty = 2:3)

##GOV lost per each PPP firm caused by bribery#####
TR2 = 1000000
Gamma1 = 2,35,05,000
N_PPP = 1225
Nb = N_PPP*0.1
GOV = Gamma1 - Nb*b + N_PPP*TR2
GOV
plot(GOV,type="l",col="2",lty = 2, ylim = c(1248504810,1248503414),xlab="Profit tax rate",
ylab="Government Revenues (unit: LAK Million)",
main="(Manshaei et al.) Government's Maximization Problem", axes = F)

##
GOV2 = Gamma1 - Nb*b2 + N_PPP*TR2
GOV2
lines(GOV2,type="l",col="3",lty = 3)

##
box()
axis(side = 1, at = c(2, 4, 6, 8, 10),
labels = c(0.2, 0.4, 0.6, 0.8, 1))
axis(side = 2, at = c(1248504810,1248505508,1248503414),
labels = c(1248504810,1248505508,1248503414))

```

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