Social Contract and Its Consequences Post COVID 19—A Systemic Perspective in Emerging Economies

SenthilKumar Anantharaman *

Posted Date: 16 June 2025

doi: 10.20944/preprints202506.1191.v1

Keywords: Covid-19; emergency health services; game theory; principal-agent model; PPP; renegotiation

 doi:10.20944/preprints202506.1191.v1

Article

Social Contract and Its Consequences Post COVID 19—A Systemic Perspective in Emerging Economies

SenthilKumar Anantharaman

senthilkumarafun@protonmail.com

Abstract: Problem Definition In emerging economies and countries such as India, during COVID 19, health facilities across the globe especially in India do not have the capacity to handle the number of patients. This research aims to reduce health disparities in Indian context through funding mechanisms to service providers who wish to serve the nation during crisis that critically affect economic growth. Academic Relevance In India PPP has been a viable solution when the government-led public sector formed a synergetic partnership with the technically advanced and innovative private sector. Through this study, we are taking a step towards modelling PPP contracts where the government is planning to integrate emergency services that may provide insights into research in health service sector and academicians/practitioners in emergency medical services in developing and emerging economies. Methodology In this study, we are taking a step towards analytical modelling of PPP contracts where the government is planning to integrate emergency services and examine various scenarios applying the principal-agent model by characterizing the equilibrium contracts among the Government and the Service provider. Results Results imply that the government needs to develop policies that require immediate action to aid service providers who have a reputation for providing quality emergency health services to survive in a circular economic situation thereby providing a solid foundation to the newly integrated emergency medical services in emerging economies like India. Managerial Implications During COVID 19, management of emergency service providers in India have to decide the capacity to handle the number of patients. Apart from this, during this crisis and scarcity, public private partnerships (PPP) bids can decide the type of service provider (Non Profit or Corporate) that can help to ensure optimal health outcomes with quality, equity, access and fair distribution.

Keywords: Covid-19; emergency health services; game theory; principal-agent model; PPP, renegotiation

1. Introduction

Medical emergencies occur anywhere, at any time, in any country irrespective of whether it is a developed, developing or an underdeveloped country. These emergencies occur by the hour, consuming a lot of resources and sometimes, without even achieving the desired results, i.e., to save lives. Medical emergencies have been around since the start of human civilization, however, they gained recognition as a specialty only around 30 years ago (Chung, 2001). An emergency medical system's goal should be to provide universal and integrative emergency care right from the time it receives information from an emergency user. Further, in a country like India, which is the second most populous country in the world with high-income disparity, the implementation and context of the emergency medical system should, in every way, try to increase health equity and not worsen current health disparities. This challenge faced by India and developing countries similar to India can be attended to by promoting systematic development of an evidence-based emergency medical system that would be more cost-effective than the ones in developed countries like the USA, Canada and certain European countries where there is lesser income disparity. To design an effective emergency medical system, there is a need to address questions such as how it would integrate with the current health-care infrastructure, local communities as well as their values, and

 doi:10.20944/preprints202506.1191.v1

the financial resources that would be needed to augment the services step by step. These questions are well addressed when the rationality of promoting emergency service systems is evaluated from the financing point of view. Further, deficiencies in healthcare can be overcome only by reform. The emergence of Public Private Partnerships (PPP) in India has provided a viable solution. In this model, the government-led public sector forms a synergetic partnership with the technically advanced and innovative private sector. The government set up 108 partnerships in 2005 with private organizations, such as GVK, Ziqitza Health Care Ltd., to deal with fatal medical emergencies to diminish the number of lives lost, for instance, as in the case of the Fani cyclone, which caused havoc in Odisha in 2019. However, the emergency services are fragmented in India, with many private services coming into play without regulation. Though this may be interpreted as a good social and altruistic sign, in the long run, it could hamper the progress of emergency services across the country. In this study, we propose a model for the funding of PPP contracts which the government can use in its plan to integrate all emergency services including fire, police with emergency health services under a common number, 112. Scenarios that were built to handle situations where there is an unprecedented demand increase, similar to that of COVID 19 are considered in this study. In the following section, we have a detailed literature review on emergency health services in developed and developing countries. Section 3 describes the base model, its assumptions, strategic decision variables that have been considered for the model. Section 4 considers the different scenarios that can occur during emergency situations like COVID 19. In the final section, we discuss the takeaways and results that make sense during COVID 19 times, when the economy in developing nations need to become more circular due to limited support.

2. Literature Review

2.1. Game Theory Models

The modeling approach in this study lays its foundations on studies by Ramy Elitzur and Arieh Gavious, (2001) who had provided a game theory-based model that involves a start-up company with three players, an entrepreneur, an angel, and a VC. Their studies addressed important gaps in the literature that addressed relationships between VC and entrepreneurs by introducing angels. Further, one of their (Rami Elitzur and Arieh Gavious, 2001) key findings was that the opportunistic behavior between entrepreneur and VC leads to moral hazard problems. Evidence is available that there are rules, roles, strategies, and pay-offs governing PPP procedures. Thus, modeling them as complex games can help better understand the failures and difficulties. (Peter Scharle, 2002). Hart's approach (Hart, 2003), states that if the characteristics of the facility are easier to specify, the government should provide the service. Hart (2003) studies also indicate that if the quality of the service is easier to measure, then the choice is between public provision and partnerships. Public provision is preferred when worker's effort is very relevant for the success of the service. Studies (Gregory Michael Kennedy, 2013) have successfully managed to apply the game theory model retrospectively to the Metronet - London Underground case and were successful in influencing decision making in their renegotiation process. Julie De Brux, 2010 has shown that social surplus improving renegotiations can often exist when parties cooperate which is often known as ''bright side of renegotiation''. Studies by Besley and Ghatak (2001) considered how the state and the voluntary sector interact in delivering public projects. Ho (2009) developed a model for financial renegotiation in PPP projects and its policy implications from a game theory perspective. Medda (2013) studied the "allocation of risks in PPP transportation projects using a game theory approach." Ho (2005) also modeled a "bid compensation decision process as a non-cooperative static game." Akintoye et al. (2004) also applied game theory in PPPs, especially in the phases before and after a preferred bidder is selected. Barr (2007) points out several elements that should be considered when evaluating the effectiveness of a PPP. Hence suitable elements need to be considered when modeling the effectiveness of a PPP.

2.2. Principal-Agent Model

 doi:10.20944/preprints202506.1191.v1

The principal-agent problem helps in stating a few policy problems that are fundamental in an integrated framework, when the outcome of the activities of the agent, Q depends on the action taken by agent and state variable S

, i.e. "Q= f (A, S)" (Bergman and Lane, 1990)

Allocation of Public services creates Principal-agent relationships between Government and the electorate (Bergman and Lane, 1990). Studies (H. P. Tserng et al., 2012) treated "the national PPP unit as an institution by defining it as an endogenous equilibrium outcome of the game in the view of New Institutional Economics (NIE)."

2.3. Models Based on Simulation

The agent-based model helps in modeling complex systems that are adaptive to circumstance, situations, environment, etc.(MacAl & North, 2010). Jennings (2000) considers an agent as one object that emphasizes autonomous behavioral characteristics. Bonabeau (2001) regards an agent to be any type of independent software or model component. Empirical studies indicate that humans are boundedly rational, and as the rules change in a game, with complex social structures and interactions (Gigerenzer and Selten, 2001; Janssen and Ostrom), agent-based modeling in combination with game theory has been applied since the early 1980s (Axelrod, 1984). The next section presents a conceptual and theoretical framework that would provide sensitivity to various aspects of a PPP contract, including that of policy levers in an EMS that we had discussed in earlier sections. This framework lays a foundational basis for agent-based simulation of various aspects of the game in the contractual cycle. The agents need to understand that in COVID 19 like situation, the circular economy can become complex. Further the agents may indicate that liberalization may happen due to vaccine development which may lead developing nations to a path that may involve agents that were in a circular economy to an economy that need support of nations that have crossed the COVID 19 era successfully.

2.4. Recommendations from Literature

1) The following are the recommendations from the literature and the real world that would help the Indian EMS to progress further from its current position to serve its citizens better. 2) The emergency medical services in India needs to sustain the population growth and in order to supply emergency medical services that consistently meet the demand of Indian population, the EMS system needs to come up with an integrated approach of pricing and costing mechanisms (contract design) between the governments and emergency service providers that would aid the service providers (agents) and government (principal) to provide quality, efficient and effective service to the patients. **3)** Integrated Approach of EMS system with competitive allocation – location approach of emergency medical services (ambulances) would be mutually beneficial to service providers, government, communities and users of emergency health services as it would improve the quality of services like appropriate ambulance allocations, minimizing response time etc. offered by the service providers in a competitive situation where there are many service providers in action. **4)** Suitable performance measures like delay of emergency services (ambulance services) for different types of incoming calls (long distance, short distance), average waiting time for these incoming calls needs to be brought in practice along with input measures like call arrival rates, average service times, mileage of travel for the different service providers of the integrated system with suitable incentives designed for the extra mile achievers. **5)** The EMS system with a suitable triage and cut off dispatch rule analogous to that as implemented by western countries, but keeping Indian context in mind, along with an accurate mathematical model deploying queuing strategies that need to address performance characteristics like Overcrowding at hospitals would aid the much-needed integration of the fragmented EMS system in India.

3. The Model

 doi:10.20944/preprints202506.1191.v1

3.1. Key Players

The key players are

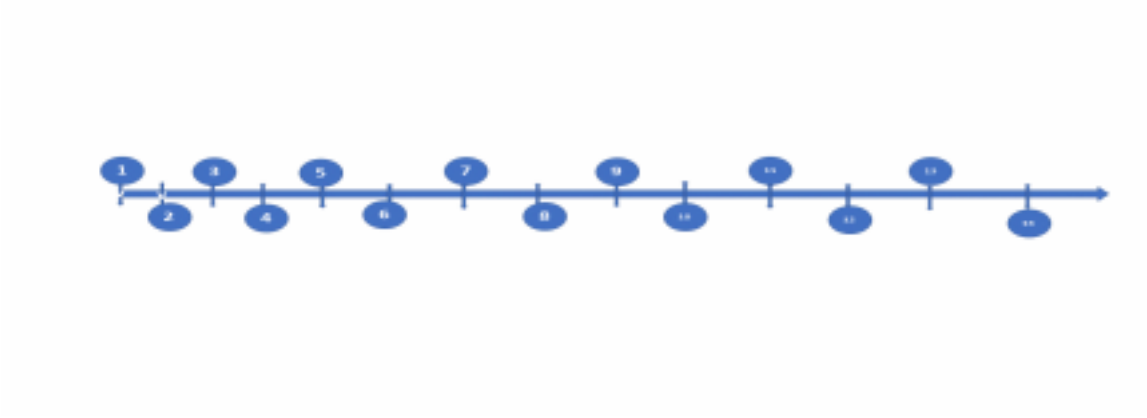
- Service Provider (/Social Entrepreneur) (SP)(Corporate/Non-Profit)
- Government
- Investor

3.2. Setting

Our setting involves an EMS provider (SP) who is risk neutral and can be of two types (corporate/ non-profit) and is in a PPP contract with the central government, who is also a risk neutral player. The goal of SP and government is to offer a high-quality equitable emergency health service for the welfare of its citizens. A total of 5 scenarios occur in this principal (government)-agent (service provider) game. One of these scenarios involve another party, an investor who funds the SP when renegotiation efforts fail between government and SP due to unprecedented rise in demand. The timeline of the game is given below.

3.3. Timeline

The timeline is given in 1(a) and 1(b) below.



(**a**)

1. Government decides on Competitive Bids for SP
2. Government Select Service Provider[SP], Provides Investment I
3. SP Accepts or Rejects
4. If SP accepts, it puts an effort e, go to step 5 or If SP rejects, govt selects next best SP, and goes to Step 1
5. Contract is executed and Pay off is realized
6. Nature Acts and Unprecedented Rise in Demand[For Ex due to Pandemic like COVID 19) for emergenc service Happens
7. SP renegotiates with Government for new Investment based on a suitable mechanism design.
8. If government Accepts, it Provides a New Investment I* to SP with share β towards renegotiating charge and if government rejects, Go To step 11
9. If SP accepts. it puts an effort e*, Go to step 10 or if SP rejects, Go to step 8 for renegotiation
10. Contract is executed and payoff is realized
11. Government selects a Investor, sets up a share δ of SP's payoff to Investor .
12. Investor accepts or rejects. If Investor accepts, It invests an amount I_{cc} (>=I*) or if it rejects, go to step 11.
13. SP accepts or rejects, If it accepts, it puts a new effort e or if SP rejects, go to step 2
14. Contract is executed and Payoffs are realized.

(**b**)

Figure 4. (a) - Event Timeline. (b) - Ordered play of Events in Timeline.

 doi:10.20944/preprints202506.1191.v1

3.4. Assumptions

• All the players are risk neutral. (It's easy to change the model to include risk averse players or a combination of risk-averse and risk neutral players).

• All the players emphasize equally service output as EMS is more humanitarian.

• If the Service Provider (SP) needs further funds and Investment, due to nature/change in demand, it can approach a VC firm with the help of the government.

• The government can take into account some target rate of Investment for post contract investment, V (Mason & Harrison, 2002).

• VC takes into account a specific rate of return, ω (Manigart et al, 2002).

• Effort e is observed only by social entrepreneurs / (Service Provider (SP)).

• The agent operates in perfect competition and has a reservation utility $\bar{U}$ • The government can monitor the benefits/outputs.

• There are two types of effort, observable effort *a* and unobservable effort *e* which is given as below

• z≡e + a

• Unobservable effort $e =$ two levels, e_H, e_L where e_H denotes effort at higher level and e_L denotes effort at lower level

• p^H is the probability for executing High Effort by the service provider who is risk neutral. We have assumed p^H = 0.5 based on a binomial short rate model. (Ho, T.S.Y & Lee, S.B. (2004))

• Effort is costly and follows the following quadratic equation:

• $C(e, a) = \gamma * a$ *when* $e < \underline{e} =$ (when 2º) $* (e - e)2 + \gamma * a\ e \geq \underline{e}$

• a is contractible effort, *e* is not contractible but efficient non verifiable effort is cost effective. (Aghion & Rey, 2000)

• The tax rate is t and can change over time. In numerical, we have taken t as 20% (0.2) according to the current corporate taxes levied in India on corporations.

• The charge for emergency services by government is k= m*r. Here m has been taken as 3 according to a survey report by EMRI and Health Ministry of India (2012).

• The production function/Output function taken here is that of Cobb-Douglas Function having the form $A * E^{\alpha_1} * I^{\alpha_2}$ where α_1 is the elasticity of effort and α_2 is the elasticity of capital/ Investment. denotes the efficiency. Value for Efficiency for Emergency Health Services (in India) =0.7 (Found by averaging monthly efficiencies for all states for the year 2014 EMRI Report, 2014)

• Cost is quadratic function of demand elasticity (The values of a, b, c. In the current study undertaken, we have found a, b and c by regressing expenditures against demand elasticity for the years 2014, 2015, 2016, 2017, 2018.), a= 4652586, b=-8152965, c= 3620336)

• Production/ Output is a decreasing function of demand elasticity i.e. here we have taken it as (Here exp = 2.718)

• In contractual situations which involve only government and service provider, $\pi(I, 0) = \pi(0, e) = 0$ i.e. payoff of SP becomes zero, SP does not provide any service if the government does not make any investment I or the SP does not exert any unobservable effort e.

• In contractual situations that involve the investor apart from government and service provider, we have $\pi(I, 0, I)$ π (Elitzur and Gavious, 2001). In other $V C = (0, e, I)$ $V C = \pi(I, e, 0) = 0$ words the payoff of SP becomes zero. Thus, SP does not provide any service if the government does not make any investment I or the investor does not make any investment *I* or the SP does not exert any effort e. $V C$

3.5. Strategic Decision Variables

 doi:10.20944/preprints202506.1191.v1

e = Unobservable effort needed by the social entrepreneur i.e. SP, has two levels

I = Investment by the government

β = Share retained by social entrepreneur/ SP on renegotiation

δ = share retained by investor (VC) in the case renegotiation fails

I_{vc} = Investment by the Investor (VC)

The base principal-agent model between government and service provider can be described as the following Principal-Agent (PA) problem: the objective function for the service provider i.e. the agent is given by

$$p^H * (1-t) * r * A * e_H^{\alpha_1} * I^{\alpha_2} - (p^H * e_H^2)/2$$

Maximize ---------- (1)

where-as the objective function of the government is given by

Maximize $p^H * t * r * A * e_H^{\alpha_1} * I^{\alpha_2} + k * p^H * A * e_H^{\alpha_1} * I^{\alpha_2} - I(1+v)$ ---------- (2) I

Subject to following constraints.

The first constraint is incentive compatibility constraint

$$p^H * (1-t) * r * A * e_H^{\alpha_1} * I^{\alpha_2} - (p^H * e_H^2)/2 \geq p^L * (1-t) * r * A * e_L^{\alpha_1} * I^{\alpha_2} - (p^L * e_L^2)/2$$

---(3)

And

$$p^H * (1-t) * r * A * e_H^{\alpha_1} * I^{\alpha_2} - p^H * e_H^2 / 2 \geq \bar{U}$$

----------(4) which is the participation constraint

The objective function has to be optimized with reference to effort….. The values of eh and el decide whether the service provider has a probability to get into the action of moral hazard.

So in a PPP contract, when the service provider bids, he has to provide that optimal value of the effort that gives him the correct Investment capital and this is high effort. This is because the government assumes that the service provider is clean and moral hazard does not take place.

Further any value higher than this optimal eh may not be practical because the government would select the lowest bidder and the service provider would not risk with higher effort levels as he may lose the contract.

Finally, there is a space and leverage for the Service provider to put an effort lower than this effort to become more profitable which need not be shared with the government. The risk with which he can afford to do this is with a probability of 0.5. This leads to moral hazard.

Solving the above PA Problem using the principle of backward induction, we solve agent's (SP's) problem first subject to the two constraints using Karush Kuhn Tucker (KKT) conditions to obtain optimal and then substituting the value of in Principal's unconstrained problem we obtain overall optimal conditions and solution for I and . Thus we have, from the agent's (service provider's) problem

$$e^H = [(1-t) * r * A * \alpha_1 * I^{1-\alpha_1}]^{1/(2-\alpha_1)}$$

---(5)

Solving the Principal's i.e. the Government's problem which is an unconstrained optimization problem

$$\underset{I}{Maximize} \quad p^H * t * r * A * e_H^{\alpha_1} * I^{\alpha_2} + k * p^H * A * e_H^{\alpha_1} * I^{\alpha_2} - I(1+v)$$

------- (6)

 doi:10.20944/preprints202506.1191.v1

Applying the first order and second order conditions which indicate that the objective function is concave

We have

$$I = \left(\frac{1+\alpha_2}{2*\alpha_2}\right)^{\frac{-(1+\alpha_2)}{(1-\alpha_2)}} * (1-\alpha_2) * \left(\frac{1+\upsilon}{(t*r+k)*(p_H*A)}\right)^{\frac{-(1+\alpha_2)}{(1-\alpha_2)}} * (r*A(1-t)) \quad \text{-------- (7)}$$

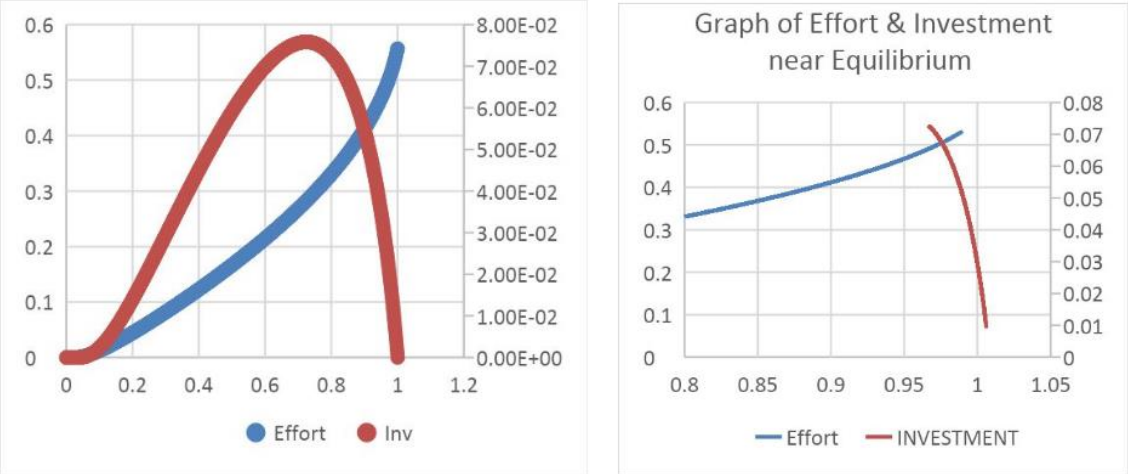


Figure 2. (a) (b) Higher Changes in effort or investment is required for changes in its respective elasticities as shown from Figure 2. As demand for this scenario is assumed to be constant, the equilibrium lies at the intersection of effort and investment curves. Following this, we arrive at the following proposition .

Proposition 1

There are only two type of equilibria in this game for the given real situation

$$\alpha_1 = 0, \alpha_2 = 1$$

1) e*= I*=0 at

2) (e*, I*) where e*>0, I*>0) at

$$\alpha_1 = .90, \alpha_2 = .1$$

$$as$$

$$\alpha_1 + \alpha_2 = 1$$

Equilibrium 1 is the situation where there is no service. This is obvious since there will be no payoffs at this point.

Equilibrium 2 (Refer Figure 2(b)) is the situation where the equilibrium investment by the government and the entrepreneur's are positive, leading to a positive payoff to the service provider at the end of the contract. This is a situation, which benefits both the service provider and the government in a PPP leading to a successful PPP contractual venture.

Proposition 2

For the second equilibrium when the service exists,

i.e. (e*, I*) where e*>0, I*>0) at

$\alpha^1 = \cdot\partial 0^2 \alpha^3 = \cdot I$

 doi:10.20944/preprints202506.1191.v1

As $\alpha_1 + \alpha_2 = 1$

Despite the payoffs being positive, there is a possibility of opportunistic underinvestment by the government despite the high effort exerted by the service provider, leading to lower payoffs.

3.6. Scenarios occurring in COVID 19 Era

3.6.1. A COVID-19 Like Pandemic and Corporate Service Provider - Government Renegotiation

Let be the investment made during renegotiation. Then the objective function for the service provider is given by

$$\underset{E^H}{Maximize}\ p^H * \beta * (1-t) * r * A * e_H^{\alpha_1} * I^{*\alpha_2} * e^{-\theta} - (p^H * e_H^2 * (a + b*\theta + c*\theta^2)/2$$

---------(8) And the objective function of the government is given by

$$\underset{\beta, I}{Maximize}\ p^H * t * (1-\beta) * r * A * e_H^{\alpha_1} * I^{*\alpha_2} * e^{-\theta} + k * p^H * A * e_H^{\alpha_1} * I^{*\alpha_2} * \exp^{-\theta} - I(1+\nu)$$

------- (9) Subject to following constraints of the service provider

$$(p^H * e_H^2) * (a + b*\theta + c*\theta^2)/2 - p^H * (1-t) * r * \beta * A * e_H^{\alpha_1} * I^{*\alpha_2} * \exp^{-\theta}$$
$$\leq (p^L * e_L^2) * (a + b*\theta + c*\theta^2)/2 - p^L * (1-t) * r * \beta * A * e_L^{\alpha_1} * I^{*\alpha_2} * \exp^{-\theta}$$

---------- (10)

$$p^H * e_H^2 (a + b*\theta + c*\theta^2)/2 - p^H * (1-t) * r * \beta * A * e_H^{\alpha_1} * I^{*\alpha_2} * \exp^{-\theta} \leq -\bar{U}$$

---------- (11)

Solving the agent's problem applying KKT conditions we have

$$e^H = [(1-t) * r * A * \beta * \alpha_1 * I^{1-\alpha_1} * \exp^{-\theta} / (a + b*\theta + c*\theta^2)]^{1/(2-\alpha_1)}$$

Now solving the Principal's Problem i.e. the government's problem which is an unconstrained optimization problem for the objective function

$$\underset{I,\beta}{Maximize}\quad (1-\beta) * p^H * t * r * A * e_H^{\alpha_1} * I^{*\alpha_2} * e^{-\theta} + k * p^H * A * e_H^{\alpha_1} * I^{*\alpha_2} * e^{-\theta} - I^*(1+\nu)$$

------ (12) Solving the first order with reference to , by back substituting the value of e

$$\beta = (\alpha_1 / 2 * t * r) * [1 + k]$$

And then solving the first order with reference to I,
We have

$$I^* = \frac{[k + (1-\beta) * t * r]^{\frac{1+\alpha_2}{1-\alpha_2}} * R^{\frac{1+\alpha_2}{1-\alpha_2}}}{(1+\upsilon)^{\frac{1+\alpha_2}{1-\alpha_2}}}$$

When we have

 doi:10.20944/preprints202506.1191.v1

Where β is substituted from prior equation.

For the objective function to be concave we see that first principal minor is negative and second principal minor needs to be positive at the stationary point (optimal point). Also as $\beta < 1$

We have $0 < \alpha_1 < 0.1$

$\beta <= \alpha_1$.

And we also obtain all values of α_1

From figure 3 we see that as α_1 <=0.1, we see that the plot of effort vs elasticity intersects at a point where

$$\alpha_1 = 0.1, \alpha_2 = 0.9$$

Which gives us the equilibrium conditions.

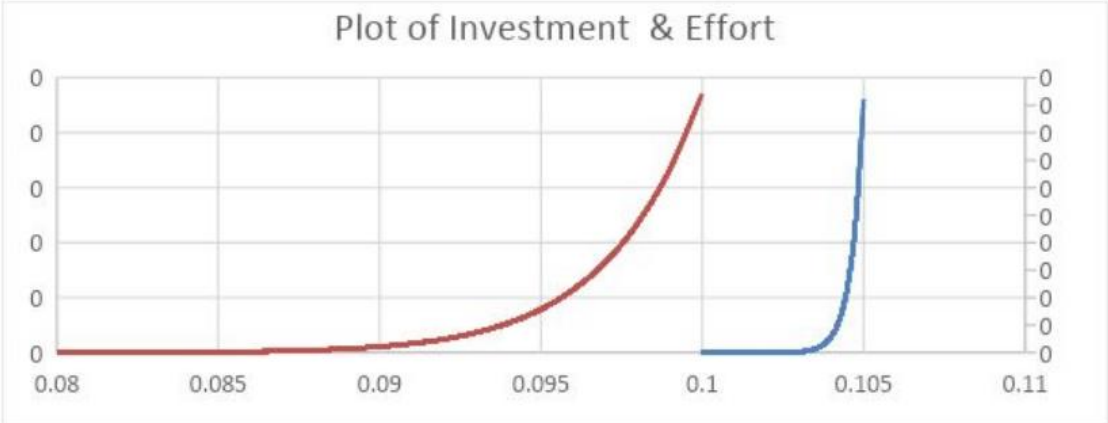


Figure 3.

Following this, we arrive at the following proposition

Proposition 3

There are two distinct equilibrium conditions in the current scenario.

They are

1) $\alpha_1 = 0.1, \alpha_2 = 0.9$

2) $\alpha_1 = (0.....0.08), \alpha_2 = (1.....0.92)$

 doi:10.20944/preprints202506.1191.v1

The first is an equilibrium point when I>0, e>0 and the payoffs are positive for both the SP and Government. The second is a set of equilibrium points where the firm ceases to exist, as both I=0 and e=0 for this set of points as seen from Figure 3.

Proposition 4

In equilibrium conditions under the current scenario, the payoffs would not be lower, as both the players, government and service provider may tend to exhibit opportunistic behaviour, unless there is risk of terminating the service.

3.6.2. A COVID 19 Like Pandemic When an Investor funds the Corporate Service Providers

The Agent's Problem i.e. the service provider's problem becomes

---

-- (13) ST

- ---

- (14) The KKT conditions are

---

(15) ---

(16) ---------- (17)

Solving in similar way to the previous situations

---

(18) The investor's problem is as follows:

----------(19)

Substituting in above unconstrained optimization problem

we have the above set of equations as

----------(20)

Solving we have

If the investor turns down reinvestment due to the low returns then and

Furthermore, we see that the objective function is concave as the double differential is negative For the Government Problem, the objective function become

---

-(21)

 doi:10.20944/preprints202506.1191.v1

Substituting from the previous equations in the above equations and simplifying it we have the equation simplifying to the following form

----------(22)

Where is a constant not effecting the optimal decision variable.

As this is an unconstrained optimization problem and as the second differential of the objective function is negative, the function is concave.

The above unconstrained optimization problem leads to following optimal solution

As we have , for which the concavity conditions are satisfied. The equilibrium is obtained at two points as shown in the Figure 4 (a) and 4(b) below.

 doi:10.20944/preprints202506.1191.v1

Figure 4. (a).

Series1= Effort, Series 2= I_{vc} Series2=I_{vc}, Series3= Effort Figure 4 (b)

Based on the above figures, we arrive at the following propositions

Proposition 5

There are two equilibrium conditions for which $I_{vc} > 0$ and $e > 0$, as shown in Figure 4 1) The first equilibrium occurs at

2) The second equilibrium occurs at

At these equilibrium points, we see with increase in elasticities, effort increases whereas investment decreases and both these equilibrium conditions provide positive payoffs to service provider, investor and the government.

3.6.3. Base Model for Non - Profit Service Providers

---------- (23)

---------- (24)

---------- (25) Applying the KKT Conditions we obtain the optimal for the agent's problem

Solving the Principal's problem, i.e. the government's problem, which is an unconstrained optimisation problem and substituting the Value of e, the Principal's objective function becomes

---------- (26)

Taking the first differential and equating it to zero, we obtain optimal solution as

The second derivative is negative, therefore the objective function is concave.

Series1= Effort Series 2= Investment

 doi:10.20944/preprints202506.1191.v1

Figure 5.

The above figure 5 shows the plot of investment and effort, leading to the following proposition.

Proposition 6

There is a unique equilibrium in this game for the given real situation

1) (E*, I*) where E*>0, I*>0) at

for constant returns of scale

Equilibrium situation occurs at I > 0, e>0 leading to a positive payoff to the service provider at exit of contract.

Proposition 7

For , both players tend to exhibit opportunistic behaviour around the equilibrium position for constant as well as decreasing returns of scale.

3.6.4. A COVID-19-Like Pandemic with Renegotiation by a Non-Profit Provider

The objective function of the service provider becomes

----------(27)

Whereas the objective function of the government becomes

---------- (28)

Applying KKT conditions for solving the agent i.e. the agent's problem first, we have

The optimal value of e=

Substituting the above value of e in Principal problem i.e. Government Problem we have

---------- (29)

Where

Solving the above unconstrained optimizing problem for the government with reference to the decision of Investment I, we have

Similarly solving for , we have

 doi:10.20944/preprints202506.1191.v1

The conditions which satisfy are

The objective function's Hessian's 1st principal minor is negative and the second principal minor is positive, demonstrating it is concave function with reference to both I and .

Figure 6.

Figure 6 shows that with an increase in elasticity the effort increases and investment increases for the region . This is followed by the following proposition.

Proposition 8

For e>0, I>0, there exist a unique equilibrium for which the service provider successfully renegotiates and executes the contract, as follows

Proposition 9

For I>0 and e>0, both players (the government and service provider) tend to exhibit opportunistic behaviour around the equilibrium point.

4. Conclusions

The financing of service providers (Corporate or Non Profit) depends on availability of resources at any particular point of time. During crisis situations like COVID 19, India has met realities in life that need to be addressed accordingly. Covid 19 has created a vacuum in healthcare with vaccine development still in its testing stage. Such critical situations need to be addressed by the government strategically. Reputation for emergency medical services in India which depend on service providers that were primarily NGOs like GVK EMRI need circular economy based funding mechanisms. These financial mechanisms can primarily be addressed by PPP that may aid in acquisition of resources which may not be available. The government thus has to rely on service providers, either private or NGO's that can operate solely on the capital provided jointly by government and investors through PPP mechanisms based on the reputation of the service provider. Situations may arise where the service provider's identity(Private or Public) needs to be hidden by the government in a PPP partnership due to differences that may arise between two due to factors like equity, access and service related information. These situations can be addressed through advertising strategies which may aid the citizens as well as the government in a way that may help the health sector when the epidemic situation ceases and the overall economy is set for liberalization.

 doi:10.20944/preprints202506.1191.v1

References

1. Agheon Phillippe et al. (2000). Agency Costs, Firm Behavior and the Nature of Competition.
2. Akintoye, A., & Kumaraswamy, M. (2004). *TG72: Public-Private Partnership Title Public-Private Partnerships Subtitle Research Roadmap-Report for Consultation Serial title CIB Publication 406 Edition 1 Year 2016* . Retrieved from www.cibworld.nl
3. Alonso-Conde, A. B., Brown, C., & Rojo-Suarez, J. (2007). Public-private partnerships: Incentives, risk transfer, and real options. *Review of Financial Economics* , *16* (4), 335–349. https://doi.org/10.1016/j.rfe.2007.03.002
4. Auriol, E., & Picard, P. M. (2013). A theory of BOT concession contracts. *Journal of Economic Behavior & Organization* , *89* , 187-209.
5. Bennett, S., & Mills, A. (n.d.). *Government capacity to contract: health sector experience and lessons* . Retrieved from https://onlinelibrary.wiley.com/doi/pdf/10.1002/(SICI)1099-162X(1998100)18:4%3C307::AID-PAD24%3E3.0.CO;2-D
6. Bergman, B. (1990). Public Policy in a Principal-Agent Framework [retrieved_2019-04-02].pdf. (n.d.).
7. Besley, T., & Ghatak, M. (2017). Public-private partnerships for the provision of public goods: Theory and an application to NGOs. *Research in Economics* , *71* (2), 356–371. https://doi.org/10.1016/j.rie.2017.04.005
8. Bettignies, J.-E. de, & Ross, T. W. (2004). The Economics of Public-Private Partnerships. *Canadian Public Policy* , *30* (2), 135–154. Retrieved from https://ideas.repec.org/a/cpp/issued/v30y2004i2p135-154.html
9. Blanken, A., & Dewulf, G. (n.d.). PPPs in Health: Static or Dynamic? *The Australian Journal of Public Administration* , *69* (S1), 35–47. https://doi.org/10.1111/j.1467-8500.2009.00656.x
10. Buso, M. (2019). Bundling versus unbundling: asymmetric information on information externalities. *Journal of Economics* , *128* (1), 1-25.
11. Carr, B. G., Caplan, J. M., Pryor, J. P., & Branas, C. C. (2006). A Meta-Analysis of Prehospital Care Times for Trauma. *Prehospital Emergency Care* , *10* (2), 198–206. https://doi.org/10.1080/10903120500541324
12. Casady, Carter B., Kent Eriksson, Raymond E. Levitt, and W. Richard Scott. 2020. "(Re)Defining Public-Private Partnerships (PPPs) in the New Public Governance (NPG) Paradigm: An Institutional Maturity Perspective." Public Management Review 22, no. 2: 161-183.
13. Chou, J.-S., Ping Tserng, H., Lin, C., & Yeh, C.-P. (2012). Critical factors and risk allocation for PPP policy: Comparison between HSR and general infrastructure projects. *Transport Policy* , *22* , 36–48. https://doi.org/10.1016/J.TRANPOL.2012.05.009
14. Chung, C. (2001). The Evolution of Emergency Medicine. *Hong Kong Journal of Emergency Medicine* , *8* (2), 84–89. https://doi.org/10.1177/102490790100800204
15. Cooley, Thomas F. and Bruce D. Smith (1987). Equilibrium in Cooperative Games of Policy Formulation. Working Paper No. 84, Rochester Centre of Economic Research.
16. David, S. S., Vasnaik, M., & TV, R. (2007). Emergency medicine in India: Why are we unable to walk the talk *Emergency Medicine Australasia* , *19* (4), 289–295. https://doi.org/10.1111/j.1742-6723.2007.00985.x
17. David Baxter1 and Carter B. Casad, (2020) Proactive and Strategic Healthcare Public-Private Partnerships (PPPs) in the Coronavirus (COVID-19) Epoch.
18. De Brux, J. (2010). The Dark and Bright Sides of Renegotiation: An Application to Transport Concession Contracts. *Utilities Policy* , *18* (2), 77–85. https://doi.org/10.1016/j.jup.2009.07.003
19. Development Bank, A. (n.d.). *Improving Health and Education Service Delivery in India through Public-Private Partnerships* . Retrieved from www.adb.org
20. Dykstra, E. H. (1997). International models for the practice of emergency care. *The American Journal of Emergency Medicine* , *15* (2), 208–209. https://doi.org/10.1016/S0735-6757(97)90107-8
21. Elitzur, R., & Gavious, A. (2003). Contracting, signaling, and moral hazard: a model of entrepreneurs, 'angels,' and venture capitalists. *Journal of Business Venturing* , *18* (6), 709–725. https://doi.org/10.1016/S0883-9026(03)00027-2
22. Elitzur, R., & Gavious, A. (2011). Selection of entrepreneurs in the venture capital industry: An asymptotic analysis q. https://doi.org/10.1016/j.ejor.2011.06.029
23. *EMERGENCY MEDICAL SERVICE (EMS) IN INDIA: A CONCEPT PAPER* . (n.d.). Retrieved from www.nhsrcindia.org

 doi:10.20944/preprints202506.1191.v1

24. *Good Governance and Partnerships for Health* . (n.d.). Retrieved from http://heartfile.org
25. Gregory, A. W., & Hansen, B. E. (1996). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics* , *70* (1), 99–126. https://doi.org/10.1016/0304-4076(69)41685-7
26. Grimsey, D., & Lewis, M. (2007). Public-Private Partnerships and Public Procurement. *Agenda* , *14* (2), 171–188.
27. Gupta, M. Das, & Rani, M. (2004). *India's Public Health System: How Well Does It Function at the National Level?* The World Bank. https://doi.org/10.1596/1813-9450-3447
28. Hart, O. (2003). Incomplete Contracts and Public Ownership: Remarks, and an Application to Public-Private Partnerships. *The Economic Journal* , *113* (486), C69–C76. https://doi.org/10.1111/1468-0297.00119
29. Hayllar, M. R., & Wettenhall, R. (n.d.). Public-Private Partnerships: Promises, Politics, and Pitfalls. *The Australian Journal of Public Administration* , *69* (S1), 1–7. https://doi.org/10.1111/j.1467-8500.2009.00657.x
30. Ho, S. P. (2009). Government Policy on PPP Financial Issues: Bid Compensation and Financial Renegotiation. *Policy, Finance & Management for Public-Private Partnerships* , 267–300. https://doi.org/10.1002/9781444301427.ch15
31. Ho, T.S.Y & Lee, S.B. (2004). The Oxford Guide to Financial Modelling: Applications for Capital Markets, Corporate Finance, Risk Management and Financial Institutions. OUP Publishers, USA.
32. Huige Xing 1, Yuelin Li 1 and Hongyang Li 2,3, (2020). Renegotiation Strategy of Public-Private Partnership Projects with Asymmetric Information— An Evolutionary Game Approach. *Sustainability*
33. Hung, K. K. C., Cheung, C. S. K., Rainer, T. H., & Graham, C. A. (2009). International EMS systems: China. *Resuscitation* , *80* , 732–735.
34. Kennedy, G. M. (2013). Can game theory be used to address PPP renegotiations ? A retrospective study of the of the Metronet - London Underground PPP By Dissertation

i. submitted in partial fulfillment of requirements for the degree of MSc in Business Administration, at the Univers, (June).

35. Klijn, E. H., & Koppenjan, J. (2016). Public Money & Management The impact of contract characteristics on the performance of public-private partnerships (PPPs). https://doi.org/10.1080/09540962.2016.1206756
36. KPMG. (2015). *The Emerging Role of PPP in Indian Healthcare Sector Prepared By In collaboration with the Indian government* . Retrieved from https://www.ibef.org/download/PolicyPaper.pdf
37. Liu, X., Hotchkiss, D. R., & Bose, S. (2007). The impact of contracting-out on health system performance: A conceptual framework. *Health Policy* , *82* , 200–211. https://doi.org/10.1016/j.healthpol.2006.09.012
38. Lv, J., Ye, G., Liu, W., Shen, L., & Wang, H. (2015). Alternative Model for Determining the Optimal Concession Period in Managing BOT Transportation Projects. *Journal of Management in Engineering* , *31* (4), 04014066. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000291
39. M, B. R., and N. (2013). Private Partnerships of Boundaries : Public- Blurring in Health Services in India. *Economic Political Weekly* , *43* (4), 62–71.
40. MacAl, C. M., & North, M. J. (2010). Tutorial on agent-based modeling and simulation. *Journal of Simulation* , *4* (3), 151–162. https://doi.org/10.1057/jos.2010.3
41. Manigart, S., De Waele, K., Wright, M., Robbie, K., Desbrières, P., Sapienza, H. J., & Beekman, A. (2002).Determinants of required return in venture capital investments: a five-country study. *Journal of Business Venturing* , *17* (4), 291–312. https://doi.org/10.1016/S0883-9026(00)00067-7
42. Mason, C. M., & Harrison, R. T. (2002). Is it worth it? The rates of return from informal venture capital investments. *Journal of Business Venturing* , *17* (3), 211–236. https://doi.org/10.1016/S0883-9026(00)00060-4
43. Medda, F. R., Carbonaro, G., & Davis, S. L. (2013). Public-private partnerships in transportation: Some insights from the European experience. *IATSS Research* , *36* (2), 83–87. https://doi.org/10.1016/J.IATSSR.2012.11.002
44. Mitroff, I. I., & Mason, R. O. (2011). The Metaphysics of Policy and Planning: A Reply to Cosier. *Academy of Management Review* , *6* (4), 649–651. https://doi.org/10.5465/amr.1981.4285721
45. Oliveira Cruz, C., & Cunha Marques, R. (2014). Theoretical Considerations on Quantitative PPP Viability Analysis. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000184

 doi:10.20944/preprints202506.1191.v1

46. Prakash, G., & Singh, A. (n.d.). *A New Public Management Perspective in Indian E-Governance Initiatives* . Retrieved from http://unpan1.un.org/intradoc/groups/public/documents/UN-DPADM/UNPAN040636.pdf
47. Privatization of Health Services: A South Asian Perspective on JSTOR. (n.d.). Retrieved April 29, 2019, from https://www.jstor.org/stable/4414156?seq=1#metadata_info_tab_contents
48. Raman, A. V., Björkman, J. W., & Björkman, J. W. (2008). *Public-Private Partnerships in Health Care in India* . Routledge. https://doi.org/10.4324/9780203886557

i. Roberts, M. J., Hsiao, W., Berman, P., & Reich, M. R. (n.d.). *Getting Health Reform Right* . Retrieved from http://www.ssu.ac.ir/fileadmin/templates/fa/daneshkadaha/daneshkade-behdasht/manager_group/upload_manager_group/manabe_elmi/e-book/english/edalat_dar_nezame_salamat/2.Getting_Health_Reform_Right.pdf

49. Ross, T. W., & Yan, J. (2015). Journal of Comparative Policy Analysis: Research and Practice Comparing Public-Private Partnerships and Traditional Public Procurement: Efficiency vs. Flexibility. *Journal of Comparative Policy Analysis: Research and Practice* , *17* (5), 448–466. https://doi.org/10.1080/13876988.2015.1029333
50. Schneider, S. M., Gardner, A. F., Weiss, L. D., Wood, J. P., Ybarra, M., Beck, D. M., … Jouriles, N. J. (2010). The Future of Emergency Medicine. *The Journal of Emergency Medicine* , *39* (2), 210–215. https://doi.org/10.1016/J.JEMERMED.2010.06.001
51. Serra, D., Serneels, P., & Barr, A. (n.d.). *Intrinsic Motivations and the Non-Profit Health Sector: Evidence from Ethiopia* . Retrieved from http://hdl.handle.net/10419/36127www.econstor.eu
52. Shi, L., Zhang, L., Onishi, M., Kobayashi, K., & Dai, D. (2018). Contractual Efficiency of PPP Infrastructure Projects: An Incomplete Contract Model. *Mathematical Problems in Engineering* , *2018* , 1–13. https://doi.org/10.1155/2018/3631270
53. Singh, A., & Prakash, G. (2010). Public-Private Partnerships in Health Services Delivery. *Public Management Review* , *12* (6), 829–856. https://doi.org/10.1080/14719037.2010.488860
54. *STABILIZING THE EMERGENCY MEDICAL SERVICES IN INDIA* . (n.d.). Retrieved from https://a2hp.mohfw.gov.in/ResourceDocuments/STABILIZING THE EMERGENCY MEDICAL SERVICES IN INDIA.pdf
55. Subhan, I., & Jain, A. (2010). Emergency care in India: the building blocks. *International Journal of Emergency Medicine* , *3* (4), 207–211. https://doi.org/10.1007/s12245-010-0223-7
56. Titoria, R., & Mohandas, A. (2019). A glance on public-private partnership: an opportunity for developing nations to achieve universal health coverage. *International Journal Of Community Medicine And Public Health* , *6* (3), 1353. https://doi.org/10.18203/2394-6040.ijcmph20190640
57. Tserng, H. P., Russell, J. S., Hsu, C. W., & Lin, C. (2012). Analyzing the role of national PPP units in promoting PPPs: Using new institutional economics and a case study. *Journal of construction engineering and management* , *138* (2), 242-249.
58. Ho, T.S.Y & Lee, S.B. (2004). The Oxford Guide to Financial Modelling: Applications for Capital Markets, Corporate Finance, Risk Management and Financial Institutions. OUP Publishers, USA.
59. Vasudevan, V., Singh, P., & Basu, S. (2016). Importance of awareness in improving performance of emergency medical services (EMS) systems in enhancing traffic safety: A lesson from India. *Traffic Injury Prevention* , *17* (7), 699–704. https://doi.org/10.1080/15389588.2016.1163689

 doi:10.20944/preprints202506.1191.v1

60. Wibowo, A., & Alfen, H. W. (2015a). Critical success factors in public-private partnership (PPP) on infrastructure delivery in Nigeria. *Asia-Pacific Journal of Business Administration* , *5* (1), 212–225. https://doi.org/10.1108/BEPAM-03-2014-0016
61. Wibowo, A., & Alfen, H. W. (2015b). Government-led critical success factors in PPP infrastructure development. *Built Environment Project and Asset Management* , *5* (1), 121–134. https://doi.org/10.1108/BEPAM-03-2014-0016