BARGAINING, COALITIONS, SIGNALLING AND REPEATED GAMES FOR ECONOMIC DEVELOPMENT AND POVERTY ALLEVIATION

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ABSTRACT

How economic agents with conflicting interests can analyse gains from bargaining, coalition, signalling and repeated games and how their pivotal positions influence the outcome of the game is illustrated using numerical examples. Dynamic Poverty game is proposed for alleviation of poverty that requires cooperation from tax payers, transfer recipients and the democratic government and the international community. These concepts are applied to analyse how the incorporation of growth pact in the constitution can set a mechanism for cooperative solution required for peaceful and prosperous Nepal without harmful conflicts that had upset the growth process over the years.

Key words: **Bargaining, Coalition, Repeated Game, Poverty Game, Nepal**

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Bargaining, Coalitions And Signalling Games For Economic Development And Poverty Alleviation

Introduction

In many circumstances optimal decisions of an economic agent depends on decisions taken by others. Dominants firms competing for a market shares, political parties contesting for power and research and scientific discoveries aimed for path-breaking innovations are influenced by decision taken by others. In all these circumstances there are situations where collective efforts rather than individual ones generate the best outcome for the group as a whole and for each individual members of the group. Concepts of bargaining, coalition and repeated games developed over years by economists such as Cournot (1838), Bertrand (1883), Edgeworth (1925) von Neumann and Morgenstern (1944) and Nash (1950, 1953) are developing very fast in recent years following works of Kuhn (1953), Shapley (1953),Shelten (1965) Aumman (1966) Scarf (1967), Shapley and Shubik (1969), Harsanyi(1967), Spence (1974), Hurwicz (1973), Myerson (1986), Maskin and Tirole (1989), Kreps (1990), Fundenberg and Tirole (1991) and Binmore (1992), Rubinstein (1982) Sutton (1986) Cho and Kreps (1987) Sobel (1985) Machina (1987) Riley (1979) McCormick (1990), Ghosal and Morelli (2004) and others. These have generated models that can be applied to analyse the relative gains from coalitions rather than without these coalitions. The major objective of this paper is to apply these concepts to analyse the rationality or irrationality of choices made by political parties in Nepal in process of transforming her political economic system aiming to create a peaceful and prosperous economy like that of her neighbours India and China. This is further refinement of the solutions discussed on bargaining and political economy and general equilibrium models analysed in Bhattarai (2006 and 2007).

It is natural that economic agents play a zero sum and non-cooperative game until they realise the benefits of coalition and cooperation. When an agreement is made and cooperation is achieved there is a question on whether such coalition is stable or not. There are always incentives at least for one of the players to cheat others from this cooperative agreement in order to raise its own share of the gain. However, it is unlikely that any player can fool all others at all the times. Others will discover such cheating sooner or later. Therefore a peaceful solution requires credibility and a punishment mechanism by which any party that tries to cheat on the agreement is punished unless it amends its uncooperative behaviours toward others.

In the context of Nepal abolition of absolute monarchy required cooperation of all parties that was achieved under the 12 point agreement in November 2005 concurred in New Delhi. Consequences of this agreement were phenomenal in terms of transformation of power among political parties. In the next stage of the game the only unifying objective of such cooperation can be the alleviation of mass scale poverty and higher rate of economic growth to catch up at least to one of her neighbours. This requires cooperative moves from all parties which can be achieved by maintaining the commitment to the growth pact among all parties. It is necessary to design an incentive compatible mechanism by which it is in the best interest of each party to stick to such a commitment.

The April (2006) revolution has brought the Nepalese Congress (NC), the Maoists (CPN-M), Marxists Leninist Communist Party (UML) along with other small political parties allied to the democratic movements in the forefront of the Nepalese politics. Political progress since then has been phenomenal - it has abolished absolute monarchy, it has created fresh competitive politics based on ideas and visions for the country, compelled reforms and democratisation of each of the parties including the unification of the breakaway fractions into their mother parties in order to survive in the new era of value based and target oriented politics. Major focus of all parties has been to conduct an election of the Constituent Assembly (CA) that would enshrine modern values, right and duties of each part of the nation and state in the constitution of the Nepalese people that would open an unhindered path for rapid growth of the economy uplifting the living standards of majority of people by eliminating illiteracy, expanding education and health sectors and fulfilling other basic needs of them to solve the problem of poverty for more than 25 million people in Nepal. No political arrangements will be successful unless all parties commit to a "grow Nepal" contract and proceed in an agreeable way by which majority start feeling that the system is moving forward and fulfilling their needs.

Following sections aim to analyse these issues using bargaining and Shapley value concept in section II and III, minimax and mixed strategies in section IV, signalling and repeated game in section V, repeated game in VI, principal agent game in VIII, and poverty game in IX. Conclusions and references are in section X.

II. Gains from Bargaining and Shapley Values of the Game

A coalition of players should fulfil individual rationality, group rationality and coalition rationality. These can be ascertained by the supper-additivity property of coalition where the maximisation of gain requires being a member of the coalition rather than playing alone.

This can be explained using standard notations. Let us take three players in the current Nepalese context N = (1= *CPM* and 2 =*UML*, 3 =*NC*). Superadditivity condition implies that the value of the game in a coalition is greater than the sum of the value of the game of playing alone by those individual members.

$$v(1 \cup 2 \cup 3) \geq v(1) + v(2) + v(3)$$

Coalitions (parties) playing together generate more value for each of its members than by playing alone. Team spirit generates extra benefits. When normalised to 0 and 1 the value of the gains from a coalition are:

$$v(i) = 0 \quad v(N) = 1 \quad \text{for} \quad i = \{1,2,........N\}$$

The fact that payoff of the merged coalition is larger than the sum of the payoff to the separate coalitions is shown by following imputations, that shows ways on how the value of the game can be distributed among *N* different players. The imputations of values characterise these allocations:

$$\Pi = \left(\Pi^1, \Pi^2 ....\Pi^n\right)$$

$$v(N) = \sum_{i \in N} \Pi^i = \sum_{i=1}^{n} \Pi^i \;;$$

Group rationality implies that total payoff to each players in the coalition equals at least the payoff of its independent actions.

$$\Pi^i \geq v(\{i\}) \quad i \in N$$

In the dynamic context players like to maximise the present value, V, of the gain from infinite period, with a given discount rate over years:

$$V = \int_{t=0}^{t=\infty} v(i) e^{-rt} dt$$

Imputations in the core guarantees, each member of a coalition, a value at least as much as it could be obtained by playing independently. At the core of the game each player gets at least as much from the coalition as from the individual action, there does not exist any blocking coalition. This is equivalent to Pareto optimal allocation in a competitive equilibrium (Scarf (1967)). Some imputations are dominated by others; the core of the game is the strong criteria for dominant imputation. Core satisfies coalition rationality.

A unique imputation in the core is obtained by Shapley value. This reflects additional payoff that each individual can bring by adding an extra player to the existing coalition above the pay-off without this player. This is the power of that player. Consider a game of three players in which the 3rd player always brings more to the coalition than the 1st or the 2nd player.

Payoff for coalition of empty set: $v(\phi) = 0$;

Payoff from players acting alone: $v(1) = 0$; $v(2) = 0$; $v(3) = 0$

Payoff from alternative coalitions: $v(1,2) = 0.1$ $v(1,3) = 0.2$ $v(2,3) = 0.2$

Payoff from the grand coalition: $v(1,2,3) = 1$

Power of individual *i* in the coalition is measured by the difference that person makes in the value of the game $v(S \cup \{i\} - v(S))$, where *S* is the subset of players excluding *i*, $S \cup \{i\}$ is the subset including player *i*. The expected values of game for *i* is found by taking account of all possible coalition that person *i* can enter with *N* number of players, $\Pi^i = \sum_{S \subset N} \gamma_n(S)[v(S \cup \{i\} - v(S))]$ where $\gamma_n(S) = \frac{s!(n-s-1)!}{n!}$ is the weighting factor that changes according to the number of people in a particular coalition. This is the probability that a player joins coalition, $S \in N$ and there are (2^N -1) ways of forming in *N* player game:

$$v(\{1\}) - v(\{\phi\}) = 0 ; \quad v(\{1,2\}) - v(\{2\}) = 0.1 - 0 = 0.1 ; v(\{1,3\}) - v(\{3\}) = 0.2 - 0 = 0.2$$

$$v(\{1,2,3\}) - v(\{2,3\}) = 1 - 0.2 = 0.8 .$$

$$\gamma_0(S) = \frac{n!(n-n-1)!}{n!} = \frac{0!(3-0-1)!}{3!} = \frac{2 \times 1}{3 \times 2 \times 1} = \frac{2}{6}$$

$$\gamma_1(S) = \frac{n!(n-n-1)!}{n!} = \frac{1!(3-1-1)!}{3!} = \frac{1}{3 \times 2 \times 1} = \frac{1}{6}$$

$$\gamma_2(S) = \frac{n!(n-n-1)!}{n!} = \frac{2!(3-2-1)!}{3!} = \frac{2}{3 \times 2 \times 1} = \frac{2}{6}$$

Shapley value for player 1 is thus

$$\Pi^1 = \sum_{S \subset N} \gamma_n(S)[v(S \cup \{1\} - v(S))] = \frac{2}{6}(0) + \frac{1}{6}(0.1) + \frac{1}{6}(0.2) + \frac{2}{6}(0.8) = \frac{19}{60}.$$

For player 2

$$\Pi^2 = \sum_{S \subset N} \gamma_n(S)[v(S \cup \{2\} - v(S))] = \frac{2}{6}(0) + \frac{1}{6}(0.1) + \frac{1}{6}(0.2) + \frac{2}{6}(0.8) = \frac{19}{60}.$$

Note as before

$$v(\{2\}) - v(\{\phi\}) = 0; \quad v(\{1,2\}) - v(\{1\}) = 0.1 - 0 = 0.1 \;;$$

$$v(\{2,3\}) - v(\{3\}) = 0.2 - 0 = 0.2; \quad v(\{1,2,3\}) - v(\{1,3\}) = 1 - 0.2 = 0.8$$

For player 3

$$\Pi^3 = \sum_{S \subset N} \gamma_n(S)[v(S \cup \{3\} - v(S))] = \frac{2}{6}(0) + \frac{1}{6}(0.2) + \frac{1}{6}(0.2) + \frac{2}{6}(0.9) = \frac{22}{60}$$

$$v(\{3\}) - v(\{\phi\}) = 0; \quad v(\{1,3\}) - v(\{1\}) = 0.2 - 0 = 0.2 \;;$$

$$v(\{2,3\}) - v(\{2\}) = 0.2 - 0 = 0.2; \quad v(\{1,2,3\}) - v(\{1,2\}) = 1 - 0.1 = 0.9.$$

As the player 3 brings more into the coalition its expected payoff is higher than by players 1 and 2. Similar configurations can be made where players 1 and 2 can bring more in the coalition. In the context of Nepal which of three parties mentioned above are pivotal depends on the value they add to the game. The value of grand coalition is the largest possible value of the game with N players. This fact is shown by the core of the game in Figure 1.

Solutions towards the core are more stable than those towards the corners which are prone to conflicts. This is equivalent to finding a central ground in politics. Ego centric solutions are less likely to bring any stable solution to the game. In the most stable equilibrium all players gain in equal proportions to their supporters.

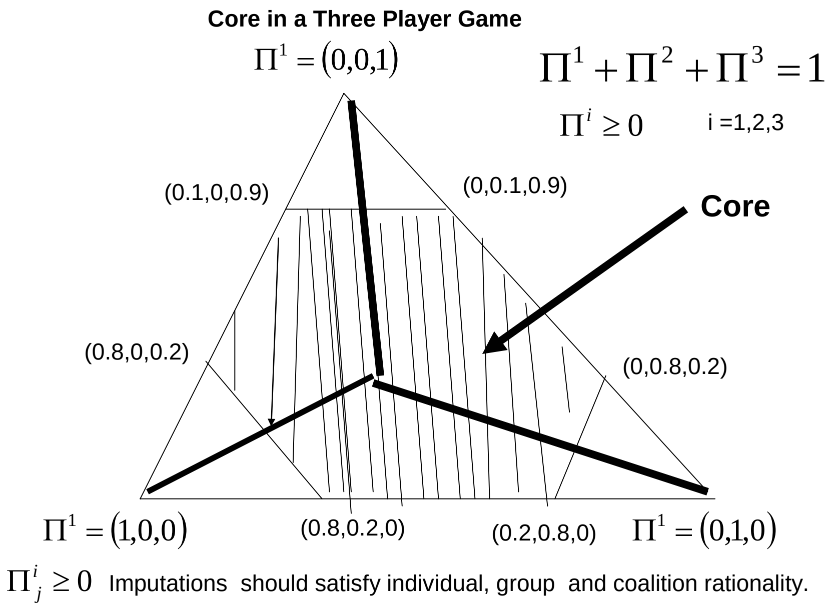

Figure 1

Pivotal player in a voting game

Ability of a player to influence the outcome of the game depends on the pivotal status enjoyed by that player. In a game with 3 players; power of player *i* is reflected by its Shapley value. Consider six possible ordering of 123 pivotal game. Three players can order themselves in 3! = 6 ways. Each of these number can appear only twice in the middle out of six possible combinations. A player located in the middle is pivotal. If parties realise this fact while bargaining, such bargaining is likely to generate a stable and cooperative solution. In the 123 game given in Table 1 the player 3 is pivotal in game (2) and (4); player 1 in (3) and (5) and player 2 in (1) and (6). The marginal contribution (Shapley value) of each player can be presented then as

I. The 123 Game with Rotating Pivotal Party

Orderings	M(1,S)	M(2,S)	M(3,S)
(1). 123	0	1	0
(2). 132	0	0	1
(3). 213	1	0	0
(4). 231	0	0	1
(5). 312	1	0	0
(6). 321	0	1	0
Shapley (i)	2/6	2/6	2/6

Therefore each player has 1/3 chance of being pivotal. If 1 is pivotal into the coalition, any coalition with 1 will win - player 1 is powerful. Players 2 and 3 are powerless. This outcome is reversed if other players become pivotal. There is always a chance that a pivotal player now may have to give up that position for other players later on.

Another configuration is to assume that certain party is pivotal all the times. As shown in Table II, in this situation the Shapley value of player 1 is 1 no matter which position it is in the coalition and it is 0 for players 2 and 3. In the context of Nepal in recent years, it seems that depending on circumstances, players NC, CPM and UML each have equal chance of being a pivotal player. Thus configurations in Table-I are more applicable than configurations in table II.

II. The 123 Game with only one Pivotal Party

Orderings	M(1,S)	M(2,S)	M(3,S)
(1). 123	1	0	0
(2). 132	1	0	0
(3). 213	1	0	0
(4). 231	1	0	0
(5). 312	1	0	0
(6). 321	1	0	0
Shapley (i)	6/6 =1	0/6=0	0/6 =0

III. **Solutions of a Bargaining Game and Risks**

Once political parties realise their pivotal status they engage in a power sharing game. Outcome of such a game can be more easily explained by Nash bargaining game that is popularly known as a game of splitting a pie between two parties, right or left. The sum of the shares of the pie claimed by players cannot exceed more than 1, otherwise each will get zero. If we denote these shares by θ_i and θ_j then $\theta_i + \theta_j \leq 1$ is required for a meaningful solution of the game where each get $\pi_i \geq 0$ and $\pi_i \geq 0$

payoff. When $\theta_i + \theta_j > 1$ then $\pi_i = 0$ and $\pi_i = 0$. Standard technique to solve this problem is to use the concept of Nash Product which can be formulated as following:

$$\max \quad U = (\theta_i - 0)(\theta_j - 0)$$

subject to

$$\theta_i + \theta_j \leq 1 \text{ or by non-satiation property } \theta_i + \theta_j = 1.$$

Using a Lagrangian function

$$L(\theta_i, \theta_j, \lambda) = (\theta_i - 0)(\theta_j - 0) + \lambda[1 - \theta_i - \theta_j]$$

First order conditions of this maximization problem are

$$\frac{\partial L(\theta_i, \theta_j, \lambda)}{\partial \theta_i} = \theta_j - \lambda = 0 \; ; \quad \frac{\partial L(\theta_i, \theta_j, \lambda)}{\partial \theta_j} = \theta_i - \lambda = 0 \; ; \quad \frac{\partial L(\theta_i, \theta_j, \lambda)}{\partial \lambda} = 1 - \theta_i - \theta_j = 0$$

From the first two first order conditions $\theta_j - \lambda = \theta_i - \lambda$ implies $\theta_j = \theta_i$ and putting this into the third first order condition $\theta_j = \theta_i = \frac{1}{2}$. In three player game similar solution generates $\theta_1 = \theta_2 = \theta_3 = 1/3$. This is the focal point of the game.

Thus Nash solution of this problem is to divide the pie symmetrically into two equal parts. Many other solutions are possible but none of them are stable (see Rasmusen (2007) and Roy Gardner (2003) for other examples).This game can easily be extended to three or more players. Nash solution is symmetric, linearly invariant and independent of irrelevant alternatives (IIR) and provides some insight on how the gains should be distributed among player in a competitive environment. How much each player gains from this game may be affected by attitude of the players towards the risks.

Risk and Bargaining

Most of the players are risk averse. In a bargaining game, a risk averse player gains a lot less than a risk neutral player. Thus players find it more rewarding to not to reveal their attitude toward risks to their opponents in bargaining. This can be illustrated using a simple example where player 2 is risk averse with utility function $u_2 = (m_2)^{0.5}$ and player 1 is risk neutral with a linear utility $u_1 = m_1$. Total amount in the table is $m_1 + m_2 = M$ or assuming to be 100, $u_1 + u_2^2 = 100$. Using a Lagrangian function for constrained optimisation

$$L(u_1, u_2, \lambda) = u_1 u_2 + \lambda[100 - u_1 - u_2^2]$$

Optimal first order conditions of this maximization are

$$\frac{\partial L(u_1, u_2, \lambda)}{\partial u_1} = u_2 - \lambda = 0 \; ; \quad \frac{\partial L(u_1, u_2, \lambda)}{\partial u_2} = u_1 - 2\lambda u_2 = 0 \; ;$$

$$\frac{\partial L(u_1, u_2, \lambda)}{\partial \lambda} = 100 - u_1 - u_2^2 = 0$$

These equations can be solved as $\frac{u_2}{u_1} = \frac{\lambda}{2\lambda u_2}$ or $u_1 = 2u_2^2$ and putting this into the third first order condition $3u_2^2 = 100$. $u_2^2 = \frac{100}{3} = 33.33$; $u_2 = 5.77$.

$u_1 = 2u_2^2 = 2(5.77)^2 = 66.6$ and $u_1 + u_2^2 = 66.67 + 33.33 = 100$

Thus the risk neutral player 1 gets 66.7 and risk averse player 2 gets only 5.7, paying a very high premium for risk aversion. Thus it is better not to reveal the attitude towards the risk to the opponents in a game even in the game of the political power.

IV. Minimax and Mixed Strategies

Many times political parties do not see gains from bargaining and take the game to be non-cooperative zero or constant sum nature and engage themselves in finding min-max or max-min solutions. Take a two player example for simplicity. The row player has two strategies such as holding an election for a Constituent Assembly (CA) or not holding an election for Constituent Assembly (NCA). The column player has three strategies CA, NCA and Delay.

A two person zero sum game set up: $\Pi^1_{i,j} + \Pi^2_{i,j} = 0$ or in a two person constant sum game: $\Pi^1_{i,j} + \Pi^2_{i,j} = a$. Consider a numerical example, $\Pi_{i,j} = \begin{pmatrix} 2 & 1 & 4 \\ -1 & 0 & 6 \end{pmatrix}$ which has a saddle point mini-max solution in pure strategy, i.e.

$$\begin{array}{ll} & \textit{RowMin} \\ \Pi_{i,j} = \begin{pmatrix} 2 & 1 & 4 \\ -1 & 0 & 6 \end{pmatrix} & \begin{array}{l} 1 \\ -1 \end{array} \\ \textit{Col}\max \; 2 \quad 1 \quad 4 & \end{array} \qquad \min_j \max = \max_i \min = 1.$$

$\min_j \max = \max_i \min = 1$; player 1 will play the first row and player 2nd will play the second column and solution of the game is 1. Player 1 guarantees pay off 1 regardless what the player 2 plays.

Other games, such as the declaring a republic from the house or the proportional representation system have no saddle point in pure strategies but at least one solution should exist in mixed strategies (Nash (1953)). Parties can randomise their strategies in order to make game more interesting. For instance:

$$\begin{array}{ll} & \textit{RowMin} \\ \Pi_{i,j} = \begin{pmatrix} 6 & -2 & 3 \\ -4 & 5 & 4 \end{pmatrix} & \begin{array}{l} -2 \\ -4 \end{array} \\ \textit{Col}\max \; 6 \quad 5 \quad 4 & \end{array} \qquad \min_j \max = 4 < \max_i \min = -2$$

There is no saddle point equilibrium in pure strategies in this game though this can be solved using a mixed strategy. Any player can only make probabilistic statements about the likely move of another player.

$$
\begin{array}{cc}
 & \begin{array}{ccc} p_1^2 & p_2^2 & p_3^2 \end{array} \\
\Pi_{i,j} = \begin{array}{c} p_1^1 \\ p_2^1 \end{array} & \begin{pmatrix} 6 & -2 & 3 \\ -4 & 5 & 4 \end{pmatrix}
\end{array}
$$

where $0 \leq p_i^j \leq 1$ denotes the probability of strategy *i* played by player *j*. Here p_1^1 is the probability of playing the 1st row and $p_2^1 = (1 - p_1^1)$, is the probability that this player will play the second row.

Value of this game under the mixed strategy is: $V = p^{1*}\Pi p^{2*} = \sum_{i=1}^{m}\sum_{j=1}^{n} p_i^{1*}\Pi_{i,j} p_j^{2*}$

$$\max_{p^1} \quad p^{1*}\Pi p^{2*} = V = \min_{p^2} \quad p^{1*}\Pi p^{2*}$$

$$V = p_1^1\left(6p_1^2 - 2p_2^2 + 3p_3^2\right) + \left(1 - p_1^1\right)\left(-4p_1^2 + 5p_2^2 + 4p_3^2\right)$$

Substitute $p_3^2 = \left(1 - p_1^2 - p_2^2\right)$ in the above take derivative wrt p_1^2 and p_2^2 to find optimal mix of strategies of the row player.

$$V = p_1^1\left(6p_1^2 - 2p_2^2 + 3\left(1 - p_1^2 - p_2^2\right)\right) + \left(1 - p_1^1\right)\left(-4p_1^2 + 5p_2^2 + 4\left(1 - p_1^2 - p_2^2\right)\right)$$

$$\frac{\partial V}{\partial p_1^2} = 6p_1^1 - 3p_1^1 - 4\left(1 - p_1^1\right) - 4\left(1 - p_1^1\right) = 0$$

$$\frac{\partial V}{\partial p_2^2} = -2p_1^1 - 3p_1^1 + 5\left(1 - p_1^1\right) - 4\left(1 - p_1^1\right) = 0$$

Solving these two first order conditions one finds optimal mix strategy for player one is to play row 1 with probability either $p_1^1 = \frac{8}{11}$ or $p_1^1 = \frac{1}{6}$.

Similarly differentiate the above function with respect to p_1^1 and p_2^1 to find optimal strategies for the column player as p_1^2, p_2^2 and p_3^2.

$$\frac{\partial V}{\partial p_1^1} = \left(6p_1^2 - 2p_2^2 + 3p_3^2\right) = 0 \Rightarrow \left(6p_1^2 - 2p_2^2 + 3\left(1 - p_1^2 - p_2^2\right)\right) = 0 \Rightarrow 3p_1^2 - 5p_2^2 = -3$$

$$\frac{\partial V}{\partial p_2^1} = \left(-4p_1^2 + 5p_2^2 + 4p_3^2\right) = 0 \Rightarrow \left(-4p_1^2 + 5p_2^2 + 4\left(1 - p_1^2 - p_2^2\right)\right) = 0\,; 8p_1^2 + p_2^2 = -4$$

and $p_3^2 = \left(1 - p_1^2 - p_2^2\right)$

$$p_1^2 = \frac{17}{37};\ p_2^2 = \frac{167}{185};\ p_3^2 = \left(1 - \frac{17}{37} - \frac{167}{185}\right) = \frac{925 - 85 - 835}{185} = \frac{5}{925} = \frac{1}{185}$$

The value V simultaneously maximises the expected payoff of player 1 and minimises expected loss of player 2. According to Nash (1953) for every game there exists at least one mixed strategy. The major problem inherent in finding solution of political games in the Nepalese context remains in quantifying the payoff profiles that is acceptable to all players which can be obtained using right set of signalling.

V. **Signalling and Repeated Game**

When intention cannot be directly revealed or stated players can signal indirectly to other players. These signals can take many forms. Signalling plays important role in strategic choices of individuals, parties, communities, regions, national and the global community as a whole. Formation of payoff discussed above depends on signalling - players do not know the moves of their opponents but based on their interpretation of signal they can however, put some numerical values to the payoff. A player $i \in N$ for $i = 1,.., N$ (ith individual, party or nation) receives a sequence of signals $\theta_{i,t} \in \Theta_t$ at for every period *t*; its actions are functions of current and past signals $a_{i,t}\left(\theta_{i,t}\right) \in \Theta_t$ for. $t = 1..T$. When these actions are ordered in a systematic way, this leads to a level of standard $s_{i,t}$ .When one action contradicts another one, marginal impacts of good action is cancelled out by bad actions. Consider action and signal profiles for all N players:

$$a_{i,t}\left(\theta_{i,t}\right) = \begin{cases} a_{1,t} & a_{i,t+1} & . & . & a_{i,T} \\ . & . & . & . & . \\ a_{n,t} & a_{n,t+1} & . & . & a_{n,T} \end{cases}$$

A rational player interprets signals correctly and chooses actions that support each other. This brings that player up in the progress ladder. Wrong interpretation of a signal results in status quo or even a gradual decline in the standard of that player. Success in the game thus relates very much on ability and dexterity in providing right signals and accurate interpretation of signals coming from other players. Interpreting those signals correctly and translating them into actions more accurately brings success; sending wrong signals or interpreting them incorrectly is a recipe of failure. Status of player *i*, $s_{i,t}$, is thus a stochastic process that depends on ability of signal extraction. Such ability depends on intuition and information set Ω_t. Popular media and public institutions and policies (such as the UN in Nepal) can contribute significantly in gathering and analysing this information which can influence productivity of players, communities and the economy and nation as a whole. A community is a coalition of a set of individuals, $I_i = \{i/i \in N\}$, a country is the set of communities, $C_i = \{C_i \in I_i / I_i \in I\}$ and global economy consists of set of these countries $W = \{w/C_i \in C\}$. In general the proper use of signalling improves the natural intelligence of these agents which results in good decisions, better actions and peace and prosperity at home and abroad. Much can be learned from the cultural values in forming right signals required for the peace and prosperity.

VI. **Repeated Games**

Very few games are plaid only once, certainly not the political economy game of conflict and growth as discussed in this paper. Economic agents, political parties, live for a long time and play games repeatedly. Economists have applied Cournot-Nash bargaining game of oligopoly to explain the consequences of cooperative and non-cooperative games on the division of gains from bargaining. It can quantitatively be illustrated using a Nash bargaining oligopoly model.

Consider a market demand for a product is $P = 130 - (q_1 + q_2)$ and cost of production for each of two firms is $C_i = 10q_i$. If the game is played infinite number of times two firms form a cartel and monopolise the market. Each will supply only 30, set market price to monopoly level at £70 and divide total profit £3600 equally; each getting £1800. This is shown by (1800, 1800) point in Figure 2. It pays to cooperate in the long run; it is sub-game perfect equilibrium. $\Pi = (130 - Q)Q - 10Q$;

$$\frac{\partial \Pi}{\partial Q} = 130 - 2Q - 10 = 0;\ Q = 60;\ P = 130 - Q = 130 - 60 = 70;\ C = 10Q = 600$$

$$\Pi = PQ - C = 70 \times 60 - 10 \times 60 = 4200 - 600 = 3600$$

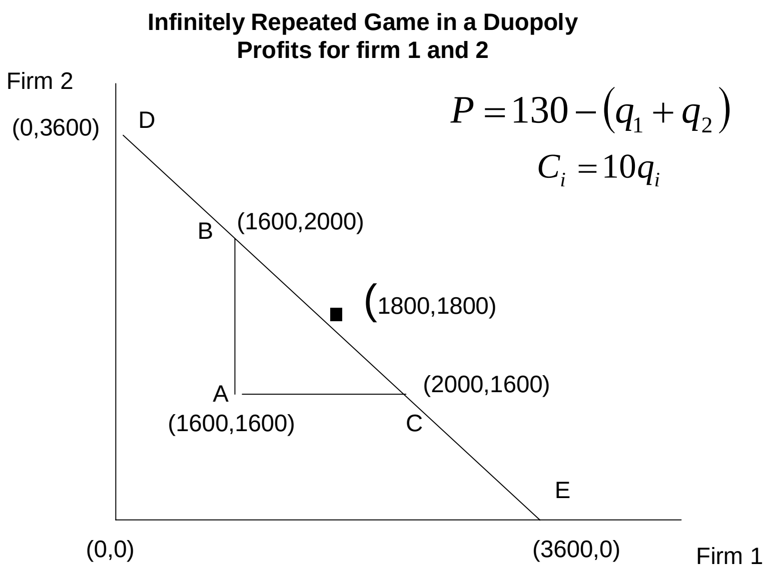

Figure 2

Cartel solution is not stable as each firm in it has incentive to cheat another and overproduce, supply more and get more profit thinking that other firms will still produce only 30 sticking to the cartel agreement. If it does the firm which cheats that another one gets 2000 but another complying and honest one gets only 1600.

However, the trick of the cheater does not last long, it will be found out by another firm which will react to this. The game will turn into a non-cooperative Cournot Nash equilibrium - each firm producing 40 units, market price of 50 and each getting profit equal to £1600. $\Pi_1 = [130 - (q_1 + q_2)] - 10q_1$ and $\Pi_2 = [130 - (q_1 + q_2)] - 10q_2$. With profit maximisation two reaction functions $2q_1 + q_2 = 120$ and $q_1 + 2q_2 = 120$, the each firm produces 40, total supply is 80, each makes profit £1600 and the market price is 50.

Now suppose firm 1 plays Cournot game but firm 2 still plays cartel and supply just 30. Then from the firm 1' reaction function $2q_1 + q_2 = 120$ and $q_1 = 60 - 15 = 45$. If firm 1 supplies 45, market price will be $P = 130 - (q_1 + q_2) = 130 - 75 = 55$; This makes profit margin of firm 1 to be 45 and its profit $\Pi_1 = 55 \times 45 - 10 \times 45 = 2025$. Firm 2 will find out that firm 1 has cheated. This will also produce according to its reaction curve. Thus the Nash equilibrium will result with each firm producing 40 and earning 1600 profit for the rest of the periods.

Table 1: Oligopoly and Political Economy

	Price	Total output	Total profit	Output of 1	Output of 2	Profit of 1	Profit of 2
Cartel	70	60	3600	30	30	1800	1800
Cournot	50	80	3200	40	40	1600	1600
Cheating	55	85	36025	45	40	2025	1600

Whether the firm 1 gains or loses by deviation from the agreement - this partly depends on the horizon and the subjective discount factor or degree of patience in the game of that player. This requires evaluation of the present value of the game from infinite series of profits on cheating and non-cheating strategies:

$\Pi_1 = (1-\delta)[2025 + 1600\delta + 1600\delta^2 + ... + ...]$ by adding and subtracting 1600 and applying the formula for infinite series

$$\Pi_1 = (1-\delta)[2025 - 1600 + 1600 + 1600\delta + 1600\delta^2 + ... + ...] = (1-\delta)\left[425 + \frac{1600}{1-\delta}\right]$$

$$\Pi_1 = 425(1-\delta)+1600 = 425-425\delta+1600 = 2025-425\delta$$

By comparing profits with and without cheating

$2025-425\delta < 1800$ or $425\delta > 2025-1800$; $\delta > \frac{225}{425}$; $\delta > \frac{9}{17}$. Whether the firm 1 will stick to agreement or not depends on whether its discount factor if greater than $\delta > \frac{9}{17}$. An impatient player with the discount factor $\delta < \frac{9}{17}$ finds it beneficial to stick to the agreement. This little example from the oligopoly game is enough to show how the cooperation is always beneficial than non-cooperation in the Nepalese context.

VII. Principal Agent Game

Players often do not have enough information about other players in a game. They have to guess intention of other players looking at their choices. People are principals of a political game, they want better standard of living, peace and prosperity in a country but they do not have enough information about the true intention of the members of political parties who act as their agents and should in principle be responsible for their principals - the common people who elect political parties frequently in the parliament. Once elected party with majority forms the government and tries to fulfil its collective interest. Political contracts are as similar as wage contracts in a labour market that are designed to match efforts put by a worker to its productivity in the labour maker. Political parties know their type but the people do not. The principals know the distribution of quality of various political parties $F(s)$, where s denotes either good or bad signal. For simplicity one can assign probability of 0.5 for observing good signals and of 0.5 for bad signals.

People offer parties a power contract, $W(q)$. A party can accept or reject this contract based on self-selection and participation constraints. Basically parties evaluate utility from the power and disutility from effort required to achieve it. They decide the amount of effort to put in. For instance, public services from good parties is related to their efforts as $q(e, good) = 3e$ and from bad party as $q(e, bad) = e$. Both people and parties are risk neutral. If parties reject the contract there is no work both parties and principal get zero payoff. Otherwise parties get pay-off of $\pi_{agent} = U(e, w, s) = w - e^3$ and people get pay-off of $\pi_{principal} = V(q - w) = q - w$. Agents, political parties, maximise their objective functions in good and bad states to determine the level of optimal efforts.

$\underset{e_g}{Max} \quad 3e_g - e_g^2$ in good state and $\underset{e_b}{Max} \quad e_b - e_b^2$ in the bad state. It is optimal for bad party to make less effort than for a good party. The first part is the gain or payoff of putting effort *e* and the second part is the cost of making this effort. These benefits and costs need to be balanced in the optimal position and are given by the first order conditions $3 - 2e_g = 0$ or $e_g = 1.5$ or $1 - 2e_b = 0$; $e_g = 0.5$.

The principals do not know what levels of efforts are appropriate for good and bad parties. They ideally like to maximise the expected gain from running the public offices which has equal chance of electing good or bad parties.

$$\underset{q_g, q_b, w_g, w_b}{Max} \quad \left[0.5(q_g - w_g) + 0.5(q_b - w_b)\right]$$

The optimal solution is to design two separate contracts, one that is predominantly appropriate for a good party (q_g, w_g) and another mainly appropriate for a bad party (q_b, w_b). Relative rewards and cost of efforts features in self-selection criteria in good and bad states $q(e, good) = 3e$ or $e = \dfrac{q_g}{3}$ in good state and $e = q_b$ in the bad state.

Contract in the good state must satisfy self selection constraint as

$$\pi_{agent}\left(q_g, w_g / good\right) = w_g - \left(\frac{q_g}{3}\right)^2 \geq \pi_{agent}\left(q_b, w_b / good\right) = w_b - \left(\frac{q_b}{3}\right)^2$$

Contract in the bad state must satisfy self selection constraint as

$$\pi_{agent}\left(q_b, w_b / bad\right) = w_b - \left(q_b\right)^2 \geq \pi_{agent}\left(q_g, w_g / bad\right) = w_g - \left(q_g\right)^2$$

The participation constraints are similarly stated as

$$\pi_{agent}\left(q_g, w_g / good\right) = w_g - \left(\frac{q_g}{3}\right)^2 \geq 0$$

$$\pi_{agent}\left(q_b, w_b / bad\right) = w_b - \left(q_b\right)^2 \geq 0$$

Participation constraint is binding for the bad state. Therefore

$$w_b = \left(q_b\right)^2$$

Self selection constrain is binding for the good state.

$$w_g = \left(\frac{q_g}{3}\right)^2 + w_b - \left(\frac{q_b}{3}\right)^2 = \left(\frac{q_g}{3}\right)^2 + \left(q_b\right)^2 - \left(\frac{q_b}{3}\right)^2$$

Putting these wage rates in the principal's objective function:

$$\underset{q_g, q_b, w_g, w_b}{Max} \quad \left[0.5\left(q_g - w_g\right) + 0.5\left(q_b - w_b\right)\right]$$

Now maximising this

function $\underset{q_g, q_b}{Max} \quad \left[0.5\left(q_g - \left(\frac{q_g}{3}\right)^2 - \left(q_b\right)^2 + \left(\frac{q_b}{3}\right)^2\right) + 0.5\left(q_b - \left(q_b\right)^2\right)\right]$ with respect to

q_g and q_b we get

$0.5\left(1 - \frac{2q_g}{9}\right) = 0$ or $q_g = 4.5$

$$0.5\left(-2q_b+\frac{2q_b}{9}\right)+0.5(1-2q_b)=0 \quad \text{or} \quad \left(-2q_b+\frac{2q_b}{9}\right)+(1-2q_b)=0$$

$$\left(-4q_b+\frac{2q_b}{9}+1\right)=0 \;;\; 34q_b=9 \quad \text{or} \quad q_b=0.265$$

Now rewards can be found from the constraints

$$w_b=(q_b)^2=(0.265)^2=0.07$$

$$w_g=\left(\frac{q_g}{3}\right)^2+(q_b)^2-\left(\frac{q_b}{3}\right)^2=\left(\frac{4.5}{3}\right)^2+(0.265)^2-\left(\frac{0.265}{3}\right)^2=2.32$$

Thus in the presence of information asymmetry , the efforts by the good party is at the first best level as the bad effort by him is not as attractive as the good effort, it is not profitable for a good party to pretend to be bad party. Good party is not attracted by the contract for the bad party. Similarly it is costly for the bad party to act as a good party - it is optimal for it to select the contract appropriate for a bad party, chance of being out of the office.

VIII. Dynamic Poverty Game

Elements of strategic modelling mentioned in above sections can be put together into a dynamic poverty alleviation game in the Nepalese context. General equilibrium modelling and strategic modelling could be combined together to set this game appropriate for the structural realities of Nepalese economy as discussed in models of conflict and growth in (Bhattarai (2007a)).

Each player in the model (poor, rich and government) has a set of strategies available to it (*s*, *l*, and *k* respectively). The outcome of the game is the strate contingent income for poor and rich, $y_t^P(s,l,k)$ and $y_t^R(s,l,k)$. The probability of being in particular state like this is given by $\pi_t^P(s,l,k)$ and $\pi_t^R(s,l,k)$ respectively. The state-space of the game rises exponentially with the length of time period t. The objective of these two players is to maximize the expected utility and the government can influence this outcome by means of taxes and transfers. More specifically, following conditions should hold in this poverty alleviation game.

Condition 1: The state contingent money metric expected utility of poor is less than that of rich, which can be expressed as:

$$\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^p(s,l,k)\cdot\delta_t^p u\left(y_t^p(s,l,k)\right)<\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^R(s,l,k)\cdot\delta_t^R u\left(y_t^R(s,l,k)\right)$$

where $\pi_t^p(s,l,k)$ gives the probability of choosing one of strategies by poor given that the rich and the government has chosen l and k strategies. Utility is derived from income as given by $u\left(y_t^p(s,l,k)\right)$ and $\delta_t^p=\frac{1}{\left(1+r_t^P\right)}$ is the discount factors for poor and $\delta_t^R=\frac{1}{\left(1+r_t^R\right)}$ the discount factor for rich.

Condition 2: Transfer raises money metric expected utility of poor and reduces the utility of rich.

$$\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^p(s,l,k)\cdot\delta_t^p u\left(y_t^p(s,l,k)+T_t^p(s,l,k)\right)<\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^R(s,l,k)\cdot\delta_t^R u\left(y_t^R(s,l,k)-T_t^p(s,l,k)\right)$$

Condition 3: Incentive compatibility requires that

$$\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^p(s,l,k)\cdot\delta_t^p u\left(y_t^p(s,l,k)+T_t^p(s,l,k)\right)>\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^p(s,l,k)\cdot\delta_t^p u\left(y_t^p(s,l,k)\right)$$

and

$$\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^R(s,l,k)\cdot\delta_t^R u\left(y_t^R(s,l,k)-T_t^p(s,l,k)\right)<\sum_{s=1}^{s}\sum_{l=1}^{l}\sum_{k=1}^{k}\sum_{t}^{T}\pi_t^R(s,l,k)\cdot\delta_t^R u\left(y_t^R(s,l,k)\right)$$

Condition 4: Growth requires that income of both poor and rich are rising over time:

$$T_t^p(s,l,k)<T_{t+1}^p(s,l,k)<T_{t+2}^p(s,l,k)<..<T_{t+T}^p(s,l,k)$$

$$Y_t^p(s,l,k)<Y_{t+1}^p(s,l,k)<Y_{t+2}^p(s,l,k)<..<Y_{t+T}^p(s,l,k)$$

$$Y_t^R(s,l,k) < Y_{t+1}^R(s,l,k) < Y_{t+2}^R(s,l,k) < .. < Y_{t+T}^R(s,l,k)$$

Condition 5: Termination of poverty requires that every poor individual has at least the level of income equal to the poverty line determined by the society. When the poverty line is defined one half of the average income this can be stated as:

$$Y_{t+T}^p(s,l,k) \geq \frac{1}{2}\sum_{p=1}^{p} Y_{t+T}^p(s,l,k)$$

Above five conditions comprehensively incorporate all possible scenarios in the Poverty Game mentioned above. Conditions 2-5 present optimistic scenarios for a chosen horizon T.

IX. Conclusion

How economic agents with conflicting interests can analyse gains from bargaining, coalition and repeated games and their pivotal positions in the game with minimax or mixed strategies and how signalling affects the outcome is illustrated using numerical examples. Dynamic Poverty game is proposed for alleviation of poverty that requires cooperation tax payers, transfer recipients and the democratic government and the international community. The concepts are applied to analyse how the incorporation of growth pact in the constitution can set a mechanism for cooperative solution required for peaceful and prosperous Nepal.

X. **References**

1 Acemoglu Daren (2001) A Theory of Political Transitions, the American Economic Review, 91:4:938-963
2 Bardhan Pranab (2002) Decentralization of Governance and Development, *Journal of Economic Perspective*, 16:4:185-205.
3 Basu Kaushik (1986) One Kind of Power, *Oxford Economic Papers*, 38:2:259-282.
4 Besley T and M Ghatak (2001) Government versus Private Ownership of Public Goods, *Quarterly Journal of Economics*, 116:4:1343-1372.
5 Binmore K (1999) Why Experiment in Economics? *The Economic Journal* Vol. 109, No. 453, Features Feb. pp. F16-F24
6 Bhattarai K. (2007a) Adding strategic and general equilibrium model in poverty measurement, mimeo, University of Hull, Business School.
7 Bhattarai K. (2007b) Static and Dynamic General Equilibrium Model of the UK Economy, Serials Publication, New Delhi.

8 Bhattarai K. (2007c) Models of Economic and Political Growth in Nepal, Serials Publication, New Delhi.
9 Bhattarai K. (2006) Consequences of April 2006 Revolutionary Changes in Nepal: Continuation Nepalese Dilemma, Indian *Journal of Economics and Business*, 5:2:315-321.
10 Biswas T and J McHardy (2007) Asking price and price discounts: the strategy of selling an asset under price uncertainty, *Theory and Decision*, DOI 10.1007/S11238-007-9031-9
11 Caminal R. (1990) A Dynamic Duopoly Model with Asymmetric Information *Journal of Industrial Economics* Vol. 38, No. 3 (Mar., 1990), pp. 315-333
12 Cho I.K. and D.M. Kreps (1987) Signalling games and stable equilibria, the *Quarterly Journal of Economics*, May179-221.
13 Coase R. H. (1937) The Nature of the Firm, *Economica*, 386-405, November.
14 Debreu, G. (1954) *The Theory of Value*, Yale University Press, New Haven.
15 Dixit Avinash (1987) Strategic Behaviour in Contests, American Economic Review, Dec., 77:5:891-898.
16 Fundenberg D and J.Tirole (1995) Game Theory, MIT Press.
17 Gardener R (2003) Games of Business and Economics, Wiley, Second Edition.
18 Ghosal S and M. Morelli (2004) Retrading in market games, Journal of Economic Theory, 115:151-181.
19 Harsanyi J.C. (1967) Games with incomplete information played by Baysian Players, *Management Science*, 14:3:159-182.
20 Hurwicz L (1973) The design of mechanism for resource allocation, American Economic Review, 63:2:1-30.
21 Jin J. Y. (1994) Information Sharing through Sales Report *Journal of Industrial Economics* Vol. 42, No. 3 (Sep., 1994), pp. 323-333
22 Lockwood B. A. Philippopoulos and A. Snell (1996) Fiscal Policy, Public Debt Stabilisation and Politics: Theory and UK Evidence *Economic Journal* Vol. 106, No. 437 (Jul., 1996), pp. 894-911
23 Machina M. (1987) Choice under uncertainty: problems solved and unsolved, *Journal of Economic Perspective*, 1:1:121-154.
24 Mailath G. J. (1989),Simultaneous Signaling in an Oligopoly Model *Quarterly Journal of Economics* Vol. 104, No. 2 (May, 1989), pp. 417-427
25 Maskin E and J Tirole (1989) The principal-agent relationship with an informed principle, *Econometrica,*
26 McCormick B. (1990) A Theory of Signalling During Job Search, Employment Efficiency, and "Stigmatised" Jobs *Review of Economic Studies* Vol. 57, No. 2 (Apr., 1990), pp. 299-313
27 ***Mookherjee D and D Ray (2001) Readings in the theory of economic development, Blackwell.***
28 Moore J. (1988) Contracting between two parties with private information, *Review of Economic Studies*, 55: 49-70.
29 James A. Mirrlees (1997) Information and Incentives: The Economics of Carrots and Sticks *The Economic Journal* , Vol. 107, No. 444 Sep., pp. 1311-1329
30 Mailath G. J. and L. Samuelson (2006) Repeated Games and Reputations: long run relationship, Oxford.
31 Milgrom P., J. Roberts (1986) Price and Advertising Signals of Product Quality *Journal of Political Economy* Vol. 94, No. 4 (Aug., 1986), pp. 796-821
32 Myerson R (1986) Multistage game with communication, *Econometrica*, 54:323-358.
33 Nash J. (1953) Two person cooperative games, *Econometrica*, 21:1:128-140.
34 Rasmusen E (2007) Games and Information, Blackwell, ISBN 1-140513666-9.
35 Rodrik D. (1989) Promises, Promises: Credible Policy Reform via Signalling *Economic Journal* Vol. 99, No. 397 (Sep., 1989), pp. 756-772
36 Rogerson W.P.(1988) Price Advertising and the Deterioration of Product Quality *Review of Economic Studies* Vol. 55, No. 2 (Apr., 1988), pp. 215-229

37 Riley J.P. (1979) Noncooperative Equilibrium and Market Signalling *American Economic Review* Vol. 69, No. 2, Papers and Proceedings of the Ninety-First Annual Meeting of the American Economic Association (May, 1979), pp. 303-307
38 Rubinstein A (1982) Perfect equilibrium in a bargaining model, *Econometrica,* 50:1:97-109.
39 Ryan M.J. (1998) Multiple criteria and framing of decisions, Journal of Information and Optimisation Sciences, 19:1:25-42.
40 Sobel J. (1985) A Theory of Credibility *Review of Economic Studies* Vol. 52, No. 4 (Oct., 1985), pp. 557-573
41 Sutton J. (1986) Non-Cooperative Bargaining Theory: An Introduction *The Review of Economic Studies*, Vol. 53, No. 5., pp. 709-724
42 Spence M. (1977) Consumer Misperceptions, Product Failure and Producer Liability *Review of Economic Studies* Vol. 44, No. 3 (Oct., 1977), pp. 561-572