

# Accounting Communication in Reducing Information Asymmetry in Primary Market: A Conceptual Modeling

Avik Sinha and Atul Mehta

*Fellow Programme in Management (Economics), Indian Institute of Management Indore, Indore - 453 556, India*

E-mail: fl1aviks@iimidr.ac.in, fl1atulm@iimidr.ac.in

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**Abstract** – Information asymmetry has been a critical issue in IPO market. Non-co-linearity of interests among market participants brings forth this problem. As a decision making tool, firms should leverage out the benefits of management information to encounter this problem, as it has a direct impact on the financial performance of IPOs. Since reduction of information asymmetry comes with a cost, firms should make an optimized way to balance the costs and benefits. Contracting parties consider this cost and enter into a game, driven by information asymmetry. Equilibrium outcomes of these games can be achieved in non-cooperative and cooperative ways.

This paper is a literature review on role of information in IPO Pricing, information asymmetry challenges in IPO Pricing, and game theoretic solution to those problems. Main body of the paper has been divided into two sections accordingly, followed by concluding remarks. In every section, several aspects of the aforementioned respective sections have been discussed, solely on the basis of existing literature.

**Keywords:** Primary Market, IPO, Information asymmetry, Uncertainty, Game theory, Principal, Agent, Negotiation

## I. INTRODUCTION

The purpose of this paper is to discuss about information asymmetry problems prevailing in the primary market arena and a game-theoretic approach to encounter those problems. Banking on the existing literature, an attempt has been made to identify abiding practices and necessity of information in management accounting domain, problems attached with information asymmetry and probable solutions by virtue of game theory. In accordance with it, this paper has been subdivided into three sections: to identify historical role of information in primary market practices and identification of problems regarding to information asymmetry in the domain of IPO pricing, to point out solutions in a game theoretical way and concluding remarks. Epistemologically the study followed in this paper is deductive. Research methodology followed in this paper is qualitative in nature and exclusively based on the review of existing literature on the concerned topic.

While talking about the pricing of an IPO, there always lies a question about the quantity and quality of information held by investors and underwriters (Benveniste & Spindt, 1989). It may also possible that underwriters attempt to germinate superfluous demand by underpricing (Welch, 1989). Moreover due to absence of prior price record, it becomes difficult to judge the predictability of offer price behavior. Due to unawareness of firm performance, credit rating is sometimes used as a proxy measure (An & Chan, 2008). In order to mitigate the information asymmetry to some extent, capability of credit rating to look beyond obvious information is considered by investors (Ederington & Yawitz, 1987). But in anyways, underwriters always try to squeeze out the information from the group of informed investors by virtue of book-building process (Benveniste & Spindt, 1989). To get away with the winner's curse situation, firms employ underpricing. In this way underwriters try to pay off the losses incurred by the group of investors who are less informed. This underpricing sometimes also takes place due to the principal-agent conflict between underwriter and issuer (Loughran & Ritter, 2004). In order to get away with the lemon's problem, long run stock performance is thus compromised (Akerlof, 1970). Driven by presented thoughts, non-co-linearity of interests among transacting parties emerges due to asymmetry of information. This phenomenon gradually leads to the principal and agent conflict (Eisenhardt, 1989). This conflict can easily be defined as optimal degree of risk sharing, given the scarcity of resources (Grossman & Hart, 1983). Loughran & Ritter (2004) focuses on three areas where these issues can be contributed. Those areas are as under:

- Shifting Risk Opus,
- Relocation of Enticements, and
- Shifting Issuer Purpose.
- Spinning
- Analyst Yearn

In the era of globalization, contextual aspects are gaining mounting importance in decision making scenario (O'Dwyer, 2005). Relevant piece of information from informed investors is highly correlated with successful stock pricing decision making (Ijiri, Jaedicke & Knight, 1966). Approbation of homogeneous management ideas and systematic implementations are enabled by standardization and congregation of the management verdicts, processes, and existing alternatives (Liu & Pan, 2007). Yet disparities remain in utilization, absorption, and analysis of the information obtainable with a view to decision making (Stigler, 1961). As time is moving ahead, global market is turning out to be further competitive day-by-day. In such a competitive scenario, firsthand apposite information endows firm with a competitive edge over competitors (Blowfield, 2005). This in turn increases the risk associated with the transaction, as uninformed or less informed party will be unable to authenticate the piece of information provided by informed party (Watts, 2003a, 2003b).

To encounter the problems attached to information asymmetry in IPO pricing, accounting communication approach can be used (Chymis, James, Konduru, Pierce & Larson, 2007). As principal and agent are bound by strategic interdependence, communicative strategies will try to predict behavior of one party based on the best response of another, given motivation and anticipated actions of both (Wilks & Zimelman, 2004). This generally pertains to the misallocation of scarce information resources leading to less optimal yields and discrepancies in payoff (Kennelly & Fantino, 2007). To address this issue, accounting communication can play a major role. Talking about popular communication strategies with a view to addressing aforementioned issue, examples of two strategies can be stated. First one is called Ultimatum Strategy, where resources are distributed on non-negotiation basis (Güth, Schmittberger & Schwarze, 1982). Second one is called Dictatorship Strategy, where the allocation is based on proposed amount by proposing party, while another one stays dormant (Forsythe, Horowitz, Savin, & Sefton, 1994). In the second case, it is mandatory to let participating parties choose among possible fixed alternatives (Bazerman, Loewenstein & White, 1992). In both cases, social welfare can be maximized due to lowering of differential payoffs and reciprocal fairness. This is the way by which strategies in accounting communication platform can bring forth social welfare maximization in IPO pricing scenario.

## II. ROLE OF INFORMATION ASYMMETRY IN PRIMARY MARKET

It has been a long researched area. In accordance with researchers in this field, first day closing price of any IPO represents only two types of reparation; either uncertainty abode by uninformed investors (Beatty & Ritter, 1986), or relevant market movement information provided by well-informed investors (Benveniste & Spindt, 1989). Beard, Neuhauser, Mantecon, & Ryan (2002) discovered that first-day returns pay off investors for putting up with uncertainty and incentivize well-informed investors for endowing underwriters with relevant market information. But information search comes with a cost (Booth & Chua, 1996). This creates a divide in the market in terms of two groups: well-informed and uninformed group of investors. Due to this prevalent gap in terms of acquired information, uninformed investors try to subscribe for the entire lot, with a view to hedging their positions (Boot & Thakor, 2001). As management outlays the issue to capitalize on anticipated progressions, in front of a band of diversely conversant investors, a subordinate value persuades additional uninformed investors to put forward their bids (Bozzolan & Ipino, 2007). This creates a nuisance in the market by crowding out the "good" investors (Akerlof, 1970).

Largely prevailing underpricing phenomenon depends on anticipated information asymmetry during the post-offer scenario, when the stock is being started to be traded (Beatty & Ritter, 1986). According to Efficient Market Hypothesis, high level of underpricing is the corollary of high inherent uncertainty (Miller & Reilly, 1987). Many times firms try to reduce this level of uncertainty by several ways, like:

- Possession preservation by insiders (Datar, Feltham & Hughes, 1991),
- Conjugation with eminent auditors (Ritter & Welch, 2002), and
- Collaborating with investment banker with high status as underwriters (Beatty & Ritter, 1986).

However, this uncertainty also comes with certain cost. To get away with this kind of transaction cost, information in the form disclosure is enforced. This cost mitigation process is manifold in nature:

- Forecasting of decision-making payoff (Jog & McConomy, 2003),
- Forecasting of revenue, expenses and cash flow (Lee, Taylor & Walter, 1999),
- Information about competitors (Leone, Rock & Willenborg, 2007), and
- Information about risk factors (Clarkson, 2009).

The problem of information asymmetry is not only amongst the group of investors. It is prevalent as well between the investors and the owners of the firm. It is quite obvious that the investors will be less informed in comparison with them (Ross, 1977). This can be attributed to several factors:

- Organizational and industrial context (Cohen & Dean, 2005),
- Screening and falsification of information before investors (Downes & Heinkel, 1982),
- Institutional voids regarding disclosure (Singh & Van der Zahn, 2007), and
- Machiavellian behavior of firm by leveraging the information asymmetry (Trester, 1998).

Here comes the role of the well-informed investors. Incentivization for the information falsification by firms is filtered by them (Spence, 1976). They become selectively receptive to the signals made available by firms (Spence, 1976; Downes & Heinkel, 1982). According to Podolny (1994), trading of prospects can be kept aside while trading qualities of commodities. It is specific to IPO market, as the quality of IPO is hard to determine by having a glance at the offer, as a commodity. Hence investors will always try to derive the economic value of signals put forward by the firm, and they will thrust aside the signals being perceived as less beneficial to them (Spence, 1976). Hence the firms will have no incentive offering low quality IPO products, as the cost of signaling is inversely proportionate with the quality of the product (Morris, 1987). Investors consider amount of possession by firm, amount of investment and status of underwriter as good signals and they try to evaluate the IPO offer on the basis these factors.

Keeping all these aforesaid reasons apart, one of the least focused factor in the existing body of knowledge is the legitimacy of top management. As per Suchman (1995), it is “a generalized perception or assumption that the actions of

an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions”. It can also be defined as level of acceptance by the setting in which it is working (Hannan & Freeman, 1989). This legitimacy is being provided by the top management team of any organization. The legitimacy of this team is translated into the behavior and image of the organization. It also helps the organization to exert a pull on wherewithal (Parsons, 1960; Zimmerman & Zeitz, 2002). The investors, who are unable to recognize the true value of firm, generally try to use this legitimacy factor as a strong signal of organizational performance and quality of offer (Podolny, 1994). The administrative cachet (D’Aveni, 1990), premeditated coalition associates, and trade associates (Podolny, 1994) also add to the legitimacy factor. Cohen & Dean (2005) state that, historically legitimacy has been a good indicator for investors, as they perceive top management is being refrained from formulating unproductive shared policies. The reasons they have stated can be as per the following:

- Due to very low opportunity cost of alliance,
- Due to very apprehension of losing the well-built status by entering into an unproductive alliance, and
- Due to rational and opportunistic behavior of managers, they try to gain out of their own investments.

Hence the legitimacy of firm, posed by the top management team works as a signal of quality and IPO performance, can largely work towards reducing the information asymmetry prevailing in the primary market. It will also help the uninformed investors enabling them to distinguish and identify the opportunity. Looking from another way, the firms and underwriters indulge themselves in producing voluntary disclosures. It is driven by the notion that IPO underpricing is predisposed to great degree of information asymmetry (Verrecchia, 1983). This is characterized by the holding back of proprietary information by firm due to organizational obligations. But on the contrary, first day closing price of the stock largely depends on level information held back by well-informed investors. Hence it is tried to signal the quality of offer via the disclosure route (Schrand & Verrecchia, 2005). There are a lot of factors which are conveyed through a proper disclosure with respect to combating information asymmetry:

- Discussion of risk factors (Clarkson, 2009),
- Forecast information, specifically for firms with highly volatile returns (Jog & McConomy, 2003),

- Futuristic disclosure with price expectancy (Schleicher & Walker, 1999),
- Providence of rich information (Leone, Rock & Willenborg, 2007), and
- Frequency of disclosure (Schrand & Verrecchia, 2004).

Therefore the disclosures are targeted at reducing prevailing information asymmetry. The motive is also to let the investors get rid of adverse selection. There is always a cost component attached with each of the adverse selections made by investors. And this cost component is bi-folded, as this affects the firm as well. The disclosures by firm are prepared in such a way that those can target higher pay-off certainty (Glosten & Harris, 1988). This in turn also helps them to manage their bid-ask spread (Skinner, 1991). On this basis, Graves, Callahan & Chipalkatti, (2002) have come up with their findings:

- Enhancement in transaction cost regarding adverse selection is associated with less amount of prospect certainty, and
- Less amount of bid-ask spread is associated with higher amount of prospect certainty.

In spite of all these factors, first five day (keeping first day return also in mind) returns of any IPO offer also pose a significant question in mind about the aforesaid factors. If looked across various diverse industrial sectors, this phenomenon is visible in almost all sectors. (Schultz & Zaman, 2001; Loughran & Ritter, 2012). Schwartz & Moon (2000) drew near the phenomenon by incorporating a “Real Options” methodology. In accordance with the findings of this model, translation of the information anticipations transformation into market price resulted in high volatility of price, which actually fell in the similar lines of efficient market hypothesis. In order to form the rationality in price behavior in market, incorporation of management accounting information into IPO offer was also suggested by Kim and Ritter (1999). As a whole, it was found that amendments in present price, pre-IPO return, and improbability (in terms of post-IPO price deviation) are the major reasons behind underpricing an IPO (Beard, *et al.* 2002).

So it is quite evident that given any solution, the prevailing amount of information asymmetry in IPO market can never be diminished in a deterministic way. Probabilistic nature of available and relevant information can be incorporated in the study of expected behavior analysis investors and issuers. The model can be designed keeping the principal-

agent conflict scenario in mind, given the transaction cost of information acquisition is positive, and market is efficient enough to incorporate the information into translated price behavior. With a view to formulating this model and to test it conceptually, game-theoretic approach can be beneficial in nature, as this part was largely ignored in the study of IPO. The literature mainly focuses on the deterministic nature of information and the translation of the same into market price. But they somewhat ignored the probabilistic nature of the information, which can determine the expected rational behavior of market actors. The behavioral aspects of market actors depend on the type and level of accounting disclosures the firms provide to them. There comes the importance of accounting communication in this scenario.

### III. ROLE OF ACCOUNTING COMMUNICATION

According to Hunton (2002), accounting is identification, measurement and communication of economic information to reinforce decisions. If we abide by this definition of accounting, then we can see importance of accounting communication in the field of accounting. If information is identified and measured by management, but is not communicated to the stakeholders properly, the decision stands void, as it leaves the least or a negative impact on the market as a whole. It affects the dynamics of market to a great extent (Saxton, 2012). Hence from the decision-making viewpoint, accounting communication plays a major role in shaping the investment decisions made by firms and the investors. Role of accounting communication plays a significant role in determining the behavior of the market participants in a high asymmetric information background. If we look at the modern business scenario, satisfying the needs of peripheral, as well as in-house stakeholders is a major concern. Accounting is needed to be designed in such a way that the information provided by this is behaviorally rational and administratively manageable. In the older days, before the advent of technology, it was a serious problem for the firms to meet the disclosure requirements. But as time has moved forward, developments in technology have made it easier for the firms to go for regular and extensive financial disclosures. Developments in the field of accounting have also complemented this growth. In the post world war scenario, three major developments in the field of accounting have made it possible to go for more extensive financial disclosures. These developments are relative contribution costing, target costing, and activity-based costing (Schweltzer, 2000).

In this background, several questions have been asked by researchers across the world about the communication parameters. These questions are as per the following:

- What kind of information should be communicated (Gordon & Miller, 1976)?
- Who should collect the information (Lieberman & Whinston, 1975)?
- How the information should be collected (Amir, 1993)?
- How the information should be communicated (Bushman & Smith, 2001)?
- When the information should be communicated (Zeithaml, Berry & Parasuraman, 1988)?
- To whom the information should be communicated (Gowthorpe & Amat, 1999)?

While answering these questions, several aspects come into picture. Till the first half of the nineteenth century, most of the reports used to be oral or handwritten. But since second half of the nineteenth century, technological advancements enabled accounting communication to be more prudent. The advancements were more visible in nature after the Second World War. Advanced communication and data analysis systems in places changed the face of accounting disclosure of firms across the world. This revolutionized organization and dissemination of accounting information in firms.

Whenever discussion about accounting communication comes into picture, it is always relevant to discuss about the stakeholders of firm, who will affect or will be affected by process of communication.

### **3.1. Management**

It is important for management to interpret the accounting data at its best, to bring forth meaningful insights out of the information and formulate significant decisions (Wood, 2000). In order to make the communication an effective tool, accounting information must be well represented; else they will be depicted as mere numbers with no importance at all. Usage of firm-specific templates enables management to communicate the financial and accounting information across the firm (Latham, 2009). It provides the standardization of communication (Bayou, 1993). It also provides familiarity and ease to the management while making any firm-wide decision.

### **3.2. Investors**

Accounting communication gained its importance due to the presence of investors for any firm. For their benefit, communication is made by firms in the form of standardized reports. Standardization of those reports is maintained through the accounting standards and principles (Ashbaugh, 2001). This gives them an idea about the business operation of the firms and their performance. On the basis of these reports, they change and optimize their investment decisions (Bourgeois, 1981). Depending on the reporting quality and frequency, they can request for focused reports from firms (Kandybin & Kihn, 2004).

### **3.3. Government**

From a regulatory perspective, accounting communication with government is needed to be maintained on a regular basis. For primary market related activities, government is needed to be informed about the firm performance. May-a-times authorized regulatory bodies act as the proxy for government (Sloan, 2001). For maintaining stability and equilibrium in the primary market, government takes decisions on the basis of information provided by the firms.

### **3.4. Banks**

In order to augment the business operation of the firms, banks need the real picture of the financial and operational position of firms. In case of primary market operations, banks take more stringent steps towards more availability of reliable information, as many-a-times they provide funds for the IPO market activities (Johnson, 1997). In order to get debt finance for the IPO activity, regular and reliable accounting communication with banks is needed.

It is also very evident in nature that the accounting communication is deliberately suppressed by the management. In order to manage earnings for a firm, a manager can indulge into disaggregation of accounting information (Sloan, 1996). Sometimes bad firms also try to pose themselves as good firms by publishing substantial amount of accounting disclosures (Sherman & Lee, 1995). This comes with a cost. Now it is the call of the firm whether to incur the cost of communication or to overlook the opportunity cost by not communicating the proper accounting information to the investors (Hughes, 1986).

Now by undertaking the cost-benefit analysis of the accounting disclosure, management is always on the edge about taking the decision on whether to communicate, or not. If the firm tries to maximize its own benefit, it should go for incurring the opportunity cost, by incorporating “Dictatorship Strategy”. But in this case, social welfare maximization objective will be foregone in totality. On the other hand, if the firm tries to maximize social benefit, it should go for forgoing the opportunity cost by taking the transaction cost, by incorporating “Ultimatum Strategy”. In this case, social welfare maximization objective will be fulfilled in totality. The cost aspects of communication have been taken into consideration in the literature predominantly (Benston, 1969). But they mostly focus on this issue from subjective perspective. Very few of them have considered the aspects of accounting communication for a strategic formulation deterministically (Francis, Khurana & Pereira, 2005). In this paper, it has been tried to formulate a comprehensive mathematical model for accounting communication in primary market by incorporating those various aspects of accounting communication already discussed in this paper. The model is deterministic in nature. On the basis of principal-agent behavior and cost considerations, this model has been designed. A decision tree has been made on the basis of the decisions to be made by the firms and the consequential decisions to be made by the stakeholders.

**IV. MODEL DEVELOPMENT**

The decision to go for incurring transaction cost or cost of lemons always lies with the firm. On the basis of the decision made by the firm, stakeholders (mainly investors) take their decisions. The decisions are highly probabilistic in nature. Stakeholder decisions include two types of costs, namely information search cost and information acquisition cost. Depending on the decisions of the firm, the probabilities attached to these costs vary (Figure 1).

In case the firm takes the decision to incur transaction cost by producing relevant information related to their IPO, information search cost of the stakeholders go down and information acquisition cost goes up, i.e.  $Q > 0.5$ . But if the firm takes the decision to incur the cost of lemons by not providing proper information and retains the information asymmetry in primary market, then the stakeholders have to incur more information search cost. In that case  $P > 0.5$ . This is also highly dependent on the price elasticity of the available information. The detailed mathematical formulation is in

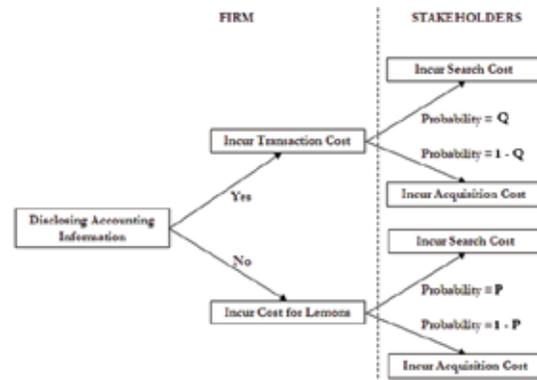


Fig. 1 Decision tree-based cost of communication model for firm and stakeholders

the appendix. Under this framework, behavioral aspects of aforesaid parties are quantitatively considered. The kind of information considered here is pre-decision in nature; hence it is critical to avail. Given the criticality of the information, transacting parties will always try to get hold of it in order to rip maximum benefit. Co-linearity of information availability to both the parties overrules the findings of Christensen (1981) and Penno (1984). Model states the availability of information to both the parties. If both of them try to hold back information, asymmetry will rise in market, though both of them will maximize their expected utilities. In presence of any regulatory body, this asymmetry reduces to a great extent.

But effect of dictatorship resides on the following conditions:

$$n c (n - 1) > a$$

and,

$$n c (n - 1) > b$$

Hence price elasticity of information must be less than the transaction cost per unit information, amplified by double degree of transaction cost factor. So while maximizing social welfare, transaction cost plays a major role than that of price elasticity of information. It brings forth two significant issues:

- For quantum of information, transaction cost per unit and degree of transaction cost factor have similar effects in both the cases. Treatment changes with price elasticity of information.
- For expected utility, price elasticity of information or degree of transaction cost factor has similar effects in both the cases. Treatment changes with transaction cost per unit.

These two conditions become important when firms decide to report their information on financial performance, earnings, operations etc. Banking on expense to be borne by management with a view to reporting and communicating accounting numerals to other transacting party, vis-à-vis criticality of information to be shared, and decisions are made by management whether contract of information is viable or not, as this may lead to moral hazard in market. A closer look into the model [appendix: (21) and (22)] brings forth another insight about negotiating aspects for two transacting parties. Both the equations can be rewritten in following form:

$$Q_p = R(Q_a^*)$$

$$Q_a = R(Q_p^*)$$

Here,

$R$  is best response function

$Q_p^*$  is best response for principal

$Q_a^*$  is best response for agent

These two equations represent mutual best responses. Negotiating aspects of accounting communication enables them to reach optimal level of best response. Hence it can be stated that other than going for individual maximization, rushing after social welfare maximization makes everyone better off.

In a nutshell, quantitative aspects of this model focused on three major aspects of information asymmetry in IPO pricing, which the top management and stakeholders need to consider while taking any decision:

- Assessment of fair value of information while making any communication,
- Assessment of transaction cost in communicating the information,
- Assessment of the best alternative available for other party, and
- Assessment of criticality of information by management.

## V. CONCLUSION

The accounting communication model for resolution of information asymmetry is developed so far. Though derived from a researcher's point of view, operationalization of the

same perhaps may bring more insight about coverage and appropriateness of the constructs. This model didn't converse much about the probability distribution of information availability. But value of information in terms of price elasticity of information covered in this model, has been somewhat ignored in existing literature. Extending the scope of dictator game, this conceptual model enables to assess various aspects related to information sharing in the field of IPO pricing in primary market.

There are some limitations of this model. This model is probabilistic in nature. It has taken absolute deterministic value of any information in terms of information quantum. Only linear demand equation has been considered for model development. On the other hand, future scope of research in this area also comes forward through these limitations. Probabilistic nature of information quanta along with price elasticity of information can be used. Non-linear demand functions can be used for more complex situation. Operationalization of this model can be done with data from firm reeling with this asymmetrical information problem. Other than following the continuous time optimization approach for expected utility, discrete time optimization may lead to specific situations where firms need to start or abandon communicating with the transacting party, depending on level of differential utility attained.

## APPENDIX - I

In order to formulate the model, let us consider following parameters:

- $P_p$  = Perceived benefit per unit information in terms of price by principal
- $P_a$  = Perceived benefit per unit information in terms of price by agent
- $P_1$  = Floor price per unit information for principal
- $P_2$  = Floor price per unit information for agent
- $E(U_p)$  = Expected utility of principal
- $E(U_a)$  = Expected utility of agent
- $E(U_d)$  = Expected utility of benevolent dictator
- $a$  = Price elasticity of information for principal
- $b$  = Price elasticity of information for agent
- $Q_p$  = Quantum of information held by principal
- $Q_a$  = Quantum of information held by agent
- $c$  = Unit cost per unit of information

The demand equations for principal agent are given by

$$P_p = P_1 - a Q_p \quad \dots (1)$$

and,

$$P_a = P_2 - b Q_a \quad \dots (2)$$

For any quantum of information  $Q_p$ , there is a probability  $p_i$  that the price elasticity of that quantum of information is  $a_i$  (for principal) and  $b_i$  (for agent). Hence,

$$\text{For principal: } a Q_p = \sum_i p_i a_i Q_i \quad \dots (3)$$

$$\text{For Agent: } b Q_a = \sum_i p_i b_i Q_i \quad \dots (4)$$

where,  $p_i \in [0, 1]$ ,  $Q_i \geq 0$ ,  $[a_p, b_i] \in \mathbb{R}$

Non-linear transaction cost function associated with communication of information between the parties is given by:

$$C = c Q_i^n \quad \dots (5)$$

where,  $i = p, a, n > 1$  and  $C = \{Q^*(1-P)\}^*(\text{Search Cost}) + \{(1-Q)^*P\}^*(\text{Acquisition Cost})$

From (1), (2) and (5), expected utilities for both the parties are given by:

$$E(U_p) = (P_1 - a Q_p) Q_p - c Q_p^n \quad \dots (6)$$

$$E(U_a) = (P_2 - b Q_a) Q_a - c Q_a^n \quad \dots (7)$$

Both the parties will try to maximize these utilities. With a view to proceeding forward with the optimization problem, (6) is differentiated with respect to  $Q_p$ , which yields,

$$\frac{d}{dQ_p} E(U_p) = P_1 - 2a Q_p - n c Q_p^{n-1} \quad \dots (8)$$

or,

$$\frac{\partial^2}{\partial Q_p^2} E(U_p) = -2a - n(n-1) c Q_p^{n-2} < 0 \quad \dots (9)$$

As the second order maximization condition is reached in (9), and then first order condition posed in (8) must be equal to zero. For achieving the solutions, limiting conditions of 'n' must be attained.

$$Q_p = (P_1 + n c) / \{2 a (n - 1)\} \quad \dots (10)$$

Similarly from (7) we get,

$$Q_a = (P_2 + n c) / \{2 b (n - 1)\} \quad \dots (11)$$

Hence expected utilities derived by both the parties while individual maximization objectives are concerned, are given by:

$$E(U_p) = (P_1 + n c) [(P_1 - n c) (2n - 3) - 2c] / [4a (n - 1)^2] \quad \dots (12)$$

and,

$$E(U_a) = (P_2 + n c) [(P_2 - n c) (2n - 3) - 2c] / [4b (n - 1)^2] \quad \dots (13)$$

Now let's assume a benevolent dictator is administering the entire process. Objective of the dictator is social welfare maximization. The dictator will not allow maximization of individual expected utilities, but the total expected utility of transaction as a whole.

The objective function of the benevolent dictator is given by,

maximize,

$$E(U_d) = (P_1 - a Q_p) Q_p + (P_2 - b Q_a) Q_a - c (Q_p + Q_a)^n \quad \dots (14)$$

subject to,  $n > 1$ .

Differentiating (14) with respect to  $Q_p$  yields,

$$\frac{d}{dQ_p} E(U_d) = P_1 - 2 a Q_p - n c (Q_p + Q_a)^{n-1} \quad \dots (15)$$

$$\text{or, } \frac{\partial^2}{\partial Q_p^2} E(U_d) = -2 a - n(n-1) c (Q_p + Q_a)^{n-2} < 0 \quad \dots (16)$$

Differentiating (14) with respect to  $Q_a$  yields,

$$\frac{\partial^2}{\partial Q_a^2} E(U_d) = -2 b - n(n-1) c (Q_p + Q_a)^{n-2} < 0 \quad \dots (17)$$

and,

$$\frac{\partial^2}{\partial Q_p \partial Q_a} E(U_d) = -n(n-1) c (Q_p + Q_a)^{n-2} = \frac{\partial^2}{\partial Q_p \partial Q_a} E(U_d) < 0 \quad \dots (18)$$

In this case of maximization, leading principal sub-matrices of the Hessian matrix formed by second order condition factors in (16), (17) and (18) are all less than zero. Hence it is possible to state that the objective function in (12) can be maximized for  $Q_p$  and  $Q_a$ .

In order to achieve optimal solution for  $Q_p$ , (15) is needed to be equated to zero.

$$P_1 - 2 a Q_p - n c (Q_p + Q_a)^{n-1} = 0$$

or,

$$Q_p = [P_1 - n c Q_a (n - 1)] / [2 a + n c (n - 1)] \dots (19)$$

Similarly to achieve optimal solution for  $Q_a$ , equating (17) to zero, we get:

$$Q_a = [P_2 - n c Q_p (n - 1)] / [2 b + n c (n - 1)] \dots (20)$$

Equating (19) and (20), we get:

$$Q_p = [n c (P_2 - P_1) (n - 1) - 2 b P_1] / [4 b n c (n - 1) - 4 b^2] \dots (21)$$

$$Q_a = [n c (P_2 - P_1) (n - 1) - 2 a P_2] / [4 a n c (n - 1) - 4 a^2] \dots (22)$$

Now calculating (6), (7), (21), and (22), individual expected utilities for both the participants are given by:

$$E(U_a) = \frac{4 a b P_2 n^2 c (P_2 - P_1) (n - 1) - 2 a^2 b P_2^2 n}{+ 8 a^3 P_2 (P_2 n - c) - b n^3 c^2 (P_2 - P_1)^2 (n - 1)^2} \dots (23)$$

$$/ [n \{4 a n c (n - 1) - 4 a^2\}^2]$$

$$E(U_a) = \frac{4 a b P_2 n^2 c (P_2 - P_1) (n - 1) - 2 a^2 b P_2^2 n}{+ 8 a^3 P_2 (P_2 n - c) - b n^3 c^2 (P_2 - P_1)^2 (n - 1)^2} \dots (24)$$

$$/ [n \{4 a n c (n - 1) - 4 a^2\}^2]$$

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