Hidden Costs of Offshore Outsourcing: An Analysis of Offshoring Decisions *

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Abstract

Offshore outsourcing has grown phenomenally as a form of industrial organisation in recent times and has also been viewed as a strategic move by firms to out-compete their rivals. The gains from this exercise may however not necessarily be at par with expectations due to the presence of a host of hidden costs which have been documented in the literature. This paper tries to address and analyse the nature of strategic interaction that takes place in the decision to offshore, in the presence of signals with imperfect precision to players(i.e. firms seeking to offshore their jobs to lower cost destinations) in a Cournot framework. It offers insights into the decision making process and outlines policy suggestions for countries which are potential hosts to offshore outsourcing. Amongst other important conclusions it is found that the precision of signals about the hidden cost and the range of possible hidden costs play a crucial role in determining offshoring destinations. Updating of information about hidden costs leads to different equilibria including the possibility of herding in offshore outsourcing.

Keywords: Offshore outsourcing, Hidden costs, Bayesian Nash Equilibrium, Herding.

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1 Introduction

Offshore outsourcing- a phenomenon that has gained precedence towards the close of the previous century has attracted the attention of media, politicians, economists and sooth sayers. Amidst wide ranging claims of cost savings and employment effects, media reports and academicians have highlighted that the benefits of offshoring may fall below expectations due to the existence of hidden costs. Offshoring jobs in the presence of asymmetric information about hidden costs in a location have strategic implications for inter firm competition. This decision to offshore and the choice of destination is analysed in this paper through a Bayesian game showing possibilities of herding in the choice of destination amongst firms. Policy implications for countries to improve their attractiveness as offshoring destinations by reducing uncertainty about hidden costs are also addressed.

The landscapes of industrial organisation and international trade have seen changes over time marked with academic interest as easily discernible from a considerable body of extant literature. Production decisions especially for multinational companies have been influenced by trading costs and difference in costs of production across geographies (Antras, 2003), (Barba, Giorgio, & Venables, 2004). This in turn has made cases in favour of horizontal FDI (Markusen J. , 1984). Alternatively, low costs of production and low costs of trading have led firms to organise themselves vertically whenever fragmentation of the production process has been possible (Helpman, 1984). Markusen & Maskus (2001) show that falling trade costs may either foster or hamper FDI (both horizontal i.e. market seeking and vertical i.e. cost saving) depending on country characteristics.

Technological achievements especially in IT and other aspects of production late last century has allowed greater fragmentation of the production process while reducing trading costs to an all-time low. Together they have fostered intra and inter firm trade in intermediate inputs (Yeats, 2001), (Borga & Zeile, 2004). Offshoring, a specific form of vertical integration and offshore outsourcing have been studied at length in economic theory (Grossman & Helpman, 2003, 2004),(Hummels, Ishii & Yi, 2001), (Hummels, Rapoport & Yi, 1998), (McLaren, 2000). Offshore outsourcing, the subject of this paper (as distinct from offshoring or outsourcing) refers to sourcing of inputs for production from a vendor located in a different country(Sabherwal, 1999).

The choice of whether to offshore outsource or offshore(where production remains within the firm boundaries but crosses the geography) has been studied in the literature in the context of transaction costs. Extant literature suggests that offshoring is preferred by firms (i.e. firms prefer in house production within its boundaries at a foreign location) in cases where transaction costs are high i.e. buying becomes costlier than easily discernable (due to divergences in quality of output obtained from third party). Offshore outsourcing (hiring a third party vendor in a foreign location to undertake a part of the production process) becomes a preferred mode in cases where transaction costs are lower (Grossman & Helpman, 2002b, 2003). The choice of whether to offshore the production activity within the firm boundaries or to offshore outsource boils down to a comparison between the governance costs of managing a subsidiary of the firm offshore and the total vendor costs inclusive of the transactions costs incurred due to offshore outsourcing. Although existences of hidden costs have been recognised the strategic dimension of offshore outsourcing in the context of offshore hidden costs has not been addressed. In this paper I argue that when costs are hidden and various firms have varying degrees of penetration in various markets of the world it leads to information asymmetries across firms. This information asymmetry leads to strategic interaction between firms in determining offshoring destinations. This is in line with the stream of literature dealing with information asymmetries and strategic interaction in investment and industrial organisation (Chamley & Gayle, 1994), (Bondt & Henriques, 1995).

The article is organised as follows: Section 2 offers a brief review of related literature focusing on offshore outsourcing decisions of firms, hidden costs and strategic interactions. Section 3 sets up the basic model and offers the solutions. Section 4 offers a simple example in the light of section 3. Section 5 offers an extension highlighting competing destinations and the offshore destination choice- the determinants thereof. Section 6 discusses model results and take aways. Section 7 concludes the paper.

2 Related Literature

Offshoring and outsourcing of IT related and professional services (previously considered strategic) picked up steam in the concluding years of the last century thanks to the internet and trade liberalisation policies of countries like India and China (Apte U. , 1990), (Carmel & Agarwal, 2002).

Statistical evidence supports the basic tenet of offshore outsourcing as outlined by academic literature i.e. cost savings (Corbett, 2005), (Doig, Ritter, Speckhals & Woolson, 2001). Amidst the great cost benefits that offshore outsourcing is slated to guarantee reality suggests that hidden costs inhibit the cost advantages, and at more extreme situations the whole cost advantage is siphoned out by the hidden costs involved. Risks of exposing confidential data, losing out on competencies developed over time through learning by doing methods, lack of customer focus are all matters of concern to the firm seeking to outsource.[1]. Overby(2003b) points out that hidden costs tend to reduce cost benefits of offshoring to India to about 20% of the original costs in some cases. It is important

[1]See http://www.flatworldsolutions.com/articles/advantages-disadvantages-outsourcing.php

here to point out what is necessarily meant by hidden costs.

Barthelemy(2001) offers four different sources of hidden costs, namely: Vendor Search and contracting, transitioning to the vendor, managing the effort and transitioning after outsourcing. Explaining them briefly, the first one relates to the cost of finding out the right vendor for the job and this increases costs if proper information is not readily available about the vendors and their competencies. The second one arises out of switching IT activities from the source to the foreign location and depends on the absorptive power of the vendor as to how fast she climbs the knowledge curve. The third one on managing the effort is the most difficult and most time consuming in that it involves monitoring to see that obligations are fulfilled, bargaining with the vendors and finally negotiating for any required contractual changes. The fourth one arises out of a need to switch vendors. something that the managers hardly think of when taking the decision to offshore.

To touch upon the other sources of hidden costs: first, one has costs of enforcing contracts (i.e. legal effectiveness). Historically, 70% of the offshore outsourcing contracts stand in for renegotiation within the first two years, 55% have disputes leading to formal alternative dispute resolution procedures or litigation (Vagadia, 2007). Issues like data security and effective laws to tackle fraudulent activities have for long been a very important source of discomfiture amongst firms who seek to offshore work processes (Herbsleb & Moitra, 2001), (DDavison, 2004), (Morstead & Blount, 2003). Second, the quality of employees which affect turnaround time poses a hidden cost for firms which outsource to foreign locations. 25.2% of the wage costs of BPO vendors stem from training professionals after recruitment (Attrition costs weigh down BPOs: Study, 2005)[2] . Arora et al (2000) report that a significant part of the training of all employees in the offshoring sector occurs only after recruitment. Third, Geographical distance (near shoring and offshoring) leads to problems of time management (Goolsby, 2002), (Apte, et al., 1997). Issues like lack of face to face discussions (Gopal, Sivaramakrishnan, Krishnan, & Mukhopadhyay, 2003) and (Herbsleb & Moitra, 2001) add to costs. Fourth, cultural differences lead to language problems and this leads to problems in understanding of tasks and the methods to be followed in terms of work flow leading to added hidden costs (Karamouzis, 2002), (Qu & Brocklehurst, 2003) and (Overby, 2003b). Finally, employee morale in the firm seeking to offshore part of its production process poses yet another hidden cost and can affect the final performance of offshore employees to whom the job is outsourced (Baruch, 2000), (Karamouzis, 2002), (Morstead & Blount, 2003), (DiamondCluster, 2004) etc. This aspect mainly arises from fears of job losses in the source country. The discomfiture among the employees has been known to attract protests by labour unions and negative publicity (DiamondCluster, 2004) which affects the brand image of the firm.

[2]See http://www.thehindubusinessline.in/2005/12/13/stories/2005121303210100.htm

Although the existence of the above hidden costs in offshore outsourcing is well recognised, there is a lack of treatment of the same in academic literature. Asymmetry of information amongst the firms with respect to the hidden cost structure when considering offshoring of tasks adds a new strategic diemnsion to the problem. Asymmetric information and investment decisions have been studied mainly in the financial economics literature (Chamley & Gayle, 1994), (Avery & Zemsky, 1998). Most of these papers make a case for herding behaviour in terms of following the leader in absence of perfect information in deciding on investment decisions (Graham, 1999). Scharfstein & Stein, (1990) show how mimicking the moves of other managers could be a rational strategy even at the cost of neglecting one's own private information when reputation is at stake. Strategic adoption of new technology under asymmetric information has been studied using game theory (Zhu & Weyant, 2003). In this paper I try to address the decision to offshore through a signalling game of imperfect information in the presence of information asymmetry amongst firms. The issue of signalling and strategic investment decisions has been studied by (Zhang, 1997); (Chamley & Gayle, 1994), (Bikhchandani, Hirshleifer & Welch, 1992) etc. The conclusions are more or less in line with (Graham, 1999) and (Scharfstein & Stein, 1990) discussed above.

I start with a Cournot duopoly model in a two period extensive game set up in a country where firms (which are otherwise similar) consider the option of offshoring(to lower production costs and increase profits) to a given location. The location and the vendor associated with this destination poses hidden costs to be incurred by the firm(s) over and above the known fixed costs of production. In the decision to offshore or not they use the expected value of hidden costs (calculated according to the signals they receive in favour of either a high or low hidden cost destination). For simplicity I assume that the whole production process is offshored and the firm purchases the end product from the offshore vendor and sells it in the home market. Conditions under which the firms choose to offshore outsource their production process are derived. A two period bayesian game is used to this effect and the player who does not move the production offshore in the first period has the opportunity to update beliefs (from his rival's actions in the first period) and offshore outsource in the second period or still continue on-shore.

I follow this up with an analysis of competing offshore destinations and what factors pertaining to hidden costs determine the optimal offshore destination. I also show how firms may herd in the wake of disregard of own information due to updated beliefs from actions of first movers.

3 The Model

The case of a Cournot duopoly is considered. The market demand function is given by:

$$P = P(Q); P' < 0; P'' \leq 0; \tag{1}$$

where P is the price level of the good and Q is the total industry output. Thus $Q = q_1 + q_2$ where q_1 and q_2 are the respective output levels of the two firms in the duopoly.

The domestic marginal cost of production is assumed to be C_d i.e. $C_{d_i} = C_d$ $\forall i$, where $i \in \{1, 2\}$. Hence I assume constant returns to scale. I first outline the pre-offshore production and profit outcomes and use this as a benchmark for comparison with the outcomes of the game played with respect to offshoring decisions.

Firm i's profit equation is given by:

$$\pi_i = [P(\sum_{i=1}^{2} q_i) - C_d]q_i \tag{2}$$

I derive the reaction functions of the two firms solving the first order conditions for profit maximisation and the reaction functions can be written as:

$$q_1 = R(q_2, C_d) \tag{3}$$

$$q_2 = R(q_1, C_d) \tag{4}$$

From the above equations the market equilibrium outputs can be easily derived and one gets $q_1^* = q_2^* = q^*$. So $Q^* = 2q^*$ and $P^* = P(Q^*)$. Finally profits are given by $\pi_i^* = (P^* - C_d)q_i^*$ and $\pi^* = 2\pi_i^*$ gives the total industry profit.

I now introduce the option of offshoring to a foreign location. All through the model I assume the act of offshoring to be an irreversible process. Once a firm offshores its activities, they cannot be in shored or offshored elsewhere. The offshore location has two components of marginal cost of production. (1)A known cost $\bar{C}$ and (2) an unknown(hidden) cost $C \in \{C_l, C_h\}$. I assume:

$$\bar{C} + C_h > C_d > \bar{C} + C_l$$

In other words, if the offshore location has high hidden costs, the total marginal cost of production is more than the onshore costs. While for low offshore hidden costs, the marginal costs of production onshore are higher than at offshore.

I outline the game being played across the periods sequentially and then look at the analytical details.

Timeline: The timeline of the game is as follows:

$$\textbf{Period 1:} \begin{cases} \text{1. Players receive signals about hidden costs} \\ \theta_i = \{C_l, C_h\}\ i \in \{1,2\} \\ \text{2. Either or both players choose to offshore based on} \\ \text{expected costs} \\ \text{3. If only Player } i \text{ has offshored player } j \neq i \text{ observes output} \\ \text{and produces as a Stackelberg follower} \end{cases}$$

$$\textbf{Period 2:} \begin{cases} \text{1. Player } j \text{ updates belief about hidden costs from Player i's} \\ \text{output if only player } i \text{ offshored in period 1} \\ \text{2. Player } j \text{ decides to offshore or not} \\ \text{3. Players produce as in Cournot duopoly} \end{cases}$$

The proceedings of each period are detailed next:

Period 1: Players receive signals on the unknown component of foreign marginal cost of production. The signal received by a firm i is given by $\theta_i = \{C_l, C_h\}\ i \in \{1, 2\}$.

Each player has a privately known precision $p_i = Pr[C = C_h|C = C_h] = Pr[C = C_l|C = C_l]$. Given the signal each player calculates the expected costs of offshore production. Depending on the value of expected cost and its value relative to the domestic cost of production the player i decides to go offshore or stay domestic. This is valid for both players and production occurs at the end of period 1. The precision may be held to be exogenous to the model for firms which have no interaction with the offshore location. However, for big firms like MNCs which have prior business relations or production activities in the offshore location catering to the offshore customers precision could well be dependent on the costs incurred through this relationship[3].

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[3]Size of firms and endogenous precision:

I offer a simple exposition of how precision may be formed in a scenario where a firm operates in multiple geographies serving the respective geographies with production in that geography.

I assume for simplicity that a firm operates in two geographies. Apart from the domestic production, it also operates in the offshore location serving the clients there with the production undertaken in that geography.

In effect the firm believes that the expected cost of production would be approximately equal to the cost of production of its output for the offshore location. In such a case, if C_o is the cost of production for the offshore geography to serve the customers offshore then,

$$C_o \simeq \bar{C} + p_i C_l + (1 - p_i) C_h$$

$$p_i \simeq (\bar{C} + C_h - C_o)/(C_h - C_l) \tag{5}$$

I highlight that p_i is dependent on C_o for given values of C_d, C_h and C_l. The lower the cost of production in the offshore location the higher the precision in favour of lower hidden cost

If both players have moved offshore then a cournot game is played with offshore production costs(I detail later in the next subsection). If both players stay domestic then the outcome is same as onshore production. The interesting case occurs when one player has moved offshore and the other stays domestic at the end of period 1.I assume without loss of generality that player 1 has moved in period 1 and player 2 has stayed domestic in terms of production location at the end of period 1. Player 2 has to wait for player 1's output choice to decide on its own production. Player 2 thus is a Stackelberg follower and Player 1 becomes a stackelberg leader. I show that in this period player 1 may choose to reveal the true costs of production or to pool so as not to reveal the true costs depending on profitability and player 2's beliefs.

Period 2: Player 2 observes player 1's action to move and the output choice made by player 1 to form an updated belief of the unknown component of marginal cost of production offshore. Player 2 then decides to move offshore or stay domestic and the firms compete on quantity. In this period since there are no more costs of production left to be revealed the game is back to the traditional cournot format irrespective of whether player 2 chooses to follow player 1 offshore or stay domestic. No cost of late movement is assumed to begin with, i.e. player 2 pays no penalty in terms of added costs for moving second to the offshore location. In other words there is no first mover advantage by way of facing lower costs of production in what has been described so far.

3.1 Period 1

Players receive signals. For a given player i if signal is C_h then his expected cost of production offshore is $\bar{C} + p_i C_h + (1 - p_i)C_l$. The strategy of any player i is thus:

- Offshore if $\bar{C} + p_i C_h + (1 - p_i)C_l < C_d$
- Stay Domestic if $\bar{C} + p_i C_h + (1 - p_i)C_l \geq C_d$

From above it is clear that for a player to offshore with a signal C_h the precision p_i must obey:

$$p_i < (C_d - C_l - \bar{C})/(C_h - C_l)$$

$$(1 - p_i) > \frac{\bar{C} + C_h - C_d}{C_h - C_l}$$

Alternatively, if the signal is C_l then the strategy of player i is:

for offshore production. So a lower offshore cost of production would imply higher knowledge about the costs and hidden costs of the location and better tackling of issues related to hidden cost thereby increasing precision

- Offshore if $\bar{C} + p_i C_l + (1 - p_i) C_h < C_d$
- Stay domestic if $\bar{C} + p_i C_l + (1 - p_i) C_h \geq C_d$

From above it is clear that for a player to offshore with a signal C_l the precision p_i must obey:

$$p_i > \frac{\bar{C} + C_h - C_d}{C_h - C_l}$$

Thus the first result of this paper is derived as follows:

Result 1:- It follows from above that for a player i to offshore in period 1 without observig the strategy of the other player, player i should believe the offshore location to have low hidden cost(C_l) with a probability $\bar{p}$ such that $(\bar{C} + C_h - C_d)/(C_h - C_l) \leq \bar{p} \leq 1$.

So at the end of period 1 one has either of the following possibilities:

- Both offshore i.e. $p_1, p_2 \geq \bar{p}$
- None offshore i.e. $p_1, p_2 < \bar{p}$
- Either player 1 or player 2 offshores and the other produces domestically i.e. $p_1 > \bar{p} > p_2$.

At the end of period 1 if only player 1 has moved it is clear that player 2 believes the offshore location to be a low cost production location with a probability $p_2 < \bar{p}$. I detail on the production and output of the three possible cases at the end of period 1 below.

3.1.1 Both players offshore

The model still remains a Cournot Model and the production decisions are taken on the basis of the revealed hidden costs:

- Hidden cost is C_h

  This implies the output $q_1^{hc} = q_2^{hc} = q^{hc} = q(J, C_h) = q(C_h) < q^*$ where $J = P^{-1}$. It thus follows that $Q^{hc} = 2q^{hc} < Q^*$ and $P^{hc} = P(Q^{hc}) > P^*$. Due to higher production costs given a particular demand function, the profits fall along with consumer surplus. In other words higher hidden costs in the offshore location act as burden on the firms and the consumers. This lowers total welfare in the source country.

- Hidden cost is C_l

This implies the output $q_1^{lc} = q_2^{lc} = q^{lc} = q(J, C_l) = q(C_l) > q^*$ where $J = P^{-1}$. It thus follows that $Q^{lc} = 2q^{lc} > Q^*$ and $P^{lc} = P(Q^{lc}) < P^*$. The profits increase along with consumer surplus. This increases total welfare in the society.

3.1.2 None of the players offshore

The result is the same as the pre-offshoring case detailed at the very start of this section. So the respective outputs and price can be simply read off from the expressions of q_1^*, q_2^*, Q^*, P^*.

3.1.3 Only one player offshores

As discussed before I assume that in such cases player 1 has moved offshore and player 2 stays domestic. Player 2 has to first observe player 1's output(in absence of any other communication) in order to produce the optimal output(catering to residual demand). Player 1 thus becomes a stackelberg leader. In this case one could have different outcomes if the first player chooses to reveal the true costs(Separating Equilibrium) or there would be a pooled equilibrium depending on the costs of production and the beliefs of player 2. I work this out after a description of period 2 proceedings.

3.2 Period 2

In the first two subcases as described in the previous section the outputs obtained in the first period will continue in this period given the setup of the game. I thus look at the third case and how the output choice of player 1 affects the production decisions of player 2.

The game in period 2 is essentially a Cournot game since there is nothing more to learn for player 2 after period 1 is over and irrespective of whether it decides to offshore or not it undertakes production simultaneously with firm 1.

I offer two Weak Perfect Bayesian Nash Equilibria for this game depending on the beliefs of player 2 formed from observing the output choice of player 1 in period 1. I list and explain the two equilibria below:

3.3 Separating Equilibrium

In a separating equilibrium, the actions of player 1 in period 1 completely reveals the level of hidden cost that would be faced offshore.Player 1 believes that if it produces output q_1^{HS} in period 1 then the offshore destination is believed to be high cost destination by player 2 and when it produces output q_1^{LS} then the destination is believed to be low cost. This gives the first proposition of this paper. However I provide a list of notations first:

Notations:

$F(C_h, C_d) = P^{HS} - (\bar{C} + C_h)$: Profit per unit of output to player 1 when player 1 has offshored to the destination with high hidden cost as a Stackelberg leader, while player 2 produces onshore as a Stackelberg follower.

$G(C_h, C_d) = P^{HC}(C_d, C_h) - (\bar{C} + C_h)$: Profit per unit of output to player 1 when player 1 has offshored to the destination with high hidden cost in Cournot duopoly, while player 2 produces onshore.

$F(C_l, C_h, C_d) = P^{HS} - (\bar{C} + C_l)$: Profit per unit of output to player 1 when player 1 has offshored to the destination with low hidden cost as a Stackelberg leader and mimics the high hidden cost type, while player 2 produces onshore as a Stackelberg follower. ,

$F(C_h, C_l, C_d) = P^{LS} - (\bar{C} + C_h)$: Profit per unit of output to player 1 when player 1 has offshored to the destination with high hidden cost as a Stackelberg leader and mimics the low hidden cost type, while player 2 produces onshore as a Stackelberg follower. ,

$G(C_h) = P^{HC}(C_h) - (\bar{C} + C_h)$: Profit per unit of output if both players have offshored to the destination with high hidden cost in Cournot duopoly.

$q_1^{HC}(C_h)$: Cournot output of player 1 when both players have offshored with high hidden costs of production.

$q_1^{HC}(C_h, C_d)$: Cournot Output of player 1 when player 1 has offshored to a high hidden cost destination while player 2 has not.

$q_1^{LC}(C_l, C_d)$: Cournot Output of player 1 when player 1 has offshored to a low hidden cost destination while player 2 has not.

PROPOSITION 1: In a separating equilibrium, where player 2's belief's are given by:

P$[C = C_l | q_1 \geq q_1^{LS}]$=1 and
P$[C = C_l | q_1 < q_1^{LS}]$=0

the equilibrium outputs of firm 1 when she faces high offshore hidden cost q_1^{HS} and when she faces low offshore hidden cost q_1^{LS} are related as

$$q_1^{HS} \in [\frac{F(C_h, C_l, C_d)q_1^{LS} + \delta[G(C_h)]q_1^{HC}(C_h) - \delta[G(C_h, C_d)]q_1^{HC}(C_h, C_d)}{F(C_h, C_d)},$$
$$\frac{F(C_l, C_d)q_1^{LS} + \delta[G(C_l)]q_1^{LC} - \delta[G(C_l, C_d)]q_1^{LC}(C_l, C_d)}{F(C_l, C_h, C_d)}] \quad (6)$$

PROOF:

I portray the separating equilibrium below where at the end of period 1 player 1 who has moved offshore chooses to reveal the correct type. Given the revelation principle, player1 can either choose to produce q_1^{HS} or q_1^{LS} and chooses to reveal only when its own incentives out of revelation are satisfied.

The incentive compatibility(IC) conditions for each cost type player are written below.

If the first player faces high hidden cost on moving offshore, the IC for him to produce the output corresponding to the high hidden cost output is given by:

IC for Player 1 when she faces high hidden costs (ICH):

$$\begin{aligned}&[P^{HS} - (\bar{C} + C_h)]q_1^{HS} + \delta[P^{HC}(C_d, C_h) - (\bar{C} + C_h)]q_1^{HC}(C_h, C_d)\\ &\geq [P^{LS} - (\bar{C} + C_h)]q_1^{LS} + \delta[P^{HC}(C_h) - (\bar{C} + C_h)]q_1^{HC}(C_h)\end{aligned} \tag{7}$$

I note here that $P^{HC}(C_d, C_h)$ is the prevailing price in the Cournot Game when player 1 uses offshore production and player 2 produces domestically. δ is the discount factor. $P^{HC}(C_h)$ is the prevailing cournot price when both players are using offshore production in the Cournot game of period 2. Similarly for $q_1^{HC}(C_h, C_d)$ and $q_1^{HC}(C_h)$. The equation can be interpreted simply as follows: the discounted value of profits from revealing the true type given the beliefs of player 2 should outweigh the discounted value of profits if player 1 was to mimic the other type.

One can write it more simply as:

$$F(C_h, C_d)q_1^{HS} + \delta[G(C_h, C_d)]q_1^{HC}(C_h, C_d) \geq F(C_h, C_l, C_d)q_1^{LS} + \delta[G(C_h)]q_1^{HC}(C_h)$$

Thus:

$$F(C_h, C_d)q_1^{HS} \geq F(C_h, C_l, C_d)q_1^{LS} + \delta[G(C_h)]q_1^{HC}(C_h) - \delta[G(C_h, C_d)]q_1^{HC}(C_h, C_d)$$

From here I obtain a lower bound for q_1^{HS}.

One can similarly write down the IC for player 1 when she faces low hidden costs as(ICL):

$$\begin{aligned}&[P^{LS} - (\bar{C} + C_l)]q_1^{LS} + \delta[P^{LC}(C_l) - (\bar{C} + C_l)]q_1^{LC}(C_l)\\ &\geq [P^{HS} - (\bar{C} + C_l)]q_1^{HS} + \delta[P^{LC}(C_d, C_l) - (\bar{C} + C_l)]q_1^{LC}(C_l, C_d)\end{aligned} \tag{8}$$

Once again one can simplify it to write it as:

$$F(C_l, C_d)q_1^{LS} + \delta[G(C_l)]q_1^{LC} \geq F(C_l, C_h, C_d)q_1^{HS} + \delta[G(C_l, C_d)]q_1^{LC}(C_l, C_d)$$

$$F(C_l, C_d)q_1^{LS} + \delta[G(C_l)]q_1^{LC} - \delta[G(C_l, C_d)]q_1^{LC}(C_l, C_d) \geq F(C_l, C_h, C_d)q_1^{HS}$$

I thus get an upper bound for q_1^{HS} for any given q_1^{LS}. Combining the expressions for the lower and the upper bound of q_1^{HS} I get the expression in the proposition.**Proved**

It is easy to check that the above inequalities hold more strongly as C_l is decreased and C_h is increased. This gives the first observation of this paper.

OBSERVATION 1: Player 1's incentive to reveal the hidden cost faced by her increases as the difference $(C_h - C_l)$ approaches ∞ .

PROOF in Appendix 1.

So, when the range between the costs is high the first player has no incentive to deviate from revealing his type. So in such cases the equilibrium stackelberg output i.e. q_1^{HS} is produced by player 1 when she faces high hidden costs correctly revealing the type to player 2. Player 2 in period 1 produces q_2^{HS} and they produce $q_1^{HC}(C_h, C_d)$ and $q_2^{HC}(C_h, C_d)$ respectively at the end of period 2 to maximise profits. Similarly, they produce for the case when they face low hidden costs of production.

It can be checked that the profit maximising output combinations for each period output would be the Stackelberg outputs in period 1 and Cournot Outputs in period 2:

1. Hidden cost C_h The Stackelberg outputs are respectively:
   $q_1^{HS} = q_1(J, C_d, C_h)$ where $J = P^{-1}$ and $q_1'(J) > 0$; $q_1'(C_d) > 0$ and $q_1'(C_h) < 0$.
   $q_2^{HS} = q_2(J, C_d, C_h)$ where $J = P^{-1}$ and $q_2'(J) > 0$; $q_2'(C_d) < 0$ and $q_2'(C_h) > 0$.
   $Q^{HS} = q_1^{HS} + q_2^{HS}$
   $P^{HS} = P(Q^{HS})$
   I note here that the comparisons with the cournot case are not obvious. One needs to put in a restriction on the demand function wrt C_h in order to establish any comparative analysis with the pre offshoring case.

   The period 2 outputs: $q_1^{HC} = q_1(J, C_d, C_h)$ where $J = P^{-1}$ and $q_1'(J) > 0$; $q_1'(C_d) > 0$ and $q_1'(C_h) < 0$.
   $q_2^{HC} = q_2(J, C_d, C_h)$ where $J = P^{-1}$ and $q_2'(J) > 0$; $q_2'(C_d) < 0$ and $q_2'(C_h) > 0$
   $Q^{HC} = q_1^{HC} + q_2^{HC}$
   $P^{HC} = P(Q^{HC})$

2. Hidden cost C_l The outputs are respectively:

   $q_1^{LS} = q_1(J, C_d, C_l)$ where $J = P^{-1}$ and $q_1'(J) > 0$; $q_1'(C_d) > 0$ and $q_1'(C_l) < 0$.

   $q_2^{LS} = q_2(J, C_d, C_l)$ where $J = P^{-1}$ and $q_2'(J) > 0$; $q_2'(C_d) < 0$ and $q_2'(C_l) > 0$

   $Q^{LS} = q_1^{LS} + q_2^{LS}$

   $P^{LS} = P(Q^{LS})$

   The period 2 outputs:

   $q_1^{LC} = q_1(J, C_d, C_l)$ where $J = P^{-1}$ and $q_1'(J) > 0$; $q_1'(C_d) > 0$ and $q_1'(C_l) < 0$.

   $q_2^{LC} = q_2(J, C_d, C_l)$ where $J = P^{-1}$ and $q_2'(J) > 0$; $q_2'(C_d) < 0$ and $q_2'(C_l) > 0$

   $Q^{LC} = q_1^{LC} + q_2^{LC}$

   $P^{LC} = P(Q^{LC})$

3.4 Pooling equilibrium

In the pooling equilibrium player 2 imperfectly updates belief about the hidden costs of the offshore location. This leads to the second proposition:

PROPOSITION 2: In a pooling equilibrium when the belief structure of player 2 is:

$$P[C = C_l | q_1 = q^p] = \bar{p}$$
$$P[C = C_l | q_1 \neq q^p] = 1$$

player 1 chooses to produce q^p in period 1 irrespective of the hidden cost faced and

$$\begin{aligned} & q^p \\ \geq [F(C_h, C_d)q_1^{HS} + \delta G(C_h)q_1^{HC}(C_h) - (1-\bar{p})\{\delta G(C_h, C_d)q_1^{HC}(C_h, C_d)\} \\ -\bar{p}\{\delta G(C_h)q_1^{HC}(C_h)\}]/[P^P - (\bar{C} + C_h)] \end{aligned} \quad (9)$$

PROOF: First, I note that $\bar{p}$ is the threshold precision level which equalises the domestic and the offshore production costs. In effect this means that player 2 updates his belief about the foreign location having low hidden costs only to the extent that she remains indifferent between offshoring and staying domestic.

In this case irrespective of the hidden cost structure being faced by player 1, she tries to produce q^p in order to protect his monopoly profits from operating in the offshore destination. This can essentially happen when the discounted profits of operating alone in the offshore location net of two periods outshines the profits if the second player follows in the second period. I look at the incentive compatibility conditions of both the high hidden cost facing firm 1 and the low hidden cost facing firm 1 below:

IC for the high hidden cost type to pool (ICH):

$$
\begin{aligned}
&[P^P - (\bar{C} + C_h)]q^p \\
&+(1-\bar{p})[\delta\{P^{HC}(C_d, C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h, C_d)] \\
&+\bar{p}[\delta\{P^{HC}(C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h)] \\
&\geq [P^{HS} - (\bar{C} + C_h)]q_1^{HS} + \delta[P^{HC}(C_h) - (\bar{C} + C_h)]q_1^{HC}(C_h)
\end{aligned} \tag{10}
$$

IC for the low hidden cost type to pool (ICL):

$$
\begin{aligned}
&[P^P - (\bar{C} + C_l)]q^p \\
&+(1-\bar{p})[\delta\{P^{LC}(C_d, C_l) - (\bar{C} + C_l)\}q_1^{LC}(C_l, C_d)] \\
&+\bar{p}[\delta\{P^{LC}(C_l) - (\bar{C} + C_l)\}q_1^{LC}(C_l)] \\
&\geq [P^{LS} - (\bar{C} + C_l)]q_1^{LS} + \delta[P^{LC}(C_l) - (\bar{C} + C_l)]q_1^{LC}(C_l)
\end{aligned} \tag{11}
$$

Now, when C_l is reasonably close to C_h the above two ICs are simultaneously satisfied when the ICH is satisfied. This is shown in Appendix 2.

Hence I get the expression for q^p as outlined in proposition 2. **PROVED**

It can also be checked that as C_l decreases for a given value of C_h the IC of the low hidden cost facing firm 1 nears equality and finally the IC seizes to be satisfied and the inequality sign reverses. Hence, this gives the second observation of this paper.

OBSERVATION 2: The incentive to pool increases as the difference $(C_h - C_l)$ approaches zero.

PROOF in Appendix 2.

This can be explained intuitively. When the hidden costs are sufficiently low, there is little to lose from the entry of a second player in terms of profits foregone for operating together in that location. Hence firm 1's incentive to protect monopoly decreases.

The pooled case outputs for each period can be written as:
$q_1^p = q_1(J, C_h, C_l, C_d)$ where $J = P^{-1}$ and $q_1'(J) > 0$; $q_1'(C_d) > 0$; $q_1'(C_l) < 0$ and $q_1'(C_h) < 0$;
$q_2^p = q_2(J, C_d, q_1^p)$ where $J = P^{-1}$ and $q_2'(J) > 0$; $q_2'(C_d) < 0$ and $q_2'(q_1^p) < 0$;
$Q^p = q_1^p + q_2^p$
$P^p = P(Q^p)$

I propose a solution for output q^p in the example below which supports the belief of player 2 that the expected cost of offshore production is same as the domestic cost of production.

The second period outputs would be same as the separating case if player 2 chooses to follow. However, if player 2 does not follow, then given this is the last period of the game player 1 reveals its true type and produces the optimal Cournot output to maximise profits i.e. q_1^{HC} or q_1^{LC} depending on whether it is facing high or low costs.

Given the above description of the game it is easy to see the implications when there is additional cost for late offshoring of tasks[4].

I next try to illustrate the model in the form of a linear example and check the results which are derived here.

4 An Example

I consider a linear example where demand is given by:

$$P = a - bQ \tag{13}$$

where $a,\ b$ are positive parameters, P is the price level of the good and Q is the total industry output. Thus $Q = q_1 + q_2$ where q_1^* and q_2^* are the respective output levels of the two firms in the duopoly.

The domestic marginal cost of production is assumed to be C_d. I first outline the pre-offshore production and profit outcomes.

In the case of domestic production, firm i's profit equation:

$$\pi_i = [a - b(\sum_{i=1}^{2} q_i)]q_i - C_d q_i$$

In the above equation i represents the firm and $i \in \{1, 2\}$. I derive the reaction functions of the two firms solving the first order conditions for profit

[4]Additional cost of moving second: Iassume that there is an additional cost of amount x for moving second to the offshore location in terms of higher hiring and setting up costs. The analysis for the first period does not change at all in this case. However, for the second player in deciding to move second she now requires that the following inequality holds true:

$$\bar{C} + x + (1-q)C_h + qC_l < C_d \Rightarrow q > \bar{p} + x/(C_h - C_l) \tag{12}$$

Thus now, the updated precision needs to be higher than the earlier bench mark $\bar{p}$ for moving ahead with offshoring.

maximisation and the reaction functions can be written as:

$$q_1 = (a - C_d)/2b - q_2/2 \tag{14}$$
$$q_2 = (a - C_d)/2b - q_1/2 \tag{15}$$

The market equilibrium outputs and price can thus be expressed as:

$$q_1^* = q_2^* = (a - C_d)/3b = q^*$$

$$Q^* = 2(a - C_d)/3b$$

$$P^* = (2C_d + a)/3$$

The profits accruing to each firm and the industry profits thus obtained are:

$$\pi_1 = \pi_2 = (a - C_d)^2/9b$$
$$\pi = 2(a - C_d)^2/9b$$

Now I introduce offshore outsourcing possibiliies as outlined in the previous section. The hidden cost $C \in \{C_l, C_h\}$ and the rest of the analysis follows though as described in section 3. Now at the end of period 1 there are three possibilities. I list them in the context of the example below:

4.1 Period 1

4.1.1 Both players offshore

Production decisions are taken based on whether it is a high or low cost destination. The model continues to be in the Cournot framework as no player enjoys a first mover advantage.

- Hidden cost is C_h

  This implies the output $q_1^{hc} = q_2^{hc} = (a - (\bar{C} + C_h))/3b$ It thus follows that $Q^{hc} = (2a - 2(\bar{C} + C_h))/3b$ and $P^{hc} = (2(\bar{C} + C_h) + a)/3$. The profits fall along with consumer surplus. This lowers total welfare in the society.

- Hidden cost is C_l

  This implies the output $q_1^{lc} = q_2^{lc} = (a - (\bar{C} + C_l))/3b$ It thus follows that $Q^{lc} = (2a - 2(\bar{C} + C_l))/3b$ and $P^{lc} = (2(\bar{C} + C_l) + a)/3$. The profits increase along with consumer surplus. This increases total welfare in the society.

4.1.2 None of the players offshore

The result is the same as the pre-offshoring case detailed at the very start of this section. So the respective outputs and price can be simply read off from the expressions of q_1^*, q_2^*, Q^*, P^*.

4.1.3 Only one player offshores

As discussed before I assume that in such cases player 1 has moved offshore and player 2 stays domestic. It is here that the game deviates from the traditional Cournot set up. Player 2 has to first observe player 1's output(in absence of any other communication) in order to produce the optimal output and hence Player 1 becomes a stackelberg leader.In this case one would have a separating and pooling equilibria as detailed in the previous section. The solutions are offered after a brief description of period 2.

4.2 Period 2

As outlined in the game in the previous section I offer two possible equilibria for this game at the end of period 2.

4.3 Separating Equilibrium

In a separating equilibrium, the actions of player 1 in period 1 completely reveal the level of hidden cost that would be faced offshore.

Player 1 believes that if it produces output q_1^{HS} in period 1 then the offshore destination is believed to be high cost by player 2 and when it produces output q_1^{LS} then the destination is believed to be low cost.

So player 2's beliefs are:
P[$C = C_l | q_1 \geq q_1^{LS*}$]=1 and
P[$C = C_l | q_1 < q_1^{LS*}$]=0.

I portray the separating equilibrium below where at the end of period 1 player 1 who has moved offshore chooses to reveal the correct type. If the first player faces high hidden cost on moving offshore, the IC for him to produce the output corresponding to the high hidden cost is of the form described in the previous section. I outline the outputs and the prices for each type of cost faced by firm 1 and the industry outputs:

The period 1 outputs depending on the hidden cost structure are:

- Hidden cost C_h The outputs are respectively:
  $q_1^{HS*} = ((a + C_d)/2 - (\bar{C} + C_h))/b$

$q_2^{HS*} = (a - 3C_d)/4b + (\bar{C} + C_h)/2b.$
$Q^{HS*} = (3a - C_d)/4b - (\bar{C} + C_h)/2b$
$P^{HS*} = (2(\bar{C} + C_h) + C_d + a)/4$
$\pi_1^{HS} = (a + C_d - 2(\bar{C} + C_h))^2/8b$
$\pi_2^{HS} = (a - 3C_d + 2(\bar{C} + C_h))^2/16b$

I note here that the comparisons with the cournot case are not obvious as described in the previous section.

- Hidden cost C_l The outputs are respectively:
  $q_1^{LS*} = ((a + C_d)/2 - (\bar{C} + C_l))/b$ and
  $q_2^{LS*} = (a - 3C_d)/4b + (\bar{C} + C_l)/2b.$
  $Q^{LS*} = (3a - C_d)/4b - (\bar{C} + C_l)/2b$
  $P^{LS*} = (2(\bar{C} + C_l) + C_d + a)/4$
  $\pi_1^{LS} = (a + C_d - 2(\bar{C} + C_l))^2/8b$
  $\pi_2^{LS} = (a - 3C_d + 2(\bar{C} + C_l))^2/16b$

In this equilibrium, when the first firm faces a high hidden cost the outputs produced by firms 1 and 2 are given by q_1^{HS*} and q_2^{HS*} respectively. In the case where the first mover encounters a low hidden cost, the outputs by the respective firms are, q_1^{LS*},q_2^{LS*}.

The second period outputs of each player, price faced by consumers and profits are given by:

In case of high hidden costs:

$q_1^{HC} = (a + C_d - 2(\bar{C} + C_h))/3b$
$q_2^{HC} = [(a - C_d) + (\bar{C} + C_h - C_d)]/3b$
$Q^{HC} = (2a - C_d - \bar{C} - C_h)/3b$
$P^{HC} = (a + C_d + \bar{C} + C_h)/3$
$\pi_1^{HC} = (a + C_d - 2(\bar{C} + C_h))^2/9b$
$\pi_2^{HC} = (a - 2C_d + (\bar{C} + C_h))^2/9b$
$\pi^{HC} = \pi_1^{HC} + \pi_2^{HC}$

In case of low hidden costs:

$q_1^{LC} = (a - \bar{C} - C_l)/3b$
$q_2^{LC} = (a - \bar{C} - C_l)/3b$
$Q^{LC} = 2(a - \bar{C} - C_l)/3b$
$P^{LC} = (a + 2(\bar{C} + C_h))/3$
$\pi_1^{LC} = (a - \bar{C} - C_l)^2/9b$
$\pi_2^{LC} = (a - \bar{C} - C_l)^2/9b$

$\pi^l = 2(a - \bar{C} - C_l)^2/9b$

Given the above one can also check the validity of observation 1 in the context of the example. This in shown in Appendix 3.

4.4 Pooling Equilibirum

In the pooling equilibrium, player 2 imperfectly updates belief from player 1's move in period 1 and the updated belief is a result of player 1's decision to move offshore and the output choice. So the updated belief at the end of period 1 for player 2 is

$\mathrm{P}[C = C_l | q_1 = q^p] = \bar{p}$
$\mathrm{P}[C = C_l | q_1 \neq q^p] = 1$

The candidate solution for q^p is the stackelberg leader output of firm 1 had firm 1 been a leader while operating domestically. This level of output satisfies the pooling ICs for a selection of values of C_l and C_h. This keeps expected costs of production offshore exactly equal to domestic production for player 2.

Hence the output in period 1:

$q_1^p = q_1^S = (a - C_d)/2b$
$q_2^S = (a - C_d)/4b$
$Q^p = 3(a - C_d)/4$
$P^p = (a + 3C_d)/4$

It can be checked that this qualifies as an equilibrium in the pooled case given the beliefs.

In the following section an extension to the model is offered. The game played after the movement of the first player remains identical in this extension. However, the extension adds light into the decision to offshore outsource. Once offshore outsourcing is decided upon, the rest of the game plays out as described in section 3.

5 Extension: Two Locations

The model is now extended to the scenario where there are two competing destinations where jobs may be offshored.

I assume the two locations to be A and B. The fixed costs are held to be $\bar{C}^A$ and $\bar{C}^B$. The hidden costs are held to be $C^A \in \{C_l^A, C_h^A\}$ for destination A and $C^B \in \{C_l^B, C_h^B\}$. The two players get signals about hidden costs for each of the two locations and the precisions for each location for each player is given by p_i^j where $i \in \{1,2\}$ and $j \in \{A,B\}$. The dynamics of the game are similar as described above and the firms offshore to the destination with the least expected marginal cost of production. However I analyse a few cases here to bring out some insightful conclusions.

First I consider the case where both players get signals of lower hidden cost from both locations. Firms offshore to the location with the lowest expected costs of production. However I claim and prove below that the destination with higher known costs of offshore production may be preferred (more profitable) under some specific cases.

Claim: An offshore destination with similar or higher known costs of production may turn out to be the more competitive destination if :

- The precision of signal from the destination is higher with similar range of hidden costs as its competitors or
- The difference between the high and low hidden costs at the destination is lower than its competitor with difference in expected ranges across destinations being lower than difference in higher bounds of hidden costs across destinations.

Proof: The above claim is proved using the following cases.

5.1 $\bar{C}^A = \bar{C}^B$

The fixed costs are same across both locations and for simplicity I assume the signals received to be in favour of a low cost destination for both the locations. Now if,

$$\bar{C}^A + p_i^A C_l^A + (1-p_i^A)C_h^A < \bar{C}^B + p_i^B C_l^B + (1-p_i^B)C_h^B < C_d \tag{16}$$

then the firms offshore to destination A. Similarly when:

$$\bar{C}^B + p_i^B C_l^B + (1-p_i^B)C_h^B < \bar{C}^A + p_i^A C_l^A + (1-p_i^A)C_h^A < C_d \tag{17}$$

then firms offshore to destination B unambiguously.

Now if $\bar{C}^B + p_i^B C_l^B + (1-p_i^B)C_h^B = \bar{C}^A + p_i^A C_l^A + (1-p_i^A)C_h^A$

then $p_i^A C_l^A + (1-p_i^A)C_h^A = p_i^B C_l^B + (1-p_i^B)C_h^B$

Now under this circumstance if $C_l^A < C_l^B$ and $C_h^A < C_h^B$ with $C_l^B < C_h^A$ then if $p_i^B = p_i^A$ the equality is violated. That is the precision level in favour of lower cost for B has to be higher than that of A for the equality to be maintained. Thus $p_i^B > p_i^A$. Hence due to a lower C_l^A destination manages to be equally competitive as destination B in spite of $p_i^B > p_i^A$.

Considering the case when $C_l^A > C_L^B$ and $C_h^A < C_h^B$ then one can write the above equation as:

$$p_i^B(C_h^B - C_l^B) - p_i^A(C_h^A - C_l^A) = (C_h^B - C_h^A)$$

For the equality to hold one must have the difference in expected range of hidden costs outweighed by the difference of the higher bounds of hidden costs across the destinations. Once again destination A is equally competitive as B irrespective of the precision of its signals. In fact destination A becomes more competitive as $(C_h^B - C_h^A)$ approaches ∞. So in spite of the lower bound of the cost distribution of A being higher than that of B there is a chance that A may enjoy the benefits of offshoring. Thus both segments of the claim are satisfied.

5.2 $\bar{C}^A < \bar{C}^B$

If now, $\bar{C}^B + p_i^B C_l^B + (1 - p_i^B)C_h^B < \bar{C}^A + p_i^A C_l^A + (1 - p_i^A)C_h^A$ Then firms offshore to B due to lower total expected costs in spite of lower known fixed costs in A. It is easy to deduce from here that

$$p_i^A(C_h^A - C_l^A) < p_i^B(C_h^B - C_l^B) + (C_h^A - C_h^B) \tag{18}$$

Under this situation if one assumes that $C_h^A = C_h^B$ then it can be seen that for the inequality above to hold true the following cases must hold:
if $C_l^A = C_l^B$ then $p_i^B > p_i^A$
if $C_l^A < C_l^B$ then $p_i^B > p_i^A$
if $C_l^A > C_l^B$ then $p_i^B > p_i^A$ is sufficient but $p_i^B > p_i^A.(C_h^A - C_l^A)/(C_h^B - C_l^B) < p_i^A$

The above expressions point out that even if the lower bound of hidden cost in location A is lower than that of B, work is offshored to B due to higher precision level in favour of signal of location B. Additionally, when lower bound of hidden cost in location B is lower than its counterpart for location A then again a higher precision surely drives the firms to offshore to B but it could also drive it even with a lower precision for B as long as it is higher than a critical value determined by the distributions of unknown costs of the competing destinations. The precision in favour of lower costs in location B can be lower, the higher is the lower bound for costs in location A. In this particular case where I have held the upper bounds of the distributions to be same, the closer the distributions the higher one needs the precision in favour of lower hidden cost in destination B for offshoring to that location. I check if this changes for more general cases below .

- $C_h^A > C_h^B$
  Operating in the same scenario where equation 18 holds:

1. $C_l^A > C_l^B$ such that $C_h^A - C_l^A = C_h^B - C_l^B$ Here $p_i^B > p_i^A$ ensures offshoring to B but if $p_i^B \leq p_i^A$ then $(C_h^A - C_h^B)$ must be large enough for the inequality to hold good.
2. $C_l^A < C_l^B$ Here $C_h^A - C_l^A > C_h^B - C_l^B$. Thus if $p_i^B = P_i^A$ then inequality sign does not change in the manner desirable in equation 18. Hence for inequality to reverse one must have either $p_i^B > p_i^A$ or a high value of $(C_h^A - C_h^B)$ i.e. dispersion in A $\gg$ dispersion in B.
3. $C_l^A = C_l^B$ The analysis is same as above.
4. $C_l^A > C_l^B$ Here again the above two cases may come up where the analysis is identical. Additionally one may have $C_h^A - C_l^A < C_h^B - C_l^B$. Here the inequality already holds true. Hence $p_i^A < p_i^B$ is sufficient for the inequality to hold true but not necessary.

- $C_h^A < C_h^B$

1. $C_l^A = C_l^B$ It is known that
   $p_i^A C_l^A + (1 - p_i^A) C_h^A > p_i^B C_l^B + (1 - p_i^B) C_h^B$
   Then, as $C_l^A = C_l^B$ and $C_h^A < C_h^B$, if $p_i^A = p_i^B$ then the inequality does not hold. Hence one needs, $(1 - p_i^A) > (1 - p_i^B)$ which implies $p_i^B > p_i^A$
   Thus for B to attract offshoring by frms with a higher dispersion of hidden cost the precision in favour of low cost in B must be higher than that of A.
2. $C_l^A < C_l^B$ I assume that $p_i^B < p_i^A$ I prove here that B can never be a best offshoring destination in this case. If $p_i^B = p_i^A$ then $p_i^A C_l^A + (1 - p_i^A) C_h^A < p_i^B C_l^B + (1 - p_i^B) C_h^B$ Now, if p_i^A increases further then LHS reduces further. Hence A will have lesser expected cost. Hence under the above conditions offshoring to B is ruled out. [Proved] Thus here it must be that $p_i^B > p_i^A$
3. $C_l^A > C_l^B$ Here $C_h^A - C_l^A < C_h^B - C_l^B$ In this case again offshoring to B is guaranteed by a $p_i^A < p_i^B$. In fact for offshoreing of jobs to B p_i^B has a lower bound below which it cannot go and given a positive value of $(C_h^A - C_h^B)$ this ends up being higher and higher with increase in C_h^B.

   So a higher dispersion in the hidden costs of a location necessarly implicates a higher precision level in favour of the lower bound of hidden costs for offshoring jobs to be drawn to that location. If precision is similar across two destinations then firms offshore to the location with lower dispersion of hidden costs provided the difference in expected ranges of hidden costs is outweighed by the difference in higher bounds of hidden costs across the locations. This is one of the key conclusions of this paper.

Hence the claim stands **Proved**.

I do not address the case of location A having lesser fixed costs than B and also lesser expected total costs than B here since it has little to offer in terms of interesting implications for the decision to offshore.

I now turn to the case where players receive signals to believe different locations to be profitable i.e. Player 1 receives signals in favour of location A being a profitable destination while player 2 receives signals in favour of location B being a profitable destination. I outline an interesting case which entails herding behaviour by one of the firms below:

5.3 Herding

I consider a special case. Let $\bar{C}^A = \bar{C}^B$

But,

$$\bar{C} + p_1^A C_l^A + (1 - p_1^A) C_h^A < C_d < \bar{C} + p_1^B C_l^B + (1 - p_1^B) C_h^B \tag{19}$$

and

$$\bar{C} + p_2^A C_l^A + (1 - p_2^A) C_h^A > C_d > \bar{C} + p_2^B C_l^B + (1 - p_2^B) C_h^B \tag{20}$$

Now, if $C_l^A = C_l^B$ and $C_h^A = C_h^B$, then players move to different destinations. However, if one considers the specific case of $C_l^A < C_l^B$ and $C_h^A = C_h^B$ then player 1 chooses to move in the first period. But player 2 may choose to wait given irreversible offshoring. Depending on the first period output and the updated beliefs of player 2, player 2 may choose to follow player 1 in period 2 to maximise profits over the two periods in the way described in the game. This case of player 2 choosing to ignore his own signals and information so as to follow player 1 forms the case for herding in offshoring.

I note here that herding occurs only in the case where precision for the rival destination remains unchanged or decreases across periods. It may be that the rival destination's precision or the range $(C_h - C_l)$ changes and then one may have no herding. It depends on the values of the parameters.

I look at the implications of the results and intuitions derived so far in this paper in the next section.

6 Discussion

Looking back into the results derived in this paper, I tried to analyse the strategic decision making process of firms in deciding firstly whether to offshore or not in a world of increasing production costs and the presence of hidden costs due to offshoring where signals with imperfect precision are available to indicate the level of hidden costs. I looked specifically at the strategic interactions that may be present amongst competing firms to increase profits by reducing costs through offshoring their production process. In this regard I started with a Cournot duopoly setup and later brought out implications of the first mover into offshoring becoming the Stackelberg leader .

Our first result looked at a threshold value of the precision required in favour of the offshore location having a low hidden cost. I have held precision to be exogenous for most part of the analysis in this paper and this threshold value is exogenous to the system and is not determined by the levels of domestic and foreign costs or hidden costs. Thinking of a coninuous distribution in place of the binary setup that I have used would imply that the larger the distribution the lower would be the density in favour of a lower hidden cost.

I then chalked out the game and how it is played amongst the two players receiving signals about the hidden costs. I offered two possible Bayesian Nash Equilibria viz: Separating and Pooling in this context. It was showed that the first mover would reveal the true costs in a case when the hidden cost distribution is sufficiently wide which makes mimicing the other type unprofitable. In the separating case the gains out of mimicing (arising due to keeping the other player away from offshoring to the location) fall short of the loss incurred by trying to mimic the other type. Correspondingly, I found that both types would pool and produce the same output in order to keep the second player away from offshoring(such that profits are not shared) in a case where the distribution of hidden costs is smaller and within a certain range. This holds true only when the belief of the second player gets imperfectly updated from the actions of the first player.

Next an extension looking at the destination choice between two competing destinations giving two signals about their hidden costs was offered. Through various cases and analyses it was showed that the destination with higher precision would attract offshore outsourcing ventures when the hidden cost distribution of both destinations is identical along with the component of known cost. However if precision in favour of low hidden costs is lower for a particular destination it can still be preferred for offshore outsourcing if the hidden costs distribution of the destination is smaller than the competing destination with the difference in expected ranges of hidden costs of the two destinations being lower than the difference in higher limits of the hidden costs across the destinations. Hence my main conclusion from this section of the paper is that for a destination to be a preffered offshoring destination it must either increase precision in favour of it being a low cost destination or it must lower the range of its distribution of hidden costs by way of lowering the possible higher value of hidden costs.

The case of the players receiving opposing signals is analysed next. Here I showed that imperfect information regarding the hidden costs of a particular destination may lead a player to restrict his move towards offshoring to a destination where she believes hidden costs to be lower and follow the first mover especially in the case where the lower hidden costs of the first mover's location is lower than the lower hidden cost of the competing destination. This is the case of herding behaviour in offshoring. It is good to specify that this is one of the possibilities and one cannot say that herding will occur for certain. It depends on the parameters and the updating of beliefs as highlighted in section 3. Additionally if precision varies for a location across periods there is a chance that herding would not occur.

7 Conclusion

In this paper I have looked at the micro aspects of offshore outsourcing decision making in the presence of hidden costs and signals of imperfect precision to indicate the level of hidden costs. I have formulated the analysis as a Bayesian game and have tried to look at the offshoring decision in a two period framework where firms interact to finally lead to interesting outcomes primarily based on the precision of signals, updating due to observation of moves by the first mover and the range of hidden costs.

The primary conclusion is that a destination that has a lower dispersion of hidden costs or a high precision in favour of low hidden costs would be a more preferred offshore destination barring cases where the distribution is very large but the density is heavily skewed in favour of the low cost side of the distribution. The first mover in case of any destination would choose to fully reveal the hidden cost faced by her in the occassion when the hidden cost distribution is very large and would choose to mimic and pool if the distribution is fairly small such that the second player cannot perfectly infer the hidden cost and hence may choose not to follow at all.

I also look at the formation of precisions and show that the precision in favour of a destination being a lower cost one is higher for geographies where a firm has presence otherwise in serving customers of that geography. This in effect explains why one finds MNCs to be moving in favour of offshoring before other firms.

In terms of policy implications, the analysis would suggest that countries seeking to grow their offshoring attractiveness should concentrate on lowering the range of hidden costs involved in working in their geography, reduce the lower limit of hidden costs as much as possible or else increase the precision in favour of hidden costs through proper policy moves which get highlighted in the international media. Initiatives of the government may include advertising, bilateral agreements with countries, initiatives to lower cultural differences etc.

The analysis can be further extended and future research on the impact of bilateral agreements and treaties between two nations towards protecting investor rights etc could be brought into this model, however the basic conclusions laid out in the paper would still hold true at a broad level.

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A Appendix 1

PROOF of Observation 1.

I simplify equation 8 and write it as:

$$F(C_h, C_d)q_1^{HS} + \delta[G(C_h, C_d)]q_1^{HC}(C_h, C_d) \geq F(C_h, C_l, C_d)q_1^{LS} + \delta[G(C_h)]q_1^{HC}(C_h)$$

where, $F(C_h, C_d) = [P^{HS} - (\bar{C} + C_h)]$ and P^{HS} is a function of C_d and C_h. $G(C_h, C_d) = [P^{HC}(C_d, C_h) - (\bar{C} + C_h)]$ and similarly for the others.

Now, from here I get the inequality expression that gives the lower bound for q_1^{HS} i.e.

$$F(C_h, C_d)q_1^{HS} \geq F(C_h, C_l, C_d)q_1^{LS} + \delta[G(C_h)]q_1^{HC}(C_h) - \delta[G(C_h, C_d)]q_1^{HC}(C_h, C_d)$$

Keeping all else unchanged I differentiate this expression wrt C_l. I note that the only term affected is the first term on the R.H.S..So differentiating this term I get:

$$F_{C_l}()q_1^{LS} + F()q_{1C_l}^{LS}$$

Now it is known that for a given demand function and the costs of production C_h, q_1^{HS} is the profit maximising Stackelberg output. For any increases in output produced the price obtained per unit is lower and costs increase along with quantity to be produced linearly. In other words as player 1 produces more output his revenues increase less than his costs given the assumption of non increasing marginal revenues. Hence at the given cost C_h it becomes more and more unprofitable to produce more output.

Hence for conventional demand functions with decreasing marginal revenue this expression comes out to be positive.

So, as C_l decreases, the RHS reduces in value. Hence the inequality holds more strongly. Thus the higher is $(C_h - C_l)$ the stronger the possibility of the high type to reveal his true hidden cost.

Hence observation 1 stands proved.

B Appendix 2

Qualitative proof of one IC binding in the pooling equilibrium:

ICH:

$$\begin{aligned} &[P^P - (\bar{C} + C_h)]q^p \\ &+(1-\bar{p})[\delta\{P^{HC}(C_d, C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h, C_d)] \\ &+\bar{p}[\delta\{P^{HC}(C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h)] \\ &\geq [P^{HS} - (\bar{C} + C_h)]q_1^{HS} + \delta[P^{HC}(C_h) - (\bar{C} + C_h)]q_1^{HC}(C_h) \end{aligned} \tag{21}$$

which can be written alternatively as:

$$\begin{aligned} &[P^P - (\bar{C} + C_h)]q^p \\ &\geq [P^{HS} - (\bar{C} + C_h)]q_1^{HS} + \delta[P^{HC}(C_h) - (\bar{C} + C_h)]q_1^{HC}(C_h) \\ &-(1-\bar{p})[\delta\{P^{HC}(C_d, C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h, C_d)] \\ &-\bar{p}[\delta\{P^{HC}(C_h) - (\bar{C} + C_h)\}q_1^{HC}(C_h)] \end{aligned} \tag{22}$$

ICL:

$$\begin{aligned}
&[P^P-(\bar{C}+C_l)]q^p\\
&+(1-\bar{p})[\delta\{P^{LC}(C_d,C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l,C_d)]\\
&+\bar{p}[\delta\{P^{LC}(C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l)]\\
&\geq[P^{LS}-(\bar{C}+C_l)]q_1^{LS}+\delta[P^{LC}(C_l)-(\bar{C}+C_l)]q_1^{LC}(C_l)
\end{aligned}\tag{23}$$

which can be written alternatively as:

$$\begin{aligned}
&[P^P-(\bar{C}+C_l)]q^p\\
&\geq[P^{LS}-(\bar{C}+C_l)]q_1^{LS}+\delta[P^{LC}(C_l)-(\bar{C}+C_l)]q_1^{LC}(C_l)\\
&-(1-\bar{p})[\delta\{P^{LC}(C_d,C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l,C_d)]\\
&-\bar{p}[\delta\{P^{LC}(C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l)]
\end{aligned}\tag{24}$$

Now it may be noted that LHS of the IC of the high type is less than LHS of IC of the low type. Similarly RHS of high type IC is less than RHS of low type IC. Given that, if LHS of the IC of the high hidden cost type is greater than the RHS of the low hidden cost, then the IC of the high type alone guarantees the low type IC as well. It is easy to note that as C_l increases profitability of the low hidden cost type falls. Hence leaving C_h unchanged one may get a situation where both inequalities are simultaneously satisfied.

PROOF of Observation 2:

Following on from above,:

$$\begin{aligned}
[P^P-(\bar{C}+C_h)]q^p \geq\ &[P^{LS}-(\bar{C}+C_l)]q_1^{LS}+\delta[P^{LC}(C_l)-(\bar{C}+C_l)]q_1^{LC}(C_l)\\
&-(1-\bar{p})[\delta\{P^{LC}(C_d,C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l,C_d)]\\
&-\bar{p}[\delta\{P^{LC}(C_l)-(\bar{C}+C_l)\}q_1^{LC}(C_l)]
\end{aligned}\tag{25}$$

Now concentrating on the above equation if one lowers C_h keeping other things unchanged, the LHS increases and the inequality holds more strongly. Hence the ICs become stronger. Thus the IC of pooling holds more strongly if the values of hidden cost C_h and C_l are close and get violated when the hidden cost distribution has a large range. **[Proved]**

C Appendix 3

I show the validity of observation 1 for the linear example considered. Here:

$F(C_h,C_l,C_d)=[\frac{a+C_d+2(\bar{C}+C_l)}{4}-(\bar{C}+C_h)]$

$q_1^{LS}=(a+C_d)/2b-(\bar{C}+C_l)/b$

Now, the expression of interest is:

$$F_{C_l}()q_1^{LS} + F()q_{1C_l}^{LS}$$

$$= \frac{1}{2}[\frac{(a+C_d)}{2b} - \frac{(\bar{C}+C_l)}{b}] - \frac{1}{b}[\frac{(a+C_d+2(\bar{C}+C_l)}{4} - (\bar{C}+C_h)]$$

$$= \frac{(C_h-C_l)}{b} > 0$$

Hence as C_l decreases keeping C_h constant the IC of the high type holds more strongly and hence his incentive to reveal improves.