Mechanism design and incentives' engineering

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Abstract. *Is 'information' truthful? Do contractors have the incentive to lie and / or disobey? If they do, how can we make them tell the truth and obey? How well does a social institution perform in its communication of information and coordination role? Does it need reform? What may be a feasible and desirable social plan and how can we make the institution implement it without any problems associated with information asymmetry? My objective is to show how agents may eliminate adverse selection and moral hazard through engineering of incentive-compatible constraints.*

Keywords. Incentives, Mechanism Design, Market System, Social Plan, Theory of the Firm.

1 Introduction

According to Myerson [17, 587], mechanism design can expand "our general view of the economic problem to include incentive constraints as well as resource constraints". Hayek [7] recommended that a social institution (such as the market system) should be viewed as a mechanism for communicating people's information and coordinating people's actions. In a market system, the actions of a market participant depend on *information* provided by other participants and on the ability of the system to coordinate the participants towards an economic outcome (preferably Pareto optimum).

As Kantarelis [9, ch. 8] and other researchers[1] ask, is *information* truthful? Do participants have the incentive to lie and / or disobey? If they do, how can we make them tell the truth and obey? For example, insurance firms are always searching for mechanisms that minimize adverse selection and moral hazard. (The problem of getting to share information honestly is called adverse selection. The problem of getting people to act obediently to a plan is called moral hazard.) Conventionally, auto insurance firms rely on deductible menus, client's recorded driving history, client's age and gender, type of car, color of car, car's technology (e.g., insurance for hybrids is more expensive relative to non-hybrids), number of traffic tickets and accidents, and so on.[2]

Similarly, banking firms try to distinguish between high / low risk borrowers (through their credit history), charge higher (lower) interest rates for high (low) risk borrowers, require a higher (lower) down payment for high (low) risk borrowers, limit the down payment so that profit does not fall below zero, and so on.[3]

Bidders in Second-Price Sealed-Bid auctions, in which the auctioneer awards the item to the high bidder who pays the amount bid by the second highest bidder have the incentive to bid honestly. Consider the following example: Let B be a bidder with the highest valuation of $300; $300 is B's true value.

If B bids $400 and the second highest bid is $200, B is awarded the item for a profit of $100 (but, a bid of $300 generates the same amount of profit.) If B bids $350 and the

second highest bid is $325, B is awarded the item but at a loss of $25. B, in this case, experiences the winner's curse. Hence, there is no incentive to bid above $300.

If B bids $250 and the second highest bid is $200, B makes a profit of $100 (the same profit that would result from the truthful bid of $300). But, if B bids $250 and someone else bids $270, B loses the auction. Hence, there is no incentive to bid below $300.

Hence, in Second-Price Sealed-Bid Auctions, or Vickrey [24 Auctions, the *revelation principle* applies: truthful revelation of bids is a dominant strategy.

How well does a social institution perform in its communication of information and coordination role? Does it need reform? What may be a feasible and desirable social plan and how can we make the institution implement it?

Consider the following example offered by Myerson: suppose a buyer and a seller (both risk-neutral, and expected profit maximizes) are willing to trade for an object so that nobody becomes worse off; their types (known only to them) are "Strong" and "Weak" each with a probability of 0.5. Obviously if both the buyer and the seller are strong, trade between the two would not take place. Table 1 displays values before trade.

Table 1 Before trade

			Buyer's type & value: Strong (0.5)	Buyer's type & value: Weak (0.5)
			$20	$100
Seller's type & value	Strong (0.5)	$80		
	Weak (0.5)	$0		

2 Coordination Mechanism 1: Split-the-Difference plan

> *Trade whenever the buyer's value is more than the seller's value, and the recommended price is always halfway between their two values.*

Table 2 displays the implied results of this split-the-difference plan. In each cell, the number on the right is the price to trade at; the number on the left is the conditional probability that the trade in that cell will take place.

Table 2 Split-the-difference plan

			Buyer's type & value: Strong (0.5)	Buyer's type & value: Weak (0.5)
			$20	$100
Seller's type & value	Strong (0.5)	$80	0, no trade	1, $90
	Weak (0.5)	$0	1, $10	1, $50

Thus, in 3 out of 4 cases this coordination mechanism enables the market participants to achieve mutually beneficial trades; hence, at first glance, the mechanism appears rational and fair. But, because types are private information, participants may find it advantageous to lie about their real types.

Let w = weak seller, s = strong seller, and ws = weak seller who pretends to be strong. For example, if the seller were weak, his expected profit would be:

$E(\Pi)w = (10 - 0)(1)(0.5) + (50 - 0)(1)(0.5) = 30.$

If the seller is weak, but he pretends to be strong his expected profit would be:

$E(\Pi)ws = (90 - 0)(1)(0.5) = 45.$

Thus, because $E(\Pi)ws > E(\Pi)w$, the seller has the incentive to lie.

Similarly, the buyer has the incentive to lie. Therefore, this split-the-difference coordination mechanism is not incentive compatible which implies that trade would not occur.

3 Coordination Mechanism 2: Symmetric Mediation plan

Consider now a different mediation plan as shown in Table 3. The cells, as above, contain probabilities and prices, where q is a conditional probability applied to the respective cells; the conditional probability for (weak, weak) remains 1.

Table 3 Symmetric mediation plan

			Buyer's type & value: Strong (0.5)	Buyer's type & value: Weak (0.5)
			$20	$100
Seller's type & value	Strong (0.5)	$80	0, no trade	q, $100 - y
	Weak (0.5)	$0	q, $0 + y	1, $50

According to Myerson (p. 591), "the probability of trade could also be interpreted as the conditional expected number of objects that the buyer would get in this case, and so $q \leq 1$ here can also be interpreted as a *resource constraint*, expressing the fact that there is only one object that they can trade; … for a strong trader to participate in this plan, y must satisfy the *participation constraint* $y \leq 20$." Proceeding as above, if the seller were weak, his expected profit would be:

$$E(\Pi)w = (y - 0)(q)(0.5) + (50 - 0)(1)(0.5) = 0.5qy + 25.$$

If the seller is weak, but he pretends to be strong his expected profit would be:

$$E(\Pi)ws = (100 - y - 0)(q)(0.5) = 0.5q(100-y).$$

Thus, to make honesty an equilibrium, q and y must satisfy the informational constraint

$$0.5qy + 25 \geq 0.5q(100-y).$$

Solving for q,

$$q \leq 25/(50 - y).$$

Therefore, the incentive constraints $\mathbf{q \leq 25/(50 - y)}$ and $\mathbf{y \leq 20}$ can generate an infinite number of possible incentive compatible plans. Consider the following examples:

(i) q = 5/6 when y = 20; at these values,

$E(\Pi)w = E(\Pi)ws = 33.33$

$E(\Pi)s = 0;$

(ii) q = 5/8, when y = 10; at these values,

$E(\Pi)w = E(\Pi)ws = 28.125$

$E(\Pi)s = 3.125;$

(iii) q = ½, when y = 0; at these values,

$E(\Pi)w = E(\Pi)ws = 25$

$E(\Pi)s = 5.$

In all examples, the expected profit from honesty is as much as the expected profit from lying.

Another example: As above, consider two traders: a seller (S) and a buyer (B). The seller believes that the buyer is strong or weak with probabilities of 0.5 and 0.5. Similarly, the buyer believes that the seller is strong or weak with probabilities of 0.5 and 0.5. Consider a mediator to whom S and B report the following reservation prices: seller strong = 100, seller weak = 10, buyer strong = 40, buyer weak = 120.

Consider the following mediation plan: no trade can take place when the traders are both strong; if they are not, they can trade subject to "split the difference" as indicated in the matrix below (where, in each cell, the number on the left is the probability of trade taking place and the number on the right is the average of the reservation prices that correspond to the cell.)

(1) Would this mediation plan work? Why yes, why not?
(2) If not, what mediation constraints may be introduced to make the traders honestly trade with each other?

			Buyer's type & value: Strong (0.5)	Buyer's type & value: Weak (0.5)
			$40	$120
Seller's type & value	Strong (0.5)	$100	0, no trade	1, $110
	Weak (0.5)	$10	1, $25	1, $65

Answers:

(1) For the seller:

$E(\Pi)w = (25 - 10)(1)(.5) + (65 - 10)(1)(.5) = 35;$

$E(\Pi)ws = 0 + (110 - 10)(1)(.5) = 50$.
Since 50 > 35, dishonesty would pay off for the seller.

For the buyer:

$E(\Pi)w = (120 - 110)(1)(.5) + (120 - 65)(1)(.5) = 30$;

$E(\Pi)ws = 0 + (120 - 25)(1)(.5) = 47.5$.

Since 47.5 > 30, dishonesty would pay off for the buyer.

Therefore, subject to split-the-difference mediation plan, both the buyer and the seller would have the incentive to be dishonest.

(2) Alternatively, the mediator may set the problem as seen in the matrix below and then search for appropriate values of "q" and "y" that will generate incentive compatibility.

			Buyer's type & value: Strong (0.5)	Buyer's type & value: Weak (0.5)
			\$40	\$120
Seller's type & value	Strong (0.5)	\$100	0, no trade	q, \$120 - y
	Weak (0.5)	\$10	q, \$10 + y	1, \$65

For the seller:

$E(\Pi)w = (10 + y - 10)(q)(.5) + (65 - 10)(1)(.5)$
$E(\Pi)ws = (120 - y - 10)(q)(.5)$;

for honesty,

$E(\Pi)w \geq E(\Pi)ws$

or,
$yq + 55 \geq 110q - yq$

or,

$q \leq 27.5/(55 - y)$.

For the buyer:

$E(\Pi)w = (120 - y - 120)(q)(.5) + (120 - 65)(1)(.5)$

$E(\Pi)ws = 0 + (120 - 10 - y)(q)(.5)$;

for honesty,

$E(\Pi)w \geq E(\Pi)ws$

or,

$yq + 55 \geq 110q - yq$

or,

$q \leq 27.5/(55 - y)$.

Therefore, the incentive constraints **$q \leq 27.5/(55 - y)$** and **$y \leq 20$** can generate an infinite number of possible incentive compatible plans.

4 Microfinancing as an application of mechanism design

Descriptive measures on the condition of the poor around the world generate a picture of misery. According to Risse (2005, p.349), the globe's population, through time is becoming worse off:

- 20% live on less than \$1 per day;
- 50% live on less than \$2 per day;
- 25% is illiterate;
- The infant mortality rate for 2.5 billion people is over 100 per 1000 births (compared to 6 per 1000 in high-income countries);
- The ratio of per capita income between global rich and poor was 3 to 1 in 1820, 60 to 1 in 1960, and 74 to 1 in 1997.

Risse (p. 366) also describes a world suffering from "radical inequality" which he defines as follows:

> (1) The worst off are very badly off in absolute terms; (2) They are also very badly off in relative terms, much worse off than others; (3) The inequality is impervious: it is difficult or impossible for the worse-off substantially to improve their lot, and most of the better-off never experience life at the bottom and have no vivid idea of what it is like to live in that way; (4) The inequality is pervasive: it concerns not merely some aspects of

> life, but most aspects of life or all; (5) The inequality is avoidable: the better-off can improve the circumstances without becoming badly off themselves.

Against this representation of misery though, there is a little picture of hope drawn up, as we speak, by microfinance practitioners (banks and other institutions) all over the world, currently alleviating economic problems for over 100 million people. As Morduch [17, 1569] very eloquently writes,

> (a)mid the dispiriting news, excitement is building about a set of unusual financial institutions prospering in distant corners of the world - especially Bolivia, Bangladesh, and Indonesia. The hope is that much poverty can be alleviated – and that economic and social structures can be transformed fundamentally – by providing financial services to low-income households. These institutions, united under the banner of microfinance, share a commitment to serving clients that have been excluded from the formal banking sector. Almost all of the borrowers do so to finance self-employment activities, and many start by taking loans as small as $75, repaid over several months or a year. Only a few programs require borrowers to put up collateral, enabling would-be entrepreneurs with few assets to escape positions as poorly paid wage laborers or farmers.

An example of a microfinance bank is the Grameen Bank in Bangladesh established by Muhammad Yunus (Peace Nobel Laureate 2006) to help desperately poor people. The bank seeks the poorest borrowers and it requires no collateral for small loans. The bank rests on the strength of its borrowers, mostly women, who are required to join the bank in self-formed groups of five. The group members provide one another with peer support in the form of mutual assistance and advice (the deal does more for each than each could do on her own.) Additionally, the group borrowers allow for peer discipline by evaluating business viability and ensuring repayment. If one member fails to repay a loan, all members risk having their line of credit suspended or reduced which keeps opportunism – adverse selection and moral hazard - at a minimum.

The business model of a microfinancing institution is based on an incentive-compatible coordination plan built around incentive constraints to curtail dishonesty and disobedience. As explained by Myerson [17, 588] the problem of getting borrowers to share information truthfully is called adverse selection whereas the problem of getting borrowers to act dutifully to a coordination plan is called moral hazard.

4.1 Microfinancing and adverse selection

Consider risk-neutral individual investors, each able to realize income Y as a member of the labor force. Group the investors into two type groups, safe (s) and risky (k), where risky fail more often than safe with probabilities of success p_s and p_k. Letting R=return and E(R)=expected return, each type can undertake a business project, which requires one unit of capital, with expected returns,

$E(R)_s = p_s R_s$

and

$E(R)_k = p_k R_k$
where $p_s > p_k$ and, when successful, $R_s < R_k$.

For simplicity, let

$p_s R_s = p_k R_k = E(R)$.

Assume now that the investors may borrow money for their respective business projects at a certain interest rate and that the loan does not require any collateral what so ever. Naturally, the lending institution will charge a higher interest rate for the risky types if it knows who they are and/or if it knows their probabilities of success; but, because it does not, it charges a uniform rate r. Therefore, each type will borrow if their expected net returns are as follows:

$[E(R) - rp_s] > Y$

and

$[E(R) – rp_k] > Y.$

But, because $[E(R) - rp_s] < [E(R) – rp_k]$, depending on the value of Y, only the risky types may find it advantageous to borrow money, in which case the lending institutions adversely select their borrowers; in other words they end up with the "lemons". Hence, adverse selection may occur when

$[E(R) - rp_s] < Y < [E(R) – rp_k].$

For example, if

$E(R)=10$, $r=0.2$, $p_s=0.8$, $p_k=0.2$ and $Y=9.90$,

then

$[E(R) - rp_s]=9.84 < 9.90$
while

$[E(R) – rp_k]=9.96 > 9.90;$

hence, only the risky types would apply for loans.

4.2 Group-lending and the mitigation of adverse selection problems

The above analysis implies that adverse selection will cause lenders to drop out or, at best, to charge prohibitively high rates with adverse consequences in terms of efficiency gains as they relate to economic development and growth. Obviously, lenders would have more incentive to service financial markets if in addition to loaning to risky types they could loan to safe types. Ghatak [5] and Ghatak and Guinnane [6], in their seminal papers, show how group-lending may come to the rescue; according to them, the lender (who like above does not know who the borrowing types are or their probabilities of success) may ask borrowers to apply in groups, subject to the following group-lending conditions (let groups consist of only two individuals):

- Without collateral, a group of two individuals apply for loans;
- Each individual in the group invests independently (each individual starts and manages her own business);
- Each borrower in the group pays nothing if her project fails;
- Each borrower pays a success fee *m* if her project succeeds;
- Each successful borrower pays a joint-liability fee *F* if the group mate fails.

Subject to the above conditions the following possible groups may form: Safe with Risky, Safe with Safe, and Risky with Risky. Since Morduch [16,158] has shown that "there is no mutually beneficial way for risky and safe types to group together" we proceed with groups characterized by common types: safe team up with safe, and risky team up with risky.

Hence, the net expected returns of the Safe/Safe partnership would be

$(\text{Net Expected Return})_s = E(R) – [m + F(1-p_s)]p_s$

where

$[m + F(1-p_s)]p_s = (\text{Price of Loan})_s,$

and the net expected returns of the Risky/Risky partnership would be
$(\text{Net Expected Return})_r = E(R) – [m + F(1-p_k)]p_k$

where

$[m + F(1-p_k)]p_k = (\text{Price of Loan})_k.$

The group-contract does not allow the lender to charge different fees to different types (the fees of *m* and *F* are common); but if *m* and *F* are selected appropriately price discrimination would be possible. For example,

if $p_s=0.9$, $p_r=0.8$ and $F>1.4m$,

then

$(\text{Price of Loan})_s < (\text{Price of Loan})_k$

and

$(\text{Net Expected Return})_s > (\text{Net Expected Return})_k.$

Thus, as the above example demonstrates, with suitable *m* and *F*, a group-lending contract can enable the lender to effectively price discriminate so that the likelihood of safe entrants increases. With safe borrowers among lenders' clients, rates of repayments would rise and borrowing rates would fall.

4.3 Group-lending and the mitigation of moral hazard

After contracts are signed borrowers may decide to act disobediently (in other words, decide to take risky activities instead of safe) thus committing moral hazard with adverse consequences for lenders' profits. As in Stiglitz [23] and Besley and Coate [2], assume that borrowers are risk-averse and that their utility functions are U(x), where $x = R_i - (m+F)$, i=s, k. With groups and contracts as above, each teammate may choose to undertake the safe activity with expected utility

$$E(U)_s = \mathbf{p_s^2}\, U(R_s - m) + p_s(1 - p_s)U(R_s - m - F),$$

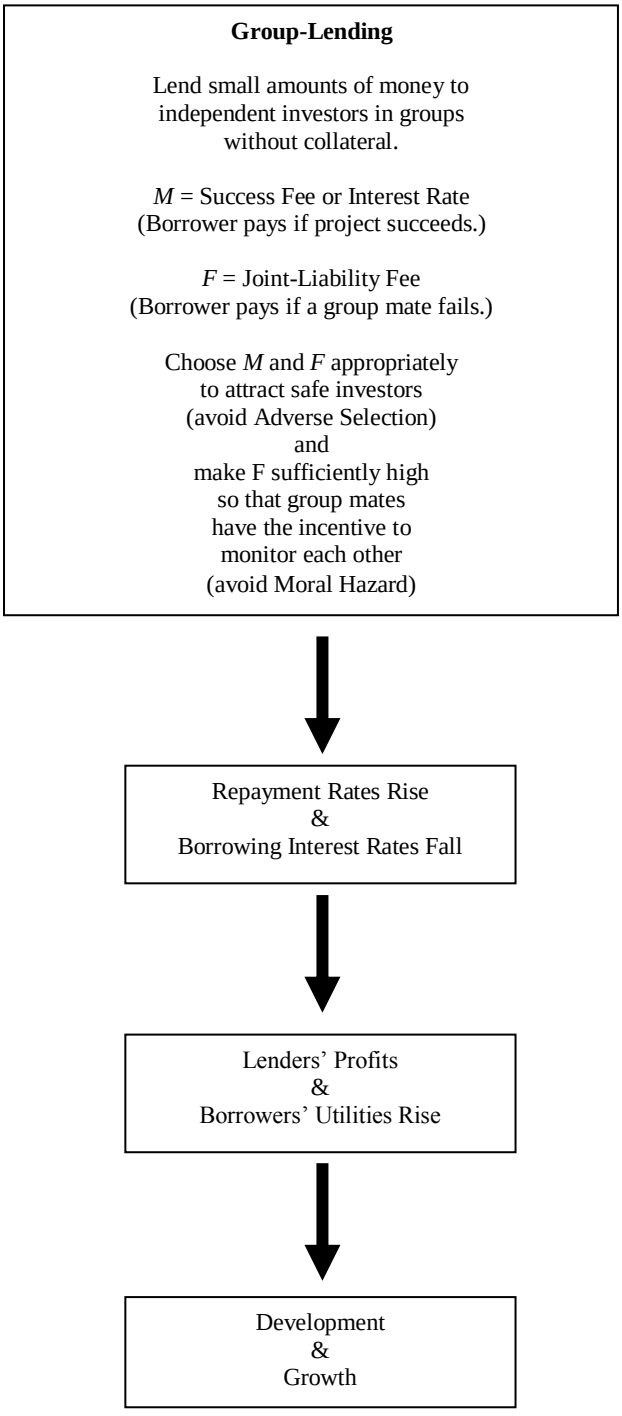
or the risky activity with expected utility

$$E(U)_k = \mathbf{p_k^2}\, U(R_k - m) + p_k(1 - p_k)U(R_k - m - F).$$

Obviously, borrowers would always choose to undertake safe instead of risky activities if the joint-liability fee *F* in the group-lending contract is set high enough so that $E(U)_s > E(U)_k$. (Naturally, to offset the cost burden to its clients the lender may lower *m*.) A high joint-liability *F* will induce groups to self-regulate (see that contracts are enforced via mutual monitoring) and thus
minimize costs associated with moral hazard. In turn moral hazard avoidance will contribute to lower borrowing rates, to higher repayment rates and of course to higher levels of expected utility.

Group-lending is nothing more than an incentive-compatible coordination plan (or mechanism) which satisfies certain incentive constraints for the avoidance of adverse selection and moral hazard. (See Figure 1 for a summary of conditions and results.) It hinges on appropriately selecting an interest rate and a joint-liability fee so that lending firms do not exclude safe or good risk borrowers; the inclusion of such borrowers implies that repayments would rise (causing lenders' profits to increase) and that average market borrowing rates would fall (causing lenders to sell more loans and experience even higher profits.) Undoubtedly, the mechanism is "win-win" since it offers incentives to borrowers to succeed and to experience higher utility levels, with positive implications for development and growth.

Figure 1. Group-lending as an incentive-compatible coordination plan



Banks, upon satisfactory repayment of small loans, may lend larger amounts especially in low mobility areas where it is less likely for defaulters to escape. This perhaps explains why most clients are women. As explained by Morduch [16, 1583] "the lower mobility of women may be a plus where ex post moral hazard is a problem (i.e., where there is a fear that clients will 'take the money and run')." Additionally, as reported by Rahman (1998), women are more sensitive to verbal hostility by fellow teammates and bank employees; they cannot shake off failure as easily as men.

Microfinancing is an excellent example of mechanism design and it enables us to better understand issues around poverty in association with markets and new institutions. In spite of its elegance as a mechanism to minimize adverse selection and moral hazard, unfortunately, it is not "the" solution to poverty. First of all, those who receive the micro-loans, primarily, help themselves (they supplement their incomes by starting their own small business enterprises) without hiring anybody else. As stressed by Morduch [16, 1609-1610] "All else the same it remains far more costly to lend small amounts of money to many people than to lend large amounts to a few. … The best evidence to date suggests that making a real dent in poverty rates will require increasing overall levels of economic growth and employment generation."

5 Conclusion

Based on the work of Myerson it has been shown how agents may eliminate adverse selection and moral hazard through incentive-compatible constraints engineered by a coordinator or social planner. The *social planner* may be a regulated institution (market), a governmental entity, a firm, an entire industry, a union, any elected officials in their capacity to introduce new laws (coordination rules) and any other non-governmental organization such as UN, Word Bank and International Monetary Fund among many more.

Microfinancing, despite its ineffectiveness in eliminating poverty, was utilized as an example of mechanism design with lenders serving as social planners.

6 Endnotes

1. See Hurwicz [8]; Maskin and Sjöström [14]; Baliga and Maskin [1]; Palfrey [19]; Serrano [22]; Salanié [21]; Fudenberg and Tirole [4]; Krishna [12]; Mas-Colell [13]; Whinston and Green [13]; Corchón [3]; Moore [15]; Osborne and Rubinstein [18]; and Jackson [9]

2. For more on insurance markets see Kantarelis [10, ch. 2]

3. For more on the banking firm see Kantarelis [11]

References

[1] Baliga, S. and E. Maskin: **Mechanism design for the environment**, in K. Mäler and J. Vincent (eds.), Handbook of Environmental Economics. Elsevier Science, Amsterdam, 2003

[2] Besley, Timothy and Stephen Coate: **Group Lending, Repayment Incentives, and Social Collateral**, *Journal of Development Economics, 46, 1995*

[3] Corchón, L.: **The Theory of Implementation of Socially Optimal Decisions in Economics**. Palgrave Macmillan, 1996.

[4] Fudenberg, D. and J. Tirole: **Game Theory,** MIT Press, 1993

[5] Ghatak, Maitreesh, **Group Lending, Local Information and Peer Selection**, Journal of Development Economics, Vol 60, #1, October 1999

[6] Ghatak, Maitreesh and Timothy W. Guinnane: **The Economics of Lending with Joint Liability : Theory and Practice** Journal of Development Economics, Vol 60, #1, October 1999 (See also erratum in Volume 69, Issue 1, October 2002).

[7] Hayek, Friedrich A.: **The Use of Knowledge in Society**, *American Economic Review*, Vol XXXV, #4, 1945, pp. 519-30.

[8] Hurwicz, L.: **The design of mechanisms for resource allocation**, American Economic Review 63, Papers and Proceedings, 1973, pp 1-30.

[9] Jackson, M.: **A crash course in implementation theory**, Social Choice and Welfare 18, 2001, pp 655-708.

[10] Kantarelis, Demetri: **Theories of the Firm,** 3rd ed., Inderscience, 2010

[11] Kantarelis, Demetri (2010): **The Banking Firm: Theoretical Principles and their Violations in the USA**, International Journal for Business Continuity and Risk Management, Volume 1, Issue 3, 2010, pp 222-232.

[12] Krishna, V.: **Auction Theory**. Academic Press, New York, 2002

[13] Mas-Colell, A., Whinston M., and J. Green: **Microeconomic Theory**, Oxford University Press. 1995

[14] Maskin, E. and T. Sjöström: **Implementation theory**, in K. Arrow, A.K. Sen and K. Suzumura (eds.), Handbook of Social Choice and Welfare, Vol. 1. Elsevier Science, Amsterdam, 2002

[15] Moore, J. : **Implementation, contracts, and renegotiation in environments with complete information**, in J.J. Laffont (ed.), Advances in Economic Theory (Sixth World Congress) Vol. 1. Cambridge University Press, Cambridge, 1992

[16] Morduch, Jonathan: **The Microfinance Promise**, Journal of Economic Literature, December, Vol XXXVII, #4, 1999, pp 1569-1614.

[17] Myerson, Roger B.: **Perspectives on Mechanism Design in Economic Theory**, American Economic Review, Vol 98, #3, 2008, pp 586-603.

[18] Osborne, M. and A. Rubinstein: **A Course in Game Theory**. MIT Press, 1994

[19] Palfrey, T.: **Implementation Theory**, in R. Aumann and S. Hart (eds.), Handbook of Game Theory Vol. 3. North-Holland, Amsterdam, 2001

[20] Royal Swedish Academy of Sciences (Prize Committee), **Mechanism Design Theory**, http://nobelprize.org/nobel_prizes/economics/laureates/2007/ecoadv07.pdf

[21] Salanié, B.: **The Economics of Contracts**. MIT Press, 1997

[22] Serrano, R.: **The theory of implementation of social choice rules**, SIAM Review 46, 2004, pp 377-414.

[23] Stiglitz, Joseph: **Peer Monitoring and Credit Markets**, World Bank Economic Review, 4:3, 1990, pp 351-366

[24] Vickrey, W.: **Counterspeculation, auctions and competitive sealed tenders**, Journal of Finance 16, 1961, pp8-37.