Applications of Unawareness

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1 Introduction

Intuitively, when we don't know a thing, it is possible that we still know our ignorance, yet it is also possible that we ignore our ignorance, and here comes *unawareness*.

Economists used to assume that the economic agents fully understand the game or the economic model as much as they do. For example, all agents have full knowledge about all possible states of nature and the identity, the possible actions and the information types of all agents. However there are many questions can not be properly addressed without relaxing this restriction. The study of unawareness hereby comes.

We understand that unawareness is a type of ignorance and its complement can be named *impreciseness*, which can be described by "I know that I don't know". The difference between them takes place when we want to model the effect of ignorance on an agent's decision. Impreciseness is equivalent to the notion of incompleteness of information, conventionally presented as an information partition of the state space. Thus taking all possibilities into consideration, an agent calculates the expected payoff function given her belief. When unawareness is the case, the agent's information structure is not only coarse but also truncated, thus her calculation may not exploit all relevant information. For example, the payoff function might have fewer arguments (say other agents' types) than it should.

The factor causes an agent to be unaware can be bounded observability, like color blindness or blindspot. It may also be bounded resource as addressed by Simon (1955). Aragones et al. (2003) make a formal argument that when computational resources run out, individuals may arrive at imperfect descriptions of the world and therefore they may be unaware of the descriptions other people use. Other reasons like limited experience and education can also be valid.

Some researchers (Congleton, 2001) gave primary thoughts on unawareness that since an agent with

unawareness gathers data from a restricted domain; consequently her estimates can be systematically biased. Although from the point of view of another agent or the outside analyst her choice is "irrational" or mistaken, she can be rational in the sense that she uses all the information she has to make the best choice. It is in the same spirit of conventional incomplete information model. Therefore, if rationality does not exclude imprecise information, it shall not exclude unawareness information either. As we will see later, one of the main virtues of unawareness concept is that, compared to other "behavioral regularities", it is a natural extension of current theory of incomplete information, and thus it is not difficult to use it in a consistent way.

2 Some Early Examples

The following examples demonstrate some behavioral notions related to unawareness in the early literature.

The first influential economic models which implicitly consider unawareness is the theory of involuntary unemployment by Friedman (1968) and Phelps (1968). They explain that an increase in inflation could lead to an increase in employment for a short term, because of the adaptive expectations of workers (the expectation of current year inflation is extrapolated from past inflation experience). This assumption, as everyone knows, violates the rational expectation assumption for it firstly **restricts the information known** to workers and secondly **allows systematic errors**. In a positive viewpoint, as in Robert E. Lucas (1972), if adaptive expectations are replaced by rational expectations, an increase in inflation never matters unless it is a **surprise**! Please note that unawareness is compatible with those characteristics in bold.

In fact, Akerlof and Yellen (1987) argue that "the assumptions required to motivate Keynesian economics are quite consistent with the behavioral regularities documented by psychologists and sociologists." Among the assumptions they emphasize **cognitive biases** which is related to unawareness.

Another significant example is the winner's curse in common value auction. According to a set of laboratory experiments, Kagel and Levin (2002) report that

> Even after allowing for some learning as a result of feedback regarding past auction outcomes, a strong winner's curse is reported for inexperienced bidders in sealed-bid common-value auctions. High bidders earn negative average profits and consistently bid above the expected value of the item conditional on having the high signal value. Further, this is

not the result of a handful of overly aggressive bidders but applies rather broadly across the sample population. Similar results are reported in low-bid wins, supply auctions with both student subjects and professional bidders drawn from the commercial construction industry.

Kagel and Levin (1986) and Kagel et al. (1995) consider a perfectly naive bidding model where all players take their signals as if they are private values and bid as if in a private-value auction. In other words, players completely ignore others' signals; it is indeed unawareness. This model brings the winner's curse. Of course, in the real world, full ignorance is unrealistic and the extent of the winner's curse is smaller than the prediction given by the perfectly naive bidding model. Kagel and Levin (2002) suggest that "agents may make partial, but incomplete, adjustments for the adverse selection effect associated with common-value auction, with the perfectly rational and perfectly naive bidding models being polar cases." Eyster and Rabin (2005) formalize this idea by the concept of cursed equilibrium, in which each player correctly predicts the distribution of other players' actions, but underestimates the degree to which these actions are correlated with these other players' signals. In this way, they provide a measure of the extent of the winner's curse allowing comparative statics study and empirical test.

In the game theory literature, unawareness is related to literatures on incomplete belief systems. Brandenburger (2002) surveys a list of questions regarding the epistemic conditions of the backward induction solution. There is a paradox that although the backward induction solution is often said to be the only solution given common belief of players' rationality, "... for many games, the backwards induction prediction is both intuitively unsatisfying and experimentally invalid." The survey addresses Complete Belief Systems by Battigalli and Siniscalchi (2002). A complete belief system contains every possible type of player in a certain sense. Battigalli and Siniscalchi (2002) prove that only when the belief system is complete, common belief of rationality can guarantee backward induction as the only valid prediction of the play of the game. On the other hand, Brandenburger (2002) presents some examples showing that when common belief of rationality holds, and given incomplete type spaces of players, the solution of the game can be different from what backward induction predicts. Clearly, the incompleteness of type spaces has a direct connection with unawareness.

3 Applications

Here we survey a few topics applying unawareness which appear in the literature. They are roughly categorized into five groups: Framing and Measuring the Effect of Unawareness, Information Disclosure, General Equilibrium with Bankruptcy, Contracting, and Persuasion.

3.1 Framing and Measuring the Effect of Unawareness

An agent may have different beliefs on the same event if the event is described in different ways. This is called framing and is related to the agent's awareness. For example, a young man may be willing to pay more for a health insurance after reading the coverage of the contract, because he becomes aware of more potential risks. Thereby in the words of the authors, his original preference undercorrects for unawareness. On the contrary, an old man may be the opposite, namely his original preference may overcorrect for unawareness.

Ahn and Ergin (2006) presents a theoretical framework based on preferences over descriptions of events, so that unawareness can be expressed through betting preference and subjective likelihood. Moreover, it is of practical interests that they provide a quantitative measurement of a decision maker who incompletely corrects for his lack of awareness. This measurement is similar to certainty equivalents or the Arrow-Pratt coefficient which express the degree of risk aversion.

3.2 Information Disclosure

In add-ons (e.g., printer cartridges, credit cards) markets, if some consumers are naive and unaware of hidden add-on costs, a firm may find it profitable to hide such information. For instance, if some people want to buy a printer without considering the costs of ink replacement, then the printer producer can highlight the low prices of its printers but later on charge a high price of ink.

Gabaix and Laibson (2006) show that although this leads to inefficiency and competing firms may have incentives to educate (disclose the information) consumers, if there are cheap substitutes of add-ons, and there are sophisticated consumers who take the advantage of both the cheap base good and the cheap substitutes, firms' incentives to educate naive consumers disappear.

Hence not only the firm exploit naive consumers, but also sophisticated consumers exploit the marketing schemes offered by the firm. If naive consumers were educated to become sophisticated, then in an equilibrium, firms would worse off by losing market share of the add-ons to the cheap substitutes.

The information-shrouding equilibrium is robust even if the cost of education is zero. In conclusion, competitive pressure does not necessarily lead to more information disclosure and undermine the exploitation based on consumers' unawareness.

Liu (2006) addresses a similar issue in stock markets. There is a disclosure regulation adopted by the SEC in 2000, called Regulations Fair Disclosure. This regulation requires issuers to disclose information publicly only, in contrast to selective disclosure where issuers may disclose information to some investors or analysts privately. The objective is to give small investors and professionals an equal access to price-relevant information.

If small investors and professionals all are aware of every uncertainty, then by letting the issuer answering questions in a public conference, full information will be disclosed, the cost of capital and the cost of information can be lower than that under selective disclosure. However, if small investors have less awareness than professionals do, then professionals do not have incentive to ask questions related to their extra awareness and would rather use other sources to find the information. Even though the cost of capital is lowered, since small investors are unaware of the information disadvantage, the cost of information may increase since professionals use costly information sources. Consequently, professionals collect less information due to the high costs.

Because of the lack of media exposure and the difficulty to be analyzed, small firms and complex firms used selective disclosure more than other firms before the regulation took effect. Hence due to the regulation, they are more likely to experience less communication with professionals. This prediction is supported by several empirical papers in the accounting literature. In general, the main conclusion is that if awareness are asymmetric, broad access to information does not always improve the efficiency and the communications between the issuers and the market.

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3.3 General Equilibrium and Bankruptcy

Modica, Rustichini and Tallon (1998) introduce unawareness of future states in a pure-exchange general equilibrium model, besides the focus on the existence of equilibria, the model naturally features bankruptcy, which agents may involuntarily experience in the unforeseen states.

Kawamura (2005) then extends their framework to study competitive equilibrium in economies with production. Unforeseen contingencies implies possible bankruptcy, which further makes a bond promising a unit constant payoff a risky asset.

The author also consider the situation when the agent who lends to the entrepreneur may be aware (ex ante) or not of the possibility of a new good in the future. A surprising result is that the effect of different level of awareness on investment decision depends on the degree of risk aversion, and in some example unawareness does not matter at all. This may imply that agents' awareness could have weak importance to production allocations.

3.4 Contracting

Filiz (2006) considers an insurance contracting problem. There is a risk neutral insurer, who has superior awareness regarding the nature of the uncertainty, and a risk averse insuree, who cannot foresee all the relevant contingencies. The insurer proposes a take-it-or-leave-it contract, which may mention some contingencies that the insuree is not aware of.

The equilibria require that both agents to optimize given his/her belief and the strategy of the opponent. Since the insuree forms her belief on her awareness, the tricky part is how she forms new beliefs when the insurer reveals new contingencies. Filiz (2006) first defines compatible beliefs based on which the new contract makes the insurer better off. Given that the insuree only forms compatible beliefs, the author shows that the insurer may offer incomplete contracts in some equilibria. For example, insurers usually emphasize the contingencies with high costs but not some with low costs. Then the author refine the belief formation by a notion called consistency, so that compared with other compatible beliefs, a consistent belief makes the offered contract the best for the issuer.

To fully characterize the equilibrium contract, the author consider the insuree a pessimist agent who is ambiguity adverse. In other words, the insuree chooses a belief from all compatible ones which maximize the minimum payoff. Then it is shown that the insurer offers a contract either only on the contingencies that the insuree initially foresees, or he announces just one contingency in addition to the ones the insuree is already aware of.

Finally the author shows that with a monopoly insurer, insurees suffer from hidden contingencies which is not revealed in contracts; but with competition among insurers, awareness will be promoted. If the size of competition is large enough, in symmetric equilibria each insurer offers a zero-profit contract which covers all contingencies.

A bilateral contracting model with moral hazard (hidden action) is considered by Zhao (2007). There either the principal or the agent is not fully aware of the action sets of his own or the others. For example, a worker could have two actions sets: a set of effort levels, and a set of choice whether

or not to manipulate his outcome for the short run, since the principal will find out the true outcome only in the long run.

Then the author shows a few comparative statics with respect to the impact of being aware of more action sets. First, he shows that either party that is aware of more action sets of himself is not necessarily weakly better off. (In a standard model, everything else the same, if you add some actions to a party, the party is always weakly better off.) But he characterizes some condition under which increasing awareness of one's action sets weakly increases a party's utility.

Then the author checks the awareness of one party regarding the other party's action sets. This will be different depending on whether the party is the principal or the agent. If the agent is not more aware than what the principal believes, then the principal is weakly better off the larger is the set of action sets of the agent of which the principal is aware. However, if the agent is more aware of the principal's action set, the agent is not necessarily weakly better off, even if the agent is aware of all action sets of which the principal is aware.

3.5 Persuasion

Persuasion happens when one agent is a decision maker and the other gives her advice. The situation is that the advisor has no information but full awareness of contingencies and he can announce some contingencies before the decision makes moves.

Ozbay (2006) studies this game and proposes a solution concept with its refinement. In a refined equilibrium, the advisor must choose an announcement such that the expected move will be the best for him given the rationality of the decision maker.

Then if there is no conflict of interest, is it always optimal to announce all of the contingencies? In a simple example, the author shows that is not true in general.

We can also make another interesting example. A mother gives advice to her son before he leaves home. She says "It may rain today." so that the son will be prepared for rain which is exactly what the mother wants. But if she tells him "It may rain and we may miss you.", then the son thinks that if she just wanted him to be prepared for rain, she would just mention the possibility of rain, so he believes that the mother probably wants him to stay instead. Therefore, announcing too many contingencies can lead the decision maker to make wrong inferences.

The justification behind this result is that the decision maker knows that the announcer is rational, and the announcer also knows it. Hence when the announcer reveals too many contingencies, the

decision maker can form his new belief in an unintended way — he thinks that if revealing less can work, why bother revealing more?

From Ozbay (2006)s' results we can make the following extension. Say an authority plays the role of the announcer, and individuals play the role of the decision maker. If the authority knows individuals' awareness very well, by revealing less, everyone is better off. But if not, and individuals find out that they could have known more awareness from the announcement, then the credibility of the authority may be in trouble. This can be coined as "the advisor's dilemma".

4 Conclusion

As we see, research topics concern not only the impact of unawareness on the elements of the economic environment like the states of nature, the identity, action sets and information types of all agents, but also the belief formation after receiving new awareness and the strategic interaction involved in communications.

References

Ahn, David and Haluk Ergin, "Unawareness and framing," 2006. mimeo, University of California at Berkeley.

Akerlof, George A. and Janet L. Yellen, "Rational Models of Irrational Behavior," *American Economic Review*, May 1987, *77* (2), 137–142.

Aragones, E., I. Gilboa, A. Postlewaite, and D. Schmeidler, "Fact-free learning," *mimeo*, 2003.

Battigalli, P. and M. Siniscalchi, "Strong Belief and Forward Induction Reasoning," *Journal of Economic Theory*, 2002, *106* (2), 356–391.

Brandenburger, A., "The Power of Paradox: Some Recent Developments in Interactive Epistemology," *Working Paper*, 2002.

Congleton, Roger D., "In Defense of Ignorance," *Eastern Journal of Economics*, 2001, *27*, 391–408.

Eyster, Erik and Matthew Rabin, "Cursed Equilibrium," *Econometrica*, September 2005, *73* (5), 1623–1672.

Filiz, Emel, "Incorporating Unawareness into Contract Theory," 2006. mimeo. Columbia University.

Friedman, Milton, "The role of monetary policy," *American economic review*, 1968, *58* (1), 1–17.

Gabaix, Xavier and David Laibson, "Shrouded Attributes, Consumer Myopia, and Information Suppression in Competitive Markets," *Quarterly Journal of Economics*, May 2006, *121* (2), 505–540.

Kagel, J. H. and D. Levin, "The winner's curse and public information in common value auctions," *American Economic Review*, 1986, *76*, 894–920.

_ , _ , and R.M. Harstad, "Comparative static effects of number of bidders and public information on behavior in second-price common value auctions," *International Journal of Game Theory*, 1995, *24*, 293–319.

Kagel, John H. and Dan Levin, *Common Value Auction and the winner's curse*, Princeton University Press, 2002.

Kawamura, Enrique, "Competitive Equilibrium with Unawareness in Economies with Production," *Journal of Economic Theory*, 2005, *121*, 167–191.

Liu, Zhen, "Fair disclosure and investor asymmetric awareness in stock markets," 2006. mimeo, SUNY at Stony Brook.

Lucas, Jr. Robert E., "Expectations and the Neutrality of Money," *Journal of Economic Theory*, 1972, *4*, 103–124.

Modica, Salvatore, Aldo Rustichini, and J.-Marc Tallon, "Unawareness and bankruptcy: A general equilibrium model," *Economic Theory*, 259-292 1998, *12*, 259–292.

Ozbay, Erkut, "Unawareness and strategic announcements in games with uncertainty," 2006. mimeo. New York University.

Phelps, Edmund S., "Money-Wage Dynamics and Labor-Market Equilibrium," *Journal of Political Economy*, 1968, *76* (4), 678–711.

Simon, Herbert, "A behavioral model of rational choice," *Quarterly Journal of Economics*, 1955, *69*, 99–118.

Zhao, Xiaojian, "Moral hazard with unawareness," 2007. mimeo, University of Mannheim.