INVESTIGATING THE EFFECTS OF INFORMATION ON INCOME DISTRIBUTION USING EXPERIMENTAL DATA[♦]

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1. Introduction

The role of a complete information system as a key determinant of an efficient market structure, and in particular the welfare implications of information, has been widely investigated over the last few decades. These studies have revealed the ambiguous effect information has on economic welfare in the presence of risky markets (Hirshleifer, 1971; Green, 1981; Campbell, 2001; Schlee, 2001; Eckwert and Zilcha, 2003).

Grossman and Stiglitz, in a seminal work from 1976, demonstrate the hypothesis that information spreads through the market by informed agents to uninformed ones. This, in turn, implies that the price is presumed to aggregate correctly and efficiently all private information[1]. This idea was at the heart of the efficient market theory (Fama, 1970).

Economists typically maintain that the market aggregates information correctly. Nevertheless, Grossman and Stiglitz establish this hypothesis using a set of paradoxes. They argue that if the information is not aggregated efficiently and correctly then there is room for extra profit out of the uninformed agents. Informed agents can gain from their advantage by interacting with uninformed agents. However, once the market is in equilibrium, there are no profits to be made – neither from trading nor from the purchase of information. Furthermore, uninformed individuals (those who have not purchased information) can infer the information that the informed individuals have obtained by observing the market price. As Grossman and Stiglitz put it: "… the price system conveys all the information from the informed individuals to the uninformed" (1976: 246).

This kind of argument is based on the equilibrium of markets and not on the process of adjustment itself. In fact, markets have been proved to be

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♦ The paper is the result of a joint work of the two authors. Nonetheless, paragraphs 1 and 5 were written by Piergiuseppe Morone and paragraphs 2, 3 and 4 by Andrea Morone. Authors' names are ordered alphabetically.

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1 For a summary of the progress made in this strand of literature see: Plott (2000).

imperfect and subject to several forms of limitations. The absence of complete and accessible information, for instance, can lead to the well-known problem of asymmetric information. In this context, situations of asymmetric information take place when one economic agent has more information than her/his counterpart, and when the price system is unable to convey all the information to the uninformed trader. In financial markets, for example, situations of asymmetric information occur when traders are unable to assess correctly the quality of financial product or when a bank is unable to assess the risk associated with a financial transaction.

An example of the negative effects of such information constrain on market economies is provided by financial crises, that often follow what appear to be bubbles in asset prices. A bubble is a phenomenon that has the same feature of herding (i.e. everybody is doing what everybody else is doing). Historic examples of this type of crisis are the Dutch Tulipmania, the South Sea bubble in England, the Mississippi bubble in France and the Great Crash of 1929 in the United States. A more recent example is the dramatic rise in real estate and stock prices that occurred in Japan in the late 1980's and their subsequent collapse in 1990. Norway, Finland and Sweden had similar experiences in the 1980s and early 1990s. In emerging economies, financial crises of this type have been particularly prevalent since 1980. Examples include Argentina, Chile, Indonesia, Thailand and South Korea.

Within this framework it is important to note that an efficient market system relies on the *quantity* of information available as much as on its *quality* (Imbriani, 2004). Hence, state intervention to control over quality and quantity of financial markets information was advocated by several authors.[2] In this context, the effort made by the European Union (as much as by single member States) to define a legal framework able to enhance and promote efficient and high quality information diffusion in the integrated European market it is noteworthy (Imbriani, 2004).

Surprisingly, a much less debated topic, both in the theoretical and in the empirical literature, is the impact of imperfect information of financial markets upon income distribution. This work aims, therefore, at bridging over this gap by means of a laboratory experiment which will directly investigate the effect of *quantity* and *quality* of information upon income distribution. We shall maintain that both higher *quality* and *quantity* of information will improve the income distribution.

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[2] Brownbridge and Kirkpatrick (2003) observed that in the aftermath of the Asian financial crisis "economists and policy analysts have been required to reconsider the role of the financial system in the development process and to develop a better understanding of the role of government in regulating domestic and international financial markets".

The paper is structured as follows. Section 2 provides the reader with a brief review of the recent experimental literature on the informational efficiency of markets. Section 3 presents the design of the experimental model and offers a description of the characteristics of the experiment. Section 4 sets the experimental parameters used and describes the characteristics of each experimental treatment as well as the differences among them. Section 5 presents our results. Section 6 concludes the paper and advances some suggestions for further research on the topic.

2. Informational Efficiency of Markets

Various experimental studies attempted to analyse the role of information within financial markets. For the sake of clarity we can categorize these studies into three groups:

- Studies addressing the issue of dissemination of information from a group of identical informed agents (insiders) to a group of identical un-informed agents.
- Studies addressing the issue of aggregation of different pieces of information owned by different traders and its dissemination.
- Studies addressing the issue of information's production.

Within the first line of research, Plott and Sunder (1982) studied the dissemination of information by running an experiment in which subjects can trade in each period a single unit of asset to. The market institution employed was a double auction. Following the experiment, the authors found that, allowing traders for replications of the same tasks over the experiment time frame, markets' behaviour closely converged towards the predictions of the rational expectations theory, where traders decipher the state of the world by observing market's phenomena.

This *approximate convergence* (i.e. convergence which occurs with a degree of volatility) was also present in an earlier experiment (Smith 1962), where convergence to equilibrium was characterised by a persistent noise. Moreover, in a recent work, Hey and Morone (2004) showed that whenever complexity increases noise increases as well.

With reference to the second group of works, there is clear evidence that information's aggregation problem depends dramatically on markets' features: information distribution, common knowledge, experience of subjects, number of assets and so on. For instance, Plott and Sunder (1988) designed an experiment on information aggregation in which traders were endowed with at least two assets in each period and the dividends of these assets were state-dependent. At the end of each period subjects received the realised dividend, but the information that they got in the trading period was noisy. The market institution was a double auction. The authors found that, first, whenever dividend varied across traders, the market could not aggregate information, and, second, that the market information aggregation process was inefficient.

The third type of approach was undertaken by several authors (Grossman and Stiglitz, 1980; Hellwig, 1980; Verrecchia, 1982; Sunder, 1992; Copeland and Friedman, 1991 and 1992) who developed noisy rational expectation models and addressed the issue of product of information by deriving equilibria in which asset markets only partially reveal information. In these models, the presence of noises impedes informed traders from recovering all the cost of acquiring information, hence generating an environment in which information is too costly.

As already mentioned, our paper aims at adding new insights into the existing literature by addressing the relationship between information and wealth distribution in a market context. By means of a laboratory experiment we will investigate the effect of *quantity* and *quality* of information present in a financial market upon income distribution, showing how both higher *quality* and *quantity* of information might have a positive impact on it.

3. The Design of the Experiment

We have a Society composed by n agents; each one is endowed with a quantity of experimental money and m units of an unspecified asset. This asset can be valuable or not and it pays its award at the end of each period. However, as the award is uncertain, there are two probable 'states of the world' (with the same likelihood): in the first scenario the award is a certain number d greater than zero, whereas in the second scenario the award is equal to zero. The experimenter decides the true state when each trading period begins. The state is not made known to the agents, who can, nevertheless, buy signals (that can have the value 1 or the value 0) which could be informative, only to a certain extent, as to the true 'state of the world'. In other words, the probability of getting a signal of 1 is p, if the true 'state of the world' pays a positive dividend equal to d, whereas the probability of getting a signal of 1 is set equal to q, if the true 'state of the world' is that the dividend is zero. This model is, in many senses, similar to the one adopted by Bickchandani *et al*. Nonetheless, there are two crucial differences: first, in the model presented in this paper signals are pricey (as each costs a positive amount c); secondly, agents are free to purchase as many signals as they want, at any time during the trading period. This means that information is not released sequentially and that the number of signals per agent can be greater than 1. These variations indeed alter the nature of the solution of the model, but they are clearly necessary in a market environment where trading takes place exclusively over the trading period. A further characteristic of the model is that agents have full information of the relevant parameters: i.e. the positive dividend *d,* the price of signal *c*, and the two probabilities *p* and *q*.

As for the trading process, we chose to employ a single-unit double-auction mechanism, where agents are free at any time to make bids or asks and accept existing asks or bids. This trading procedure has shown to be, in numerous experiments (however in simpler contexts), a rapid and efficient mechanism to reach the competitive equilibrium.

The experiment was programmed using the Z-tree software of Urs Fischbacher and run at the laboratory of ESSE at the University of Bari (the pilot), and at the laboratory of EXEC at the University of York.

We ran four different sessions. They differed in terms of the parameters we used. The key parameters of the experiment are the cost of buying a signal, *c*, and the two probabilities *p* and *q.* We took two values for the cost *c* and two pairs of values for *p* and *q*. With the aim of keeping the experiment as simple as possible, we set $p = 1 - q$ in both pairs. Hence, accounting for all the possible combinations of these parameters, we ran a total of four different treatments. Each treatment was introduced by a briefing Power Point presentation containing the correct parameters.

The payment mechanism was set as follows: agents start-off with some experimental money and with *m* units of the asset. During the trading process they can increase or decrease the number of units of the asset that they own and, depending upon the prices at which they trade, their stock of experimental money will increase or decrease during the period. At the end of each treading period the true dividend for that period is announced and the appropriate dividend is distributed in experimental money to the asset owners. Accordingly, agents will end-up with a stock of experimental money at the closing of each period (which may be more or less than the amount with which they started that period). An agent's trading profit for any trading period is given by the difference between the final stock of the experimental money and the initial one. The overall payment to each agent is simply the sum of the profits made over all trading periods of the experiment. There is a fixed rate of exchange between experimental money and real money.

Note that agents can incur losses. To avoid some of the problems associated with subjects experiencing real losses in experiments, we endowed all agents with a participation fee, which could be used (if the subject agreed) to offset potential losses. Once this participation fee is exhausted, any further lose has to be covered by the subjects themselves; while some subjects chose this option, others chose to leave the experiment once they had used up their participation fee.

4. Experiment Setting

We had $n = 15$ agents, each of whom was endowed with 10 Sterling Pounds of 'experimental' money (actually equivalent to real money as the exchange rate was one for one) and 10 units of the asset. The dividend on each unit of the asset was either ($d =$) 10p or 0p. The experiment consisted in four practice periods and 10 real periods. Players were paid only for the profits made over the 10 real periods.

As noted above, the key parameters are the cost of buying a signal c, and the two probabilities p and q. We took two values for c, 4p and 6p, and two pairs of values for p and q, which were set respectively as: 3/5 and 2/5, and 4/5 and 1/5. Combining these values produced four different treatments, as described in Table 1.

The values assigned to these parameters were carefully selected (for more details, see: Morone and Hey, 2003). With regard to c, the signal's cost, we predicted that higher values would induce agents to buy less signals. This would increase the degree of fuzziness of the market system (due to a scarcity of information). In turn, this might result in a more unequal distribution of income. We might therefore expect a less equal distribution of income in better informed treatments. As far as the two probabilities are concerned, as p rises and q falls the signals become more reliable – hence, the quality of the information present in the system improves – and this might produce some considerable effect on income distribution. We shall expect a more equitable distributed income in Treatment 4 compared to Treatment 1. However, a comparison between Treatment 2 and Treatment 3 would not be as straightforward.

	c = 4p	c = 6p
p = 3/5 and q = 2/5	Treatment 1	Treatment 2
p = 4/5 and q = 1/5	Treatment 3	Treatment 4

Table 1

Subjects' pay-off depends considerably upon the parameters choice, but evaluating a possible earning interval without information on agents' strategy is a very complicated task.

A possible strategy is "doing nothing". In this case agents would get a dividend of 10p with probability 0.5 and a dividend of 0p with a probability 0.5. Their expected pay-off will be 50p in each trading period, and hence, their overall pay-off will be £5 plus the £3 of participation fee. Thus, on average, subjects made £8 from participating in this experiment.[3]

However, there was a considerable variation around this average figure: some subjects gained less than their participation fee whereas others got paid a considerably higher sum than the participation fee plus the average dividend.

5. Analysis of the Results

Now we will focus our attention on the income distributions. We run this experiment for eight different societies. First, we distinguish between societies that experience positive growth ($d > 0$) and societies that experience no growth ($d = 0$). Within each of these two groups we characterise societies on the basis of the quality and the cost of information. Hence, we design four different scenarios, each one corresponding to a different box in table 2.

These 4 scenarios differ in terms of the information's quality and the associated cost. We shall maintain that the more and better informed is a society, the more equally distributed will be the income.

Quality of infromation	Cost of information	
	Treatment 1: *low/low*	Treatment 2: *low/high*
	Treatment 3: *high/low*	Treatment 4: *high/high*

Table 2

Since d was randomly chosen at the beginning of each period, we do not have the same number of observations in each scenario. In the following table we report the Gini coefficients of the income distribution in the different treatments and periods as well as the number of signals acquired and the value of d. We also report, in the second part of the table, the average level of the Gini coefficient calculated for comparable experiments, and its standard deviation.

[3] Since the experiment is a zero-sum game for each subject, this will be the amount paid out on average.

	Treatment 1			Treatment 2			Treatment 3			Treatment 4		
	Gini	Signal	*d*	Gini	Signal	*d*	Gini	Signal	*d*	Gini	Signal	*d*
Period 1	0.1560	31	0	0.2122	85	0	0.2170	34	0	0.2631	78	0
Period 2	0.3984	46	0	0.3823	73	10	0.1063	33	0	0.1501	73	0
Period 3	0.4969	33	10	0.2716	90	10	0.2887	31	0	0.2579	58	10
Period 4	0.3940	25	10	0.1683	92	10	0.2190	29	0	0.1929	47	0
Period 5	0.5715	29	10	0.3068	72	10	0.4299	29	10	0.3413	43	10
Period 6	0.3295	27	10	0.2811	107	10	0.3043	22	0	0.2704	42	10
Period 7	0.3891	22	10	0.2088	79	10	0.2332	26	10	0.1660	25	10
Period 8	0.2997	18	10	0.2580	58	10	0.1553	23	0	0.2117	22	10
Period 9	0.3646	24	10	0.2106	77	10	0.2741	21	0	0.1879	16	0
Period 10	0.4414	23	10	0.2324	73	0	0.1599	18	0	0.1680	19	0

d=0	Cost of information	
Quality of infromation	low/low 0.277 (*sd.* 0.121)	low/high 0.223 (*sd.* 0.010)
	high/low 0.215 (*sd.* 0.066)	high/high 0.192 (*sd.* 0.038)

d=10	Cost of information	
Quality of infromation	low/low 0.411 (*sd.* 0.083)	low/high 0.261 (*sd.* 0.062)
	high/low 0.331 (*sd.* 0.098)	high/high 0.249 (*sd.* 0.058)

Table 3

Comparing Treatment 1 and Treatment 2, we can observe two states of the world where information's quality is the same but its cost varies. Hence, we should expect that in the first Treatment the income would be more equally distributed (since information cost is lower and subjects should therefore purchase more signals). Surprisingly, this is not the case. In fact, the Gini coefficient is higher for treatment 1 than treatment 2. Nonetheless, this finding is not undermining our prediction that more informed systems (i.e. systems where more information is acquired) should be also more equal. In fact, interestingly enough, we can observe that subjects purchased more information in Treatment 2 than in Treatment 1 (see table 3). A possible explanation to this odd behaviour is that all our subjects were sophisticated enough to make *strategic* decisions. To our understanding, each trader might have predicted that if the information in question is expensive, a relatively small number of subjects will buy it. This, in turn, means that they can take greater advantages from its purchase. Of course, if everybody behaves in this way, a great deal of information will be purchased. Comparing Treatment 1 with Treatment 2, we have clear evidence that there is a *quantity* effect. This result is also supported by the comparison of Treatment 3 and Treatment 4: whenever more information is acquired, the income is distributed more evenly, yet the more expensive the information is the more keen agents are to acquire it!

Comparing Treatments 1 and 3, and Treatments 2 and 4, we can investigate the role played by the information *quality*. In fact, treatments 3 and 4 have got superior information in terms of quality (i.e. the probability value associated to p is higher, whereas the probability value associated with q is lower). In all the four cases it is clear that the higher the quality of information is, the more equally distributed is the income. This produces strong evidence in favour of a *quality* effect.

6. Final Remarks

The aim of this paper was to analyse, through a simple experiment, the effects of information on income distribution. We started with societies where, initially, individuals had exactly the same endowments of income, information and assets. Moreover, all subjects had access to additional information (which was bought at a fixed price). Acquiring more information allowed agents to better estimate the values of assets traded in the market. All assets traded had the same value. This value v was set equal to or greater than zero. If v was greater than zero, the traded asset was valuable. Agents had no a-priori information on the assets' value (i.e. they were ignorant as for the value of the asset). During the experiment, players were asked to trade. After trading, each player received a pay-off linked to the profit made. The experiment was run for eight different societies. We first distinguished among societies which experienced positive growth and those which did not. Within each of these two groups, we characterised societies on the basis of the associated *quality* and *cost* of information.

From the evidence gathered, we can conclude that the better and more informed an economic system is, the better distributed is the income. These experimental findings confirm our predictions and introduce a new element into the picture: the occurrence of *strategic behaviours* might undermine the role of information pricing upon the propensity to buy information. This, in turn, might produce an odd result in which the demand curve of information is positively sloped. This peculiar result would require further investigation; we shall leave this as a suggestion for future work.

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