

The relative advantages of efficiency and redundancy in facing with environmental shocks and the moderating effects of agents' opportunism

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Abstract

Almost all literature in economics and some part of management science claim for efficiency and consequently blame redundancy. Conversely, cybernetics was traditionally more concerned with systems effectiveness, that is its ability to survive and react to environmental changes. Under the label of slack resources, the perspective viewing the positive aspects of redundancy has been shared by behavioural and evolutionary economics as well as by a growing part of management science. In this view, through an agent-based model of industry competitiveness based on suppliers quality it has been shown that knowledge redundancy gives a competitive advantage in facing with radical environmental shocks. Moreover, it has been demonstrated that if firms exchange their knowledge industry performance improves substantially respect of the case of non cooperation. However, if they behave opportunistically by giving false information, their apparent advantages are vanished and the whole industry performance lowers under the level of the non cooperation case.

Key-words: agent-based models, decision making processes, environmental shock, opportunism, redundancy, slack resources.

1. Introduction

Redundancy indicates an excess of something respect to its minimum requirement, which instead means efficiency. Depending on the discipline redundancy can be measured in terms of rules or signals (information theory), variety (cybernetics), links among nodes (network analysis), etc. In economics and management redundancy is indicated by the concept of slack resources, which can refer to production capacity (Leibenstein, 1966, 1987), human resource (Williamson, 1974, 1985), finance (George, 2005), power (Bourgeois and Singh, 1983), and labour (Love and Nohria, 2005; Nohria and Gulati, 1997). Indeed, the major interest of literature has been focused on the financial and personnel forms of redundancy, also because if an easier way to measure and gather data. For the same reason most studies look for the effects of personnel redundancy in terms of downsizing and behavioural consequences.

At a closer sight it appears that, given the extension and rather chronic existence of redundancy, both its theoretical and empirical analysis has been really little. A good explanation of this surprising lack of studies lies into the deep core of mainstream economics, because its focus on general economic equilibrium and on the perfect rationality of agents made the case for redundancy definitely implausible. Even when industrial and managerial economics (Leibenstein, 1966, 1987; Williamson, 1974), agency cost theory (Jensen and Meckling, 1973; Jensen, 1993), and transaction cost economics (Williamson, 1975, 1985) did deal deeply with the inner structure and functioning of firms, the most important imperative for economics remained efficiency. Hence, redundancy was (and is) always considered as a handicap for firms performance and competitiveness.

A different story can be told for management and organization theory. Starting from Cyert and March (1963) seminal book on the behavioural theory of the firm, slack resources have been recognized as a normal state. Further research developed their analysis showing that redundancy comes from agents' bounded rationality and the ambiguity of information they exchange and, especially in large organizations, from the power games of groups of coalition (Pfeffer and Salancick, 1978; Sharfman *et al.*, 1988). Besides explaining its rationale, scholars argued also for

the existence of its positive effects, especially for enhancing innovation (Geiger and Cashen, 2002; Geiger and Makri, 2006) and for managing risk (Hambrick and Snow, 1977; Singh, 1986).

However, these scholars are as well concerned that firms should be efficient to be competitive, and so Nohria and Gulati (1996) argued for a curvilinear relationship between redundancy and performance: the optimum is supposed to be at an intermediate level. Most studies focused attention to deliberate causes and consequences of the various types of slack resources.

In this paper it has been followed another line of reasoning, closer to the tradition of cybernetics, and in particular of Ashby's law of requisite variety, and somehow quite consistent also with economic theory. The idea is that if the world were quite predictable and stable, then actually efficiency would be the primer. However, if environment is likely to change, then it is necessary to perceive it and promptly react, especially if changes were radical. Since both perceptions and reactions consume resources, in order to survive and face with radical environmental changes it is necessary to have a certain amount of slack resources. In particular, in order to cope with uncertainty information becomes a strategic resource: two hypotheses concerning the effectiveness of different decision making patterns and one specifically referred to knowledge redundancy are set up and tested through a series of virtual experiments.

Through an agent-based simulation model of a three-segment industry some structural and cognitive characteristics of agents' searching, choosing and learning have been operationalized. Cognitive characteristics enable agents to explore their competitive environment, and are based on their computational capacity, which consists: i) in gathering and comparing various amounts of information required to select the best quality suppliers; ii) in building and updating their memory, which notwithstanding is affected by various types of forgetfulness effects. Structural characteristics consist in different segments and levels of quality suppliers. Their behaviour is path dependent and they learn in a basic, substantial though not sophisticated sense.

Virtual experiments examine also agents' cheating attitude at the opposite extremes of full honesty or dishonesty. Since it is supposed that in this industry competitiveness is strictly related to product quality and this latter to suppliers' quality, agents' main goal is selecting the best suppliers. A set of virtual experiments is run distinguishing the cases of honest and opportunistic agents, who always lie when consulted by their competitors about suppliers' quality. Performance parameters are average quality and total profit at segment and industry level.

This study exploits the architecture of CIOPS model, which is a network of agents representing firms that interact through structural and cognitive links. The structural network is a productive system constituted by agents connected each other by (vertical) economic relationships, and interacting through orders and products. Conversely, information flows horizontally among agents of the same filiere segment. Industry is taken in a medium (200 firms) size, and sales and profits of FP depend on the quality of FT, which in turn depends on that of their suppliers (the segment of raw materials). It is supposed that clients always can sell products on the final market, and select subcontractors but not vice versa.

Cognitive variables are: type and amount of information available to agents, their rationality (computational capacity, forgetfulness effects, and levels of aspiration), their types of decision making processes, and attitude to cheat. Agents' decision making process is constituted by three types of choices that are compared each other in each step: random choice (RND), direct (DEBT) and indirect (INDEBT) experience-based. Clients ask other agents information concerning supplier's quality, and compare it with that existing in their memory. This way they move within information space, while their learning is undermined by some forgetfulness effects. Moreover, their rationality is bounded also by the limited number of information they can ask. In essence, there are two dynamic networks, a structural and a cognitive one, which overlap and interact in multiple ways, and each agent develops his own cognitive representation of the structural network.

The paper proceeds as follows. In next section some hypotheses are raised as concerning the effects of environmental shocks on the level and stability of industry competitiveness in terms of average quality. These effects are analyzed in a context of honest or opportunistic behaviors. In section three

the simulation model is described and the parameters of virtual experiments are summarized. Then, in the next section results are discussed and analyzed in terms of final outcomes after 400 simulation steps, and in terms of dynamic patterns.

2. Hypotheses

If agents have difficult access to each others experience or if they have any good reason to avoid communicating, then they rely on their own experience. However, the exploitation of reciprocal experience could help substantially exploring decision space and so knowing faster and better the best suppliers. In other words, cooperation in the form of exchanging information is expected to increase the whole industry performance. That is, indirect experience-based trust is a leverage of industry performance. Therefore, it could be raised the following:

Hypothesis 1: in industries where agents use the decision making pattern including both direct and indirect experience (INDEBT DMP) the collective performance is significantly higher than in industries where agents rely only on their own direct experience.

It is commonly acknowledged that trust is a crucial competitive factor at firm and industry level (Lane and Bachmann, 1996, 1998). In fact, if agents behave opportunistically, they can, among other forms of opportunism (Williamson, 1996), lie as concerning economic or social issues. If asked by a competitor regarding his best suppliers and if this is a critical factor of success, opportunist agents cheat to damage their competitors. If all agents lie and they are all equal under all respect (size, information access, productivity, etc.), then opportunism should damage the whole industry. Hence, it is possible to advance the following:

Hypothesis 2: in industries characterized by cheating agents collective performance is significantly lower than in industries with honest agents.

When agents exchange information they build large memories concerning good and bad suppliers, as well as reliable and unreliable informers. Especially when agents lie a huge amount of knowledge is produced, because, in order to achieve an individual satisfying performance, they have to gather and test much more information. In fact, most of them are wrong and its discovery implies a lot of cognitive work. A lot of knowledge reveals redundant and, though forgetfulness mechanisms work as “periodical cleaners” of agents’ memory, a large share remains inactivated at each interval. Moreover, forgetfulness plays in two contrasting directions: on one side it makes agents more cognitively efficient, but on the other side, especially with dishonest agents, it weakens their ability to detect false informers, and therefore to explore decision space and to exploit their knowledge.

However, if an environmental shock would radically change the landscape of good and bad suppliers, such a redundant knowledge could be very helpful looking for good suppliers and detecting false informers. Hence, it could be suggested the following:

Hypothesis 3a: when information is exchanged a radical environmental shock determines a relatively lower performance loss than what would occur without information exchange.

Hypothesis 3b: when information is exchanged a radical environmental shock determines a relatively faster absorption of performance loss than what would occur without information exchange.

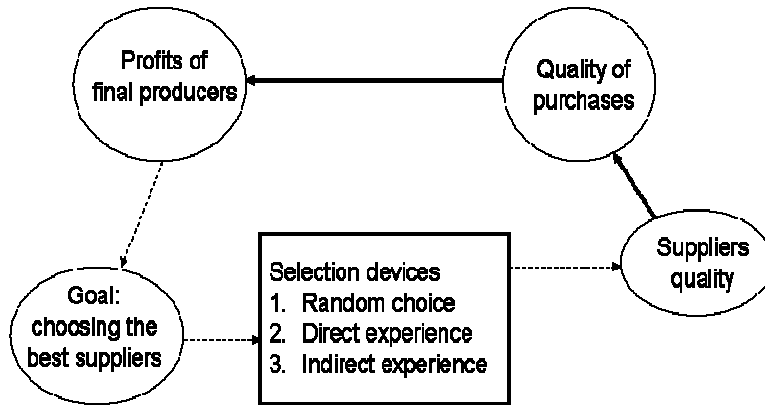
3. Model structure

A general view of the model (fig. 1) shows its logical structure: profits of final producers depend on the quality of their purchases, which in turn depends on supplier’s quality. Thus, the goal of final

producers is to choose the best suppliers. Since final producers don't know suppliers quality, they have to select them through one of four selection mechanisms: random choice, direct and indirect experience. The latter two imply information transfer between final producers, who play the role of reciprocal informers.

Fig. 1

The general model structure



The major points of interest of this model are in the characteristics of agents and in the ways in which they affect their selection mechanisms. Agents are trustworthy or variably opportunistic, and they act this latter behavior through a certain propensity to cheat. This represents the main threat to the individuation of the best suppliers, and consequently to the achievement of high profits. Moreover, agents are boundedly rational, in that they have computational limits: they recognize only a limited number of agents and can ask only a limited number of questions, and they suffer of forgetfulness effects. Finally, they are satisfiers and not maximizers, and exchange information only among them and not with FT.

Suppliers are selected according to their quality. However, actual suppliers' quality is verified only after transactions, because clients either could not know it in advance or they could have incorrect information. In this model information reliability is not evaluated as such, but instead it depends on informers' reliability. Actual suppliers' selection depends on clients' experience and cognition: knowledge, computational capacity, expectations, and decision making processes.

In order to choose their subcontractors clients: i) scan their own memory on past direct and indirect experience with suppliers; ii) ask other agents as informers. Notice that questioners are allowed to ask information only to members of their segment.

Questioners' analysis of informers' trustworthiness leads to set up a list including only full reliable informers. If the number of informers entering the list is minor than the number of questions that the questioner is able to ask, in this case the questioner asks also some unknown informer randomly chosen. The number of questions that the questioner is able to ask represents his exploration capacity, which is fixed at 4, and is kept uniform for all clients and constant during the whole virtual experiment.

Informers' trustworthiness depends on the truth of information that that informer passed previously to the specific questioner. If, in the past, a given questioner followed the indication of a given informer, then the questioner could verify informer's reliability. Specifically, reliability is defined as the absolute value of the difference between suggested quality and actual quality of a specific supplier. An informer is maximally reliable -reliability 1- when the gap between expectation and actual outcome is zero. Conversely, this degree lowers to zero, according with the formula:

$$1 - |Q_{is} - Q_{as}|$$

where:

Q_{is} = supplier S quality indicated by informer i ,

Q_{as} = supplier S actual quality.

Unknown informers are assigned maximum trustworthiness value, as it is also for the required level of informers' reliability. Informers can tell truth or falseness depending on their inclination toward cheating. True informers indicate the best supplier among the ones directly experienced. False informers indicate the worst supplier as if it were their best. That is, cheaters say that the worst has the quality of their best. There is no answer when informers have no information.

Agents have an inclination towards cheating, as the probability that in each interval is given false information, and it is kept constant during the virtual experiment. If the attitude is zero, then agents pass always true information, and vice versa. It is crucial to underline that cheating concerns only the content and not the type of information. In other words, informers can indicate their worst bad experience as if they were the best, but they cannot say, for instance, that they have direct experience if they don't, or any other kind of falsity concerning the source of the information they pass.

Agents build their own cognitive network by coping with a number of direct experiences and getting information from others. Through their direct experience agents get information on suppliers' actual quality and informers' reliability by interacting with the given supplier. Indirect experience-based information originates from informers' direct experience.

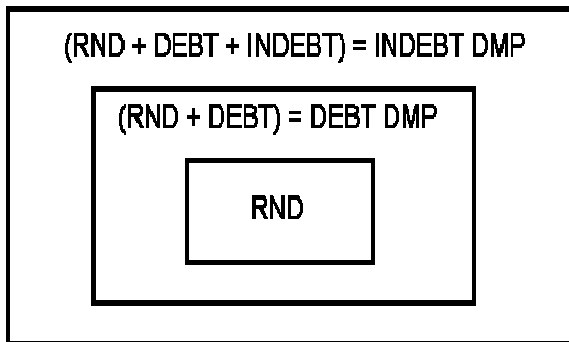
Agents collect and verify a set of INDEBT information, which are stored in their cognitive network in order to build and update their memory. If confirmed by experiments (direct experience), that part of memory made of INDEBT information becomes DEBT. Experimentation concerning INDEBT information and memory gives a feedback on the reliability of the agents who gave it, and of course on the corresponding supplier's quality. However, all the types of memory are weakened by some forms of forgetfulness, which concerns information inactivated for long time: after 100 intervals of inactivated direct experience, and 40 steps of inactivated indirect experience. Similarly, non consulted informers for more than 60 steps disappear from questioners' memory.

It should be noted that the three decision making processes are in a nested reciprocal relationship (fig. 2), because the DEBT decision making *pattern* (DMP), besides the DEBT decision making process includes also the RND option, and analogously INDEBT DMP, besides the INDEBT decision making process includes also the DEBT and the RND options. Hence, in virtual experiments DMP and not single decision making processes are confronted¹.

Fig. 2

¹ Of course, the RND DMP concerns only the RND decision making process.

The nested complexity of decision-making patterns (DMP)



What do agents do? Agents are all equal in cognitive terms, and respect to goal seeking and expectations. In each virtual experiment they are facing the same environment and are provided with the same opportunities. They are equal also under structural respects, with the exception that first and second (source) tiers are randomly assigned a given quality, and that to FP and FT certain initial opportunities are randomly offered.

Agents differ on which type, how much and how reliable is their knowledge. Knowledge at industry level is just the sum of agents' knowledge, but not all knowledge circulates. For instance, in those configurations in which direct experience is prevalent, and especially in which indirect experience is inhibited, transferred knowledge is only a small portion. Noticeably, though their simplicity agents store and transfer different types and amount of knowledge. Moreover, they develop different images of the others, and so they enact different cognitive networks.

As concerning trust and opportunistic behaviors, agents' attitude could be defined as "prudent trust" in the sense that they trust others but check their information and keep track of the corresponding result. Though they do not necessarily react through pure forms of retaliation, once an informer has been recognized as unreliable, they cancel him from the list of future potential informers. Hence, even if their reactions to cheating are "soft" and only passive, agents are not "blind trustees", because they check information and learn consequently. Moreover, it should be noticed that agents acquire free information, because it has no price and informers cannot refuse to give it. Finally, it should be taken into account that in this model all these cognitive operations are costless. In short, there are no direct costs of misplacing trust or checking information coming from indirect experience.

However, though there are no such direct costs, "prudent trust" has an indirect cost, that turns to produce effects on performance: at least in consequence of the first lie received from a cheating informer, the questioner is addressed to a bad supplier, and thus, his own performance is damaged. Being industry performance simply the sum of that of individual agents, industry profitability is negatively affected.

Configurations of virtual experiments. Parameters and initial conditions used in these virtual experiments² are shown in table 1. In each step a whole cycle choice/order/production/payment takes place. Supposing that it can represent a reality in which it lasts 5 working days, 400 steps describe 10 years of industry evolution from the very beginning. This could approximate a simple-

² The program running the model will be available on the URL of Knownetlab Research Center (www.knownetlab.it). To run the program is needed the platform and language LSD (Laboratory on Simulation Development), placed at www.business.auc.dk/lsd.

product industry, whose production cycle is very short and can be realized completely in one week, but whose quality represents a competitive advantage. Medium-high quality segments of some consumer goods markets like clothing, footwear, leather, etc. could satisfy these characteristics. The time span consideration is very important to give sense results of dynamic patterns, because while in some cases performance stabilizes already before 50 steps, in many other situations it still remains uncertain after 400 steps. Sometimes performance becomes definitely unpredictable in the short run, while in the long run keeping stable around a mean value.

Indeed, complex products would better match the crucial role assigned suppliers' quality, as it is characteristic of biotechnology, aerospace, biomedical, and most high-tech industries. However, they have production cycles extending far beyond two or even six months, and they require even long time to define product and contractual characteristics. If such a real correspondence is given each step, it is clear that even 50 intervals addresses to a very significant time span.

Experiments are executed varying: i) the presence or absence of an environmental shock; and ii) agents' inclination to cheat (0 or 1), while keeping constant other parameters. Due to the high number of variables and the value that each variable may assume for each agent, within each virtual experiment suppliers differ only in quality while keeping constant other parameters, and agents have the same quality threshold, employ the same decision making *pattern* (which is composed by the four decision making *processes*: random, direct and indirect experience-based, and reputation-based), and have the same inclination to cheat.

Other parameters not specifically discussed before are the following:

- quality threshold: this refers to agents' aspiration levels (March, 1988; Simon, 1982, 1991, 1997), who consider a supplier satisfying only if his quality is not lower than 0.75;
- clients' requirement of informers' reliability, which here it is supposed to be full reliability. In other words, an informer is supposed to be credible only if he is completely reliable.

Tab. 1 Virtual experiments parameters

Structural parameters with constant values	
Filiere segments	3
Industry size	200 firms
Ratio FP/FT = 1/2	40 downstream firms, 80 suppliers in intermediate segment and 80 suppliers in upstream segment.
Quality	Randomly uniform distribution between 0.5 and 1
Outsourcing degree	1 subcontractor for each client
Cognitive parameters with constant and uniform values	
Decision making processes	RND, DEBT, INDEBT.
Number of questions agents can ask to explore the environment	4
Quality threshold	0.75
Clients' requirement of informers' reliability	1
Number of intervals to forget inactivated DEBT	100
Number of intervals to forget inactivated INDEBT	40
Number of intervals to forget inactivated informer	60

Varied structural parameters	
Environmental shock	At 201 st interval suppliers' quality is randomly uniformly re-distributed
Varied but uniform (among agents) cognitive parameters	
Inclination to cheat	0 or 1

In this paper only the whole industry performance is investigated, that is single firm's course is not examined. Therefore, the main indexes are industry average quality (labeled as AP) and total industry profit (TP). Since in sequential technology FP are client of intermediate firms that on their own buy products from upstream suppliers, it is possible and interesting to keep distinguished FP and FT average profit. It is important to point out that: i) when required to deliver their products, FT previously check whether they can find a satisfying and available supplier (second tiers) on their own. If not, they do not accept any engagement and stay inactive in that interval; ii) exploration and experimentation capacity assigned to client hold for FT too, because they act as such respect to the segment of second tiers.

4. Main results

Although average quality does not change significantly (tab. 2) total cumulated profit actually shows substantial variations (tab. 3), because in the long run information exchange among honest agents (INDEBT) increases of nearly 3% without any shock and more than double with one shock respect to the situation in which agents don't trust each other. In fact, when agents cooperate by exchanging their own true information FP reach maximum profit sooner and remain there with fewer and narrower oscillations (fig. 6). In the FT segment occurs almost the same, with a wider gain without any shock. Thus, there is a net gain for the whole industry in allowing information to circulate and in trusting each other, even though this is a sort of "prudent trust" and not blind trust, because agents always keep in memory their past experience and confront it with others' information. Thus, the first hypothesis is confirmed.

Things reverse if agents behave opportunistically, because in this case false information³ severely damages industry profitability of about 12% in both segments. Opportunism brings performance not only lower the one associated with honest agents, but even lower than that without exchanging information at all. It means that, if somebody understands that nobody is trustworthy, then it is better trusting only his own direct experience. Thus, the second hypothesis is confirmed as well.

However, it should be noted that the better performance of INDEBT DMP is obtained at the price of minor *cognitive efficiency*, that is employing a higher number of information. It means that, especially with dishonest agents, choices are made gathering, confronting and storing a much higher number of information respects to what happens with DEBT DMP. A lot of information is redundant and, though the inactivated ones are periodically cancelled, they are continually accumulated. Actually, forgetfulness mechanisms act as redundancy reducers.

Tab. 2 INDEBT – DEBT DMP Comparisons

	without shock				with shock			
	FP		FT		FP		FT	
	AQ	TP	AQ	TP	AQ	TP	AQ	TP
DEBT	0.87	1.17	0.86	1.12	0.86	1.14	0.86	1.12
INDEBT no cheating	0.88	1.20	0.87	1.20	0.87	1.19	0.87	1.18
INDEBT all cheating	0.85	1.06	0.85	1.07	0.84	1.05	0.85	1.06

³ In this case, if asked to indicate the best supplier, agents give the worst as if he were the best.

Tab. 3	Profit variation among DMP	
	no shock	shock
Final Producers		
DEBT-INDEBT honest	2.68%	6.55%
INDEBT honest - INDEBT dishonest	-12.11%	-10.23%
DEBT - INDEBT dishonest	-9.75%	-4.35%
First Tiers		
DEBT-INDEBT honest	4.67%	6.10%
INDEBT honest - INDEBT dishonest	-12.29%	-10.34%
DEBT - INDEBT dishonest	-8.20%	-4.86%
Whole industry		
DEBT-INDEBT honest	3.66%	6.33%
INDEBT honest - INDEBT dishonest	-12.20%	-10.28%
DEBT - INDEBT dishonest	-8.98%	-4.61%

Which decision-making pattern does face better with shocks? Actually the third hypothesis suggests that knowledge redundancy becomes a competitive advantage when facing with environmental shocks, or more generally with high uncertainty. The test of the third research hypothesis is a little bit more complex, but the following three tables and four figures help giving a clear answer. A radical environmental shock occurring at mid time of industry life cycle determines a profit loss of 4.7% when no information circulates, that is when agents do not trust anyone else, and they trust only their previous direct experience (tab. 4). Conversely, when information circulates profit loss drops down to 1.11% with honest agents and basically vanishes with dishonest agents⁴. Almost the same occurs at the whole industry level, with respectively 3.5% and 1% for DEBT and INDEBT decision making pattern with honest agents. However, the performance of FP segment is more significant, because industry competitiveness is measured in terms of downstream firms, which bring products on the market. These results confirm the hypothesis 3a, because the smaller amount of knowledge memorized by agents makes shock impact more than four times heavier.

If we look at the time required to neutralize the damage of environmental shock, we see that without information exchange 200 intervals are necessary, that is it should be employed half industry life (tab. 5). Conversely, when agents exchange information 43 intervals are enough, that is less than 25% of time required for mistrusting agents. Indeed, in this case agents react less promptly than in the case of only direct experience (fig. 6), but after 35 steps they have accumulated enough knowledge to jump suddenly to maximum performance, while in the case of using only direct experience agents slowly grow to maximum level⁵.

As concerning the industry with dishonest agents, environmental shocks seem to have no any influence (tab. 4 and 5). This absence of negative impact is due to the fact that the whole dynamics is essentially chaotic (fig. 5), with extremely wide and continuous oscillations. Performance is more sensitive to forgetfulness effects than to environmental shocks or, put it better, *forgetfulness effects act as forms of shock*. This is particularly true as concerning DEBT forgetfulness, that is agents' own direct experience. In fact, the major crashes occur right after each 100 intervals, which is exactly the time needed to forget the knowledge referred to bad suppliers. Being not activated, they disappear from the memory, and so they can be re-engaged and produce profit losses.

⁴ A small profit loss as 1% over 400 intervals can be done also to variance due to random initial distribution and shock re-distribution of suppliers' quality.

⁵ The fact that in fig. 6 INDEBT lies slightly over and DEBT under the level of 120 is due to a pure accidental case related to random distribution.

Tab. 4	INDEBT – DEBT DMP Comparisons			
		no shock	Shock	
		TotCumProf	TotCumProf	Profit loss
Final Producers		Abs. val.	Abs. val.	
DEBT		468	446	4.70%
INDEBT- honest		481	475	1.11%
INDEBT-dishonest		422	427	-1.00%
First Tiers				
DEBT		457	446	2.34%
INDEBT-honest		479	474	1.00%
INDEBT-dishonest		420	425	-1.21%
Whole industry				
DEBT		925	893	3.53%
INDEBT-honest		959	949	1.05%
INDEBT-dishonest		842	851	-1.11%

Tab. 5	Impact of shock on different DMPs			
		Profit loss	Profit loss	steps to neutralize
Final Producers		Abs. val.	% TotCumProf	
DEBT-shock		22	4.70%	200
INDEBT-honest-shock		18.4	3.83%	43
INDEBT-dishonest-shock		0.22	0.05%	2
First Tiers				
DEBT-shock		6	1.33%	45
INDEBT-honest-shock		6.39	1.33%	103
INDEBT-dishonest-shock		No impact		

Fig. 3

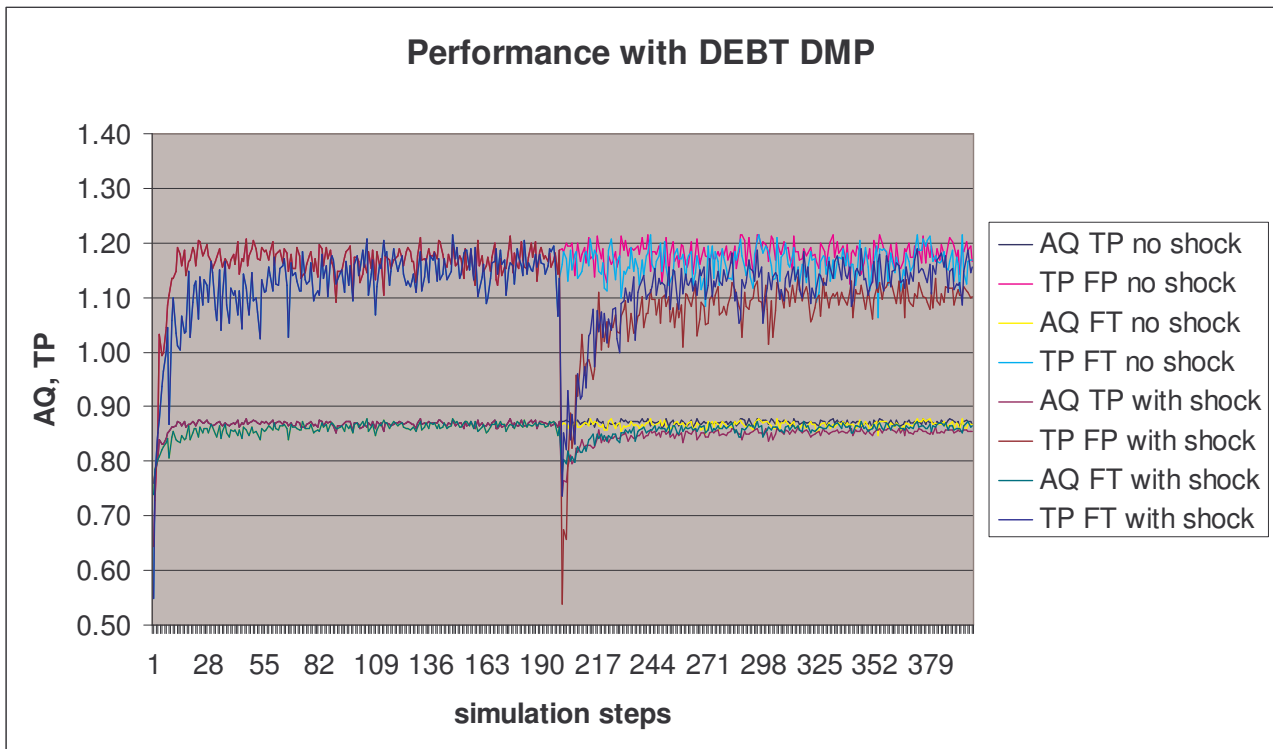


Fig. 4

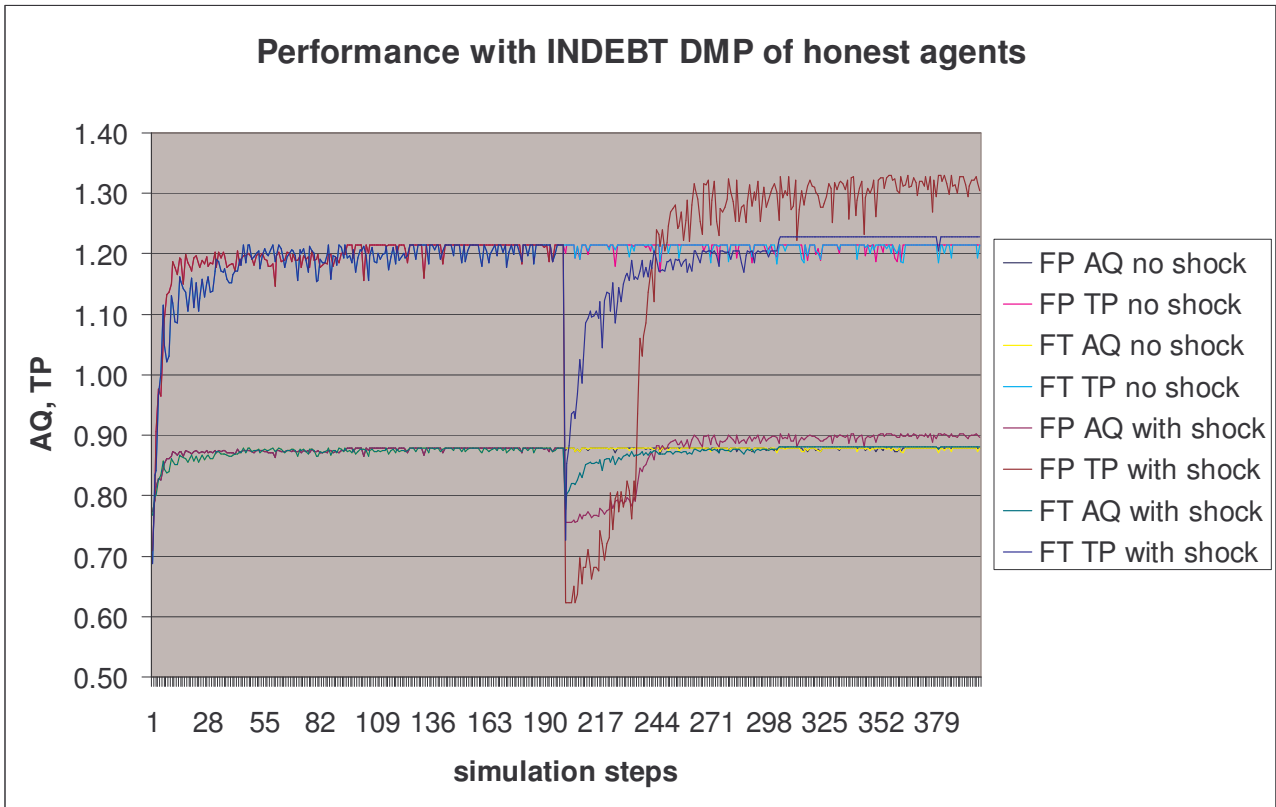


Fig. 5

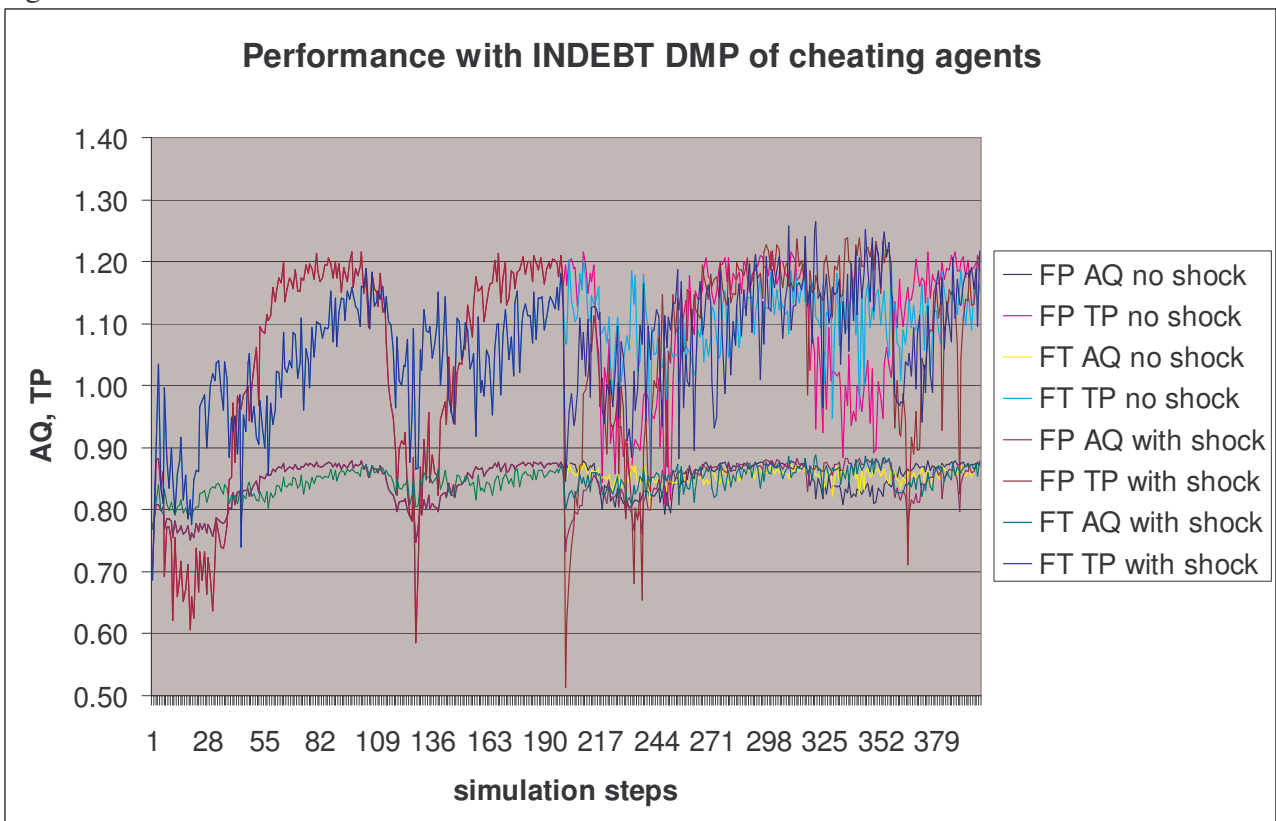
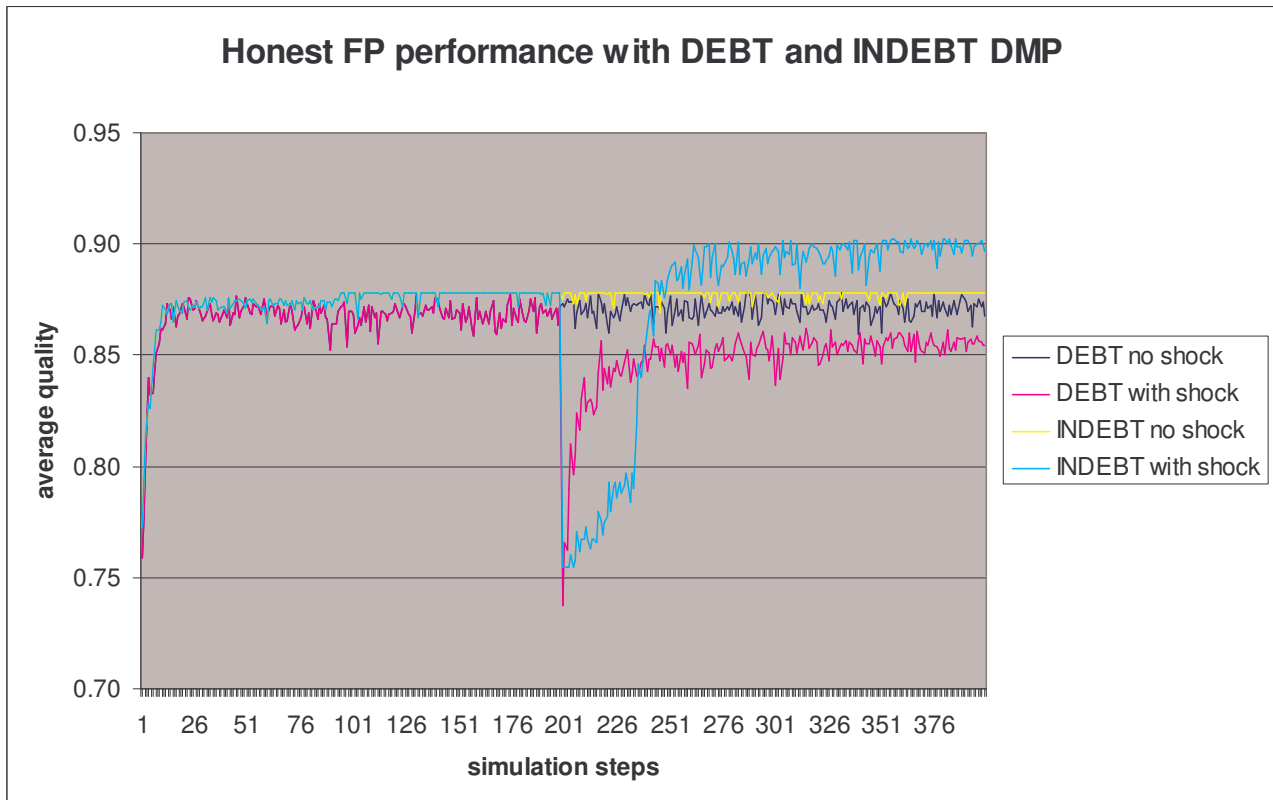


Fig. 6



Conclusion

This paper shows that when firms exchange information its competitiveness increases. That is, cooperation through knowledge exchange improves industry performance. However, such significant advantage vanishes whether firms behave opportunistically, hoping to gain some net benefit by damaging their own competitors. It is demonstrated that if all do that way, performance at the whole industry level sharply decreases far under the level of the case of communication lack. Moreover it is shown that, especially when firms cooperate exchanging information coming from their past direct experience, knowledge redundancy can be helpful facing with radical environmental shocks. Firms reduce the negative impact because of more prompt reaction and faster time to come back to previous profit levels. However, when agents are full dishonest and always cheat about their past experience, then the negative effects of environmental shocks become indistinguishable from those of forgetfulness effects.

It is possible to argue that in presence of radical uncertainty knowledge redundancy becomes a competitive advantage, because it allows firms to better react. In future agenda, this advantage should be contrasted with the costs to acquire and handle such redundant knowledge, and with the corresponding previous profit losses. It could be found a break-even point between cost and benefit of knowledge redundancy.

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