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The value of information when preferences are dynamically inconsistent

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Abstract

The paper reviews the main findings on individual decision making under time inconsistent preferences, incomplete information, and different learning environments. First, when agents choose whether to learn or not, avoiding costless information can be their optimal strategy. Strategic ignorance predicts a systematic bias in the agents' perceived payoff. Second, when information flows exogenously (as in the literature on investment under uncertainty), agents may undertake irreversible investments anticipating expected losses. Such decisions are taken only as a commitment device against the acquisition of future information undesirable from the current perspective. Furthermore, several equilibria coexist: the agent will succeed in avoiding investments with losses or not depending on the degree of trust on his future behavior. Third, under learning through consumption, abstention can be part of an equilibrium strategy in activities where moderate consumption (if feasible) would yield a higher payoff.

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1. Introduction

Traditional economic analyses have considered the individual (from now on 'he') as *one entity*. Scholars have then implicitly assumed that the goals of

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a rational agent at different dates *may be in competition but can never be in conflict*. In the absence of intrapersonal conflicts, an individual modifies his decision only if the external environment changes. The major objection to this approach is its lack of realism: it cannot explain individual willpower, impulsiveness, self-deception, and many other human conducts widely documented in the Psychology literature.

In recent years, there has been a renewed interest for including psychological findings in modeling individual preferences. From the viewpoint of Economists, one of the most 'successful' modifications of the standard postulates has been to consider hyperbolic rather than exponential discounting in the preferences of individuals. As it is by now well established, individuals tend to overweight immediate gratification. According to this way of evaluating the future, short-term rewards are discounted *relatively more heavily* than long-term rewards. As a consequence, the optimal dynamic plan of actions of an individual from his current perspective may no longer be optimal when reconsidered some time later. More informally, under such alternative discounting of upcoming returns, the individual is no longer one entity but a collection of 'selves': his goals at different dates are *not only in competition but also in conflict*.

Let us illustrate with two simple examples the difference between competition and conflict of intertemporal goals within a single person. Suppose that my most awaited movie of the year is coming out this Wednesday and I have to choose between going alone to the première or going on Saturday with some friends. Under traditional theory, if on Monday I decide that enjoying a nice company during the film is worth a delay of three days, then I will stick to that decision during the whole week. Under hyperbolic discounting, the previous reasoning may be true on Monday and not anymore on Wednesday afternoon. My preferences for these two actions at two different points in time can be in conflict. Now, consider a second situation. I need to fix my car, and I can bring it to the garage on Wednesday (so that it will be repaired by Friday) or on Saturday (in which case I will not be able to enjoy it during the weekend). A time inconsistent agent may on Monday decide that having the car for the weekend outweighs the cost of a sooner effort and, at the same time, decide to delay the repairing to Saturday when the time to bring it to the garage approaches. Overall, when the competing activities involve an immediate benefit (as in the movie example), the tendency to satiate immediate gratification incites the individual to 'rush', i.e. to undertake the activity earlier than optimal from his ex ante perspective. By contrast, if activities require an immediate cost (as in the car repair case), hyperbolic preferences push the agent to 'procrastinate', i.e. to delay excessively the completion of the task.

Incorporating this intrapersonal conflict into the analysis of decision making raises several questions. This paper summarizes the findings on one issue which can be of special importance in a variety of environments: *the value of information*. In standard theory, information is always desirable. Some pieces of news

may not be acquired when they are excessively costly but, as long as they are free, they will never be avoided. By contrast, the papers we review show that information can be harmful when preferences are dynamically inconsistent and commitment to future actions is not possible. Indeed, the news acquired today may be used at future dates suboptimally from the current perspective, because the objectives have changed. This provides a rationale for strategic ignorance.

In the next section we introduce the formalization of time inconsistent preferences and the different scenarios involving uncertainty. The results are presented in an informal way, with the emphasis on the economic significance. For the formal proofs and for lengthy discussions of the applications we refer the reader to the corresponding papers.

2. Decision making under dynamically inconsistent preferences

We consider an individual with dynamically inconsistent preferences in the sense of Strotz (1956). Formally, the agent's marginal rate of substitution between consumption at two consecutive periods t and $t+1$ increases as date t approaches.[1] Denote by V^t the intertemporal utility from the perspective of the agent at date t (from now on called 'self-t'). Denote also by u_t the instantaneous utility of self-t. A simple way of capturing most of the properties of hyperbolic discounting was first suggested by Phelps and Pollak (1968). According to their formulation, the intertemporal utility from the perspective of self-t is

$$V^t = u_t + \beta \sum_{i=1}^{+\infty} \delta^i u_{t+i}.$$

In this modeling, β (< 1) is the extra weight or 'salience' of current rewards relative to future streams of payoffs.[2] The intrapersonal conflict of the individual can and will become apparent when there is a *temporal delay* between the costs and benefits of the possible alternatives. Two different cases need to be analyzed separately depending on whether costs come earlier or later than benefits. From now on, the first type of situations will be denoted by $[-/+]$ and the second one by $[+/-]$.

We are interested in analyzing the role of *information acquisition* by rational agents who are aware of their intrapersonal conflict and cannot make binding commitments on future decisions. To this purpose, we will analyze different environments involving *uncertainty*. More specifically, in the next subsections we

[1] See Ainslie (1992), Loewenstein and Prelec (1992) and the references there-in for a comprehensive theoretical discussion and empirical relevance of hyperbolic discounting.

[2] Note that $\beta = 1$ is the standard case of exponential discounting. As β decreases the agent is less able to internalize his conflict of preferences, and so his intrapersonal problem becomes more acute.

will consider three learning scenarios in which acquiring information is costless. In the first one, the information on the realized value of the uncertainty parameter is available but the agent can decide to strategically stay away from it. In the second scenario, information flows exogenously. At each date and given the current state of knowledge, the agent decides whether to undertake an irreversible activity or to postpone it and get extra information. In the third scenario, there is learning through consumption. In each of these situations, the combination of uncertainty, possibility of learning and time inconsistent preferences leads to original predictions about the value of information and the behavior of individuals.

2.1. Endogenous and costless decision to learn

To simplify the analysis, suppose that at date $t = 1$ the agent has to decide whether to undertake an activity or not. This activity yields either a cost at $t = 1$ and a benefit at $t = 2$ (type $[-/+]$ situation) or a benefit at $t = 1$ and a cost at $t = 2$ (type $[+/-]$ situation). Moreover, there is some uncertainty either on the cost, or on the benefit, or on both the cost and the benefit. At date $t = 0$, that is the period before undertaking the activity, the agent has the opportunity to freely learn the realization of the uncertainty parameter.[3] In this situation, we have the following result.

Result 1 (Carrillo and Mariotti, 1997): *(i) An agent with time inconsistent preferences may optimally decide to avoid collecting free information.*

(ii) On average and conditional on the truth, there is a systematic bias in the beliefs of the agent. In the $[-/+]$ *case, the agent will keep excessively optimistic prospects concerning the payoffs. In the* $[+/-]$ *case, he will keep excessively pessimistic prospects.*

From the perspective of self-0, both the cost and the benefit are discounted by the salience parameter β. By contrast, only the benefit (resp. the cost) keeps the extra discount factor β from the perspective of self-1 in $[-/+]$ (resp. $[+/-]$) situations. Therefore, in the absence of learning, the two selves may have conflicting goals. On the one hand, the agent is (as in the time consistent case) willing to obtain information so as to improve his knowledge before undertaking any action. On the other hand, the decision will be taken by a future self, whose goals do not coincide with the current ones. Suppose that with no information some action is optimal from the viewpoint of both self-0 and self-1. Acquiring some pieces of news may plunge the agent in a state of beliefs such that the previous action is still the most desirable one from self-0's perspective

[3] The analysis can be generalized to an infinite horizon model where both learning and undertaking the activity is possible at every period.

but not anymore from self-1's perspective. In such a case, self-0 would strictly prefer to remain uninformed. Note that the pure public good nature of knowledge (any information is automatically transmitted between selves) is a key factor for the optimality of ignorance.

This theory yields clear predictions about the cases in which information is most likely to be avoided. Consider first a $[-/+]$ situation: suppose that at date 1 the agent may start a research project which requires a current effort and provides a benefit at date 2 with some probability. At date 0, the agent can freely learn the true probability of success of the project. In that case, the intertemporal conflict pushes the agent to undertake at date 1 the activity less often than what is optimal from his perspective at date 0. If initial prospects are sufficiently bad, the agent anticipates that without extra information he will never undertake the research activity at date 1. Then, he does not lose anything by learning the truth. But, if prospects are sufficiently good, and in particular if under no learning the project is undertaken by self-1, there is an argument for avoiding free information. Indeed, self-0's fear is to learn that the probability is 'intermediate' in which case a project valuable from his viewpoint is not started at date 1. Naturally, ignorance has also some costs. The true probability may be so low that pursuing the project is worthless even from self-0's viewpoint. The final decision whether to remain ignorant will tradeoff the benefit of avoiding inefficient procrastination and the cost of taking uninformed decisions. To sum up, anticipating that the activity is undertaken 'too late' (or too infrequently), the agent at date 0 is willing to keep a positive view about the expected payoff of the activity so as to encourage self-1 to undertake it. Conditionally on the truth, the average ex post perceived expected payoff will be higher than the objective one, and the realized level of activity higher than under complete learning. As should be clear by now, a similar argument suggests that in $[+/-]$ situations, individuals will keep excessively negative views in order to avoid undertaking the activity 'too early' (or too often). For example, consider the question of having an unprotected sexual relation. For some beliefs about the probability of transmitting the HIV virus, self-0 may find unreasonable to take any risk, while self-1 may in the heat of the moment go for an unprotected intercourse. Keeping an excessively pessimistic prior about the overall expected payoff can be a device to avoid rushing in such unreasonable activities.[4] Overall, the average ex post perceived expected payoff will be smaller than the objective one, and the realized level of activity smaller than under learning. We want to insist on the fact that

[4] An informal questionnaire reveals that the vast majority of the population estimate the probability of contagion during unprotected sexual intercourse with and HIV positive partner on the order of 0.3 and above. The true probability depends on a large number of factors but it is on the order of 0.003. Similar divergence in estimates of objective and perceived risk occur for tobacco (for both smokers and non smokers).

individuals update information in a Bayesian way. The aggregated expected bias is thus conditional on the true state of the world and it is due to the *endogenous* decision to stop learning.

Pursuing this line of work, Brocas and Carrillo (1999a) argue that time inconsistency is a key factor to obtain a systematic and testable bias. They show that the same results would not be obtained in a model with time consistent agents and costly learning. Under this alternative approach, individuals with sufficiently good and sufficiently bad prospects would, respectively, go and not go for the activity, without incurring the learning cost. Only for intermediate priors would agents decide to learn. Hence, the ex post perceived payoff could be biased either downwards or upwards with respect to the objective one depending on the parameters of the model. Using this observation as a starting point, the paper analyzes the following $[-/+]$ situation. An entrepreneur has to decide whether to invest in a project. At date 0, he can either learn at no cost the probability of success of his own project or remain uninformed. The investment decision is taken at date 1, based on the information obtained at date 0 or on the prior distribution of probabilities in case of no learning. It requires two immediate costs: a capital investment and an individual specific effort (or opportunity cost of investing). If the project is successful, it generates a positive benefit at date 2. From Result 1, we know that entrepreneurs will tend to behave 'boldly', i.e. they will on average keep excessively optimistic prospects and blindly invest. Furthermore, agents are cash constrained and they need to borrow the capital. They have also limited liability, so repayment is possible only in case of success. Assuming perfect competition in the credit market, an exogenous risk-free rate, and individual probabilities of success independently drawn, the paper derives the next result.

Result 2 (Brocas and Carrillo, 1999a): *(i) Good conditions in the credit market (i.e. a low risk-free rate) foster entrepreneurial boldness and excessive investment. It also implies some entry mistakes.*

(ii) High-ability entrepreneurs are more likely to behave boldly and incur in entry mistakes than low-ability entrepreneurs.

The tendency of entrepreneurs to adopt a bold attitude and 'blindly jump into the water' can be labeled as 'observational optimism'. On the one hand, ignorance is followed by investment. The level of entrepreneurship in the economy is therefore excessively high, just as if agents were intrinsically optimists. On the other hand, keeping high prospects is an optimal decision to avoid inefficient procrastination. Overall, time inconsistency offers an alternative explanation for entry mistakes, without relying on agents' bounded rationality, which is observationally similar to optimism.

The novelty of Result 2 is that agents are linked to each other by their dynamically inconsistent preferences. In fact, the decision of an agent to privately learn his own and independent probability of success will depend on the

interest rate charged by banks. However, the competitive interest rate will endogenously be set conditional on the learning decision of all the agents. So, interest rate and level of entrepreneurial boldness are jointly determined in equilibrium. When the risk-free rate is low, competitive banks do not need to impose a large interest rate to satisfy their break even constraint. Besides, if the interest rate is low, agents are more willing to avoid information and blindly invest, because ignorance is relatively less costly the smaller the repayment obligation. Hence, there is a positive relation between risk-free rate and level of entrepreneurial boldness in the population. When the credit market is in 'good times', agents undertake more investments for two reasons. First, a trivial motive: if the opportunity cost of investing is low, a high proportion of individuals are willing to invest. This effect highlights the usual relation between the state of the credit market and the number of *profitable* investment projects initiated. Second, as the risk-free rate decreases, more agents are willing to remain strategically ignorant and blindly invest. This effect relates the state of the credit market to the number of *excessive* investment projects initiated (or entry mistakes). In other words, a good state of the economy fosters boldness and therefore exhibits a high level of entry mistakes. This departs from the standard view, according to which spontaneous optimism revitalizes the economy by increasing the level of investment, and this comes at the expense of some entry mistakes.

Defining high entrepreneurial capacity as the ability to select projects with high profits in case of success, the paper shows that individuals with high-skills invest more than their low-skills peers. Indeed, the expected value of their investment is higher, so they are more willing to remain ignorant and boldly invest. Overall, ability leads agents to undertake more profitable investments but also to incur in more entry mistakes.

2.2. Exogenous flow of news and decision to stop learning

The role of information in the decision to undertake irreversible consumption or investment has attracted a great deal of attention in Economics. The basic idea is the following. At each date, the agent can undertake an irreversible activity (from now on 'consumption' decision) yielding an uncertain payoff. Delaying the decision to consume has costs and benefits. On the one hand, future payoffs are discounted, so other things equal it is better to consume immediately. On the other hand, some news are exogenously revealed between periods, so information about payoffs is more accurate the longer the agent waits. The optimal decision rule trades off these two effects. In this literature, there is at each period a cutoff in the expected payoff above which the agent consumes and below which he waits at least until the next date. The difference between the payoff at the cutoff and the expected payoff of never consuming is the information (or option) value of waiting. Although each particular model

has its own characteristics, they all share some properties.[5] The information value of waiting is always non negative. Moreover, when the consumption horizon is finite, then the information value of waiting strictly decreases as the number of periods in which it can be exerted decreases. In the last period, the information value of waiting is nil so that the payoff at the cutoff is equal to the value of never consuming.

Brocas and Carrillo (1998) analyze a special class of this game in which a time inconsistent agent faces a $[+/-]$ situation with a finite consumption horizon. The analysis applies to *individual* time inconsistent preferences (in the tradition of Strotz, 1956) as well as to 'implicit' *social* preferences dynamically inconsistent (as in Phelps and Pollak, 1968). The kind of situations in mind are credit purchases and impulse buying (for individual decisions) and destruction of the tropical rainforest or preservation of endangered species (for choices of organizations). The results are the following.

Result 3 (Brocas and Carrillo, 1998): *(i) When the flow of information transmitted between periods is small, the information value of waiting is negative and increasing over time. The agent may then decide to consume a good that procures a negative expected net present value (NPV).*

(ii) Public intervention can remove or at least mitigate this inefficiency by restoring partial commitment on future decisions or increasing the value of not consuming.

In the time consistent situation, information is always valuable. Hence, waiting for the exogenous flow of news has some potential benefits that must be compared to the costs of delaying the reward. The analysis changes when there is an intrapersonal conflict. As noticed in Results 1 and 2, information may have a negative value in that case. It is therefore not surprising that it can induce a quantitative inefficiency.

More striking is the observation that the inefficiency can be of a qualitative nature: the information value of waiting can be negative and increasing over time. The intuition is as follows. Under hyperbolic discounting and a $[+/-]$ situation, current benefits are overweighted relative to future costs. There is what the authors label as an 'inconsistency region' such that undertaking the project has an expected positive NPV from the current perspective, and an expected negative NPV from a past perspective. As a result, the decision of each self whether to consume in the current period will be contingent *on the anticipation of what future selves plan to do*. Naturally, the behavior of those future selves will be a function of the signals they receive. Therefore, the amount of information transmitted between two periods is crucial in determining the incentives of the current self to exert his information value of waiting. The interesting situation arises when the flow of information is 'small', i.e. when the expected profitability of the project varies only slightly from period to period. Suppose

[5] For a review of this literature see Dixit and Pindyck (1994) and the references there-in.

that the agent's beliefs are below the inconsistency region (so that consuming has negative NPV from the current perspective) but close to it. Then, conditional on not consuming in the current period, there are relatively high chances that the collection of information plunges the agent into the inconsistency region. This will happen if the information revealed is 'moderately positive' and in that case, the next self will consume with positive NPV from his perspective but highly negative from the current one. In order to avoid it, the individual prefers to rush and consume with a current negative (but close to 0) NPV. Then, consumption takes place only as a *commitment device* against a future decision non-desirable from the present perspective. Overall, the expected information value of waiting is negative and smaller the longer the horizon in which it can be exerted. Last, note that if the initial prospects are sufficiently bad, the agent is better-off if he does not receive any information ever (in which case he never consumes) than if he receives some information at each period (in which case the likelihood of rushing into consumption is considerable).

As in most of the literature on hyperbolic discounting, partial commitment helps in reducing the inefficiencies due to inconsistent preferences. However, in most settings not all selves benefit from the possibility of commitment, which raises the issue of what is an appropriate welfare criterion. By contrast, in Brocas and Carrillo (1998) commitment avoids rush, so it may enhance welfare from the perspective of *all selves*. The inefficiency due to inconsistent preferences can also be reduced by modifying the costs and benefits of future actions. One possibility is to spend resources to decrease the benefits of future consumption. A much better alternative consists in increasing the payoff of never consuming. Formally, it has the same effect of reducing the future net incentives to undertake the activity. However, it has the advantage that the resources are not wasted.

Brocas and Carrillo (1999b) study a modified version of the previous paper. More precisely, they consider both $[+/-]$ and $[-/+]$ situations and an infinite consumption horizon. Furthermore, they study the effects of direct interactions between time inconsistent agents. Individuals may pursue competing activities (only the first one to undertake it obtains the payoff) or complementary activities (they benefit from a spillover when both undertake their own one). The conclusions obtained are as follows.

Result 4 (Brocas and Carrillo, 1999b): (i) *In* $[+/-]$ *situations there are multiple, rankable equilibria. Agents will avoid rushing or not depending on the degree of trust on their future behavior.*

(ii) Both in $[+/-]$ *and* $[-/+]$ *situations, competition can be beneficial while complementarity of activities can be harmful for the welfare of all selves.*

As already noted in Result 3, in a $[+/-]$ situation the individual is tempted to rush and consume 'too early' as a commitment against future inefficient decisions. This may even imply consumption with a negative expected NPV. Interestingly, if the horizon is stochastic the individual faces a *coordination*

problem with himself that gives rise to multiple equilibria. In fact, when the current expected payoff of consuming is sufficiently low (and in particular when the expected NPV is negative) each self is willing to avoid rushing only as long as future selves do not rush themselves. By contrast, if the agent anticipates future rush, then it is better to rush in the present date so as to (at least) reap the overweighed current benefit. Then, two equilibria may coexist. In the first one, patient/trustful selves only consume when the expected NPV is positive and sufficiently high. In the second one, impatient/distrustful selves may consume with a negative NPV. Naturally, the former equilibrium yields a higher utility to all selves than the latter. In other words, the behavior of the agent crucially depends on the degree of trust on his future incarnations. This suggests that agents may greatly benefit from building some 'self-reputation' for being patient.

We illustrate the effects described in part (ii) by considering a $[+/-]$ situation in which activities are in competition and a $[-/+]$ situation in which activities are complementary. First, competition can mitigate the incentives of impatient (or distrustful) individuals to rush. Indeed, when agents compete for the activity, commitment against future actions with negative payoffs can be achieved at no cost if the rival rushes himself. So, by introducing competition each individual does not become intrinsically more patient but uses the intrapersonal conflict of the rival to his advantage: he 'lets the rival rush'. Second, complementarity exacerbates the incentives of agents to procrastinate. Exerting the current cost is not sufficient to enjoy the future benefit. Each agent has to rely on his teammate's willingness to undertake his own action, but realizes his partner's natural tendency to procrastinate. It may result that each agent wants to complete the task at each date with a positive but smaller probability than his partner. In such case, the unique symmetric equilibrium is such that tasks with positive net value are never undertaken.

2.3. Learning through consumption

The negative effects on health implied by ingestion of alcohol, tobacco, marijuana and other soft drugs is partly individual specific. Hence, the personal degree of tolerance to those substances can best be learned through consumption. Similarly, the 'pleasure' of gambling or having an extramarital relation and the costs of sticking to a strict diet can only be evaluated after repeated exposure. Carrillo (1998) investigates why in these type of $[+/-]$ examples – which include activities *both subject and not subject* to addiction – moderation is more infrequent than both abstention and excesses. The paper studies the per period (non-negative) *amount* of consumption chosen by a time inconsistent individual. It derives the following results.

Result 5 (Carrillo, 1998): *(i) Convergence to and persistence of abstention can be part of an equilibrium strategy even for goods where moderate consumption (if feasible) would yield a higher payoff.*

(ii) Consumption at every period is always another equilibrium. However, it yields a weakly lower expected utility to all selves than the utility obtained in any equilibrium featuring abstention.

As long as there is some consumption, the agent learns about the expected net payoff of consuming (for example, to which extent past consumption affected negatively his current health). A time inconsistent agent may fall in a state of beliefs where he wishes high current consumption and moderate future consumption but, due to his inability to commit, ends up overconsuming in every period. When beliefs are such that the expected intertemporal payoff under continual excesses (high consumption at every period) is smaller than under sustained abstention, the agent prefers not to consume at all. Abstention is only a second best solution. By construction, moderate consumption at every period would be preferable, but this is not feasible due to hyperbolic discounting. Moreover, the strategy of abstaining is the agent's way of not learning. Therefore, it is his only possible commitment strategy to avoid sinful temptations also in the future. To sum up, the paper proves not only *convergence to* but also *persistence of abstention* as the agent's optimal self-commitment device. It is important to realize that the 'complete abstention' strategy is not imposed on the grounds that it acts better than any other rule as a focal point (as sometimes suggested in the literature). Rather, it endogenously becomes a basin of attraction due to its learning properties.

Naturally, abstention is valuable only insofar as it is followed by every future incarnation: no self is willing to abstain if, for the same beliefs, his immediate successor is going to reinitiate consumption. Therefore, there is an intrapersonal coordination problem on the region of posterior beliefs where abstention takes place. As in Result 4, this immediately gives rise to multiple equilibria. In particular, consumption in every period is always a sustainable strategy: if the agent anticipates that he will consume at every future date independently of his present behavior, then he has no incentives to abstain in the current period. Yet, whenever abstention is sustainable, it yields a higher welfare from the perspective of the agent at every date than (over)consuming. Suppose that, for given beliefs, the agent decides to refrain from consuming. Future selves stick to abstention only if consumption reinitiates a learning process that leads to an expected intertemporal utility smaller than under abstention. Therefore, the very existence of an equilibrium with abstention implies that it must dominate from the perspective of every self a strategy of consumption, otherwise they would deviate.

3. Concluding remarks

If we consider the agent as a collection of selves with intertemporal conflicting goals, committing to future actions becomes one of his central objectives. Recent

papers dealing with time inconsistent preferences have used *exogenous* commitment tools (investment in illiquid assets or in inefficient technologies, private side bets, promises, etc.) as the starting point to analyze some issues on individual decision making. Some of the papers reviewed in this essay (Brocas and Carrillo, 1998, 1999b; Carrillo, 1998) belong to this line of work: irreversible consumption decisions or learning through consumption creates a direct commitment mechanism. By contrast, in Carrillo and Mariotti (1997) and Brocas and Carrillo (1999a) ignorance is a purely *endogenous* commitment device. In the infinite horizon version of these models, the agent can at every single period freely acquire all the relevant information, and yet decides to remain uninformed.

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