Social learning and herding

Social learning and rational expectations

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Abstract

This paper argues that some of the pathologies identified by the social learning literature are not robust. Incorrect herds need indivisibilities and signals of bounded precision to arise. In smooth models convergence to the correct action and full revelation of information obtains. However, in the presence of noise convergence is slow. Two robust properties of learning from others are identified. The first, a self-correcting property, responsible for the convergence (self-enhancing facet) at a slow rate (self-defeating facet). The second, the existence of an information externality responsible for herding and underinvestment in public information and relevant from the welfare point of view. The results imply that convergence to full-information equilibria in rational expectations market models may be slow. Nevertheless, this does not apply to models in which learning is mostly from the environment. Furthermore, appropriate market mechanisms may speed up convergence even when learning is from others.

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1. Introduction

Recently there has been a surge of interest in social learning, the process by which certain mechanisms in society aggregate the information of individuals. People do learn from other people, most particularly from their actions. For example, consumers purchase the most popular brands, tourists patronize well-
attended restaurants, depositors withdraw money from a bank with a long line of customers waiting to recover their deposits, and readers buy best-sellers. Although learning from others can use informal routes, like word-of-mouth about the experience of other agents, often in economic situations information about the choices of other agents is obtained via noisy aggregates, prices or quantities, for example. The study of prices as aggregators of information, since the seminal ideas of Hayek, 1945, has been developed extensively, particularly in the rational expectations literature. The study of information conveyed by quantities has been less extensively examined although some of the examples above suggest that it is indeed important for economic decision making.

The social learning literature has emphasized the possibility of inefficient outcomes in contexts with fully rational agents. For example, agents may 'herd' on a wrong action disregarding valuable private information (Banerjee, 1992; Bikhchandani et al., 1992). This literature seems to stress market failure and feeds into a tradition of study of excess volatility and crashes in financial markets, fads, and coordination failures. (See, for example, Shiller (1981), Shiller (1984), Shiller (1989), and De Long et al. (1990)). The literature on rational expectations and market efficiency provides a striking contrast with its emphasis on the market mechanism as an aggregator of the dispersed information of agents. (See, for a sample of this work, Grossman (1981), Grossman (1976), Hellwig (1980), and Bray (1985)).

At the heart of the problem is market performance in an asymmetric information world. Do markets work then? Rational expectations models have induced the hope that repeated interaction in the marketplace would lead to the eventual revelation of the unknown parameters (see Townsend, 1978; Bray and Kreps, 1988). This would mean that the full-information Walrasian equilibrium would be a reasonable approximation in an asymmetric information world with repeated market interaction. In this respect, nevertheless, the Grossman and Stiglitz (1980) paradox must be confronted. In short, with endogenous and costly information acquisition informationally efficient markets are impossible. Indeed, if the market price were to reflect all private information of traders then no trader would have an incentive to collect costly information, but in this case the market price could not possibly be informative!

In this paper we will briefly survey some social learning models, based on rational behavior, and explore to what extent social learning models cast a doubt on reliance on the market mechanism. We will be concerned not only about convergence to full-information equilibria but also, in case it obtains, about its rate. Indeed, if it is very slow, the full-information approximation may not be

1 Scharfstein and Stein (1990) explore the consequences of herd behavior for management investment decisions.
relevant at all. The implications of costly information acquisition will be considered also.

The plan of the paper is as follows. The basic herding/informational cascades model is presented in Section 2. A smooth and noisy model is expounded in Section 3. Section 4 explores the applications of the models presented to market environments and the links with rational expectations equilibria. Section 5 characterizes the information externality present in models of learning from others. Concluding remarks follow.

2. Herding, informational cascades, and social learning

The herding/informational cascades literature has used a sequential prediction model where each agent moves at a time, choosing among a finite number of options, having observed the actions of the predecessors and receiving an exogenous signal (of bounded precision) about the uncertain relative value of the options (see Bikhchandani et al. (1992) - BHW henceforth). The simplest model involves two states of the world, two signals and two actions. The model of Banerjee (1992) has a continuous action space but payoffs are degenerate: only by hitting the right choice agents obtain a positive payoff. In the models in this family the payoff to an agent depends on the actions of others only through the information they reveal. It is shown that an 'informational cascade' (as defined by BHW) may occur, with agents eventually disregarding their private information and relying only on public information. Furthermore, it is possible that all agents 'herd' on a wrong choice despite the fact that the pooled information of agents reveals the correct choice. Obviously, in those models it is not the case that the actions of agents (public information in general) are always sufficient statistics for their information. Indeed, otherwise all information of agents would be aggregated efficiently and the correct choice identified.

Two important assumptions lie behind the possibility of incorrect herds.

First of all, the model presents indivisibilities in terms of a discrete action space. With continuous action spaces (containing potentially optimal actions) and agents being rewarded according to the proximity of their action to the full-information optimal action convergence to the latter obtains. (In fact, in this case the actions of agents are always sufficient statistics for their information.) With a discrete action space there is always a positive probability of herding in a non-optimal action since agents can not fine-tune their actions to their information (see Lee, 1993).

Secondly, signals must be of bounded precision. Indeed, as shown by Smith and Sorensen (1994) in the context of the BHW model, if signals are of

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2 Banerjee (1992) obtains herding with a continuous action space but with degenerate payoffs.
unbounded informativeness then (almost surely) eventually all agents take the right action. Otherwise, herding occurs (almost surely) and it may be on the wrong action. With signals of unbounded precision incorrect herds are overturned by the action of an agent with a sufficiently informative contrary signal (and this individual eventually appears). 3

In summary, either with continuous action spaces and regular payoffs, or with discrete action spaces and signals of unbounded precision incorrect herds can not arise and convergence to the optimal action obtains. In this sense incorrect herds are not a robust phenomenon. In order to arise indivisibilities and signals of bounded precision are needed.

Several extensions of the basic model have been considered in the literature.

First, in the basic model the order in which individuals act is exogenously given. If the order of moves is endogenous then agents learn both about the actions and the delay (no-action) of other agents. There is a trade-off between the urgency of acting (impatience) and the benefit of waiting and acting with superior information. According to Gul and Lundholm (1992) this creates clustering (similarity of agents' actions) by allowing first movers to infer some of the information of later movers and by allowing agents with more extreme signals to act first. The endogenous timing of actions leads also to inefficiencies: an agent by choosing when to act does not take into account the externalities imposed on the other agents. Charnley and Gale (1994) explore the forms of market failure involved in delaying action and how do they depend on the speed of reaction of agents. Market failure tends to lead to too little information revelation and it may involve 'collapse' in the sense that no information is revealed at all.

Second, in the basic model it is assumed that each agent observes the sequence of the actions of his predecessors. Smith and Sørensen (1995) assume that agents observe imperfect signals ('reports') of some number of predecessors' posterior beliefs and consider two cases: learning from aggregates (the aggregate number of agents taking each action, for example) and learning from samples of individuals. The latter encompasses word-of-mouth learning and bounded memory. They find in both cases that complete learning obtains eventually with unbounded informativeness of privates signals. Proofs are complicated because in general public beliefs in their model are not martingales. In fact, the authors find systematic biases in the forecasts agents make of future beliefs held by successors (with 'mean reversion' in the sampling case and the converse 'momentum' in the aggregate statistic case).

Finally, Banerjee and Fudenberg, 1995 have studied word-of-mouth learning in a model of successive generations making choices between two options. They find that convergence to the efficient outcome obtains if each agent samples at least

3 Smith and Sørensen (1994) show that adding noise (individuals who choose randomly) does not preclude complete learning with signals of unbounded precision.
two other agents, each person in the population is equally likely to be sampled, and signals are sufficiently informative. Convergence is obtained without agents observing the popularity or 'market shares' of each choice.

The basic model and the extensions considered are still very rough approximations to the phenomenon of social learning. Typically, the interaction of agents is constrained to a rigid sequential procedure in which individuals take decisions in turn having observed past decisions. Although many examples have been given to apply the basic model, ranging from choice of investments, stores, technologies, candidates for office, number of children, drugs, medical decisions, and religion, to all kinds of fads, it is not clear that the model really fits any of those situations. A fortiori, the model is still far from capturing the functioning of markets in which agents have a large flexibility in terms of actions (quantities and/or prices, for example), interact both simultaneously and sequentially, observe aggregate statistics of the behavior of others, and the system is subject to shocks. In the next section we consider a stylized statistical prediction model which conforms better with these stylized features of markets and helps to understand some robust principles of learning from others. Furthermore, the model is a step in the direction of bridging the gap with rational expectations analysis.

3. A smooth and noisy model of learning from others

Consider a continuum of long-lived agents interacting repeatedly in the market $\theta = 0.1, \ldots$. The agents are rewarded according to the proximity of their prediction to some random variable $\theta$, unobservable to the agents. At any period there is an independent probability $1 - \delta$, with $1 > \delta \geq 0$, that $\theta$ is realized and the payoffs up to this period collected. The expected loss to agent $i$ in period $t$ when choosing an action/prediction $q_{it}$ is the mean squared error: $L_{ii} = E(\theta - q_{it})^2$. The agent has available two pieces of information in period $n$. A private signal $s_i = \theta + \epsilon_i$ (the same for every period) and a public information vector: $p_n = \{p_0, \ldots, p_{n-1}\}$, where $p_t$ is the average action of agents in period $t$, plus noise: $p_t = \frac{1}{n} \sum_{i=1}^{n} q_{it} + u_t$, where $\{u_t\}_{t=0}^{\infty}$ is a white noise process. In short, agent $i$ in period $n$ has available the information vector $I_n = \{s_i, p_{n-1}\}$. All random variables are jointly normally distributed. Let the mean of $\theta$ be equal to 0, let signals be conditionally independent with the same precision $\tau_i (= 1/\sigma_i^2)$, and make the convention that errors on average cancel out (so that the average signal reveals $\theta$). Noise prevents public information from revealing the joint information of agents ($\theta$).

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5 This section follows Sections 2 and 3 of Vives (1995a) and Burguet and Vives (1995).
In the present context, myopic behavior, $\min \mathbb{E}((\theta - q)^2 | I_{in})$ and setting $q_{in} = \mathbb{E}(\theta | I_{in})$, is (individually) optimal. Indeed, an agent is infinitesimal and can not affect the public statistics. This shows that the formulation encompasses also the case of short-lived agents (and, in fact, with minor variations, if signals of agents of the same generation are allowed to be correlated the case of perfect correlation corresponds to sequential decision making as in the basic herding model but with transmission noise).

In the model agents act simultaneously in every period and noise avoids their average action fully revealing $\theta$. The dynamics of public information are easily characterized. Given our linear-normal model it is immediate that $\theta_n = \mathbb{E}(\theta | p^n)$ is a sufficient statistic for public information $p^n$ and follows a martingale: $\mathbb{E}(\theta_n | \theta_{n-1}) = \theta_{n-1}$. Let $\tau_n$ denote the informativeness (precision) of public information in the estimation of $\theta$ (that is, $\tau_n = (\text{Var}(\theta | \theta_n))^{-1}$). Then the posterior mean of $\theta$ with information $I_n = (s_i, \theta_{n-1})$ is, as usual, a weighted average of the signals received with weights according to their precessions (the private signal with precision $\tau_p$ and the public with precision $\tau_{n-1}$):

$$E(\theta | s_i, \theta_{n-1}) = \alpha_n s_i + (1 - \alpha_n) \theta_{n-1}, \quad \text{with} \quad \alpha_n = \tau_p / (\tau_p + \tau_{n-1}).$$

Further, since $\tau_n = \tau p + \tau u \sum_{t=0}^{\infty} \alpha_t^2$, it can shown that public precision is accumulated unboundedly but at a slow rate. These results are a manifestation of a self-correcting property of learning from others whenever agents are imperfectly informed and public information is not a sufficient statistic of the information agents have (Vives, 1993; Vives, 1995a; Smith and Sørensen, 1995). Indeed, the weight given to private information $\alpha_n$ is decreasing in the precision of public information $\tau_{n-1}$, and the lower $\alpha_n$ is the less information is incorporated in the public statistic $p_n$. A higher inherited precision of public information $\tau_{n-1}$ induces a low current response to private information $\alpha_n$, which in turn yields a lower increase in public precision. In this sense learning from others is self-defeating. Conversely, a lower inherited precision of public information $\tau_{n-1}$ induces a high current response to private information $\alpha_n$, which in turn yields a higher increase in public precision. In this sense learning from others is self-enhancing.

The self-enhancing aspect means that public precision $\tau_n$ will be accumulated unboundedly. If this were not the case the weight given to private precision would be bounded away from zero, necessarily implying that $\tau_n$ grows unboundedly, a contradiction. The self-defeating aspect means that accumulation is slow. It is possible to show that $\tau_n$ grows at the rate of $n^{1/3}$. This obtains because as $n$ grows unboundedly, $\alpha_n$ tends to zero and so does the amount of new information incorporated into $p_n$. (For purposes of comparison it is worth to recall that the

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6 Similarly, in Banerjee and Fudenberg (1995) convergence to efficiency is obtained when people use samples larger than one because this allows the possibility of 'mixed' samples which are relatively uninformative and consequently induces agents to rely on their private information and enhance the information flow into the system. This is again the self-enhancing aspect of learning from others.
standard linear rate \((n)\) for increase in precision obtains in the benchmark case of iid noisy observations of \(\theta\). The result is that \(\theta_n\) tends to \(\theta\) almost surely at the rate of \(1/\sqrt{n^{1/3}}\) (that is, \(\sqrt{n^{1/3}} (\theta_n - \theta)\) tends in distribution to a normal random variable with zero mean and finite variance).

**Remark.** Examples of the stylized model include reaching consensus, learning by doing and consumer learning (see Vives (1995a) for details).

**Remark.** Herd behavior or informational cascades are extreme manifestations of the self-defeating aspect of learning from others. With discrete action spaces and signals of bounded informativeness public information may end up overwhelming the private signals of the agents, who may (optimally) choose not to act on their information.

**Remark.** Convergence obtains at the standard rate \(1/\sqrt{n}\) if there is a positive mass of perfectly informed agents. The reason is that perfectly informed agents can not learn from public information and therefore put a constant weight on their (perfect) signals. The consequence is that at every round a the amount of information incorporated into the public statistic is bounded away from zero and learning is not self-defeating.

The enrichment of the model with costly endogenous information acquisition provides new insights. In Burguet and Vives (1995), it is assumed that agents are short-lived and can purchase a private signal paying a cost \(C\) increasing (and convex) in its precision \(\tau_\varepsilon\). The self-correcting property of learning from others corresponds to the fact that private \((\tau_\varepsilon)\) and public \((\tau)\) precision are strategic substitutes in the minimization of the loss \(L = (\tau_\varepsilon + \tau)^{-1} + C(\tau_\varepsilon)\). That is, \(\partial^2 L/\partial \tau_\varepsilon \partial \tau > 0\). This implies that the purchase of private information is decreasing in the amount of public precision. An increase in \(\tau\) reduces the incentives to purchase private information and moderates the increase in \(\tau\) since the weight to private information \(\alpha = (1 + \tau/\tau_\varepsilon)^{-1}\) is reduced. Furthermore, it is found that full revelation of \(\theta\) obtains if and only if the marginal cost at zero is zero \((C'(0) = 0)\). Otherwise, if this marginal cost is bounded away from zero, public precision can not accumulate without bound since then the marginal benefit of acquiring private information would tend to zero. These results provide a hint for a dynamic resolution of the Grossman–Stiglitz paradox when \(C'(0) = 0\). In that case, the market will be asymptotically strongly efficient in informational terms, that is, fully revealing of \(\theta\), and agents will have an incentive to purchase private information all along. The contradiction between eventual full revelation of \(\theta\) and incentives to acquire information disappears. On the contrary, if \(C'(0) > 0\) then the paradox is confirmed in the dynamic model. Furthermore, parametrizing appropriately the distance from the exogenous signal case, it is found that when \(C'(0) = 0\)
the speed of learning decreases as we move away from the exogenous signals situation.

4. Markets, prices, and rational expectations

Do the results obtained extend to more complex economic situations closer to the actual functioning of markets? In particular it is important to know whether convergence to full-information equilibria will obtain at a (relatively) fast rate in markets environments. Otherwise, as stated in the introduction, the Walrasian model may not be a good approximation of the behavior of agents in the economy even when repeated interaction has given the opportunity to prices to reveal information.

The smooth noisy model of learning from others of Section 3 is close to classical rational expectations models. In the latter prices are noisy aggregators of dispersed information and agents choose from a continuum of possible actions with smooth payoffs as rewards. Nevertheless, the slow learning results can not be applied mechanistically. Indeed, markets are more complex than the simple models of the previous sections. A general reason is that, unlike in the pure learning/prediction model, in market models the payoff of an agent depends directly on the actions of other agents. For example, the profit of a firm depends on the outputs of rivals firms. Furthermore, learning need not be always from others, agents can learn also from the environment. An example is provided by the classical learning in rational expectations partial equilibrium model with asymmetric information (as developed by Townsend (1978) and Feldman (1987)). Let us recall that in this model firms, endowed with private information about an uncertain demand parameter $\theta$, compete repeatedly in the marketplace. Inverse demand in period $t$ is given by $p_t = \theta + u_t - x_t$, with $x_t = \int x_i d_i$ being average output, and production costs are quadratic. The result here is that learning $\theta$ and convergence to the full-information equilibrium (or shared-information equilibrium in which $\theta$ is revealed) occur at the standard rate ($1/\sqrt{n}$). The reason is that public information (prices) depend directly (independently of the actions of agents) on the unknown parameter $\theta$. Even if agents had no private information they would learn from prices at the standard rate because, for a given output $x_t$, the price observation $p_t$ corresponds to an iid noisy signal of $\theta (\theta + u_t)$. In contrast, in a variation of the classical model (Vives, 1993) where the unknown $\theta$ is a cost parameter (a pollution damage, for example) prices will be informative

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7 This section is based, among other work, on Vives (1993) and Vives (1995b).
8 In general, learning $\theta$ and converging to a full-information equilibrium are not equivalent. Jun and Vives (1995) make the point in the same model with persistent shocks.
about $\theta$ only because they depend on the actions of firms, and the strength of the dependence will vanish as $n$ grows large due to the self-defeating facet of learning from others. Indeed, expected profit maximization yields an optimal production which is linear in the conditional expectation of $\theta$ and in past prices, and the result is that, as in the purely statistical model of Section 3, firms learn slowly about $\theta$ and convergence to the full-information equilibrium is also slow.

The speed at which prices reveal information is particularly important in financial markets where price or value discovery mechanisms are in place. An example is provided by the information tâtonnement designed to decrease the uncertainty about prices after a period without trade (overnight) in the opening batch auction of some continuous stock trading systems. At the beginning of trade there is a period where agents submit orders to the system and theoretical prices are quoted periodically as orders accumulate. No trade is made until the end of the tâtonnement and at any point agents may revise their orders. It is important that this information aggregation mechanism performs its value discovery purpose fast. A stylized version of the this mechanism is considered in Vives (1995b) where it is shown that information is aggregated at a fast rate in the presence of a competitive market making sector while without it convergence is slow (as in Section 3). The model considered is a competitive dynamic version of Kyle (1985) with risk averse investors. The reason why market makers (or agents using limit orders and supplying liquidity to the market) speed up convergence is as follows. Market makers, by expanding market depth, induce risk averse agents not to respond less to their private information as prices become more informative about the fundamental value of the risky asset. The presence of market makers prevents the self-defeating facet of learning from others from settling in. The outcome is that price quotations converge to the underlying value of the asset at a rate of $1/\sqrt{n}$.

In a related vein, Avery and Zemsky (1995) show how introducing a competitive market making sector in the basic model of BHW (adaptation of the Glosten and Milgrom (1985) model of sequential trading in financial markets) convergence of the price to the fundamental value obtains. Furthermore, and interestingly, the authors show that when traders are uncertain about the quality of information (precision) held by other traders then short-run price bubbles and ‘booms and crashes’ based on herd behavior are possible. The reason is that a poorly informed market may not be easily distinguishable from a well informed one from the point of view of competitive market makers. A similar explanation of market crashes has been offered by Romer (1993).

In the financial market examples considered there is learning from others and we see how changes in the market microstructure have consequences for convergence and the speed of learning. This shows that caution must be exercised when applying herding and slow learning results to market situations. Nevertheless, the models presented show how crashes and important departures of prices from fundamental values may be consistent with rational behavior on the part of traders.
5. The information externality

At the root of the inefficiencies detected in models of learning from others lies an information externality. An agent when making its decision (prediction) does not take into account the benefit this will report to other agents. Consider the model of Section 3, the (ex-ante expected) loss of a representative agent in period \( n \), \( L_n = (\tau_i + \tau_{n-1})^{-1} \), is decreasing in public precision \( \tau_{n-1} \). A larger response of agents to their private signals in period \( n \) will lead to a larger precision in period \( n \), \( \tau_n \), and consequently a lower loss in period \( n + 1 \) (and in subsequent periods).

The analysis of the information externality leads naturally to a welfare-based definition of herding as an over reliance on public information with respect to a well-defined welfare benchmark. The welfare benchmark we propose is the team solution which assigns agents decision rules so as to minimize the discounted sum of period losses (Radner, 1962). This solution internalizes the externality respecting the decentralized information structure of the economy. Optimal learning at the team solution involves incurring in short-term losses to increase long-run benefits; that is, it involves experimentation.

The solution to the team program characterizes the information externality. First of all, there is herding, in the sense that for any given public precision, the optimal solution always calls for a larger weight to private information than the market. Secondly, the market underinvests in information: the team solution at any period has accumulated more public precision than the market. Both results follow from the fact that the value function of the team program (with public precision \( \tau \) as state variable) is strictly decreasing. Nevertheless, slow learning at the market solution is not suboptimal. The team solution has exactly the same asymptotic properties as the market. The reason is that for \( n \) large the market and the optimal program look similar because the value function of the latter is almost flat for \( \tau \) large. In both, the responsiveness to private information tends to zero as \( n \) grows. Indeed, this is the only way to enjoy the benefits of the accumulated public precision. It may be worth pointing out that from a full-information first best perspective, in which agents share their information and \( \theta \) is revealed, it is no consolation that the slow market learning is team-optimal. Indeed, in the full-information first-best losses are zero in any period.

Costly information acquisition raises several interesting issues and accentuates in general the effects of the information externality. Consider now a second best welfare benchmark in which private information purchases can be controlled, via tax-subsidy mechanisms, but otherwise agents are free to take actions (make

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9 The analysis in this section follows Vives (1995a) and Burguet and Vives (1995).

10 \( L_n = E(\theta - E(\theta | I_n))^2 \). Note that \( L_n \) is independent of \( i \) since the information structure is symmetric. It follows that \( L_n = \text{Var}(\theta | I_n) = (\tau_i + \tau_{n-1})^{-1} \).
predictions). Notice that it is not obvious now that generating more public information will be welfare improving. The reason is the self-defeating aspect of learning from others. Indeed, increasing public precision today reduces the weight agents will put on private information (for a given precision \( \tau_r \)) tomorrow. In order to maintain a certain weight on private information \( \alpha \) (which is what determines the increase in the next period public precision) more effort has to be devoted to acquire private information (that is, to raise \( \tau_r \)). This is the counterpart of the fact that private information acquisition at the market solution is decreasing in inherited public precision. In consequence, the reduction of the prediction losses today may make more costly to decrease future losses. The possibility is borne out by an example, in a variation of the basic herding model, by Smith and Sørensen (1995). They show how the observation of larger samples of predecessors ('more public information') does not necessarily improve welfare at the market solution. In a somewhat related vein, Banerjee (1993) in a model of the economics of rumours finds that speeding up the transmission of information (the rumour) has no welfare effect since then the rumour must be received sooner to be trusted (in his model after a certain, endogenously determined time, a rumour is not trusted). Despite these possibilities, in the model of Burguet and Vives (1995) it is shown that for a large enough initial public precision \( \tau \) more of it is always good at the second best solution. Notice that this would always be true in a first best world where the team manager can assign decision rules to agents as well as control information purchases. It follows that for large \( \tau \) there is herding and subaccumulation of public information at the market solution with respect to the second best. This subaccumulation may be very severe when \( C'(0) > 0 \) and the discount factor \( \delta \) is large. Relative welfare losses at the market solution either with respect to the first or second best are increasing with the distance from the exogenous signals case and peak for intermediate values of public noise \( \tau_u \). That is, the relation between improvements in information transmission (increases in \( \tau_u \)) and relative welfare losses is not monotonic. This should not be surprising since the information externality bites in an intermediate range of \( \tau_u \). If it is very low public information is very imprecise anyway and if it is very high public information is almost fully revealing.

6. Concluding remarks

The literature on social learning has demonstrated that surprising behavior of agents, involving sometimes apparently erratic market performance and inefficient outcomes can be explained without departing from the rationality paradigm. The explanation of short-run price bubbles and crashes stands out in this respect. Nevertheless, we have also argued that incorrect herds, are not a robust phenomenon. They depend on the action space of agents and the information structure. Working with a stylized smooth model, which is closer to the actual
mechanisms of market interaction, we do isolate two robust properties of learning from others. First of all, learning from others has a self-correcting property which in its self-enhancing facet tends to promote full revelation, but that in its self-defeating one slows it down. Secondly, learning from others involves an information externality and generates inefficient outcomes.

The first result implies that there is no contradiction between rational expectations models and the social learning literature. Nevertheless, although in the smooth model convergence obtains, it is slow. This would indicate that full-information equilibria may not be a good approximation to the economy with private information even after repeated market interaction. Two caveats must added. First, the slow learning result applies to situations where learning from others dominates while in some markets there is mostly learning from the environment (like in the classical rational expectations model of Townsend (1978)). Second, even in ‘learning from others’ cases there are market mechanisms, like the presence of a market making sector, which may speed up learning.

The analysis of the information externality shows that although welfare losses at the market solution may be important, relative to either first or second best benchmarks, the rate of convergence is not distorted. That is, slow learning is not suboptimal. The information externality explains herding and the tendency towards subaccumulation of public information.

The study of costly information acquisition provides a dynamic resolution of the Grossman–Stiglitz paradox: when \( C'(0) = 0 \) the market is asymptotically informationally efficient and the incentives to purchase information are preserved. In general, however, costly information acquisition accentuates the information externality problem.

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