1 Relevance to the call for proposals

The proposed project comply with the requirements of being basic research within economics. We believe our project will provide output of a high scientific quality.

2 Aspects relating to the research project

2.1 Background and status knowledge

Decades of controlled laboratory research shows a stunning efficiency in most experimental markets. They clear under a wide range of market institutions, and converge to new equilibria surprisingly fast in reaction to various types of imposed shocks (e.g. Plott & Smith 2007, parts I & II). Most remarkably, however, efficiency frequently results under conditions were standard theory predicts market failure. In the words of Vernon Smith (2008) the latter aspect is "good news for markets, but bad news for economics".

Results from experiments on non-market, strategic, decision making in small groups paint a radically different picture. A large body of replications document that behavior in a small number of generic games deviates significantly from the equilibria of the standard model (= rational and purely self regarding players). Deviations are particularly pronounced if distributive conflicts are increased (e.g. Bolton *et al.* 2007; Camerer 2003:ch 2 &4; Fehr & Fischbacher 2005; Murningham 2007). Still, subjects are often able to coordinate more effectively than predicted by standard theory in games with multiple equilibria and modest distributive conflicts (see Camerer 2003:ch 7 for an overview).

We propose to study two market institutions experimentally: Markets with search costs, and markets with network externalities. In markets with search costs the standard model provides fairly clear predictions about behavior (Mortensen 2000; Pissarides 2005). However, questions of bargaining power - and thus small group strategic interaction - are integral to search theories. A large body of experimental research shows large deviations from the equilibria of standard bargaining models (e.g. Camerer 2003:ch 7; Roth 1995).

In markets with network externalities, the standard model offers less clear cut predictions (Caillaud & Julien 2001, 2003; Ellison & Fudenberg 2003; Ellison *et al.* 2004; Ambrus & Argenziano 2009; Rochet & Tirole 2002, 2003). The ambiguity largely results from the absence of an accepted theory of equilibrium selection, and the fact that multiple equilibria are integral to markets with network externalities. Still, as noted, subjects are often quite good at coordinating in generic coordination experiments.

In terms of lab behavior, markets with search costs and markets with network externalities fall between the optimism of anonymous, decentralized market behavior, and the pessimism of small group strategic interaction. It makes these markets both demanding and interesting to study.

2.2 Approaches, hypotheses and choice of method

Our approach is laboratory experiments. Satisfactory field data tests of markets with costly search and network externalities are challenging to perform. This is due to measurement problems on key variables, as well as thorny questions of endogeneity, reversed causation and intervening third variables.

Laboratory experiments offer far greater control with the central building blocks of these theories; such as market size, information structure, payoffs and rules of the game. Key variables

can be measured precisely, and true exogenous variation is produced by controlled manipulation, allowing for firm conclusions about causality. This is the great advantage of experimentation.

The cost is uncertainty with respect to external validity. We share the view that laboratory experiments are useful supplements to field data studies, and can play an independent role in providing new input for theory building. We also share the view that the final arbiter is field data (Bolton 1998).

The methods of experimental economics are well developed (Kagel & Roth 1995; Roth 1988; Smith 1994). Implementation of experimental protocols follow a set of established rules in which deception is prohibited, and participants are subjected to monetary incentives. A set of matching protocols have been developed to ensure the containment of reputational effects in the lab, and to facilitate the collection of independent data from experiments. We plan to run the experiments on a software that is widely used in experimental economics (Fischbacher 2007).

2.2.1 Experimental markets with network externalities

Theory A core hypothesis in markets with network externalities and competing platforms, is that such markets will favor the platform that enjoys an initial monopoly position ("lockin"). This is due to multiple equilibria and coordination problems. If the initial monopolist is Pareto-dominated by later challengers, lock in results in a welfare loss.

Positive network externalities arise when a good is more valuable the more users adopt the same good or compatible ones. Telephone is an example of such a good; the utility of having a phone is small if few others have one.

The presence of network externalities can have profound impact on the behavior of firms and consumers in the market (Shy 2001). The market may have multiple equilibria where in one equilibrium all adopt a platform, while in another equilibrium no one adopts it. The market outcome depends on the formation of expectations on the market size of the platform. Network externalities may lead to inefficiency. For instance, the diffusion of a new promising technology may be severely halted because consumers cannot coordinate (Farrell & Saloner 1985).

When a game has two or more equilibria, it is far from obvious which of these equilibria players should coordinate on. In particular, it is not regarded as sufficient that one equilibrium Pareto-dominates the others. The seminal work on equilibrium selection is due to Harsany & Selten (1988). Their theory says that if one particular equilibrium is pareto-dominant (PD) as well as risk dominant (RD) it ought to be selected. To get a feeling of the RD-concept, consider a game with two equilibria, such as for instance the 2X2 stag hunt game. Calculate the loss of a player when the opponent deviates from an equilibrium. The equilibrium with the larger product of deviation losses is said to risk dominate the equilibrium with the smaller product of deviation losses. Extension to more than two players is non-trivial, and several (partially non corresponding) formalizations exist (see the discussion in Carlsson & van Damme 1993). If the two criteria conflict, so that one equilibrium is PD while the other is RD, things are less straight forward even in 2X2 games. Harsanyi & Selten (1988) argued that the PD equilibrium would be chosen by rational players in such situations. Harsanyi (1995) later revised this opinion, and settled for risk dominance as the relevant selection criterion. Furthermore, several evolutionary game models for large populations claim that players might fail to coordinate on the PD equilibrium, and instead end up in Pareto dominated, RD equilibria (Samuelson 1997:75-81).

Summing up, it is fair to say that i) conflicting criteria would seem to make coordination harder; and ii) that the jury is still out with respect to the rational way of selecting between equilibria.

Experimental evidence The experimental literature on multiple equilibria and coordination is large. Several papers deal with equilibrium selection criteria (Straub 1995, Van Huyk et al 1990; cfr. Camerer 2003:ch 7). In general it is found that coordination on an equilibrium is more likely the smaller the product of deviation losses is for this equilibrium. Another literature - partly within psychology - deals with the importance of focal points (Schelling 1960) in solving coordination problems (Bacharach & Bernasconi 1997; Mehta et al. 1994). It finds that focal points do play a prominent role in equilibrium selection.

A particularly relevant paper on coordination is Fehr & Tyran (2008). They show - in a context of money illusions - that even though people frequently make mistakes, they tend to acknowledge this rapidly. If unilateral corrections can be carried out, initial mistakes will be corrected without delay. However, mistakes can (and do) have persistent effects in strategic contexts, since mistakes may (and do) lead subjects to coordinate on inferior equilibria and get locked in to them.

Only a couple of experimets focus explicitly on coordination in markets with network externalities. Hossain & Morgan (2009) investigate the lockin hypothesis experimentally. In their design a platform is given monopoly status in the first 5 periods of a 10 period session. In periods 6-10 of the session a competing platform is introduced. The competitor Pareto-dominates (PD) the initial monopolist. Clear results are obtained: Behavior is tipping to the PD platform. Coordination happens fast and is powerful. Furthermore, tipping does not depend on the relative entry fees of the two platforms; markets are tipping to the PD platform even when it has the higher entry fee. In a series of controls it is shown that if the initial monopolist PD the subsequently introduced challenger, the initial monopolists market share is kept. Again; the result does not depend on the relative entry fees of the two platforms.

In a later paper (Hossain *et al.* 2010) markets in which no platform is given an initial monopoly is studied. Under a wide range of conditions (relative entry fees; co-existence of a mixed equilibrium; market size) these markets are tipping in favor of the PD platform.

An exception is were PD and RD conflicts. In such situations the market does not seem to tip clearly in the direction of either the PD platform or the RD platform. Conflicts between RD and PD are of particular interest given the role they play in theories of equilibrium selection (Harsanyi & Selten 1988; Carlsson & van Damme 1993).

The prominence of such conflicts is amplified by the fact that these criteria also seem to explain behavioral differences in generic coordination experiments (references above).

Hypothesis and design In Hossain & Morgan (2009) all PD platforms are also RD. We suspect that this fact is driving the strong results obtained. For this reason we wish to run experiments were a PD (RD) platform is given an initial monopoly, while a RD (PD) platform is introduced subsequently. As in Hossain & Morgan (2009) we intend to run controls in which the PD and the RD platform respectively has the lower entry fee; and whether a mixed equilibrium co-exists or not. In addition we wish to run control sessions with substantially larger markets than in current experiments (we have a capacity of up to 68 participants). We also want to expand this experiment systematically by running sessions in which the focal point attributes of the platforms are varied systematically.

If the results in Hossain & Morgan (2009) are shown to be sensitive to conflicts between PD and RD the possibility of lockin resurfaces in experimental markets with network externalities. If conflicts between criteria turns out to creates lockin in experimental markets, the argument of Hossain & Morgan (2009) must be qualified. Since it is difficult, if not outright impossible, to determine whether platforms conflict in actual markets, such experimental results would reinvigorate the debate about coordination failure in real markets.

We propose to test the following general hypothesis:

- Does initial monopoly prevent tipping to a PD platform when PD and RD conflict over platforms?
- Can focal point characteristics prevent or promote tipping to a PD platform when PD and RD conflict over platforms?
- Which focal point characteristics prevent and promote tipping to a PD platform when PD and RD conflict over platforms?

2.2.2 Experimental markets with search frictions

Theory Search theory departs from the standard model of competitive markets in that finding a trading partner is time consuming and costly. Search models are used to analyze prize setting and equilibrium price distributions in retail markets, as well as wage setting and unemployment formation in the labor market. Search models of the retail markets show that details of the information structure have profound effects on equilibrium prices (Diamond 1971; Burdett & Judd 1983; Stahl 1989). In labour market search, the standard model framework is the so called Diamond-Mortensen-Pissarides (DMP) model (Diamond 1982; Mortensen 1986; Pissarides 2000). In the DMP-model unemployed workers and firms with vacancies search for each other, and are slowly matched. When forming a match, the worker and the firm bargain over how to split the resulting match surplus. The outcome of bargaining is determined by exogenously given bargaining weights. The model is closed with a zero profit criterion for the establishment of vacancies. Due to the simple structure of the model, it delivers clear predictions for how macroeconomic conditions influence job creation and the equilibrium unemployment rate.

Experimental evidence Only a handful of experiments on search behavior exist. The main part of the literature deals with optimal stopping. Subjects draw a "wage offer" randomly from a specified distribution, and receiving an offer is costly. Search theory provides clear predictions about when a subject should accept an offer, and when the subject should continue searching. Results from the lab in general corroborates the theoretical predictions on this points (Harrison & Morgan 1990; cfr. Cox & Oaxaca 2008 for an overview).

A couple of experiments analyze price determination when it is costly for buyers to "sample" price offers. Once again, theory provides clear cut predictions about equilibrium prices. In particular theory shows that equilibrium prices are very sensitive to changes in the information structure. Here results from the lab are more mixed. By systematically manipulating the information structure one is able to move price behavior in the lab in the direction of equilibrium prices. None the less; actual price behavior is far less extreme than theory would predict. A hypothesis that has been suggested – but has not been systematically investigated – is that deviations from equilibrium predictions are due to the fact that social preferences come into play (Abrams, Sefton & Yavas 2000:737).

Evidence in Cason & Friedman (2000) are more uplifting and indicate that prices stay within a certain bound given by equilibrium price distributions in experiments with many robot buyers (that are programmed to follow equilibrium behavior). In their experiment various (non-overlapping) equilibrium price distributions are created by manipulations of search costs and the probability of more than one price quote. Sessions with none, few and many robot buyers are conducted. With many robot buyers sampling is from a large universe. This is thought to boost learning and convergence. An alternative interpretation (not discussed by the authors) is that many robots also weed out social preferences. Sellers does not know wether they are facing a human or a robot in any given round, but the probability of facing a robot is significant in the many robots treatment. Human buyers can "hide behind the robots". This may make them more

inclined to pursue pure self-interest. So, whether results are due to learning or the suppression of social preferences is an open question.

In search theory there is a huge difference in prices, depending on whether the buyer observes one or more than one price in the market. In the first case the seller captures the entire rent, in the latter case perfectly competitive prices result. No additional insights are produced in the theory by letting the buyer observe more than two prices. With only one price quote, the bargaining protocol essentially allow the seller to offer an ultimatum price to the buyer. As soon as the buyer can turn to an alternative seller, the bargaining powers of sellers are eroded by a Bertrand process.

Hypothesis and design We propose to investigate three hypothesis; the role of social preferences in the determination of prices; the mechanisms of learning and price convergence; the importance of outside options for search behavior and price determination.

Social preferences: As noted, in Abrams, Sefton & Yavas (2000) prices does not converge fully to the competitive level when buyers get two price quotes. Roth et al. (1991) show that in pure ultimatum bargain (no search market) with four buyers (firms/proposers) and one seller (worker/responder), offers from buyers quickly approach the competitive price where the seller gets the entire surplus. This finding holds over subject samples in four different countries. With this as a back drop it seems interesting to replicate the Abrams, Safton & Yavas (2000) experiment - but introduce two, three and four price quotes. If prices do not reach competitive levels as the number of price quotes increases there seems to be "something other" than social preferences over the division of the surplus at work. Results from such an experiment should provide clues as to what "it" is, and how to design follow-up experiments that can pin-point "it".

Learning and convergence: Several papers suggest that learning helps reproducing major features in experimental data (see Erev & Roth 1995, Camerer 2003:ch 6). Modeling agents with learning helps explaining for example the autocorrelation in player's choices, the importance of initial conditions under slow learning. Various learning models have been used to structure data from laboratory experiments: in general agents are assumed to learn from past experience (putting bigger weight on strategies that performed well in the past) We will draw on this literature to explore the dynamic paths of play revealed by the data generated in our experiments.

Learning about the game and about other player's strategies happens through experience: players observe and react to prior play. Therefore, decreasing noise in the history facilitates learning. Cason & Friedman (2000) show that using many robot buyers speeds up convergence of learning. Our hypothesis is that *robot buyers* may also speed up convergence because they *weed out social preferences*. To check wether this is the case, we plan to run sessions with large markets of human buyers. Our capacity at BI allow us to run sessions with as many as 68 human subjects in one market. In the existing literature experimental search markets are typically small, comprising 4-8 (human) subjects on each side of the market.

An alternative way to achieve convergence under learning, is to *increase the number of trading periods*. Fairly long runs have been performed in the literature, with sessions comprising as many as 140 trading periods being implemented by Cason & Friedman (2000). To ensure that subjects keep attentive for such protracted periods in the lab, it is seems advisable to run with payments that are generous enough to make each trade worthwhile. In Cason & Friedman (2000) stakes per trade are modest. We wish to run sessions with few/many trading periods, in small/large markets in order to study learning and convergence more systematically. These experiments will require resources.

Impact of continued search on bargaining: We plan to take the Diamond-Mortensen-Pissarides model to the lab. To the best of our knowledge we will be the first to do so. Firms are (at least initially) robots, and their programmed behavior is public knowledge. When unemployed

workers is matched with a firm, wages must be bargained. We design the bargaining game such that the equilibrium corresponds to the (cooperative) Nash equilibrium of wage bargaining in the DMP model. In the bargaining game the alternative to agreement is for the worker to continue searching. Theoretically the search option should impact crucially on the division of surplus between workers and firms. We wish to analyze whether and to what extent search behavior and wage formation in the experiments coincide with the predictions of the DMP model. We also wish to explore the sources of deviations between the DMP model and lab behavior. In particular we are interested in exploring the effects of "unemployment benefits" (non-wage income of unemployed workers while searching) on search behavior and wage levels, and hence also on the implied "unemployment rate" (fraction of workers searching). Finally we wish to analyze the sensitivity of worker behavior to changes in firm productivity, measured as changes in the range of feasible agreements in the bargaining game.

We propose to test the following general hypothesis:

- Is there a difference between getting two and getting more than two price quotes in experimental search markets? And if so, why?
- Do subjects learn to play the equilibrium (or something close to it) in large search market with human players?
- Are large markets more or less conducive to convergence than sessions with many trading periods?
- How do subjects learn to play the equilibrium?
- To what extent is the DMP model confirmed by actual behavior in the lab
- How does search behavior and wage setting respond to "unemployment benefits" and firm productivity in experimental markets?

2.3 The project plan, project management, organization and cooperation

A detailed project plan is accounted for in the online application.

The project team consisist of Espen R. Moen (project leader); Leif Helland and Tom-Reiel Heggedal - all at the Economics Department / BI Norwegian School of Management; Krisztina Molnár - at the Economics Department / Norwegian School of Economics and Business Administration; and Jean-Robert Tyran - at the Economics Department / Unversity of Vienna. The team includes experienced and merited reserarchers within their fields. Together they cover search theory; theory of network externalities; experimental design; behavioral economics; and learning theories.

The project will be a part of the project portfolio of the Center for Research in Economics and Management at the Economics Department / BI Norwegian Business School, directed by professor Espen R. Moen. The center already houses several projects, including "Incentives in Labor Market Equilibrium" financed by the Research council under the FRIPRO programme, and "R&D, Industry Dynamics and Public Policy" financed by the Research Council under the programme "Vekstforsk".

The economics laboratory at the BI Norwegian School of Management is state of the art. It has the largest capacity of the Norwegian permanent economics laboratories. In standard set up it runs with up to 48 subject machines in a dedicated room, in which each subject machine is boxed in by a permanent cubicle (to minimize experimenter effects). The lab can be expanded with an

additional 20 subject machines located in a separate room. We have access to 7.500 (updated) undergraduate e-mail adresses, from which we are free to recruit subjects to experiments.

2.4 Budget

The project has a total budget of 8 million NOK over the four year period 2012-16. Details of the budget is found in the online application.

3 Key perspectives and compliance with strategic documents

3.1 Compliance with strategic documents

The proposed project will be in full compliance with the strategic documents for FRISAM.

3.2 Relevance and benefit to society

The markets covered by the application have real world counterparts. Markets with network externalities and coordination challenges over platforms cover as diverse phenomena as credit cards; search engines on the net; online dating sites; operating systems; and stock exchanges. Most markets have tangible search costs - and search and matching are central to crucial markets such as those for labor and consumer durables. Expanding our knowledge of the mechanisms at work in such markets should ultimately improve policy advise on how to make them function better. The welfare gains of improved advise could be considerable.

3.3 Environmental impact

The proposed project will not have direct or indirect environmental impacts.

3.4 Ethical perspectives

We will obey the ethical codes of the experimental economics society. In particular we will follow a strict no-deception policy in execution of the proposed experiments. This means that what subjects are told will happen in a session, is what happens in the session.

Anonymity of subjects will be preserved during all experiments, and results will be presented on a format that precludes identification of individuals.

3.5 Gender issues

We summarily include gender as a variable in analysis of experimental data - to check wether gender effects are discernible. This requires recruitment of fairly balanced samples of subjects to our experiments, enabling roughly equal numbers of male and female students to benefit from the experience of participating in experimental markets.

The project team includes a prominent female researcher - Krisztina Molnár.

Under conditions of roughly equal competence in the pool of applicants, we will select a female PhD student to the project.

4 Dissemination and communication of results

4.1 Dissemination plan

The first year of the project period will be used for design, programming and execution of (pilot) experiments. By the second year of the project period working papers based on data collected in the laboratory will appear. These will be discussed at seminars, workshops and conferences. Based on discussions, it may be necessary to execute follow-up experiments. We expect the first research papers to be ready for submission in high quality journals one and a half year into the project period, and further submissions to take place through the period. In addition a Phd-dissertation on experimental markets with search costs and/or market externalities is expected by the end of the fourth year after initiation of the program.

4.2 Communication with users

Results will be communicated to the Norwegian Research Council as required.

At times, results from the economics laboratory are "colorful", and therefore prone to catch the attention of the public at large. Due to the parameterization of the experimental games used in our project, results will be more readily comprehensible to non-expert audiences than general theory and field data results. Both "colorfulness" and comprehensibility facilitates communication of results to broad, non-expert, audiences through media and the popular press. Such communication will be prioritized in the project.

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