HOW BUSINESS MANAGEMENT GAMES CAN BE USED TO ANALYZE THE BOUNDEDLY RATIONAL BEHAVIOUR OF ECONOMIC AGENTS

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Abstract

Regulatory policies often aim to steer the behaviour of economic agents by changing their economic environment. Assessing the potential impacts of regulatory policies requires predictions about how humans adapt to such changes. One important prerequisite for meaningful policy impact analysis is in-depth knowledge of why and to what extent economic agents behave in a boundedly rational way. We propose that business management games be used to contribute towards better understanding of agent behaviours since they provide an inexpensive opportunity to reach beyond existing anecdotal evidence concerning "behavioural anomalies". Modifying an existing business management game in which investment, financing and production decisions have to be made, we demonstrate how bounded rationality can be quantified and separated into its two components: incomplete information and limited cognitive abilities. The resulting data show that decisions made by participants in this game are strongly influenced by bounded rationality. They also show that both incomplete information and limited cognitive abilities are relevant components of the bounded rationality displayed by players.

Introduction

Policy impact evaluation aims at forecasting which impact regulatory measures have on the decision-making of economic agents. Often, such forecasts are quite inaccurate and the policy measures do not have the desired and expected effect. One example is the German legislation on the promotion of organic farming in 2001 which was expected to lead to a 20%-share of organic farming by the year 2010. With a present share of organic farming of approximately 5%, this objective is far from being achieved. Regarding meaningful policy analysis the question arises whether the conception of homo œconomicus and conventional rational-choice models are an adequate base to predict how actors will behave in a changed economic environment. One school of thought argues that human beings do not act completely rational, but rather boundedly rational (Simon, 1956). Bounded rationality can be understood as a deviation from rational behaviour in the sense of inconsistency between individual goals and decisions actually made by the individual. Such sub-optimal decisions can be caused by incomplete information and/or limited information-processing abilities.

Good forecasts require good understanding of entrepreneurial decision-making (cf. Smith, 2010). As altered economic conditions only affect micro-level decisions if they are actually perceived and considered in the planning process, regulatory impact analysts need to take into account the real characteristics of economic agents, including their bounded rationality. Otherwise, one runs the risk of designing measures for economic agents who do not exist in the real world.

Data used for analyzing and predicting decision behaviour can be classified into five ideal types along a continuum of approaches: (i) naturally occurring field data, (ii) field data from randomized control trials, (iii) data from surveys with choice experiments, (iv) data from business management games, and (v) data from laboratory experiments. The controllability of contextual conditions and, thus, internal validity increases from the analysis of field data and surveys to the analysis of management games and lab experiments. In contrast, external validity in the sense that observed relationships can be taken as being valid for relevant real-life contexts decreases from one end of the continuum to the other (Roe and Just 2009). In laboratories, conditions can almost completely be controlled and

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deliberately varied (cf., e.g., Hudson 2003). While management games allow for marginally less control, the essential characteristics of a decision situation can still be purposefully designed according to the researcher's needs.
Business management games have a long tradition in both economics and agricultural economics (cf., e.g. Keys and Wolfe, 1990; Longworth, 1969 and 1970). Besides the pedagogic effect of students' learning, business management games produce a large amount of data. With careful game design, high-quality data can be obtained under controlled conditions and at low cost. In addition, the data gathered by business management games is very suitable for analyzing decision-making behaviour of economic agents. As economists, we should exploit these synergies and use such games in both teaching *and* research.

Existing work on the quantification of bounded rationality usually resorts to surveys or lab experiments (cf. Conlisk, 1996). Musshoff, Hirschauer and Wassmuss (2009) analyze the magnitude of anomalies in hypothetical financing decisions made by farmers via a survey. Trip, Huirne and Renkema (2001) use information matrices that have been generated by specialized flower producers in workshops to analyze whether these producers consistently choose cultivars that fit their personal preferences.

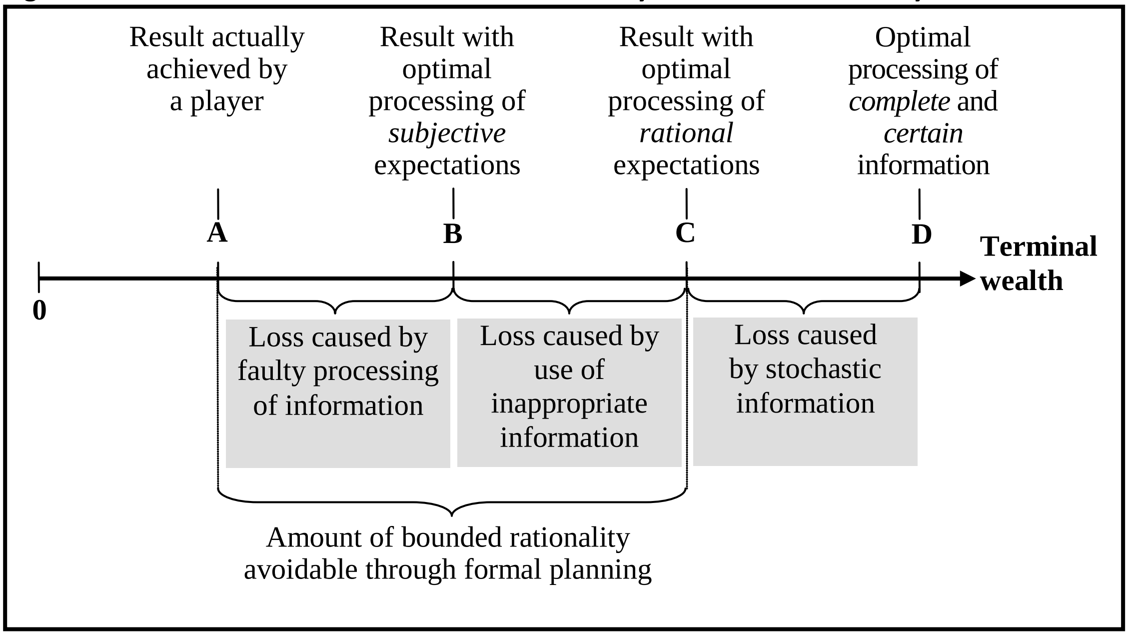
This paper examines the degree of bounded rationality of students in an incentive-compatible multi-period and multi-person business management game. The game, in which investment, financing and production decisions have to be made, is about maximizing terminal wealth in a competitive environment. Using various normative benchmarks, we examine the relevance of incomplete information and limited information-processing capacities.

The structure of this paper is as follows: We first illustrate the meaning of the various normative benchmarks that are used as reference in our analysis of bounded rationality. We then describe the design of the game and address the relevant implications for isolating bounded rationality. The results are then described and the paper ends with conclusions.

Design of the Study

The essential features of the game can be summarized as follows: (i) players make investment, financing and production decisions in consecutive periods; (ii) the players' goal in the game is to maximize terminal wealth; (iii) prize money is awarded to ensure that participants consider their decisions carefully; (iv) individual success depends on product prices which, in turn, result from the production decisions made by all participants; and (v) benchmarks are defined for each business showing the terminal wealth that would have been possible if more rational behaviour had been employed (cf. Figure 1).

Figure 1: Normative benchmarks used to analyze bounded rationality



The exact and relative positions of points A, B and C are unknown a priori. They are rather the objects of the study.

Our analysis is based on the potential improvement over each player's actual terminal wealth (point A) a fictitious player could have gained if she or he had applied formal and consistent planning. We determine consecutive reference points (benchmarks B to D) indicating the various components of improvement potential.

Reference point B is the result of a multi-period linear programming model in which the subjective price expectations of each player are formally processed in a methodically adequate way. Being player-specific, the idiosyncratic benchmark B indicates, separately for each player, the extent to which she or he acts in a way consistent with individual expectations. A gap between A and B is the result of faulty information processing and corresponds to the first component of bounded rationality.

Reference point C assumes formally correct decision making based upon naïve price prognosis. While all players have the same knowledge about the rules of the game as well as the available strategies and pay-off functions, future prices are uncertain in the sense that it is impossible to determine their probability distribution. This is due to the fact that the production decisions of the other players cannot be assessed. Even though one knows that prices depend on the production decisions of all players they cannot be derived through axiomatic assumptions concerning opponents' behaviours. In this context, Arthur (1994: 406) talks of agents having to form "subjective beliefs about subjective beliefs". Another way of saying this is that the determination of a game-theoretic equilibrium would require that all players had a "common knowledge of their respective bounded rationality". Since empirical time series are not available, the probability distribution of prices cannot be determined through statistical prognosis either. In this state of information, a naïve price prognosis represents the most plausible and, thus, rational price assumption that a player can come to. In brief, benchmark C is based on the assumption that price changes from one period to the next are zero; i.e., the last observed price is used for planning until new information becomes available (cf., e.g. Theil, 1966). Benchmark C indicates the terminal wealth that a fictitious player could have achieved if she or he had rationally processed the most rational price expectations. As points B and C only differ in price assumptions, the gap between the two reflects the component of bounded rationality caused by the use of inappropriate information. The distance between points A (actual terminal wealth) and C (achievable terminal wealth) reflects the total degree of bounded rationality.

It should be noted that point D is the result of a model based not only on rational price expectations but also – unrealistically - on certain information. That is, the production decisions of the other game participants are assumed to be a priori knowledge of one fictitious player. Hence, benchmark D can neither be beaten by actual players nor by other benchmarks. It represents an "unfair" reference since forecasts cannot be made with certainty neither in our business management game nor in reality. This is why point D is used only for a relative positioning of the actual results and the other benchmarks.

It should furthermore be noted that points B, C and D denote strategies which we label "individual" because they are based on the perspective that one fictitious "marginal player" –without influencing the game's market price – adopts the respective strategy. A "collective" perspective (which we do not adopt) would imply that all players adopt the strategy.

The business management game

We use a modified version of the business management game "Sparrow or Pigeon", which was developed for teaching purposes by Brandes (2002). The most important modification is that we offer prize money to ensure incentive compatibility. Each participant controls a business for which she or he has to decide on investments, finance and production in eight consecutive periods. Decisions have to be made weekly.
The starting situation at the beginning of period 1 is identical for all players: everybody has a starting capital of 2,000 monetary units (MU), and everybody has the same set of entrepreneurial choices. Nobody owns any production facilities yet. Two production activities, sparrows and pigeons, can be chosen. The price for sparrows is deterministic and known to everybody. Future pigeon prices are uncertain, as they depend on aggregate pigeon production. The production of a period has to be sold at the price valid in that period; that is, stock keeping is not possible.

Players can choose between different types of investments to build up production capacities. Disinvestments are not possible; that is, investment costs are completely sunk. The deterministic price of sparrows exceeds their production costs. Hence, there is a safe way to earn profits. Funds which are not used for production purposes yield an interest rate of 4% per period.

At the beginning of each period, players (businesses) make their investments, determine their production program and decide on how to finance their decisions. Furthermore, fixed costs occur for each business in each period. At the end of each period, the production is sold at the corresponding price and debt services are due. At the beginning of the next period, each player may make new decisions.

Funding requirements can be met by accumulated liquid funds (equity) or an overdraft credit. In addition, some production facilities can be partly financed by annuity loans. The players always have to be liquid. A business is automatically retired from the game if it cannot meet its payment obligations at the beginning of a period.
The objective of the game is to accumulate the highest terminal wealth by the end of period 8. To provide incentive compatibility, we announced prize awards for the five best players, totalling 300 €. The rank of players was not disclosed until the end of the game to prevent players from dropping out because of poor performance. We also asked the players at the beginning of each round to make a price prediction for the following three periods. The best overall price prognosis was rewarded with 50 €.

The game was played twice without changing any of the rules, once in the winter term of 2008/09 (group 1) and once in the summer term of 2009 (group 2), with participants being mostly students of agricultural science at Göttingen University who had differing economic knowledge. In each group we were able to analyze 23 players.

Isolating bounded rationality

The prerequisite for a meaningful investigation into bounded rationality is a clear and precise definition of rationality. We identify rationality with a profit-maximizing but risk-averse meta-planner who takes the costs of planning into account. From this conceptual view, two questions arise regarding the isolation of bounded rationality:

1. Can we assure that differences between players' results and benchmarks are not (partly) caused by players accounting for their individual planning costs, which are unknown to the game authority?
2. Can we assure that differences between players' results and benchmarks are not (partly) caused by players exhibiting individual levels of risk aversion, which are also unknown to the game authority?

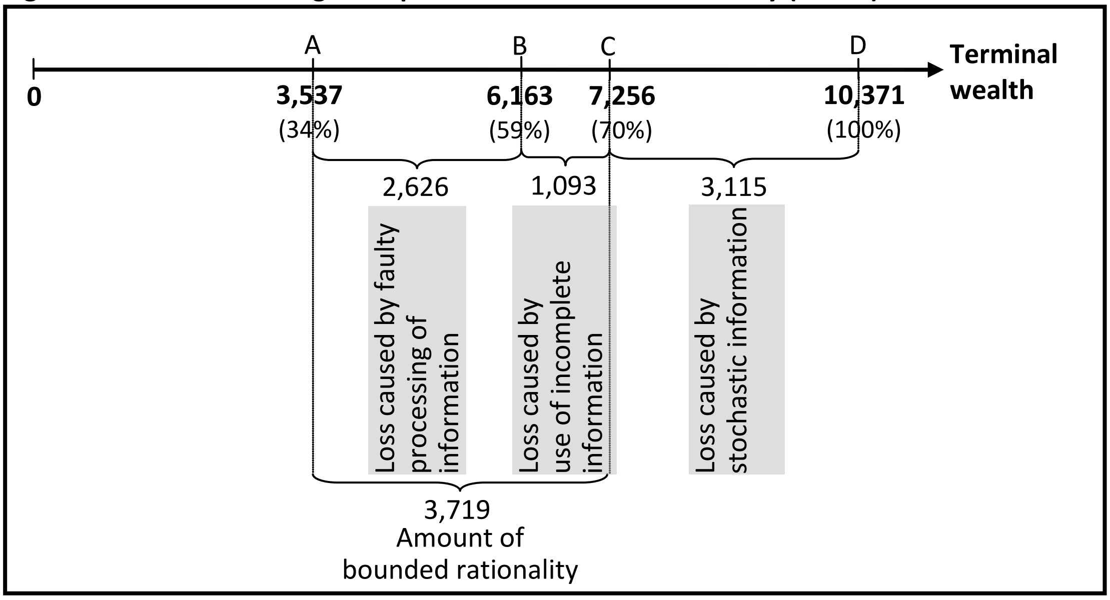
Regarding question 1: Considering the impact of individual planning costs is connected to the related question of whether incentive compatibility exists to a sufficient enough degree to convince players to put serious effort into their decision-making. Inevitable budgetary limitations regarding the prize money reduce the marginal revenue of additional planning efforts compared to a real-life situation where the actual realization of terminal wealth would be possible. If, for this reason, an individual player put less effort into planning, a bias due to insufficient incentive compatibility would occur. In a game, this can only be reduced – but usually not completely ruled out – by offering higher incentives. However, relevant literature suggests that incentive compatibility bias is marginal and may be neglected if relevant incentives are offered. If this is the case, generalizable causal relationships can be obtained from the findings of such games (cf., e.g. Schoemaker, 1982). We argue that the offer of prize money to students in conjunction with the "will to win" observed as part of their gaming fun represent a relevant incentive and that, thus, lower performance in comparison to a benchmark can be used as a proxy for the loss caused by bounded rationality (cf. also Holt, 1999: 605).

Regarding question 2: The design of the game allows for two types of outcome: First, one obtains no prize money if one is not among the top five players who achieve the highest terminal wealth. Second, one obtains prize money if one is among the top five. Due to this asymmetric payoff structure, the only relevant part of the distribution of terminal wealth is the upper 5/N percentile. The probability of winning prize money increases if one employs strategies that lead to higher expected values and a higher volatility of terminal wealth. Higher expected values are only achievable by producing pigeons the prices of which are – in contrast to sparrow prices – fraught with risk. This is why – regarding the "real" objective of winning prize money –strategies that maximize expected terminal wealth – independently from risk attitude – absolutely dominate other strategies in the game.

Results

Comparing the players' results with the results of the benchmarks allows conclusions to be drawn regarding the components of bounded rationality. Figure 2 summarizes the findings.

Figure 2: The average components of bounded rationality (in MU)



On average, an increase of 3,719 MU could have been achieved by formal planning compared to the players' actual results. This improvement potential, which we term "amount of bounded rationality", has two components: 2,626 MU (71%) are caused by faulty information processing, i.e. by the fact that the players did apparently not process their subjective price expectations in a methodically adequate multi-period linear programming model. 1,093 MU (29%) are caused by the inappropriate price expectations, i.e. by the fact that using the players' subjective price forecasts yields worse results than using a naïve price prognosis which represents the most rational price assumption that a player can come to given the rules of the game. A comparison of means shows that faulty information processing (t-test, $p < 0.01$) as well as inappropriate price expectations (t-test, $p < 0.01$) are statistically significant. Without uncertainty, that is, if the ex-post observed prices had been a priori knowledge (point D), the terminal wealth could have been increased by a further 3,115 MU.

The only data regarding the players' decision process are their subjective price forecasts. Knowing these forecasts enabled us to separate suboptimal information processing from suboptimal forecasting. However, no information has been gathered in the study regarding the planning methods and decision calculi that were actually used by the individual players in the game. This is why suboptimal decision-making could not be investigated beyond the identification of the relative share of the two components of bounded rationality. It thus remains unknown how the players formed their expectations and which methodical mistakes and inadequate heuristics they used.

Conclusion

In order to quantify bounded rationality and isolate incomplete information and limited cognitive capacity as its components, we compared the performance of student players in a business management game with normative benchmarks that were consistently derived from formal planning models. On average, we found that players' performance was reduced by more than 50% by bounded rationality. Inconsistent information processing caused over 70% of this loss and inappropriate information caused nearly 30%. These findings represent additional empirical evidence that decision makers exhibit a substantial amount of bounded rationality and that both of its components, incomplete information and limited information processing abilities, are relevant.

However, while producing internally valid results, the structure of our business management game may be devoid of many real-life complexities (cf., e.g., Tversky and Kahnemann, 1987). Furthermore, the players, being recruited from a convenience sample of students, may exhibit other characteristics than real-life actors who are of interest in a particular analysis. External validity thus being low, the results have to be interpreted with caution and can only be tentatively generalized to other populations and contexts.

We can make the general conclusion that, due to the potential relevance of bounded rationality, rational-choice models are not always adequate for assessing the behavioural outcomes following changes in the economic environment. When searching for adequate models, regulatory impact analysts must therefore make a critical and deliberate choice, which accounts for bounded rationality in all contexts where it exerts a significant influence on behaviour.

A correct regulatory impact analysis requires the construction of a decision model that closes the gap between actual behaviour and rational-choice prognoses (c.f. Rubinstein, 1991: 910), which, in turn, requires the policy analyst to take into account the heterogeneity of agents in terms of their individual bounded rationalities and assessments. Usually, this kind of individual data is either not available or prohibitively costly to come to. Thus, the attempt to define a boundedly rational choice model for each agent is out of question in most cases.

A feasible alternative may be to use context-specific business management games with representative groups of economic agents to simulate their boundedly rational adaptation to novel environments. Such a game simulation of expected behavioural adaptation has two advantages. First, it provides an adequate combination of internal and external validity: through an apt control of conditions, analysts can isolate behavioural effects caused by the policy measures under investigation. Due to the representativeness of the group, they are also able to generalize the effects identified in the game to the population of interest. Second, games with representative groups provide the opportunity to carry out an ex-ante analysis of regulatory impacts. Such a prospective analysis may save taxpayers' money compared to econometric analysis and conventional randomized control trials in the field, which represent an ex-post evaluation after costly policy measures have been implemented.
The use of context- and group-specific business management games seems especially attractive since the costs of generating meaningful data are very low, both compared to other methods and compared to the costs of ineffective and erring policy measures. They exhibit a particular potential if the policies to be evaluated are novel, i.e., if an econometric analysis of data observed from past policy implementations and environmental conditions do not "unveil" the agents' preferences and boundedly rational behaviours under changed environments.

Our study indicates that rational choice is not always suitable for explaining economic decision-making. It is therefore important to get a better understanding of the decision-making process of boundedly rational agents. To achieve this, heuristics, algorithms and calculi used in the decision have to be unveiled. It is also important to know which kind of real-life situations requires a thorough consideration of bounded rationality. A systematic classification of such real-life situations could start from the distinction of two ideal-types: in highly competitive markets boundedly rational actors who are slow learners will rather quickly be "competed out of the market". In such cases, rational-choice models are rather appropriate. In contrast, in situations where competition and selection pressure are low, there will be room for prolonged boundedly rational behaviour, the consequences of which can only be analyzed adequately by methods, which account for the actors' true characteristics. Sometimes the distinction may not be unambiguous. In such cases, an adequate methodical choice may involve combining rational-choice models with context- and group-specific business management games.

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