

Albert, Max; Hildenbrand, Andreas

Working Paper

Industrial organization in the laboratory

MAGKS Joint Discussion Paper Series in Economics, No. 05-2012

Provided in Cooperation with:

Faculty of Business Administration and Economics, University of Marburg

Suggested Citation: Albert, Max; Hildenbrand, Andreas (2012) : Industrial organization in the laboratory, MAGKS Joint Discussion Paper Series in Economics, No. 05-2012, Philipps-University Marburg, Faculty of Business Administration and Economics, Marburg

This Version is available at:

<https://hdl.handle.net/10419/56556>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

MAGKS



**Joint Discussion Paper
Series in Economics**

by the Universities of
**Aachen · Gießen · Göttingen
Kassel · Marburg · Siegen**

ISSN 1867-3678

No. 05-2012

Max Albert and Andreas Hildenbrand

Industrial organization in the laboratory

This paper can be downloaded from
http://www.uni-marburg.de/fb02/makro/forschung/magkspapers/index_html%28magks%29

Coordination: Bernd Hayo · Philipps-University Marburg
Faculty of Business Administration and Economics · Universitätsstraße 24, D-35032 Marburg
Tel: +49-6421-2823091, Fax: +49-6421-2823088, e-mail: hayo@wiwi.uni-marburg.de

Industrial organization in the laboratory

Max Albert and Andreas Hildenbrand

January 18, 2012

VWL VI: Behavioral and Institutional Economics, Justus Liebig University Giessen, Germany

Max Albert, VWL VI: Behavioral and Institutional Economics, Justus Liebig University Giessen, Licher Straße 66, 35394 Giessen, Germany. Telephone: +49 641 99-22200. Telefax: +49 641 99-22209. Electronic Mail: max.albert@wirtschaft.uni-giessen.de

Andreas Hildenbrand, VWL VI: Behavioral and Institutional Economics, Justus Liebig University Giessen, Licher Straße 66, 35394 Giessen, Germany. Telephone: +49 641 99-22203. Telefax: +49 641 99-22209. Electronic Mail: andreas.hildenbrand@wirtschaft.uni-giessen.de

Industrial organization in the laboratory

Theories of industrial organization (IO) are tested in the laboratory more and more often. The example we consider throughout the paper is oligopoly theory, specifically, the Cournot and the Stackelberg model of duopolistic quantity competition with homogeneous products. These models have often been subjected to tests: participants were told that they represented firms and received profits according to their chosen quantities. However, testing a theory in the laboratory requires that the experimental design falls into the domain of the theory. The domain of mainstream IO is market behaviour of large (i.e., multi-agent) firms. The basic hypothesis is that these firms maximize profits. This hypothesis cannot be tested in experiments where single agents are told that they represent firms. For a test, it would be necessary to assume that multi-agent groups and single agents show the same behaviour. This assumption is inconsistent with all current theories of individual behaviour and has, moreover, been falsified in many experiments. It follows that many alleged experimental tests of IO models are irrelevant to mainstream IO. This raises the question of whether relevant laboratory tests are possible at all. The answer is positive if one considers theories of the firm that relate organizational behaviour to the internal structure of the firm, like Alchian and Demsetz's (1972) contractual view of the firm.

Keywords: industrial organization; oligopoly theory; behavioural economics; laboratory experiments; theory of the firm; homo oeconomicus

1 Introduction

Industrial organization (IO) is one of the areas in economics where experimental methods have been applied first (see Plott 1982; Roth 1995, pp. 13-19). Nevertheless, modern IO developed quite independently of experimental economics (cf. Holt 1995, pp. 352-355). Specialized IO journals typically did not publish experimental work. This is not surprising. Early experiments in IO were concerned with market organization and individual behaviour in oligopolistic settings. In contrast, modern IO is basically concerned with the structure and behaviour of firms (see, e.g., Tirole 1988, p. 3; Scherer and Ross 1990, p. 1). It is not obvious how experimental methods may be brought to bear on these issues. After all, whatever individual agents may do in markets or in oligopoly games, the (typically, quite large) organizations taking centre stage in modern IO (see, e.g., Shapiro 1989, p. 330; Scherer and Ross 1990, p. 199) may act quite differently. We refer to this problem as the “problem of organizational behaviour”.

However, the explosive development of experimental economics has changed the situation. Industrial economists increasingly begin to take note of experimental economics. This does not mean, unfortunately, that they are facing up to the problem of organizational behaviour.

In a recent special issue of the *International Journal of Industrial Organization* devoted to experiments in IO, Normann and Ruffle (2011, p. 1) point out the advantages of experimental methods in IO. In their opinion, experimental control of the decision environment “makes possible *ceteris paribus* comparisons” that “permit clear-cut interpretations of causality”, while “[w]ith field

data causality remains elusive and one is left with mere correlations.” This “advantage [of experimental methods] is particularly salient in IO experiments” where these methods “allow us to address questions that are otherwise outside the purview of empirical research due to the unobservability of the underlying cost and demand parameters or the outcome variable, namely, the firm’s behavior.” With a view on the debate of the relative merits of laboratory and field experiments, they argue that experiments in IO are “largely immune to many of the criticisms launched at laboratory methods in the social sciences”. They believe that “framing is ordinarily not an issue in [IO] experiments” because “experimental market results are robust to the context in which the decision is imbedded”. And then comes what we think is a crucial point: “[f]urthermore, while experiments on individual choice and social preferences have been shown to be sensitive to moral considerations and the degree of anonymity of laboratory subjects’ decisions, these considerations are typically orthogonal to any experiment in industrial organization.”

In this paper, we are not concerned with the advantages of controlled experiments over other kinds of empirical tests. On this point, we largely agree with Norman and Ruffle. What is problematic in their position is the assumption that experiments studying individual decision making allow us to observe firms’ behaviour and to draw conclusions about its causes. On the one hand, they argue that framing is not an issue in IO experiments. On the other hand, they view participants’ “moral considerations” as “orthogonal” to IO experiments—although the only difference between, say, a simple Cournot duopoly experiment and a prisoners’ dilemma experiment is that the duopoly experiment frames decisions as decisions of firms. In a nutshell: we are led to believe that framing in IO experiments is ineffective except that it removes the problem of participants’ “moral considerations” (or, more generally, of participants’ other-regarding, or social, preferences).

This questionable argument results from an unresolved methodological problem, namely, the problem of organizational behaviour. Experimental industrial economists wish to contribute to the mainstream of modern IO but their claim that they observe firms’ behaviour in laboratory experiments is, to put it mildly, dubious. What they bring into the lab is the theory of single-agent firms (like Hotelling’s ice cream vendors), not a theory of the kind of firm that has been studied in empirical IO on the basis of field data (see, e.g., Schmalensee 1989; Sutton 2007). The latter kind of firm is, typically, a quite large organization. It is plausible that framing and social preferences play very different roles in organizational behaviour on the one hand and individual behaviour on the other. This difference cannot be studied by framing individual decision making as organizational decision making.

The problem is not the problem of external validity, which we consider as a red herring, here and elsewhere. The problem of external validity, put into the present context, turns on the question of whether (or when, or in which respect) one is allowed to generalize observations of individual decision making in the laboratory to organizational decision making on markets outside the laboratory. The solution to this problem is quite simple. Everybody is allowed to generalize as much as he wants. However, since all generalizations go beyond the observations that gave rise to them, the generalizations should be put to the test. How can this be accomplished? This is the question we are concerned with in this paper. The answer does not at all depend on where the theory under test has come from.¹

Rather than thinking about the justification of generalizations, we argue that solving the problem of organizational behaviour requires that we first answer the question of what shall be tested. If experiments in IO aim at contributing to a field concerned with organizational behaviour, the focus of experimental work must change. Testing a theory in the laboratory requires that the experimental design falls within the domain of the theory; then, and only then, the experiment is a test of the theory.² To put it more concisely: testing a theory by an experiment requires (i) that a prediction follows deductively from the theory (possibly extended by auxiliary hypotheses) and a description of the experimental design, and (ii) that the experimental design makes it possible to check the prediction by observation.³ Once we know what shall be tested, we can think about how to test it.

¹ External validity is one of the quality criteria for judging experiments that have been proposed originally in psychology (see Campbell 1957; Campbell and Stanley 1963). The idea of external validity is connected to an inductivist view of science, according to which generalizations can be more or less justified. This inductivist view, however, is untenable and has, at least in the natural sciences, been replaced by the idea that science works by unjustified speculation and generalization followed by severe testing in order to weed out false hypotheses (see Popper 1959; Musgrave 1993). Accordingly, external-validity considerations have been heavily criticized for a long time from the theory-testing perspective (see, most notably, Gadenne 1976 and further sources discussed by Shadish, Cook and Campbell 2002, ch. 14). In experimental economics, the theory-testing view has for a long time been prevalent; only recently, with the new popularity of field studies and increasing concerns about the “artificiality” of the laboratory environment, external-validity considerations have seriously entered the debate on the methodology of experimental economics (see Schram 2005). Our considerations in this paper are based on the theory-testing view. Nevertheless, one concern typically discussed under the heading of external validity is also valid from the theory-testing perspective (see Gadenne 2011). It would not be a good idea to develop economic theory only with reference to experiments with student participants. The reason is not, however, that students might differ from other groups—any group might differ from any other. The reason is that we already know, from everyday experience and, increasingly, from experimental work (see, e.g., Murnighan and Saxon 1998), that students’ social behaviour differs from other groups’ social behavior. It is, of course, always possible to falsify a general theory of behavior in an experiment with student participants. However, if the theory survived such a test, this would not be sufficient for accepting it as empirically confirmed or corroborated. Acceptance presupposes severe testing, and given that we know students’ social behaviour to differ from that of other groups, severe testing requires that we look more widely for potential falsifications.

² See also Cubitt (2005); Bardsley et al. (2010), pp. 46-94. Some authors write of “legitimate” or “valid” tests, implying that there exist “illegitimate” or “invalid” tests. This makes no sense from a theory-testing point of view. An experiment provides a test of a theory (in conjunction with auxiliary hypotheses, if any) if and only if conditions (i) and (ii) below are satisfied; otherwise, the experiment is not a test, not even an illegitimate or invalid test.

³ Thus, the wording of Schram’s remark (2005, p. 229) that experimental tests require an auxiliary hypothesis stating that the theory is applicable to the experimental design is misleading. Such an auxiliary hypothesis would be a meta-

The paper is organized as follows. In section 2, we begin with the methodological question of what the theories of modern IO are about and how they are related to the purported experimental tests. Section 3 illustrates section 2's discussion by relating it to oligopoly theory as a typical IO theory. Specifically, we consider the Cournot and the Stackelberg model because both models are workhorses in IO and have often been implemented in the laboratory. Section 3 also discusses these experiments and the specific auxiliary hypothesis that must be introduced in order to interpret these experiments as tests of IO theories. We show that the auxiliary hypothesis must be considered as falsified, which implies that the experiments provide no tests of IO theories. Based on the methodological arguments of section 3, section 4 proposes an alternative approach to testing IO theories. We invoke institutional considerations along the line of Alchian and Demsetz's (1972) contractual view of the firm and suggest an experimental approach to IO theories. The final section concludes with a summary and discussion.

2 Industrial organization and the theory of the firm

In principle, neoclassical economics is based on methodological individualism, that is, the requirement that, roughly, all social phenomena should be explained in terms of the actions of individuals (see, e.g., Kincaid 1998).⁴ In practice, neither the theory of competitive markets nor the neoclassical theory of the firm conforms to this requirement.⁵ Specifically, the neoclassical theory of the firm assumes that firms maximize profits on the basis of a given technology but ignores the question of how individuals within the firm coordinate their actions in order to achieve profit maximization.⁶

There are, of course, single-agent firms like ice cream vendors. If the neoclassical theory of the firm applies to all firms, it also applies to single-agent firms. Any experiment testing the theory of single-agent firms is therefore a test of the neoclassical theory of the firm: if this theory fails for single-agent firms, it is false.

hypothesis about theory and design; it must be false if the theory is actually not applicable; and it cannot lead to predictions that do not already follow from the theory. Instead, the whole theoretical system, theory and auxiliary hypotheses (if any), must be applicable (and not just said to be applicable) to the design, that is, it must be possible to deduce a prediction from the theory, the auxiliary hypotheses, and a description of the design. It is purely a question of logic, not of the theorist's willingness to test, whether a given theoretical system is applicable to a given design.

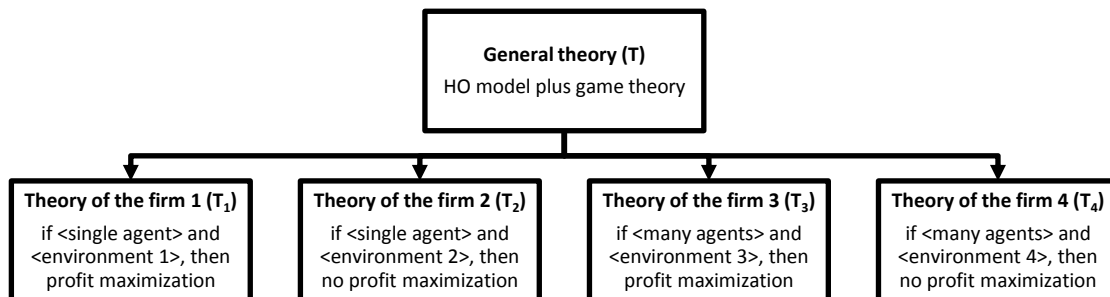
⁴ For a review and a discussion of different meanings of the term "methodological individualism", see Hodgson (2007).

⁵ The theory of competitive markets cannot explain how the market-clearing price emerges from individual actions because it assumes that all market participants are price takers (see also Morgenstern 1972).

⁶ See, e.g., Nadiri (1982). Of course, given the wide-spread commitment to methodological individualism in economics, the fact that the neoclassical theory of the firm lacks an individualistic basis was seen as problematic. Alchian (1950) tried to bridge the gap between individual and organizational behaviour by invoking an evolutionary argument. Friedman (1953) introduced his as-if reasoning as a kind of methodological panacea. In contrast, Vining (1956, pp. 10-11) discusses firm behaviour as a result of management's choice of an organizational structure that is believed to lead to a good performance; this seems to be broadly consistent with the perspective of the modern theoretical IO literature.

Can we bring single-agent firms into the laboratory? Can we bring multi-agent firms into the laboratory? How, exactly, does a firm differ from a single agent or some multi-agent group? The neoclassical theory of the firm provides no answers. It only says what a firm does: it maximizes profits on the basis of a production technology, and if it is a price taker, it does so by choosing input and output quantities. The theory does not say how to recognize a firm. One way to resolve this problem in a systematic way is to turn to extensions of neoclassical economics that make the theory of the firm (more) consistent with methodological individualism.⁷ This extension is institutional economics. Its neoclassical version retains the homo oeconomicus (HO) model and combines it with game theory in order to derive predictions of behaviour in non-market settings. For the purposes of this paper, it suffices to identify game theory with the assumption of rational expectations (if necessary, also in those parts of the game tree that are not reached in equilibrium).⁸ Under the HO model, we understand, roughly, the hypothesis that people are perfectly rational and purely egoistic and materialistic. The HO model together with game theory is a very general theory (T) that can be applied to derive predictions for many specific circumstances or environments (see figure 1). It is well known that T predicts profit maximization by individuals or groups for some environments but not for others.

Figure 1: deductive tree



The different theories of the firm follow deductively from the HO model by applying the model to specific institutional environments where a single agent or several agents take choices that result in profit-maximizing behaviour or not. In such a deductive tree, falsifications go up but not down: if T_1 is falsified, T is also falsified, but T_2 is not. See Albert (1996, pp. 464-466) for a general discussion of falsification and tree-like deductive relations.

If the HO model were well-tested and well-corroborated, the situation in IO would be relatively straightforward. Like meteorologists, who can rely on well-corroborated physical

⁷ Perfect consistency with methodological individualism is not a reasonable aim given the complexity of large organizations. Theories connecting organizational structure with market behaviour offer a reasonable compromise between representative-agent approaches on the one hand and (infeasible) reductions of economics to psychology on the other hand. This compromise is, for instance, exemplified by Elinor Ostrom's (1990) approach to governance of a commons.

⁸ "Rational expectations" in a non-stochastic setting means "perfect foresight". In a stochastic setting, it means using the true probabilities conditional on one's own observations. In game theory, the two hypotheses of HO behaviour and rational expectations also cover those part of the game tree not reached in equilibrium.

theories, researchers in IO would have to find out in which environments agents make choices and derive the consequences. As meteorology shows, this may be a difficult task even when the basic laws are known. Two problems are involved: the empirical problem of improving the descriptive part of complex models, and the theoretical problem of finding the implications of the basic laws when applied to such a description. The predictive performance of the models must be evaluated and turned into a programme of further improving the descriptive parts. In meteorology, laboratory experiments play a relatively small role in this programme. Instead, simulations become very important because it is impossible to derive predictions from these complex models by analytic methods.

Alas, the situation in economics is very different. The HO model must be considered as falsified, not least due to experimental work. The logical and methodological consequences of this fact are often overlooked.

Consider, for instance, the behaviour of a single-agent responder in an ultimatum experiment framed as a situation of unilateral price-setting by the proposer. Let us call the environment of the responder “environment 1” (see figure 1). The general theory T (HO model plus game theory), applied to environment 1, implies that the responder maximizes his monetary payoff. The responder can be viewed as a single-agent firm. Thus, we can deduce a theory of the firm, called T_1 , from T: if a single agent acts in environment 1, he maximizes his profit. This simple theory of the firm has been falsified experimentally (Hoffman et al. 1994). It follows by deductive logic that T is falsified because T must be false if T_1 is false. Moreover, since the responder needs to form no expectations, the failure of T is usually blamed on the HO model.

However, even if the HO model must be considered as falsified, it does not follow that any of the other theories of the firm that can be derived from it can be considered as falsified. Even if the HO model were false, any specific deductive consequence of it might be true. Thus, it may very well be true that single agents maximize profits in some “environment 2”, and, of course, groups composed of many agents may maximize profits or not, just as the HO model predicts. A falsification of the HO model implies that all the different theories of the firm, which before could have been viewed as deductive consequences of a general theory, become isolated, so to speak: if the HO model is true, all its deductive consequences must be true; but if the HO model is false, any proper subset of its consequences can be true or false.

Let us apply this argument to the situation in IO. Many experiments falsify the HO model. Some of these experiments can even be viewed as falsifications of simple theories of single-agent firms, theories that predict profit maximization. Nevertheless, the theory of the profit-maximizing firm is alive and kicking in IO. From a naive point of view, this may be viewed as the often

lamented fact that economists fail to take falsifications seriously (in this vein, see Blaug 1980). However, as explained above, such a view would involve a logical mistake. It does not follow from these experiments that the neoclassical theory of the firm as a theory of organizational behaviour must be considered as falsified. In fact, in many environments, other general theories of behaviour contradicting the HO model might predict profit maximization by groups, even in situations where the HO model would not predict profit maximization.

Consider the following four-player game. Each player $i = 1, 2, 3, 4$ chooses a nonnegative variable L_i called effort. Players act simultaneously. Efforts determine outputs $x_A = f_A(L_1, L_2)$ and $x_B = f_B(L_3, L_4)$ according to neoclassical production functions f_A, f_B . The output price is determined according to an inverse demand function $p(x_A + x_B)$. Players receive fixed shares of the revenue they generate with their team partner. Players' material payoffs are equal to their revenue share minus their costs, which are increasing in effort. Thus, each two-player team forms a firm that produces an output and competes in a standard Cournot duopoly against another firm. Each player bears the costs of his own effort but shares the revenue with his colleague, implying that each firm faces an internal team production problem.⁹

It is easy to see that the neoclassical HO assumption that players rationally maximize their own material payoffs does not lead to profit maximization by teams or firms. Under this motivational assumption, the team production problem induces free-riding and leads to firm outputs that are lower than those of profit-maximizing firms. If, alternatively, both firms solve their internal cooperation problems by invoking "moral considerations", profit maximization results, which leads to the standard Cournot-Nash equilibrium. Obviously, the team production problem, if unsolved, reduces efforts in comparison to the standard model of profit maximization.¹⁰

Thus, depending on the motivational assumptions, a theory of the firm that takes account of the firms' internal organization may predict profit maximization or not. Specifically, demonstrating that participants in laboratory experiments are able to overcome cooperation problems, like the problem of team production, falsifies the HO model but not the hypothesis that multi-agent firms maximize profits. Quite to the contrary: in some environments (like the four-player game

⁹ Here is a simple specification with explicit solutions. Production functions are $f_A(L_1, L_2) = L_1^{0.5}L_2^{0.5}$ and $f_B(L_3, L_4) = L_3^{0.5}L_4^{0.5}$. The inverse demand function is $p = a - b(x_A + x_B)$. The material payoff of players $i = 1, 2$ is $\pi_i = p x_A/2 - c L_i$ and the material payoff of players $i = 3, 4$ is $\pi_i = p x_B/2 - c L_i$, where $0 < c < a$. With free-riding, the unique Nash equilibrium in which both firms serve the market is $L_i = \frac{a-c}{3b}, i = 1, 2, 3, 4$. Internal cooperation leads to the standard Cournot-Nash equilibrium with $L_i = \frac{a-c}{3b}, i = 1, 2, 3, 4$. With internal cooperation and collusion between the firms, the solution is $L_i = \frac{2a-4c}{8b}, i = 1, 2, 3, 4$. If $a = 10c$, free-riding leads to collusion.

¹⁰ Of course, a reduction in outputs may improve the situation for all players if it brings them closer to the collusive solution. Depending on the specification, the equilibrium outcome achieved by four free-riding homines oeconomici may be higher than, lower than, or equal to the collusive optimum. Situations where players profit from solving their team production problems are possible.

considered above), the solution of internal cooperation problems is a precondition of profit maximization. Of course, finding the solution to the combined problems of internal cooperation and profit maximization is difficult for real people, who are boundedly rational at best. In addition to the motivational aspects, we have to take cognitive limitations into account. Since difficult optimization problems may be solved better by a cooperating team (see Davis 1992 for a review of selected examples on group decision making), the consideration of cognitive aspects creates further possibilities for theories that predict profit maximization by teams but not by single agents.

To summarize: organizational behaviour depends on three elements, namely, agents' motivations, agents' cognitive abilities, and the rules of the game. It is not impossible, and, given what we know about human behaviour, not even implausible that well-designed organizations maximize profits – or at least come close to profit maximization – while single agents do not.

In consequence, experimental research on single-agent decision making in market-like environments cannot test a theory that assumes profit maximization of multi-agent firms. Whether firms maximize profits or not depends on how they solve their internal problems of cooperation. Of course, nothing in the argument presented here is new or surprising. What is surprising is the fact that experimental IO seems to ignore this problem. Currently, there are two kinds of experimental IO: one is concerned with market behaviour of the (single-agent) firm, the other is concerned with internal organization of the firm. What is mainly missing are experiments connecting the two,¹¹ and a clear idea of what should be tested.

What, then, can and shall be tested if one wishes to contribute to a theory of multi-agent firms? If it is admitted that experimental economics has falsified the HO model, and with it the assumption that individuals maximize profits, the domain of the neoclassical theory of the firm has to be restricted. Only in a restricted form, the theory can be upheld. Restricting it to multi-agent firms is one reasonable possibility. And this restricted theory cannot be tested in experiments where firms are represented by single individuals.

The alternative is to consider theories of the firm that focus on the link between organizational structure and market behaviour. This link takes centre stage in modern IO theory (see, e.g., Holmstrom and Tirole 1989), which incorporates the early insights from Berle and Means' (1932, pp. 352-357) "New Concept of the Corporation", later developments like Alchian

¹¹ See Sauermann and Selten (1959) and subsequent work by Selten (cf. Engel 2010, pp. 449-450) for early exceptions, and Kirstein and Kirstein (2007) and Raab and Schipper (2009) for recent ones. See also Engel (2010) for a useful but quite terse survey of the empirical literature on the behavioural differences between individuals and corporate actors (or, as we say, teams). Engel refers to many results where teams behave more in line with the HO model than individuals, both cognitively and motivationally. However, there are also many results that point in the opposite direction. Importantly, and as emphasized by Engel, the internal organization of teams matters. However, most of the literature surveyed by Engel bears no immediate relation to mainstream IO, although almost all of it may have some relevance.

and Demsetz's (1972) contractual view of the firm, and Williamson's (1975) transaction cost approach.

If one wishes to retain the assumption that firms maximize profits, it must be assumed that organizational structure transforms individual utility maximization (or individual boundedly rational behaviour) within the firm into profit maximization on the market. However, the number of theoretical studies that examine the interrelation between organizational structure and oligopolistic market behaviour is currently small (cf. Kirstein and Kirstein 2007, pp. 3–5). Nevertheless, there is a clear-cut role for experimental economics in such a context, namely, to test hypotheses on the link between organizational structure and profit maximization (or other kinds of firm behaviour, if the assumption of profit maximization by firms cannot be retained).

The advantage of experimental economics is that it can test basic hypotheses in this area. One obvious question concerns the relation between cooperation in a team and collusion on the market. For instance, does internal cooperation come at the cost of cooperation with other groups? Other questions concern the relation between delegation and hierarchy within the firm and behaviour on markets (see Berninghaus et al. 2009, Kirstein and Kirstein 2007, or Fehr and Falk 1999 on experimental labour markets). In all these contexts, agents' social preferences will most likely affect internal cooperation and, in this way, behaviour on markets. For this reason, agents' "moral considerations" are not orthogonal to the problems of interest in IO; rather, they are in the centre of interest, as in other areas of experimental economics.

3 Testing oligopoly theory in the laboratory

3.1 Oligopoly games

In many areas of applied IO, economists consider the output decisions of a small number of competing firms under the assumption of market-clearing prices. The defining characteristics of an oligopoly are that a firm's market behaviour does not only affect its own profit but also affects the profits of the other firms in the market, and that all firms are aware of this interdependence.

The two benchmark models of oligopoly theory, to be found in every IO textbook, are the Cournot and the Stackelberg model of oligopolistic quantity competition with homogeneous products. In the Cournot model, firms act simultaneously; in the Stackelberg model, firms move sequentially. If there are only two firms in the market, these models are referred to as "the Cournot and the Stackelberg model of duopolistic quantity competition with homogeneous products". Subsequently, we solely concentrate on these two models, to which we refer as "the Cournot model" or "the Stackelberg model", respectively. These are also the models that are most often implemented in the laboratory.

Let us shortly review both models. There are two firms, A and B, which produce homogeneous products, meaning that, in the eyes of the consumers, each unit of output is as good as any other, no matter who produced it. In the Cournot model, firms decide simultaneously (that is, not knowing the other firm's decision) how much to produce. In the Stackelberg model, firms decide sequentially, that is, one firm moves first (leads) and the other firm, knowing the leader's decision, moves second (follows); thus, the follower reacts to the leader's decision. In both models, the total output is then sold at a uniform market clearing price, that is, at a price just low enough so that consumers want to buy all units of output. Firms' profits are equal to their revenues minus their production costs.

The theoretical predictions of neoclassical theory for the situations described above result from two independent hypotheses: first, firms maximize profits, and, second, firms have rational expectations or beliefs. In the Cournot model, equilibrium means Nash equilibrium: each firm correctly anticipates the other firm's choice and plays the profit-maximizing answer (or one of the profit-maximizing answers if there are several). In the Stackelberg model, equilibrium means subgame-perfect Nash equilibrium: the second-moving firm maximizes its profits given the first moving firm's choice, and the first mover correctly anticipates the second mover's reactions to all possible choices and maximizes profits in the light of these anticipations. These equilibria, called Cournot and Stackelberg equilibria, respectively, exist under quite general conditions (see also Novshek 1985). Under less general conditions, these equilibria are unique (see also Long and Soubeyran 2000). In case of linear demand and linear cost functions, unique Cournot and Stackelberg equilibria, and equilibrium outputs of both firms are positive if the costs of producing the first unit of output are not too high.

This description specifies the five elements of a game: (1) the players, (2) players' action possibilities, that is, the order of moves and players' possibilities for action when they move, (3) the probability distributions over exogenous events, (4) the players' beliefs, and (5) the players' motivations (in traditional game theory described by utilities and the assumption of utility maximization) and cognitive abilities (unlimited in traditional game theory).¹² Elements (1,2,3) are often referred to as the "game form". Specifically, (1) players are the two firms, (3) exogenous events are absent in the basic versions of the models considered here, (4) players' beliefs are

¹² The five elements are adapted from Fudenberg and Tirole's six (1991, pp. 77–82). We generalize by replacing players' payoffs by players' motivations and cognitive abilities. This generalized version also covers behavioural extensions of game theory. Moreover, we have replaced players' knowledge by players' beliefs. Some of the beliefs of players are observational (they can observe some actions); other beliefs are expectations about other players' moves. In traditional game theory, observational beliefs are assumed to be correct, and expectations about other players' moves are assumed to be rational.

rational, and (5) players' maximize their own profits. Thus, we can also speak of the Cournot game or the Stackelberg game, respectively.

3.2 Experimental games

There are important differences between the description of a game in game theory and the description of an experimental game. An experimental game is defined by the experimental design. The relation between the experimental game and the description of a game in terms of the five elements above is entirely hypothetical. Some of the hypotheses are those the experimenter wants to test. These are often hypotheses about the motivations and cognitive abilities of the participants. Other hypotheses are auxiliary hypotheses that the experimenter hopes to be unproblematic. These are often hypotheses about the effects of design elements on participants' beliefs.

For instance, consider the game form, especially elements (1) and (2). One of the main points in experimental design is to make sure that there are no unknown players and no unknown possibilities for action. This requires that the relevant game begins and ends in the laboratory and is not just a stage in a larger game played by the participants and, possibly, further persons, with actions that are taken outside the laboratory. Such a larger game would result if players, for instance, retaliated for unfriendly actions outside the laboratory or tried to impress bystanders. For this reason, many experiments do not let participants know with whom they are matched in the experimental game and who did what (anonymity) so that the experiment is cut off from any interactions among players and between players and others outside the laboratory.

However, anonymity in this sense is not sufficient. The experimenter must convince the participants that anonymity holds. He does so by carefully explaining the relevant parts of the experimental design and by presenting himself as credible. It is, however, entirely a matter of participants' beliefs whether this works. The central assumption is not that, objectively, anonymity prevails, but that participants believe in anonymity. Whether this condition is fulfilled in a given experiment cannot be observed. Implicitly or explicitly, the experimenter relies on an auxiliary hypothesis that connects his experimental design (including the performance of the instructor etc.) with the participants' beliefs about the form of the game.

Obviously, this point generalizes. Much of the experimental design is based on auxiliary hypotheses, implicit or explicit, about how to control participants' beliefs. Typically, the experimenter tries to convince participants that they are not deceived in any way in order to make sure that participants do not speculate about possible consequences of their actions other than those that are explained in the instructions. Nevertheless, an important element of many experiments is that payoffs are unknown. Experimental games specify material (mostly, monetary) payoffs, but

participants may care for other things besides their own earnings. This has already been mentioned under the heading of “moral considerations” or social preferences.

In general, then, it is not known which game participants play in the context of a given experimental design. There is some hypothesis the experimenter wants to test with the help of the experiment, the target hypothesis. The design is chosen such that it is possible to test the target hypothesis. Let us assume that the target hypothesis is concerned with (5) players’ motivations and cognitive abilities. The experimenter may then choose a game form (1,2,3) as a basis for the experimental design, a game form that is suitable to test the target hypothesis if (4) participants believe that they act within this game form. The experimental design must be specified such that the experimenter can be reasonably sure that participants actually have these beliefs. Moreover, predictions are often equilibrium predictions, which presuppose that participants have rational expectations about other players’ actions. If it cannot be assumed that participants have rational expectations from the start, the experimental design must allow participants to learn about other participants’ behaviour.

In general, the experimenter must know enough about the five elements of the game in order to draw conclusions about the target hypothesis. Although the presentation of the experimenter’s arguments is mostly informal, the central part is a deductive argument from several premises to a prediction which is then borne out by the data generated in the experiment or not. The premises consist of the target hypothesis, the description of the experimental design, and several auxiliary hypotheses that connect the design elements with the five elements of a game. Of course, the target hypothesis may be derived from a general theory of behaviour like the HO model or some other theory, which may be the real target.

Although this situation can be quite messy in any specific case of experimentation, it is straightforward enough from a methodological point of view. The fact that we need auxiliary hypotheses in a test of some target hypothesis means that we are confronted with the so-called Duhem-Quine problem: failed predictions can, from a logical point of view, be blamed on any of the premises from which the prediction was derived.¹³ The experimental design, which is part of the premises, may deviate from the experimenter’s description; for instance, the experimenter may mistakenly believe, and report, that anonymity was preserved. The auxiliary hypotheses may be false, as when the experimenter believes that he insured, by his procedures, that participants understood the instructions while, in fact, many did not. And, of course, the target hypothesis may be false. If the deduction of the prediction from the premises is correct—which is often not, as when critics discover implicit auxiliaries—, at least one of the premises must be false if the prediction

¹³ On the Duhem-Quine problem, see Cross (1998) and Gadenne (1998).

failed. The Duhem-Quine problem is the problem that the scientific community may follow a strategy of blaming predictive failures on the auxiliaries and counting predictive successes as corroborations of the target hypothesis, thus making experimentation a pointless exercise that never can lead to the falsification of a target hypothesis even if it is false.

This problem has been discussed extensively in general methodology and in the methodology of experimental economics. Duhem, who is usually credited with seeing the problem first, did not think of it as unsolvable. The developments in experimental economics demonstrate how the solution looks like in principle. Economists consider many hypotheses and many different experiments involving different subsets of the hypotheses. Given some predictive failures and some predictive successes, the scientific community decides which assignments of truth values to hypotheses provide the best explanation for the observed failures and successes (see Albert 2011). It is not quite clear how this decision is made. However, the process is in principle open-ended since new hypotheses and new experimental results change the situation and further constrain the possible assignments of truth values. Critics can come up with new experiments that show that a previous consensus is not tenable by combining accepted hypotheses to derive a new prediction that is then shown to be false.

In this paper, we assume that the Duhem-Quine problem can be solved along these lines in a rational way. We are not concerned with this problem in general but with the specific target hypothesis and auxiliary hypotheses that come into play when oligopoly theory, viewed as a part of mainstream IO, is brought to the laboratory.

Oligopoly games have been played in the laboratory for about 50 years now. In 1959, Hoggatt (1959) and Sauermann and Selten (1959) published the first experiments in this field of research. Within the following years, further experimental studies on oligopoly theories were done by Siegel and Fouraker (1960) and Fouraker and Siegel (1963).¹⁴ However, most of these experiments were not designed to test hypotheses about individual or organizational behaviour. Instead, they were of an exploratory nature.

In contrast, recent experimental studies are driven by theory and are designed to test hypotheses.¹⁵ Holt (1985) is considered to be the first to proceed in this way (see, e.g., Plott 1989). Holt experimentally examined the Cournot game described above with a linear inverse demand function and costless production (Holt, pp. 322-323). The experiment was run in lecture halls with pen and paper at the University of Virginia. Overall, twelve students from various fields of study participated in one session. The session consisted of ten rounds and lasted about sixty minutes.

¹⁴ For an early survey, see Cyert and Lave (1965). For a recent survey of the early Cournot oligopoly experiments, see Bosch-Domènech and Vriend (2008).

¹⁵ For a review of Cournot oligopoly experiments (in the broader sense), see Requate and Waichman (2011, p. 39).

Participants' average earnings were about \$ 8.50. Each subject was told to be a "seller" and had to choose its quantity from a (19×19) payoff bimatrix. In each period, pairs were matched randomly. Therefore, ten (one-shot) Cournot games were played by each subject.

Holt tested whether subjects who are just told that they are "sellers" behave according to a symmetric Nash equilibrium prediction in a Cournot game.¹⁶ He found that average quantities per round are close to the Nash equilibrium quantities. Similar results have been found in other, recent experimental studies (see, e.g., Huck et al. 2004).

To our knowledge, the first to implement the Stackelberg game were Huck et al. (2001). In their design, producers face a linear inverse demand function; production costs are linear.¹⁷ The experiment was run in lecture halls with pen and paper at Humboldt University Berlin. Overall, 134 students from various fields of study participated in seven sessions. Sessions consisted of ten rounds and lasted between sixty and 75 minutes. Participants' average earnings were about € 8.01. Each subject was told to represent a "firm" and had to choose its quantity from a (13×13) payoff bimatrix. In each period, pairs were matched randomly. Therefore, ten (one-shot) Stackelberg games were played by each subject.

Huck et al. tested whether subjects who are told to represent "firms" behave according to the unique (asymmetric) subgame-perfect Nash equilibrium prediction in a Stackelberg game. They find that leaders mostly chose a lower quantity than predicted, and followers typically chose a higher quantity. As the number of rounds increased, the variance remained approximately constant. Similar results have been found in other experimental studies (see, e.g., Huck and Wallace 2002).¹⁸

3.3 The relevance of the experimental results to IO

We are not going to discuss the many auxiliary hypotheses these oligopoly experiments share with other experiments. Instead, we focus on the specifics of oligopoly experiments.

Assuming that the usual auxiliary hypotheses are correct, the experiments discussed above show that single agents who are told that they are sellers or represent firms do not, in general, maximize their monetary payoffs, that is, their profits, in duopoly games. This fits in with many other experimental results where single participants do not maximize their own monetary payoffs. Many of these experiments differ not much from duopoly games except for the framing, that is, the fact that participants in duopoly experiments are told that they are sellers or represent firms.

¹⁶ Holt's design leads to further, asymmetric Nash equilibria.

¹⁷ In addition, Huck et al. examined a repeated Stackelberg game and one-shot as well as repeated Cournot games.

¹⁸ In the recent past, many more such experiments were run. Often, the standard duopoly games were extended by a pre-play stage in order to endogenize the sequence of play. For example, see Huck et al. (2002), Fonseca et al. (2005), Fonseca et al. (2006), and Müller (2006). For a survey, see Hildenbrand (2010).

As already explained, mainstream IO is concerned with firms, and these firms are assumed to be large organizations. The basic hypothesis in oligopoly theory, as it is employed in mainstream IO, is that these firms maximize profits. Reconsider, then, the deductive hierarchy of figure 1. Let us assume that our basic theory of human behaviour is the HO model plus game theory (T). From this model, individual profit maximization follows deductively for many games, duopoly games and others.

If the usual auxiliary hypotheses can be assumed to be true, the hypothesis of individual profit maximization has been falsified in many experiments. The simplest ones are dictator and ultimatum experiments (see, e.g., Camerer 2003, ch. 2). The Stackelberg experiments discussed above are a bit more complicated but very similar. Since individual profit maximization in these experimental games follows deductively from the combination of T with the above-mentioned auxiliary hypotheses, these experiments also falsify T.

Thus, let environment 1 in figure 1 be the environment of the Stackelberg game discussed above. Theory T_1 , which predicts profit maximization by single-agent firms in this environment, is falsified, implying that T is falsified. Now consider a theory like T_3 that considers multi-agent firms in environment 3. This environment is also characterized by Stackelberg competition between firms. However, this specification is insufficient for determining whether T predicts profit maximization by firms or not. Let us assume that environment 3 specifies, in addition, that the agents of each firm have entered a verifiable and binding contract that forces them to pay a lot of money to some third party if they collectively deviate from profit-maximizing behaviour. With this specification, T_3 follows from T. While T is falsified, T_3 is not falsified, and it is quite plausible that agents who failed to maximize profits in environment 1 maximize profits in environment 3. Thus, we have no reason at all to reject T_3 just because we falsified T.

Of course, there are other environments (say, environment 4, where agents face a team production problem) where profit maximization of multi-agent firms does not follow from T. But given that T is falsified anyway, this does not matter. Given the falsification of T, theories of multi-agent firms that consider different environments for the agents survive or die on their own.

In fact, given that T is falsified, the critical potential of T is also lost. As long as it was rational to believe in T (if it ever was), it was rational to reject the theory T^* that all multi-agent firms, no matter how their internal structure, maximize profits because T implies that it depends on the internal structure whether profit-maximization is achieved, that is, T implies that T^* is false. Once T is falsified, T^* can again be taken seriously. Of course, we may argue that we know enough about team-production problems from other experiments in order to reject T^* . But we do not know

enough from experiments in order to reject a hypothesis like T^{**} , namely, that the management of a large firm is able and willing to choose an internal structure that leads to profit maximization.

Thus, logic does not force IO theorists to give up their basic hypothesis because of the experiments we have discussed so far. Of course, the hypothesis of profit maximization started out as a general hypothesis about all firms, including single-agent firms. (Never mind that, in this general form, the hypothesis would be inconsistent with T .) The duopoly experiments show that this general theory is false. From this perspective, retreating to the hypothesis that only large firms maximize profits is a defensive move of restricting the domain of a hypothesis so that it no longer covers those situations in which it had been falsified. These kinds of moves are usually frowned upon because following a strategy of domain restrictions in the face of falsifications leads to theories with less and less content. Still, it is perfectly possible that the general theory is false while the restricted theory is true. For this reason, a methodological rule that just forbids domain restrictions could prevent us from finding the truth. For this reason, domain restrictions cannot be forbidden.

In the present case, however, the domain restriction is especially problematic because of the presumption, well expressed by Norman and Ruffle (2011), that the hypothesis of profit maximization by multi-agent firms is difficult to test in the field. Restricting the basic hypothesis of applied oligopoly theory such that it becomes untestable would turn this part of IO from science into ideology.

One might consider the possibility of introducing a specific auxiliary hypothesis that bridges the gap between the behaviour of individuals and multi-agent firms. Thus, the claim that the duopoly experiments are relevant to mainstream IO might be considered as assuming, implicitly, that individuals and multi-agent firms show the same behaviour (auxiliary hypothesis AH). This auxiliary hypothesis just applies the representative-agent assumption often used in economics to firms independently of any theory of individual behaviour. Under AH, all kinds of experiments involving individual behaviour and all theories explaining the experimental results would become directly relevant to mainstream IO.¹⁹ Specifically, we can conclude that deviations from profit-maximizing behaviour found in the single-agent experiments shed light on the behaviour of multi-agent firms. That is, we could develop a theory that explains the behaviour of single-agents in Stackelberg games (where the hypothesis of profit maximization fails) and test it in further single-agent experiments, all the time relying on the fact that our theorizing is relevant to mainstream IO because of AH.

¹⁹ Something like AH is implicitly assumed if one “generalizes” from single-individual experiments to the behaviour of firms. “Inductive” generalizations are best reconstructed as deductive arguments with implicit premises; see Musgrave (2011).

However, in order to make use of AH in this way, AH itself should be corroborated, that is, it should have been confirmed in severe tests. At least, we should be able to show that the assumption that AH is true explains the results of many different tests (see the discussion of the Duhem-Quine problem above). However, this is not at all the case.

From the perspective of neoclassical theory, AH is not convincing as we have shown in the second section. That is, our theory T implies that AH is false: depending on the organizational structure, the behaviour of multi-agent firms may differ from individual behaviour.

From the perspective of behavioural economics, AH is also not convincing. Individuals exhibit social preferences in many experiments like dictator or ultimatum games (see, e.g., Roth 1995). It seems to be highly implausible that firms behave in this way. Individuals with social preferences will, when acting as members of teams,²⁰ take their team members into account, not only outsiders. In fact, prisoner's dilemma experiments, which can be thought of as simplified Cournot experiments, frequently show in-group favouritism, that is, participants interacting with an out-group member are less cooperative than participants interacting with an in-group member (see, e.g., Yamagishi and Kiyonari 2000; Yamagishi and Mifune 2009). Thus, it seems that members of teams are more likely to cooperate with their colleagues, which, as we have shown, can easily lead to more competitive behaviour of the team against outsiders.

Actually, as far as the experimental evidence goes, more speaks in favour of the idea that teams maximize profits than for the idea that teams behave like individuals. For example, Bornstein et al. (2008) experimentally examine a market for a homogeneous good in which two producers compete in prices. Producers act simultaneously. Each producer is represented by either a participant or a group of participants consisting of two or three members. Sessions consisted of one hundred rounds. The number of rounds was not revealed to the participants. Producers and groups were matched randomly at the beginning of the sessions. The matching remained constant. Thus, participants played repeated Bertrand duopoly games. Bornstein et al. found that single agents behaved differently from groups: prices were significantly higher in competition between individuals than in competition between groups. That means that groups come closer to profit-maximizing behaviour.

Other results from experiments on group decision making also suggest relevant behavioural differences between individuals and groups. In a series of prisoner's dilemma experiments, group behaviour is found to be more competitive and less cooperative than individual behaviour (see Schopler and Insko 1992). In ultimatum experiments, similar behavioural patterns are observed:

²⁰ We use the term "team" whenever groups of participants collectively take the role of a firm in a market experiment or if their collective decisions are framed as "firm decisions". In other cases, we use the term "group".

groups in the role of proposers offer less than individuals, and groups in the role of responders are typically willing to accept less than individuals (see Robert and Carnevale 1997; Bornstein and Yaniv 1998). That is, in both prisoner's dilemma and ultimatum experiments, the (subgame-perfect) Nash equilibrium solution is a better predictor of group behaviour than individual behaviour. This is also true for dictator, gift exchange, trust, and centipede experiments (see Bornstein 2008 for a review).

However, Raab and Schipper (2009) do not find significant behavioural differences between individuals and teams in a Cournot triopoly experiment. The same is true for Müller and Tan's (2011) Stackelberg experiment on individual and group decision making. Producers act sequentially. Each producer is represented by either a participant or a team of participants consisting of three members. Sessions consisted of one or 15 rounds. Producers and groups were matched randomly at the beginning of the sessions. Producers were randomly rematched after each round. Thus, participants played one or 15 (one-shot) Stackelberg duopoly games. While Müller and Tan found that teams came closer to profit-maximizing behaviour than individuals, these findings were not statistically significant. Thus, it seems that there are conditions where teams and individuals behave alike in oligopoly games, but other conditions where this is not the case.

Due to the elaborated theoretical arguments and experimental results, we are highly skeptical about AH, the hypothesis that single-agent firms and multi-agent firms show the same behaviour. Moreover, we see no tenable alternative to AH that would allow us to consider the Cournot and Stackelberg experiments on individual decision making as relevant to mainstream IO. Some other experimental approach to IO, then, is needed—some approach that avoids the implicit reliance on the dubious hypothesis that single-agent and multi-agent firms show the same behaviour.

4 Organizational structure and organizational behaviour

In the preceding section, we have argued that restricting the domain of the profit maximization hypothesis to multi-agent firms is problematic from a general methodological perspective. Such a move is also not satisfying when we consider the structure of economic theory. As already discussed in the second section, economists have adopted, by and large, the principle of methodological individualism. This principle requires that organizational behaviour is explained in terms of a theory of individual behaviour. Sticking, without further explanations, to the hypothesis that multi-agent firms maximize profits violates this principle. This violation would be less problematic if the hypothesis were testable and corroborated. Even in this case, we would still prefer to have a deeper explanation in terms of a theory of individual behaviour, but failures to find

such an explanation would not shake our confidence in the hypothesis, especially since multi-agent firms are quite complex institutions.

However, if we accept the view that the multi-agent profit-maximization hypothesis is difficult to test, or even untestable, by field data, and if we refuse the auxiliary hypothesis that individuals and multi-agent firms generally show the same behaviour, the situation is different. We then have to find a way to bring empirical methods, and experimental methods specifically, to bear on the theory of multi-agent firms.

This can, in our view, be achieved if we follow the principle of methodological individualism and turn to approaches that link the market behaviour of multi-agent firms, or teams, to their internal structure. As already discussed, such approaches yield hypotheses that can be tested, and are tested, with experimental methods. Subsequently, we outline one experimental approach along these lines, although there are, of course, other possible approaches.

Our experimental approach to IO is based on Alchian and Demsetz' (1972) contractual view of the firm. For Alchian and Demsetz (p. 783), a firm is a contractual structure “with (1) joint input production, (2) several input owners, (3) one party who is common to all the contracts of the joint inputs, (3a) who has rights to renegotiate any input's contract independently of contracts with other input owners, (3b) who holds the residual claim, and (3c) who has the right to sell his central contractual residual status” (the numbers are modified). Moreover, (4) individuals within the firm maximize (expected) utility on the basis of a utility functions that is increasing in income and leisure and has no further arguments. And, last but not least, (5) the firm is organized in a way that individual utility maximization within the firm is transformed into profit maximization on the market (see also Holmstrom 1982).

Items (1) to (3) put restrictions on the internal structure of the firm. Item (4) is a consequence of the HO assumption; it follows from the HO assumption if leisure is more satisfying than work throughout and if there is no possibility of consumption within the firm. Item (5) requires further specifications of the organizational structure within the limits given by items (1) to (3); these specifications depend on the relevant theory of individual behaviour, here given in (4).

One might be tempted to think that this theory of the firm is doomed from the start because its central behavioural assumption follows from the HO model, which we consider as falsified. However, just to repeat this elementary point, it does not follow from the falsity of the HO model that people are never rational, egoistic, and materialistic. They may still behave like that under specific circumstances, like those in a firm organized according to the principles considered by

Alchian and Demsetz. That is, certain environments may make people behave in line with the HO model, even if the HO model is false in general.²¹

As long as we are explicit concerning the kind of environment that supposedly triggers HO behaviour, this restricted HO model is testable in principle. Moreover, if the relevant kind of environment is described in universal terms, that is, as long as we refer to an organizational structure and not just to “the environment of a big 21st century US corporation”, it is quite likely testable by experimental methods.²²

It is, of course, not necessary to stick to (restricted versions of) the HO model. As we have shown by the simple model used in the second section, a theory of team production where free riding is prevented not by material incentives but by something like group solidarity or informal sanctions may also predict profit maximization. Moreover, we need not restrict theories of the firm to those that imply profit maximization on the market. There are other theories of the firm, like Leibenstein’s (1966) theory of X-inefficiency, which can also be derived from theories of human behaviour together with assumptions on the organizational structure.²³ Thus, we do not intend to defend (restricted versions of) the HO model or the profit maximization hypothesis. These hypotheses serve as examples. We show that it is possible to take them seriously without either retreating to a sterile ideology (by declaring them untestable) or by relying on an experimental research programme that requires the acceptance of highly dubious, untested, or even falsified auxiliary hypotheses.

Let us turn to what we believe is the simplest experimental setup for testing the Cournot and the Stackelberg model in the laboratory using the contractual view of the firm. The experimental design features two pairs of participants who act as teams. Each team chooses numbers from a payoff bimatrix. In an experimental Cournot game, teams choose simultaneously; in an experimental Stackelberg model, teams choose sequentially. The payoff bimatrix is derived from a continuous Cournot/Stackelberg model of duopolistic quantity competition with homogeneous products by allowing only finitely many quantity choices. An example is the (13×13) payoff bimatrix used by Huck et al. (2001). Under the assumption that the (restricted) HO model holds, requirements (1), (2), (3), and (5) concerning the organizational structure are satisfied if one team member is passive and the other one is a decision maker who is motivated by an incentive-compatible contract. The passive participant can be interpreted as the owner of the firm who contributes capital and is the residual claimant. The decision maker can be seen as a manager who

²¹ According to Schotter (1981, p. 11) and Hodgson (1988, p. 10), this is characteristic of social institutions.

²² There are, of course, exceptions. If the organizational structure requires very large teams and a lot of face-to-face interactions (thus ruling out internet experiments), it may become too expensive to test the theory.

²³ For a survey of the new institutional theories of the firm, see Furubotn and Richter (2005, pp. 361–469).

contributes labour. An incentive-compatible contract requires that the decision maker receives a fixed percentage of the team's monetary payoff. If the duration of the experiment is independent of the actions, subjects are predicted to maximize their monetary payoffs, which—in this simple setup where there are no conflicts of interest between owner and manager—implies that the decision maker maximizes the team's monetary payoff (5), which can be interpreted as the firm's profit.

The difference between these duopoly games and those we have discussed before is that we test a hypothesis about how individual motivations are influenced by organizational structure. There is no need to tell participants of such experiments that they represent firms. We have implemented an element that is central to a specific theory of the firm. Even if the HO model is false in general, and even if individuals do not maximize profits in oligopoly games despite being told that they represent firms, it may still be true that individuals acting within an incentive-compatible contract turn out to be profit maximizers.

This view opens up a broad range of experiments that are relevant to mainstream IO. On the one hand, it is possible to analyse existing firms and build hypotheses concerning the link between organizational structure and individual behaviour that translates into organizational behaviour. If these hypotheses are general and stated in universal terms, it is quite likely that they can be tested in the laboratory. The results of these tests can then feed back into the process of theory formation. It is in no way necessary to stick to restricted HO models and profit maximization; we have just used these (after all, still prominent) hypotheses as an example.

Of course, such a strategy may or may not be successful. At least, success is conceivable. That is more than can be said of the alternatives that we have analysed in this paper.

5 Conclusion

Oligopoly games have been played in the laboratory for about 50 years. Unfortunately, as we have argued at length, this does not mean that oligopoly theory, as it is used in mainstream IO, has been put to the test: the experimental designs were either not within the domain of the theory—because the theory is about multi-agent firms while the experiments just told single agents that they represented firms—or rested on a highly dubious auxiliary hypothesis, namely, that multi-agent firms and single agents show the same behaviour. This problem is common to all theories in which multi-agent firms are treated as corporate decision makers. For that reason, much of IO is affected. Since Amazon, IBM, or what have you cannot be brought into the laboratory, there are no experimental tests of these theories.

This does not mean, however, that experimental methods are irrelevant to mainstream IO. The ad hoc assumption that multi-agent firms maximize profits, which is the basic hypothesis in,

e.g., oligopoly theory and other areas of mainstream IO, is itself in need of explanation, especially since it is difficult to test with data on firm behaviour on real markets. The modern theory of IO, following Berle and Means, Alchian and Demsetz, Williamson, Holmstrom, and others, tries to explain the behaviour of firms by linking their organizational structure with their market behaviour. According to methodological individualism, the link is provided by theories of individual behaviour. It is exactly these theories that can be tested by experimental methods.

Following this line of argument, we have provided what we believe is the simplest experimental design that implements Alchian and Demsetz' contractual view of the firm and allows for an experimental test of duopoly theory: two firms, each consisting of one passive residual claimant and one active decision maker, who earns profits on a duopolistic market under an incentive-compatible contract.

Actually, one of us has run this experiment (Hildenbrand in preparation). Reporting on the exact experimental design and the results go beyond the scope of the present paper, which just presents the methodological background to the experiment. However, it seems that this simple organizational structure brings decision making in a Stackelberg game more into line with profit maximization than the usual framing (telling people that they represent firms). Whether this is due to "moral considerations" and in-group effects (cooperation with the passive team mate squeezing out cooperation with the other team) or whether the contract structure makes people more selfish is an open question. More about this can be learned from experiments where there are conflicts within the team. Whatever the results, it is clear that such experiments, in contrast to many other oligopoly experiments, are in fact relevant to mainstream IO.

Acknowledgements

For detailed comments, we are grateful to Siegfried Berninghaus and Björn Kuchinke. For further comments and suggestions, we thank Hartmut Kliemt and participants at the 2011 Karlsruhe Seminar on Behavioral Economics, the 2011 ESA European Conference, the 2011/12 MAGKS Workshop, the 2011/12 Tübingen Economic Workshop, and the 2011/12 Hohenheimer Oberseminar.

References

- Albert, M. (1996), "Unrealistische Annahmen" und empirische Prüfung', *Zeitschrift für Wirtschafts- und Sozialwissenschaften*, 116, 451–486.
- Albert, M. (2011), 'Critical Rationalism and Scientific Competition', *Analyse & Kritik*, 32, 247–266.
- Alchian, A.A. (1950), 'Uncertainty, Evolution, and Economic Theory', *Journal of Political Economy*, 58, 211–221.
- Alchian, A.A., Demsetz, H. (1972), 'Production, Information Costs, and Economic Organization', *American Economic Review*, 62, 777–795.
- Bardsley, N., Cubitt, R., Loomes, G., Moffatt, P., Starmer, C., Sugden, R. (2010), *Experimental Economics: Rethinking the Rules*, Princeton: Princeton University Press.

- Berninghaus, S.K., Güth, W., Hoppe, C., Paul, C. (2009), 'Duopolistic Hiring and Sales Competition: A Theoretical and Experimental Analysis', Working Paper, Karlsruhe Institute of Technology, Department of Economics and Business Engineering.
- Berle, A.A., Means, G.C. (1932), *The Modern Corporation and Private Property*, New York: Macmillan.
- Blaug, M. (1980), *The Methodology of Economics*, Cambridge: Cambridge University Press.
- Bornstein, G. (2008), 'A Classification of Games by Player Type', in *New Issues and Paradigms in Research on Social Dilemmas*, eds. A. Biel, D. Eek, T. Gärling, and M. Gustafsson, New York: Springer, pp. 27–42.
- Bornstein, G., Kugler, T., Budescu, D.V., Selten, R. (2008), 'Repeated Price Competition between Individuals and Between Teams', *Journal of Economic Behavior & Organization*, 66, 808–821.
- Bornstein, G., Yaniv, I. (1998), 'Individual and Group Behavior in the Ultimatum Game: Are Groups More "Rational" Players?', *Experimental Economics*, 1, 101–108.
- Bosch-Domènech, A., Vriend, N.J. (2008), 'The Classical Experiments on Cournot Oligopoly', in *Handbook of Experimental Economics Results*, eds. C.R. Plott and V.L. Smith, Amsterdam: North-Holland, pp. 146–152.
- Camerer, C.F. (2003), *Behavioral Game Theory: Experiments in Strategic Interaction*, New York: Russell Sage Foundation.
- Campbell, D.T. (1957), 'Factors Relevant to the Validity of Experiments in Social Settings', *Psychological Bulletin*, 54, 297–312.
- Campbell, D.T., Stanley, J.C. (1963), *Experimental and Quasi-Experimental Designs for Research*, Boston: Houghton Mifflin.
- Cross, R. (1998), 'The Duhem-Quine Thesis', in *The Handbook of Economic Methodology*, eds. J.B. Davis, D.W. Hands, and U. Mäki, Cheltenham: Edward Elgar, pp. 107–110.
- Cubitt, R. (2005), 'Experiments and the Domain of Economic Theory', *Journal of Economic Methodology*, 12, 197–210.
- Cyert, R.M., Lave, L.B. (1965), 'Collusion, Conflict et Science Économique', *Économie Appliquée*, 18, 385–406.
- Davis, J.H. (1992), 'Some Compelling Intuitions About Group Consensus Decisions, Theoretical and Empirical Research, and Interpersonal Aggregation Phenomena: Selected Examples 1950–1990', *Organizational Behavior and Human Decision Processes*, 52, 3–38.
- Engel, C. (2010), 'The Behaviour of Corporate Actors: How Much Can We Learn from the Experimental Literature', *Journal of Institutional Economics*, 6, 445–475.
- Fehr, E., Falk, A. (1999), 'Wage Rigidity in a Competitive Incomplete Contract Market', *Journal of Political Economy*, 107, 106–134.
- Fonseca, M.A., Huck, S., Normann, H.-T. (2005), 'Playing Cournot Although They Shouldn't: Endogenous Timing in Experimental Duopolies with Asymmetric Cost', *Economic Theory*, 25, 669–677.
- Fonseca, M.A., Müller, W., Normann, H.-T. (2006), 'Endogenous Timing in Duopoly: Experimental Evidence', *International Journal of Game Theory*, 34, 443–456.
- Fouraker, L.E., Siegel, S. (1963), *Bargaining Behavior*, New York: McGraw-Hill.
- Friedman, M. (1953), 'The Methodology of Positive Economics', in *Essays in Positive Economics*, ed. M. Friedman, Chicago: University of Chicago Press, pp. 3–43.
- Fudenberg, D., Tirole, J. (1991), *Game Theory*, Cambridge: MIT Press.
- Furubotn, E.G., Richter, R. (2005), *Institutions and Economic Theory* (2nd ed.), Ann Arbor: University of Michigan Press.
- Gadenne, V. (1976), *Die Gültigkeit psychologischer Untersuchungen*, Stuttgart: Kohlhammer.
- Gadenne, V. (1998), 'Spielarten des Duhem-Quine-Problems', *Logos*, 5, 117–148.
- Gadenne, V. (2011), 'Über die Validität von Experimenten in der Ökonomie', in *Philosophie und Ökonomie*, eds. V. Gadenne and R. Neck, Tübingen: Mohr Siebeck, pp. 51–64.

- Hildenbrand, A. (2010), 'Cournot or Stackelberg Competition? A Survey of Experimental Research', MPRA Paper 26845, University of Munich, Munich Personal RePEc Archive.
- Hildenbrand, A. (in preparation), 'Teams Playing the Stackelberg Game: Using the Contractual View of the Firm for Doing Industrial Organization in the Laboratory', Working Paper, Justus Liebig University Giessen, Department of Economics.
- Hodgson, G.M. (1988), *Economics and Institutions: A Manifesto for a Modern Institutional Economics*, Cambridge: Polity Press.
- Hodgson, G.M. (2007), 'Meanings of Methodological Individualism', *Journal of Economic Methodology*, 14, 211–226.
- Hoffman, E., McCabe, K., Shachat, K., Smith, V. (1994), 'Preferences, Property Rights, and Anonymity in Bargaining Games', *Games and Economic Behavior*, 7, 346–380.
- Hoggatt, A.C. (1959), 'An Experimental Business Game', *Behavioral Science*, 4, 192–203.
- Holmstrom, B.R. (1982), 'Moral Hazard in Teams', *Bell Journal of Economics*, 13, 324–340.
- Holmstrom, B.R., Tirole, J. (1989), 'The Theory of the Firm', in *Handbook of Industrial Organization*, eds. R. Schmalensee and R.D. Willig, Amsterdam: North-Holland, pp. 61–133.
- Holt, C.A. (1985), 'An Experimental Test of the Consistent-Conjectures Hypothesis', *American Economic Review*, 75, 314–325.
- Holt, C.A. (1995), 'Industrial Organization: A Survey of Laboratory Research', in *The Handbook of Experimental Economics*, eds. J.H. Kagel and A.E. Roth, Princeton: Princeton University Press, pp. 349–443.
- Huck, S., Müller, W., Normann, H.-T. (2001), 'Stackelberg Beats Cournot: On Collusion and Efficiency in Experimental Markets', *Economic Journal*, 111, 749–765.
- Huck, S., Müller, W., Normann, H.-T. (2002), 'To Commit or Not to Commit: Endogenous Timing in Experimental Duopoly Markets', *Games and Economic Behavior*, 38, 240–264.
- Huck, S., Normann, H.-T., Oechssler, J. (2004), 'Two Are Few and Four Are Many: Number Effects in Experimental Oligopolies', *Journal of Economic Behavior & Organization*, 53, 435–446.
- Huck, S., Wallace, B. (2002), 'Reciprocal Strategies and Aspiration Levels in a Cournot-Stackelberg Experiment', *Economics Bulletin*, 3, 1–7.
- Kincaid, H. (1998), 'Methodological Individualism/Atomism', in *The Handbook of Economic Methodology*, eds. J.B. Davis, D.W. Hands, and U. Mäki, Cheltenham: Edward Elgar, pp. 294–300.
- Kirstein, R., Kirstein, A. (2007), 'Inefficient Intra-Firm Incentives Can Stabilize Cartels in Cournot Oligopolies', Working Paper 04, Otto von Guericke University Magdeburg, Faculty of Economics and Management.
- Leibenstein, H. (1966), 'Allocative Efficiency and X-Efficiency', *American Economic Review*, 56, 392–415.
- Long, N.V., Soubeyran, A. (2000), 'Existence and Uniqueness of Cournot Equilibrium: A Contraction Mapping Approach', *Economics Letters*, 67, 345–348.
- Morgenstern, O. (1972), 'Thirteen Critical Points in Contemporary Economic Theory: An Interpretation', *Journal of Economic Literature*, 10, 1163–1189.
- Müller, W. (2006), 'Allowing for Two Production Periods in the Cournot Duopoly: Experimental Evidence', *Journal of Economic Behavior & Organization*, 60, 100–111.
- Müller, W.; Tan, F. (2011), 'Who Acts More Like a Game Theorist? Group and Individual Play in a Sequential Market Game and the Effect of the Time Horizon', Working Paper 1111, University of Vienna, Department of Economics.
- Murnighan, J.K., Saxon, M.S. (1998), 'Ultimatum Bargaining by Children and Adults', *Journal of Economic Psychology*, 19, 415–445.

- Musgrave, A. (2011), 'Popper and Hypothetico-Deductivism', in *Handbook of the History of Logic*, vol. 10, eds. D.M. Gabbay, S. Hartmann, and J. Woods, Amsterdam: North-Holland, pp. 205–234.
- Musgrave, A. (1993), *Common Sense, Science and Skepticism: A Historical Introduction to the Theory of Knowledge*, Cambridge: Cambridge University Press.
- Nadiri, M.I. (1982), 'Producers Theory', in *Handbook of Mathematical Economics*, eds. K.J. Arrow and M.D. Intriligator, Amsterdam: North-Holland, pp. 431–490.
- Normann, H.-T., Ruffle, B. (2011), 'Introduction to the Special Issue on Experiments in Industrial Organization', *International Journal of Industrial Organization*, 29, 1–3.
- Novshek, W. (1985), 'On the Existence of Cournot Equilibrium', *Review of Economic Studies*, 52, 85–98.
- Ostrom, E. (1990), *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press.
- Plott, C.R. (1982), 'Industrial Organization Theory and Experimental Economics', *Journal of Economic Literature*, 20, 1485–1572.
- Plott, C.R. (1989), 'An Updated Review of Industrial Organization: Applications of Experimental Methods', in *Handbook of Industrial Organization*, eds. R. Schmalensee and R.D. Willig, Amsterdam: North-Holland, pp. 1109–1176.
- Popper, K.R. (1959), *The Logic of Scientific Discovery*, New York: Basic Books.
- Raab, P., Schipper, B.C. (2009), 'Cournot Competition Between Teams: An Experimental Study', *Journal of Economic Behavior & Organization*, 72, 691–702.
- Requate, T., Waichman, I. (2011), "'A Profit Table or a Profit Calculator?'" A Note on the Design of Cournot Oligopoly Experiments', *Experimental Economics*, 14, 36–46.
- Robert, C., Carnevale, P.J. (1997), 'Group Choice in Ultimatum Bargaining', *Organizational Behavior and Human Decision Processes*, 72, 256–279.
- Roth, A.E. (1995), 'Bargaining Experiments', in *The Handbook of Experimental Economics*, eds. J.H. Kagel and A.E. Roth, Princeton: Princeton University Press, pp. 253–348.
- Sauermann, H., Selten, R. (1959), 'Ein Oligopolexperiment', *Zeitschrift für die gesamte Staatswissenschaft*, 115, 427–471.
- Scherer, F.M., Ross, D. (1990), *Industrial Market Structure and Economic Performance* (3rd ed.), Boston: Houghton Mifflin.
- Schmalensee, R. (1998), 'Inter-Industry Studies of Structure and Performance', in *Handbook of Industrial Organization*, eds. R. Schmalensee and R.D. Willig, Amsterdam: North-Holland, pp. 951–1009.
- Schopler, J., Insko, C.A. (1992), 'The Discontinuity Effect in Interpersonal and Intergroup Relations: Generality and Mediation', *European Review of Social Psychology*, 3, 121–151.
- Schotter, A. (1981), *The Economic Theory of Social Institutions*, Cambridge: Cambridge University Press.
- Schram, A. (2005), 'Artificiality: The Tension Between Internal and External Validity in Economic Experiments', *Journal of Economic Methodology*, 12, 225–237.
- Shadish, W.R., Cook, T.D., Campbell, D.T. (2002), *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*, Boston: Houghton Mifflin.
- Shapiro, C. (1989), 'Theories of Oligopoly Behavior', in *Handbook of Industrial Organization*, eds. R. Schmalensee and R.D. Willig, Amsterdam: North-Holland, pp. 329–414.
- Siegel, S., Fouraker, L.E. (1960), *Bargaining and Group Decision Making: Experiments in Bilateral Monopoly*, New York: McGraw-Hill.
- Sutton, J. (2007), 'Market Structure: Theory and Evidence', in *Handbook of Industrial Organization*, eds. M. Armstrong and R. Porter, Amsterdam: North-Holland, pp. 2301–2368.
- Tirole, J. (1988), *The Theory of Industrial Organization*, Cambridge: MIT Press.

- Williamson, O.E. (1975), *Markets and Hierarchies: Analysis and Antitrust Implications*, New York: Free Press.
- Vining, R. (1956), *Economics in the United States of America. A Review and Interpretation of Research*, Paris: UNESCO.
- Yamagishi, T., Kiyonari, T. (2000), 'The Group as the Container of Generalized Reciprocity', *Social Psychology Quarterly*, 63, 116–132.
- Yamagishi, T., Mifune, N. (2009), 'Social Exchange and Solidarity: In-Group Love or Out-Group hate?', *Evolution and Human Behavior*, 30, 229–237.