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Designing and evaluating business process models: an experimental approach

Yuecheng Yu · Alexander Pelaez · Karl R. Lang

Abstract This paper presents an experimental approach to compare the performance of alternative business process designs. We use an example case of an electronic group buying setting to demonstrate how our approach can be applied in practice. More specifically, we chose a standard business process, the sales process as implemented on a group buying platform, to illustrate how a business process may be redesigned in order to better meet the needs of customers. For that purpose, we introduce a social technology feature to support cooperation among buyers in the sales process and then analyze the performance impact of the proposed business process redesign. We combine principles from design science and experimental economics to aid the business redesign process. To allow for an experimental evaluation in a controlled laboratory setting, we implement a simplified prototype model and an experimental electronic group-buying platform in the laboratory. We then employ the methods of experimental economics to generate process performance data and evaluate the effectiveness of the new process model design in the lab that can provide valuable insights to platform managers for redesigning the real-world system. We posit that combining the principles of design science and experimental economics offers researchers a useful and cost-effective method to systematically evaluate theoretical predictions about process model design.

Keywords Design science · Electronic group buying · Experimental economics · Mechanism design · Social commerce · Virtualization theory

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1 Introduction

Many firms, especially in the electronic commerce and social commerce sectors, depend critically on continuously developing an online business platform that implement various interconnected automated business processes that support their business. As markets and technology evolve businesses need to consider redesigning core business processes to better meet the needs of their customers. In many cases, businesses may be able to test new design features with traditional software development methods before deploying them on the public platform or conduct real-time Internet field experiments. In some cases, however, the impact of altering a core business process on business performance or customer satisfaction may be uncertain and present a significant business risk. In this paper, we propose combining design science (Hevner et al. 2004) with experimental economics (Smith 1989) as a novel approach to systematically examine new business process model designs. This approach is particularly appropriate for process model analysis of business processes that newly incorporate virtual features.

In order to demonstrate how our proposed business process evaluation works we choose a particular example of an online platform based business from the social commerce sector and focus on the design of one specific business process. In recent years, a number of different social commerce platforms have been developed on the Internet and some of them have been widely adopted by consumers (Liang and Turban 2012). These social commerce sites, which are using social technology[1] to support some form of implicit or explicit consumer-to-consumer coordination, are evolving and reshaping the business environment by offering consumers new ways of shopping for products and services (Lang and Li 2013–2014). This includes coordinating group purchases on electronic group-buying sites like Group on or Living Social. The dynamic and interactive features of social commerce business processes increase the complexity of business process modeling and analysis, compared to the conventional business to consumer sales process. In the present paper, we look at the issue of how businesses can evaluate alternative business process designs that incorporate new technology features using the example of a standard business process (sales process) for one specific platform based business(electronic group buying).

Applying Overby's (2008) virtual process theory, we propose an IT-driven process redesign (Davenport and Short 1990), introducing a trading mechanism that adds social features to the sales process. In accordance with design science (Hevner et al. 2004) we develop and evaluate the new business process design. While the majority of design science research is primarily concerned with the original development of quality software artifacts, information systems researchers are particularly well positioned to address the important issue of evaluating the business performance of the system design (Hevner et al. 2004; Gregor and Hevner 2013). However, system evaluation in an organizational context is difficult and expensive and there is a lack of clear guidelines how to conduct it without disrupting business operations (Peffers et al. 2008).

[1] Social technology refers to software that connects users and supports user-to-user interactions, and is typically deployed over Internet or mobile platforms.

To address this gap, we propose controlled experiments as a cost-effective system design evaluation approach that can be done in the laboratory prior to real-world deployment without disturbing business. While lab experiments cannot fully replicate the richness and complexity of a real-world business setting, they can generate valuable performance indicators that business management can use as critical information input to decide if the new design should be launched or reconsidered. As our particular evaluation method, we propose using experimental economics and implement a simplified prototype that creates an exchange platform for group buyers and sellers who are trading items and compare the performance of two trading mechanism designs (Chen and Ledyard 2010).

Our particular aim in the paper is three-fold. First and foremost, we propose combining principles of design science and experimental economics as versatile and useful approach for businesses that need to decide what new platform features to offer to their customers in uncertain market environments. We suggest that this approach presents a cost-effective way to learn about the effects of new features in laboratory experiments, which can supply businesses with valuable information that they can use to make the decision what new features to deploy commercially in the market. Second, we present an example business process design to demonstrate how, in principle, our approach would work in practice. For that purpose, we use a typical sales process in electronic group-buying and develop an alternative business process design that incorporates a social communication feature. We then show how laboratory experiments can be used to efficiently evaluate the new business process design.

The paper is organized as follows. Next, in Sect. 2, we introduce a new design for the group buying business process. Following the new design, we will discuss three theoretical aspects—economic performance, information exchange behavior, and market efficiency—for the purpose of evaluating the new design. Correspondingly, we will propose specific hypotheses derived from our theoretical discussion. In the next section, we present the experimental design and procedures. In Sect. 5, discuss our data analysis and the results. Finally we discuss our findings and conclude the study.

2 Redesigning the group buying sales process

Group buying is a specific type of social commerce, where an intermediary provides a platform allowing potential buyers to group together to purchase a good or service. According to economic theory, group buying benefits both buyers and sellers, in the sense of lowering transaction cost and aggregating consumer demand (Anand and Aron 2003). Through analytical modeling, research suggests that an improved cooperation process among group buyers can benefit both buyers and sellers in terms of profits (Chen et al. 2009; Jing and Xie 2011). Interestingly, however, on most current group buying platforms, including Groupon.com, for example, there are no specific social media tools available that would assist buyer coordination and cooperation. Instead, potential buyers cooperate as groups only implicitly, for example by joining a deal that is on offer. Thus, and in accordance with Overby

(2008) we make an effort to explore an explicit, virtualized process design that includes some social technology support for user coordination and cooperation. Specifically, we choose a group-buying platform with buyer competition that includes a double auction as our specific trading mechanism.

Our study follows principles of design science research as stipulated by Gregor and Hevner (2013). As indicated in Table 1, we design, implement, and evaluate an IT artifact (in our case an electronic group-buying platform system). More specifically, we redesign a particular business process (sales negotiation between buyers and sellers) that is implemented on the group-buying platform, and compare the performance of the old and the new design. In this study we focus in particular on step (5) of the DSR principles (evaluation) by using methods from experimental economics to evaluate the two designs with respect to organizational and economic performance measures. In this paper, and as indicated in Table 1, we distinguish between the commercial platform software in the real-world setting that is the target system for the redesign (IT artifact) and the simplified prototype model that we usefor our experimental evaluation in the laboratory.[2]

Drawing on the theory[3] of consumer informedness (Clemons 2008; Granados et al. 2010) and the theory of media synchronicity (Dennis et al. 2008), we propose a business process model for one specific group buying setting, in which social communication is supported—in form of a private communication channel that is implemented as a standard chat box—to improve buyer coordination. Informedness theory conceptualizes the level of information that is available to consumers and specifically argues that consumer informedness is increasing because of advances in electronic communication (including social communication tools) and that this reduces information asymmetry between sellers and buyers. Media richness theory argues that for electronic communication to be most effective it must be aligned with the communication task at hand and that performing more complex tasks needs richer media support. Hence, communication level is our primary independent variable of interest. Increasing communication level is directly associated with increasing consumer informedness. The specific choice of the chatbox tool to increase communication level is derived from media richness theory.

We also consider the possibility of buyer competition, that is, that there are more potential buyers in the market than can be accommodated by the available offer. Group size, that is, the number of potential buyers, is also an important factor and we decided to control for it experimentally. Hence, we manipulate two independent variables, availability of social communication (supported/not supported) and also the size of the buyer groups (small vs. big) as a secondary variable of interest.

Our main dependent variable of interest is economic performance of the group buyers measured as buyer surplus. In a group-buying auction with buyer

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[2] In a fully developed business application, the experimental platform would likely include a simplified and scaled-down version of the commercial platform software and might use a formal business process language like UML to specify the alternative business process designs that are evaluated. Our prototype model is implemented with the z-tree software.

[3] While it is desirable to base business process redesign proposals on theoretical arguments, our evaluation approach can also be used with purely exploratory rather than theoretically grounded hypotheses.

Table 1 Application of design science research principles

Principle steps in DSR [based on Gregor and Hevner (2013, p. 342)]	Example case: group-buying platform design
Identify problem	Should we redesign the business process that governs the sales negotiation between buyers and sellers on our group-buying platform and add a new social communication feature (e.g. a chatbox)?
Define solution objectives	Improve buyer coordination and group performance
Design and development	Business process model (shown in Fig. 1)
	Experimental lab prototype implemented with z-tree software (see "The experimental software: z-tree" of appendix)
Demonstration	Pilots were run with various user groups who followed the buyer/seller user instructions (see "Instructions for buyers" and "Instructions for sellers (small groups)" of appendix). The example screen shots ("Example buyer screens" and "Example seller screen" of appendix) demonstrate the look and feel of the (experimental) software
Evaluation	Controlled laboratory experiments that evaluate the impact of redesigning the group buying sales process by introducing a social communication tool on group performance in terms of coordination and buyer profits (detailed in Sects. 4 and 5)
Communication	Communication between the principle investigators of the experimental evaluation study and the business mangers who are in charge of the group–buying platform and business operations. This would include research reports that summarize the results of the evaluation experiments, interpretation of the findings, and discussion of possible modifications

competition, buyers work cooperatively to generate a joint bid with a commonly agreed-on price, while they face at the same time peer competition as only the individual buyers with the highest bids will eventually join the group bid. Standard economic theory on competitive markets holds that buyers will tend to bid higher (and closer to their maximum willingness to pay) than in markets with less competition, thus reducing buyer surplus. However, recent research in electronic commerce also suggests that introducing a communication channel among buyers will increase market transparency and reduce uncertainty by improving the buyer's informedness through information exchange (Clemons 2008; Granados et al. 2010).

From a technology perspective, we need to decide how to implement the information exchange tools (i.e. the social communication tool). To that regard, we focus on task-technology fit, that is, on how the technological feature fits the task requirements present in group buying. The communication process pertaining to the group-buying task is a typical convergent process, which demands verification, negotiation, and clarification (Lind and Zmud 1991). According to the theory of media synchronicity, a synchronous instant messaging tool can nicely fit the communication process needs (Dennis et al. 2008). With the appropriate communication tools, group buyers can collaborate more effectively in order to reach an agreed bidding price and consequently generate better payoffs (Zigurs and Buckland 1998).

In the management literature, a business process is typically defined as a set of linked steps, activities and tasks that generate an organizational output or customer product (Davenport 1993; Hammer and Champy 1993; Rummler and Brache 1995). They are often represented with some kind of formal or informal flowchart as sequences of events, activities and decision points. For our case, we use the flowchart in Fig. 1 to depict the group buying business process model, showing the business process that governs how buyers purchase items from sellers at a conceptual level,[4] and indicates how the addition of a social communication tool alters the process. Notice that the sales process shown in Fig. 1 is composed of several sub-processes that model bidding, review and approval, and consumer coordination. On the left hand side of Fig. 1, we show the original business process that does not feature social communication support. The right hand side presents the redesign of the group buying sales process that shares the principle design of the original process but critically adds social communication support among buyers by adding the two activities "post/read messages" and "observe the market."

3 Theoretical background and hypothesis development

In the new design of the group buying business process, we introduce an information exchange capability for the buyers, by adding a communication channel available to buyers. The communication is private to buyers and cannot be accessed by the seller. To evaluate the impact of the added communication capability, we focus on three theoretical aspects—economic performance, information exchanging behavior, and market efficiency.[5]

Looking at economic performance, we can analyze the direct effect of adding the communication channel on group buying performance. Under competition, buyers should tend to increase their bidding prices more aggressively in order to win the bid over the competition from other potential buyers (Ku et al. 2005). Without the availability of a private communication channel, buyers need to make their bidding decisions solely based on public information, that is, by observation of the market prices that are posted publicly on the trading platform.

Information exchange supported by communication channels can help buyers acquire more information directly from other buyers, information beyond the signals that buyers send when posting their bid prices on the trading platform. However, in our case there is no regulation or monitoring what information buyers can share in the private communication channel, which means that the information quality in terms of relevance, correctness, accuracy, and efficiency is uncertain to the receiver of the information. Nevertheless, Theories of consumer informedness and information transparency (Clemons 2008; Granados et al. 2010; Holthausen and Verrecchia 1990) argues that more information release will result in both positive informedness effects and consensus effects, meaning consumers or agents will become more knowledgeable about the market or product and they can reach

[4] We use a simple and informal representation of the group-buying business process. In real business settings, it would be preferable to use some formal business process model representation language, such as UML, for example (Russel et al. 2006).

[5] For readers who are interested in a more general overview of related studies on group buying behavior and economics tested in laboratory experiments we refer to Pelaez et al. (2013).

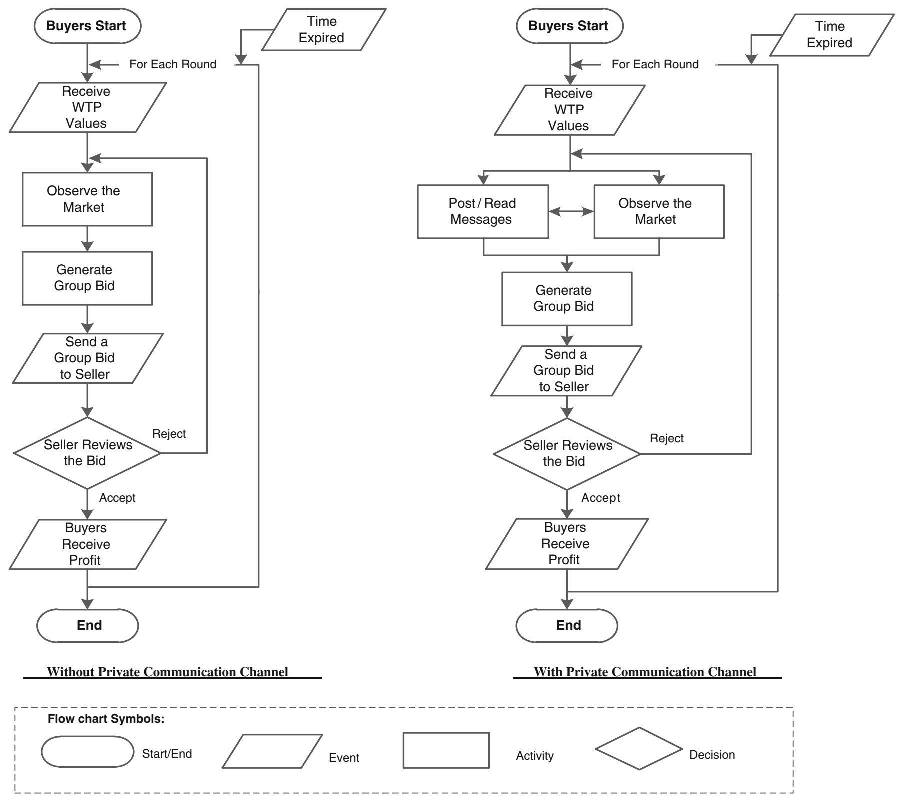


Fig. 1 Business process model design (group buying sales process)

agreement more easily. In the group buying context, informedness and consensus are critically important for making better bidding decision and achieving better bidding outcomes in terms of higher buyer surplus.

Another important factor for economic group buying performance is group size. Researchers have found that buyer concentration is a source for countervailing power, which can lower seller margins and accrue more surplus at the buyers' side (Galbraith 1952; Scherer and Ross 1990). Galbraith (1952), in his influential work, originally focused on the buying consortiums of his time and noted that large buying groups were able to resist actions by monopolistic sellers. Galbraith recognized that it was theoretically possible for consumers to exercise some form of direct countervailing power, too, but pointed out that it would be unrealistic to expect it to occur in practice at any significant level because of the difficulty for them to coordinate effectively. Rha and Widdows (2002) extended this view to electronic commerce settings. Recent economic experiments on countervailing power have shown that even a small number of buyers can influence monopolist pricing, concluding that group size matters (Ruffle 2000). Therefore, we propose that

Hypothesis 1 Introducing communication channels among group buyers will increase buyer profits.

Hypothesis 2 Increasing the group size of buyers in a group-buyer model will increase buyer profits.

The second theoretical perspective that we take to investigate the effects of our new business process design is market efficiency. We assume that under an efficient market, all buyers make rational decisions. Simon (1972) suggests that there are three prerequisites for rational decision-making: the identification of all potential alternatives, the determination of all implied consequences, and the capability to evaluate the effectiveness of each set of consequences. In reality, however, individual decision makers have cognitive difficulties in acquiring and correctly processing the information about all the possible alternatives and consequences. Without social communication, buyers tend to make decisions in a closed system using only a limited number of variables and consequence (Simon 1972), and the central objective of buyers in these circumstance is to merely find some solution that satisfies their own personal goal constraints, even if it is less than what could be achieved.

The information exchange among buyers, supported by the presence of communication channels, can not only provide more information about potential alternatives, but also enable explicit cooperation among buyers even though competition still exists. The information transparency and shifting the focus from pure competition to cooperation under competitive conditions should lead to a more efficient market. The buyers in an efficient market perform differently from the buyers in an inefficient market in two major aspects.

First, in an efficient market, such as a double auction, the buyers with low willingness to pay (Lo-WTP) tend to be more active in terms of moving the bids to a level that is acceptable to their personal constraints. Bidding price initiation is critical important for a group bidding, because inexperienced bidders look to other bidders to conceptualize their bidding strategies (e.g. Rasmusen 2006; Simonsohn and Ariely 2008). Second, in an efficient market, which carries less uncertainty, all buyers tend to make more rational decisions. Specifically, everything else being equal, in an efficient market, the buyers with high willingness to pay (Hi-WTP) are more likely to join the final bidding price, while buyers with Lo-WTP are less likely to be able to join in the final bidding price because of their given constraints imposed by their different WTP values. Hence, we propose the following.

Hypothesis 3 Introducing a private communication channel among group buyers will improve market efficiency, so that Lo-WTP buyers are more active in terms of leading the bidding prices than the buyers in the groups without communication channels.

Hypothesis 4 Introducing a private communication channel among group buyers will improve market efficiency, so that more Hi-WTP buyers will win the bid in the groups with communication channels than in the groups without communication channels.

To open the black box of the group buying business process, we also investigate how the buyers, who have distinct needs, use the communication channel. In the group buying process, buyers will experience risk and uncertainty. Theory of information search suggests that when perceived market uncertainty increases, the intensity of information search will increase (Rothschild 1974; Kuhlthau 1999). With incomplete and imperfect market information, buyers tend to search for the lowest price available in the market (Rothschild 1974). Compared with the buyers with Hi-WTP, the buyers with Lo-WTP are subject to higher perceived uncertainty because they have less chance to win the bid and even winning the bid, they will acquire lower surplus. Thus buyers with Lo-WTP should show a stronger motivation to exchange messages with other buyers. In the similar vein, compared with the buyers in small groups, the buyers in bigger groups experience a higher level of market uncertainty. When group size increases, the task complexity will increase as well. The groups with more potential buyers have more diverse needs and more potential conflicts that derive from the differences in their WTP values, which together will result in more market uncertainty. Driven by the uncertainty, buyers in bigger groups tend to be more active in the information exchange activities than those in small groups. Therefore we propose that:

Hypothesis 5 Buyers with low WTP tend to post more messages than buyers with high WTP.

Hypothesis 6 Buyers in bigger groups tend to post more messages than buyers in small groups given more potential competition and higher level of market uncertainty.

4 Experimental design and procedures

In order to simulate an electronic market with a group-buying platform that connects buyers and sellers in the laboratory we need to implement a functioning trading platform that our subjects can use to coordinate, negotiate, and buy items in the experiment. This includes specific trading rules that specify how sellers and buyers interact and how transaction prices are determined as well as calculating economic indicators (like buyer profit) that measure group performance in economic terms.[6]

We use a variant of a double auction mechanism to facilitate price determination.[7] When a buyer initiates the bidding process, at a certain price, other buyers can join the bid if they agree with the price. When the number of followers reaches the seller's threshold requirement, the group bid will be routed to the seller, who will then decide to accept or reject it. If the seller accepts the offer, only the buyers who joined the group bid win, the rest of them lose the bid. If the seller rejects the bid, a new round of bidding, or price negotiation, starts. Under the traditional design, group buyers participate in bidding and price negotiation through public bidding platforms with no

[6] The trading terms (economic performance measures like buyer profit or surplus), bidding rules, and mechanism (double auction) are standard techniques in experimental economics.

[7] Research in experimental economics has shown that the continuous double auction is generally the best performing pricing mechanism in terms of allocative efficiency of resources and also in terms of convergence speed, which is particularly important in laboratory experiments where trading sessions have be very short. For those reasons, double auctions are the default pricing mechanism for market experiments.

private buyer communication. Our revised business process design offers a social communication tool to buyers for private message exchanges. We then compare the performance of the two process designs experimentally in the laboratory.

We designed an economic experiment that created an electronic group buying market in the laboratory where participants were asked to coordinate group purchases of a single, private value product from a monopolistic seller (see "Instructions for buyers" and "Instructions for sellers (small groups)" of appendices for the specific buyer and seller instructions that were used in the experiment). Each individual buyer is given a pre-assigned value, the willingness to pay (WTP), for the same single product. This induces demand heterogeneity on the buyer side. Consumer valuations vary across buyers and each buyer needs to buy one unit of the product. The experimental environment and sales process prototype were developed using the z-tree software (see "The experimental software: z-tree" of appendix for an overview of z-tree and its applications) and implemented in a Windows client–server networked environment (Fischbacher 2007).

A total of 224 participants were recruited for the experiment from an undergraduate student subject pool at Baruch College that is associated with taking the introduction course to information systems that is required for all business students. All of them were business majors and the proportion of females and males were about even. The subjects were fairly homogeneous in terms of age, educational background, and IT savvy. For completing the experimental task they were compensated with course credit. They received instructions (shown as "Instructions for buyers" of appendix) that explained the nature of the experiment and the tasks they were asked to complete in the experiment.

We used a 2 $\times$ 2 design, shown in Table 2, in which we manipulated two variables at two levels, group size (4 or 8) and communication support (a private communication channel available, and not available). The 224 participants were assigned to 32 groups, with 8 groups for each cell of the 2 $\times$ 2 design. Each group participated in 10 rounds of the experiment. Each session consisted of groups with 1 seller (monopolist) and either 4 or 8 potential buyers. Example trading screens for seller and buyer participants are included as "Example buyer screens" and "Example seller screen" of appendices. In small groups, 4 potential buyers bid for 2 products from the seller, meaning only two potential buyers will win the bid. Similarly, in big groups, 8 potential buyers bid for 4 slots to obtain a unit of the product. Buyer competition occurs because there are fewer slots for joining a bid than there are potential buyers in the market. We induced time pressure by limiting the auctions to two-and-a-half minutes each. Ten rounds of auctions were conducted, and in each round of auctions buyers the randomly generated WTP values were reused and rotated. We used the same trading platform that was developed by Pelaez et al. (2013) for a different study.

5 Data analysis and design evaluation

The 224 participants were assigned to 32 groups. 8 groups for each cell of the 2 $\times$ 2 factorial design. Each group participated in 10 rounds of the experiment. Among the 320 bids, 277 bids were accepted by sellers within the given time limit, and only those data records were included in our data analysis.

Table 2 Descriptive statistics

Avg. buyer profit	Without communication			With communication				
	n	Mean	SD	n	Mean	SD	n	Total
GS = 4	69	32.19	20.42	68	38.46	21.02	137	35.30
GS = 8	70	37.75	22.53	70	38.52	21.19	140	38.14
Total	139	34.99	21.99	138	38.49	21.11	277	36.73

The buyer profits are normalized by group size (GS) and average willingness to pay (WTP)

In order to test our hypotheses H1 and H2, which involve relationships using group size and communication level as the independent variables and average buyer profit as the dependent variable, we ran a multiple regression test. The descriptive results are displayed in Table 2 and, in addition, the most interesting finding is also highlighted graphically in Fig. 2. The test regression results are summarized in Table 3.

We find from Table 2 that the bigger groups (GS = 8) generate about 8 % more profit ($38.14) than the smaller groups (GS = 4; $35.30). As seen from model 1 in Table 3, this difference between larger and smaller groups was statistically significant ($p < 0.05$). Regarding the effect of providing buyers with a private communication channel, our analysis (Table 2) shows that groups with the communication channel present perform about 10 % better overall ($38.49) than the groups without private communication ($34.99). According to model 2 in Table 3, this difference between groups with and without communication channel was statistically significant ($p < 0.05$). Interestingly, however, we also find (as indicated graphically in Fig. 2) that the benefits from using a private communication channel went mostly to small groups, which were gaining almost 20 % in profits. Large groups, on the other hand, only benefited marginally from it. In "Example chatbox messages" of appendix , we include a few sample message postings to illustrate how buyers were using the communication tool. In the regression model, as indicated in Table 3, we used the binary variables P1 through P9, representing the experimental periods 1 through 9,[8] to control for the effect of repeated measurements. These results support our hypotheses 1 and 2.

To evaluate market efficiency, we examined if adding the communication channel increased market efficiency, meaning that it would benefit the Hi-WTP buyers more than the Lo-WTP buyers. As hypothesized in H3 and H4, we compared Lo-WTP buyers (i.e. buyers who were given a low WTP parameter value) and Hi-WTP buyers (those who were given a high WTP value) in terms of winning percentage and bidding initiation level. To indicate bidding activity we looked at level of bidding price initiation, comparing Lo-WTP and Hi-WTP bidders. To measure the winning percentage we also looked at the number of winning bidders versus bidders losing out in the final bid. We expected that introducing the private communication channel would have a positive effect on the bidding performance of

[8] Recall that we repeated the experiment ten times over ten experimental rounds in which the WTP parameters were rotated among the buyers. We arbitrarily chose period 10 as the reference period, and used dummy coding to indicate the specific round. For example, period 1 was coded as P1 = 1 and P2, …, P9 = 0.

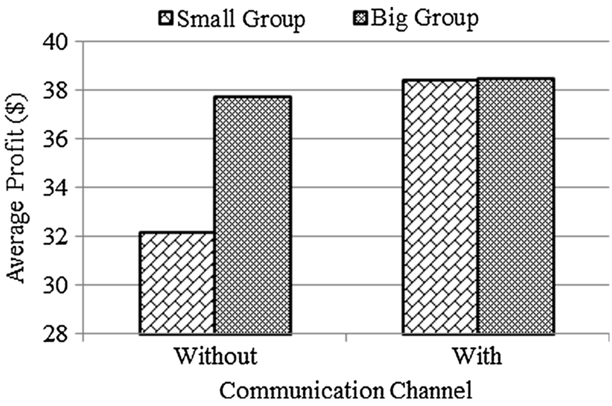


Fig. 2 Small groups benefits from communication

Table 3 Regression test

	Model 0 B	Model 1 B	Model 2 B
(Constant)	35.72**	34.27**	32.48**
P1	1.87	1.92	1.86
P2	0.18	0.13	0.19
P3	1.82	1.71	1.71
P4	2.66	2.61	2.67
P5	3.51	3.51	3.51
P6	4.82	5.02	5.02
P7	−2.72	−2.72	−2.58
P8	−3.55	−3.55	−3.85
P9	1.05	0.83	0.97
GS		2.91*	2.89*
CM			3.58*
R	0.041		
ΔR^2		0.015	0.023

Model 0: baseline

Model 1: model with group size effects only

Model 2: model with both group size and communication effects

* Significance level 0.05; ** significance level 0.01

the Hi-WTP and benefit them more in terms of winning percentage and bidding activity than the Lo-WTP buyers, and thus increase market efficiency. We summarize the results in Table 4.

According to our data, and consistent with H3, Lo-WTP buyers are more active in terms of price initiation in the market with communication channels (2.07 bid initiations per buyer) than in the market without communication channels (1.84 per buyer). However, the difference was statistically not significant. In terms of the

Table 4 Market efficiency evaluation

	Without CC			With CC		
	Average profit	# of bid winner	# of price initiation	Average profit	# of bid winner	# of price initiation
Lo-WTP	20.44	198	1.84	22.77	182	2.07
Hi-WTP	50.07	220	2.47	51.33	234	2.38
Total		418	2.17		416	2.24

CC stands for communication channel

winning bid analysis, Hi-WTP buyers were winning more often than Lo-WTP buyers in the market with communication channels (234 times out of 416 auctions) than in the market without communication channels (220 out of 418), but again the difference was statistically not significant. Hence, while the descriptive results are consistent with both of our Hypothesis 3 and 4 with respect to market efficiency, the differences in the data were not strong enough to statistically support either of the two.

We did, however, do some additional analysis on efficient market theory, also indicated in Table 4, and did find support in our data for two basic efficient market properties, which we had not formalized as hypotheses. As standard efficient market theory would predict, Hi-WTP buyers should outperform their Lo-WTP buyers in terms of winning more auctions overall (and independent of communication setting) and obtain on average higher profits. On average, Hi-WTP buyers made about two and a half times more profit that Lo-WTP in the auctions they won. Among the auction winners, there were also significantly more Hi-WTP bidders than Lo-WTP winners. These results confirm that allocative resource efficiency, a standard property of efficient markets, does occur in our experiment. In our context, this means that scarce resources (the items sold through the auction) should be allocated (i.e. sold) to buyers who have more spending power and a higher willingness to pay for them. However, we did not find that providing a communication channel increases market efficiency.

Finally, we investigated the overall usage of the communication tool in terms of level of messaging. As seen in Fig. 3, we find that buyers with Lo-WTP tended to post more messages than buyers with Hi-WTP, but the difference was statistically not significant and our Hypothesis 5 is not supported. Buyers in big groups posted more messages than those in small groups, and the difference was statistically marginally significant ($p < 0.1$) and thus our Hypothesis 6 is weakly supported. Overall, our data regarding the impact on group size WTP level on information exchange activity remains inconclusive.

To summarize, our data supports three out of the six stated hypotheses. Most importantly, our two key hypotheses, stating that communication level (H1) and group size (H2) positively impact economic buyer performance, were supported. While we were also able to show that our group buying market exhibits the principle characteristics of an efficient market in the sense that buyers with higher willingness to pay should perform stronger in the group auctions that those with lower willingness to pay in terms of winning auction and generating profits, our data did not support our specifically stated hypotheses that introducing a social communication tool would

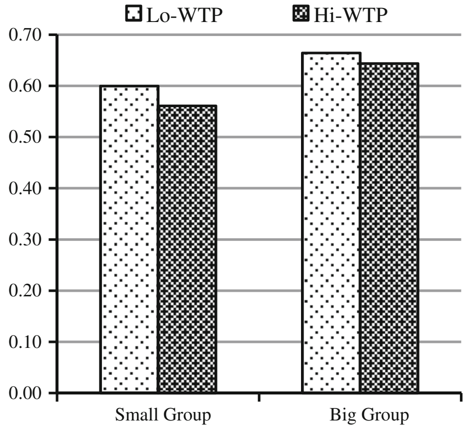


Fig. 3 Messages posted per buyer

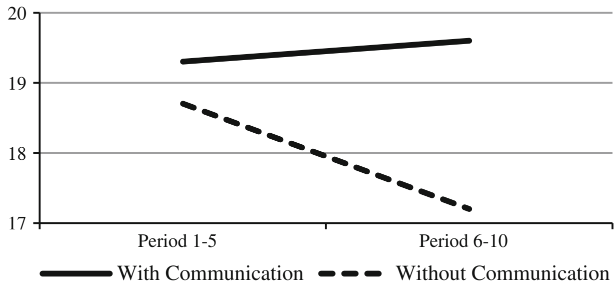


Fig. 4 Buyer surplus over 10 round

increase market efficiency in terms of putting pressure on buyer with lower willingness to pay to initiate bidding more aggressively (H3) and helping buyers with higher willingness to pay win even more auctions (H4). Concerning the factors that drive information exchange we only found some support for our hypothesis that buyers in larger group will use messaging more (H6), but could not support our hypothesis that buyers with lower willingness to pay would post more messages (H5).

5.1 Post-hoc analysis

Over the ten rounds of bidding periods, groups without communication channels tend to make lower profits as they approach the 10th and final round; groups with communication channels tend to acquire higher profit close to the 10th round (Fig. 4). The competition in the market without communication channels among users becomes fiercer, as buyers became more mature or more experienced. The fierce competition among buyers might result in the lower bidding price and lower buyer surplus. The communication channels will facilitate cooperation among buyers, which can help buyers make more rational decisions even under the competition condition. When buyers become more experienced over the time, the rational cooperation might lead them to even better bidding strategies and higher surplus.

To evaluate the effectiveness of offering private communication channels, we also examined the number of messages posted and the length of the messages both across bids and within the successful bids (see Table 4). At the group-bid level, we compared the accepted with the failed bids. According to the experimental results, the groups that did not make the bid within the time limits actually posted three times more messages and three times longer messages than the groups that did make the final bid. However, within the groups that made the bid, the winners use the communication channels slightly more often than the buyers who did not win. The result suggests that if buyers cannot use communication tools effectively, they will suffer from potential information overload (Fig. 5). If buyers cannot use communication tools effectively and get distracted with engaging in excessive messaging, the cost of information searching and exchange could be very high and could mean losing a winnable auction. Because the acceptance of a bid, however, depends on interaction effects between buyers and the seller, alternative explanations could account for that as well. For example, it is possible that for some failed bids, buyers spend more effort to make the deals and thus send out messages with more information, but sellers eventually decline the deals for some other reasons.

6 Conclusion

In this paper we used principles of design science—designing a business process, implementing it, and finally evaluating it—and experimental economics to demonstrate how business process model designs can be evaluated and potentially improved. It also complements theoretical analyses like process virtualization theory (Overby 2008), which predicts the virtual evolution of business process model designs based on theoretical arguments (Table 5).

As an example, we compared two alternative designs fora sales process in a group buying setting in the laboratory. As a case in point, we focused on only one design element, the incorporation of a social communication feature in the group buying sales process that is implemented on the group buying platform, and then examined the impact on business process performance. In order to facilitate a systematic performance evaluation we developed some performance hypotheses based on theoretical predictions about buyer performance. In our preliminary analysis, we find mixed support for the hypotheses, but more importantly, our findings offer interesting insights about the business process performance of the two designs which show that the sales process with social communication support does help buyers to better coordinate group purchases.

From a business perspective, the intermediary that runs the group-buying platform could use the findings of such a study to decide whether or not to redesign the sales process they offer to their customers and provide a social communication feature to their customers. Our findings suggest that buyers, especially buyers in smaller groups, would benefit from using a social communication tool in terms of group purchase coordination. Naturally, a business would likely want to run a few more experiments, comparing various refinements and modifications regarding the

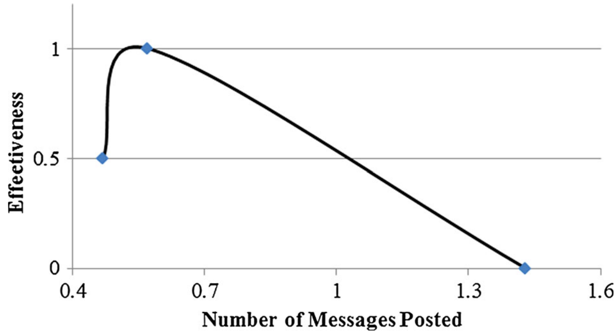


Fig. 5 Information overload curve

Table 5 Messaging use per bid

	Number of MSGs	Total length of MSGs
Failed bids	1.43	24
Accepted bids	0.47	7.30
Not win		
Accepted bids win	0.57	9.63

specifics of the communication tool and the bidding rules, and also consider more explicitly the implications for their seller customers, before making a final decision.

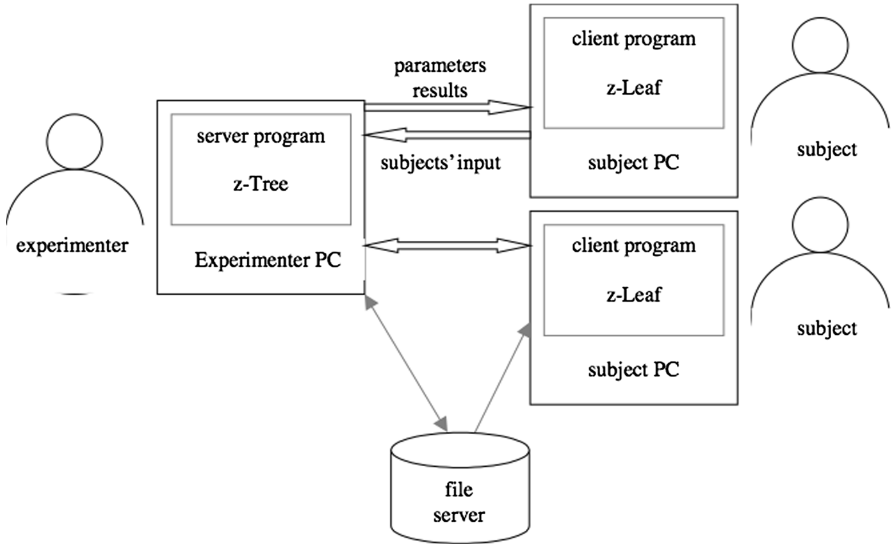
But in any case, our primary goal in this paper was to explain and demonstrate how in principle, businesses can use experiments in the laboratory to evaluate alternative business process designs prior to launching new features on their commercial platforms. Obviously, though, transferring findings from a necessarily simplified lab environment to the more complex real business platform setting must be approached with caution and prudence. The key point, however, is that business process performance evaluation comparing alternative process designs can in many situations be done much cheaper in the lab than in the real business setting and may offer businesses a valuable tool to help them with redesigning business processes in order to improve business performance and customer satisfaction.

Given the constraints of laboratory experiments, we could only investigate relatively small groups in this study. In future research, some field experiments with much larger group size should be considered as well. In terms of IT-enabled capacity, we only examined the effect of one such tool, a simple chatbox. In future research, other and perhaps more sophisticated social technology features and social media tools, which may better support coordination in larger groups, for example, should be considered too. Also, we only looked at the buyer side performance in a group buying market. In future research, we should look more specifically at the seller side, too. Another interesting research direction would be to use formal business process modeling languages to implement the process model designs that are experimentally examined in the laboratory.

Appendix

The experimental software: z-tree

The Z-Tree Software Architecture



In z-tree a market and the parameters of the market experiment are set up on the central computer, known as the server (left of diagram). The experimenter starts the z-tree software and loads up the file that contains the code and configuration, which will be used by each of the participants that are running z-leaf on computers in the lab. Data is stored on the file system of the z-leaf server as data files, where the experiment is controlled by the experimenter (bottom of diagram). Files are saved in both a proprietary format and excel files for easy import into statistical analysis packages such as SAS, R, STATA, SPSS, etc. A special module of R is available (at http://www.kirchkamp.de) to easily import data from these formats maintaining the structure of the data objects and is available.

Each z-leaf client runs independently (subjects on the right of the diagram) but connects to the server via the network to display market conditions or values. Response times within the application are excellent and transactions occur sub-second between the server and each Z-Leaf client. Once the experiment has concluded the z-leaf client shows a blank screen and awaits for the next experimental session to begin again, while the Z-leaf server saves the results in a separate file and resets the values from the previous session, which begins when the experimenter runs the next session with new participants. Researchers in economics have used z-tree to run experiments on many different topics as summarized in the table below. Some specific example studies include Anderhub et al. (2002a, b) and Hey and Morone (2004).

Economic models and treatments supported by z-tree

Public goods game (Falkinger mechanism) (punishment mechanism)	Conditional cooperation	Oligopoly experiments
Ultimatum game	Comparative advantage	Money illusion
Prisoner's dilemma game	Principal agent	Absolute stranger
Battle of the sexes	Posted offer	Bargaining
Double auction (in an asset market) (with effort choice)	Two person two strategy (simultaneous) (sequential)	Collective action
		Collective markets

Adapted from http://www.iew.uzh.ch/ztree/index.php

Instructions for buyers

General overview

You will be presented with one item to place a bid. Each product has a specific value to you. A small time cost is assessed to you as the round progresses. During each round you will try to acquire each of the items for the best (lowest) possible price. You must work with other buyers to purchase the product. It requires two buyers to agree on a price before the seller can accept an offer. Your goal is to generate as much cumulative profit as possible, which is equal to the values of the products minus the sum of amounts you pay for them and your time costs. Each round will last two and a half minutes. There will be one practice followed by a number of "real" rounds. The total time for the entire exercise will be approximately one hour.

Bidding rules

Any buyer may submit a bid. You may join a bid that is no greater than the value of the item. You may submit a new bid as long as it is greater than the highest bid. Start your bidding low to maximize potential profit. New bids can only be done in increments of 1; therefore they can be 1 dollar higher than the maximum bid or 1 dollar lower than the minimum bid. Once you join a bid you will not be able to remove yourself from that offer. Once two bidders join an offer, the bid is automatically submitted to the seller. If the value of the item drops below the current bid price, the offer will be removed. The value of an item may be different for each buyer.

Making money

The profit you earn is equal to the value of the item bought, the bid you submit for the item, minus the time cost you spend for it. For example, if "item A" is worth \$90 to you and you won the item at the end of the auction with a joint bid of \$65, and your time cost spent is \$5, you will earn a profit of (\$90 − \$65) − \$5 = \$20.

Your total game profit will be equal to the total of all your ten individual round profits.

Key summary points

- Your goal is to make money.
- You have a cost associated with the time you spend in the auction.
- Keep a close watch on the clock especially as it counts down to the end.
- Make sure you work with other buyers to get the best possible price.
- Remember you need at least two buyers to make an offer.
- Start your bidding low to give yourself the best possible profit.

Instructions for sellers (small groups)

General overview

You will be presented with two units of one item that you want to sell in an auction. You have a small cost associated with the time you spend in the auction. During each round you will try to sell your item for the highest possible price. Your goal is to generate as much profit as possible, which is equal to the price at which you sell the item minus the time cost you spend for it. Each round will last two and a half minutes. There will be one practice round and a number of "real" rounds. The total time for the entire exercise will be approximately one hour. Instructions for the big group treatment are similar and not included.

Bidding rules

Your product is automatically entered into the auction allowing bidders to submit bids, which you may accept. A bid will only be submitted to you when 2 buyers join the offer. You may choose to accept the bid at anytime or allow the bid to expire. The auction will end once you accept an offer or at the end of, 150 s (two and a half minutes).

Making money

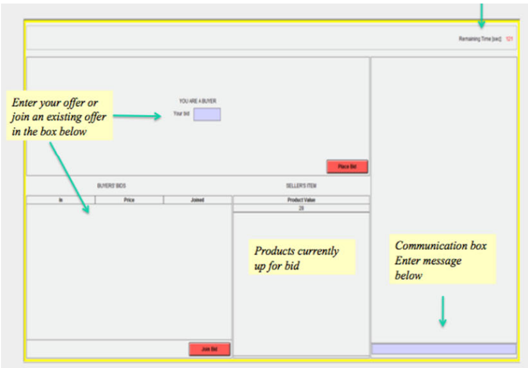
The round profit you earn is equal to the highest offer you accept for the item minus the time cost for the item. For example, if the offer you accept is \$90 at the end of the auction, and your time cost is \$10, you will earn a profit of $\$90 - \$10 = \$80$. Your total game profit will be equal to the total of all your round profits.

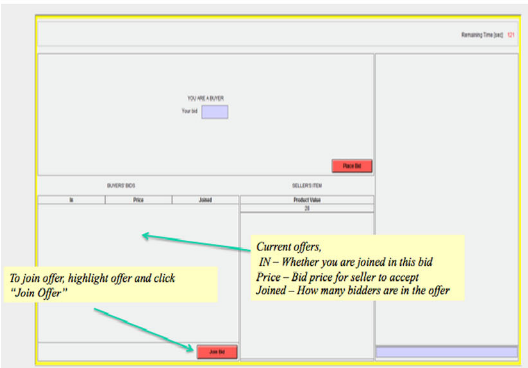
Key summary points

- Your goal is to make money.
- Try and get the largest profit possible.

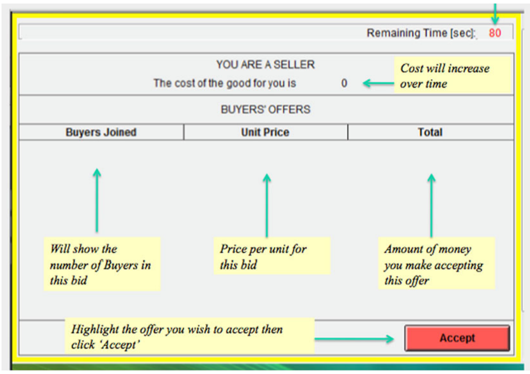
- You have a cost associated with the time you spend in the auction.
- Keep a close watch on the clock especially as it counts down to the end.

Example buyer screens

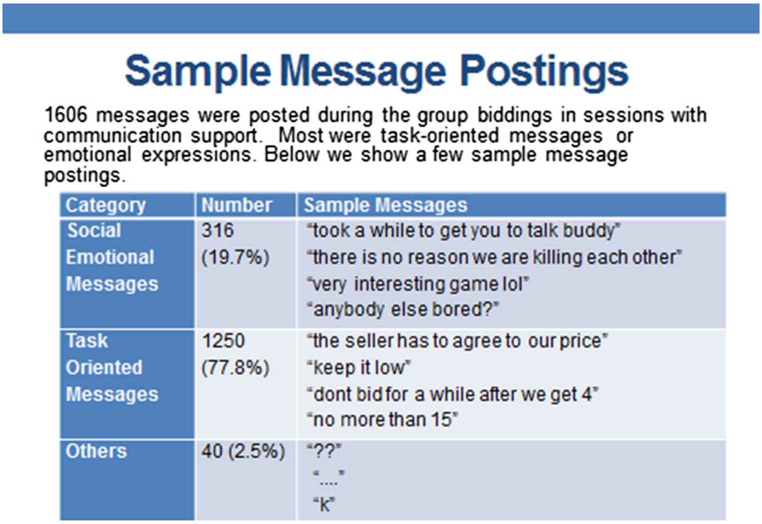




Example seller screen



Example chatbox messages



Sample Message Postings

1606 messages were posted during the group biddings in sessions with communication support. Most were task-oriented messages or emotional expressions. Below we show a few sample message postings.

Category	Number	Sample Messages
Social Emotional Messages	316 (19.7%)	"took a while to get you to talk buddy" "there is no reason we are killing each other" "very interesting game lol" "anybody else bored?"
Task Oriented Messages	1250 (77.8%)	"the seller has to agree to our price" "keep it low" "dont bid for a while after we get 4" "no more than 15"
Others	40 (2.5%)	"??" "...." "k"

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