Participatory Budgeting -

An Experimental Approach to Online Allocation Mechanisms

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Contents

Part I

Introduction and Foundations

Chapter 1

Introduction

"Democracy will win - because a government's legitimacy can only come from citizens; because in this age of information and empowerment, people want more control over their lives, not less; and because, more than any other form of government ever devised, only democracy, rooted in the sanctity of the individual, can deliver real progress."

(Barack Obama, 2014)

1.1 Motivation

Everything we want to know today, is just one click away. The level of accessible information has rapidly increased and this may affect our decision-making. With the increasing complexity of our society and economy, political foundations have to adapt simultaneously (Shah, 2007). This challenges policy makers and institutions to be aware of changes within society and react to novel situations.

Representative democracy has been reflecting the situation of civil society for many years. Individuals elect representatives, who are supposed to have the opportunity and time to access necessary information and focus on complex decisions. The group of representatives, e.g. the government, has the overarching goal of increasing common benefits of the individuals and strive for welfare gain (Franklin et al., 2009). Therefore, representative democracy has enabled people to

have an (indirect) impact on the decision-making on local, national, and global level despite having a limited information level compared to the representatives. Furthermore, representative democracy comes with the advantage that a small, representative group can discuss and decide efficiently on important and complex topics without having a time-consuming and often unrealistic discussion with the entire population (Goodin, 2008).

With the rise of the internet not only the way we communicate has changed drastically but also the level and speed of information available for citizens has increased. Modern news and journalism comply with this trend of faster and more flexible information (Parmelee, 2013). Today, conventional information sources like print media, radio, or television, have been complemented and to some extent even been replaced by more modern means like quickly adapting online dictionaries, mobile news apps, and social media (Li, 2013). Hence, for the individual it is more difficult to trust the correctness of information and balance fact-based sources and unfiltered ones like Twitter[1] or Wikipedia[2]. Overall, the possibilities of new perspectives, increased information flow, and rapid global communication enables people to conceive an opinion even on complex topics. This trend also leads to the impression to be more informed just by the fact that more information is accessible and we are constantly exposed to a variety of information.

Concurrently, with this new information access level of the individual also comes a new role of citizens in modern politics. As the imaginary distance between parliament and people's living rooms shrinks with a few mouse clicks, mere elections of representatives with a certain political program over a fixed term do not reflect the desire and wide range of opinions of well-informed citizens anymore. This trend is unequivocally observed by decreasing numbers of junior party members and lower voter turnout, while, in contrast, general interest in politics remains high (Franklin, 2004).

All these trends combined result in a desire for participation in public decision-making. Citizens do not want to leave important decisions to representatives anymore (Hague and Loader, 1999). Hence, politics is forced to break new ground and offer new ways of participation. The grand challenge is to support people to

[1] `twitter.com`, last accessed on January 30th, 2017
[2] `www.wikipedia.org`, last accessed on January 30th, 2017

collaboratively find solutions on topics that affect them by creating mechanisms that manage the information flow between stakeholders. Participatory processes involve several stakeholders that need to be taken into account. Usually, an institution, such as a public authority, government, or even an enterprise, is the initiating party that offers to involve a group of its constituents in its decision-making. Both sides can profit from participatory processes and need to be taken into account when designing such processes (Hellmanns et al., 2016). While institutions gain insights in the preferences of their constituents, citizens have the opportunity to make an impact by participating in decision-making. While participatory processes may include discussions on local problems or the proposal of public projects, a process that has a far-reaching and binding impact is the allocation of public budget in form of a participatory budgeting (Shah, 2007).

Participatory budgeting is a decision-making process through which citizens (and civil society organisations) deliberate and negotiate over the allocation of public resources (Shah, 2007). The process addresses all citizens of a community and focusses on financial issues with limited resources in limited time. It includes discussions on the budget allocation and a binding statement of the organisers on the proceeding with outcomes of the process (Herzberg, 2006; Sintomer et al., 2012). Participatory budgeting is found to be a possibility to further increase the level of democracy, social inclusion, and social equity, as well as transparent administration (Sintomer et al., 2008).

The demand of citizens for participation comes with great opportunities for institutions. Offering participation processes enables institutions to gain more insight in the opinions and needs of their constituents. Participation in policy making increases trust in the institution that offers the involvement in decision-making and strengthens the political and democratic awareness (OECD, 2015). The challenge is, however, finding suitable participation processes by which to involve individuals in institutional decision-making. This includes well-defined mechanisms that transform individual decisions into a collaborative one, e.g. collaboratively allocating a public budget by means of participatory budgeting.

Participatory processes today face new opportunities by the rise of the internet. What was previously considered an obstacle, such as time and space, has been

simplified by digital participation in political, as well as in corporate or private contexts (Macintosh, 2008; Hall, 2015). This led to a considerable change in participation processes as well as participation behaviour (Boulianne, 2009). Even discussions on complex topics have been found to result in qualitatively valuable outcomes (Powell and Kleinman, 2008).

Participatory processes should, however, not replace representative democracy but pose as constructive complements (Goodin, 2008). Therefore, participatory processes initiated by institutions, as well as the formation of citizens' initiatives and local campaigns on specific topics expand the traditional representative democracy.

With these positive developments at hand, it is reasonable to assume that partaking in online participation could trend in the same direction as e-commerce and social networking (Hellmanns et al., 2016; Niemeyer et al., 2016). Despite the fact that, to date, most institutional participation is limited to referenda or public discussions which are resource-consuming and place-bound, the use of information and communication technologies to bring people together for online discussions, project suggestions, and voting increases (Shah, 2007). The bi-directional information flow between institution and individuals is an important foundation of successful participation processes (OECD, 2001) and should be involved in collaborative decision-making. Therefore, mechanisms to support the information flow and participatory decision-making need to be further investigated.

However, information and communication technologies (ICT) offer more possibilities than discussions and votes, as the example of crowdfunding shows (Muller et al., 2013; Sorenson et al., 2016). Crowdfunding mechanisms enable the collaborative funding of projects by a group of individuals online (Belleflamme et al., 2013). Crowdfunding even enabled the funding of projects in places that have typically been excluded from venture capitalists (Sorenson et al., 2016).

There is a large number of users on crowdfunding websites and over 100,000 projects have been funded on Kickstarter over the last years (Kickstarter, 2017). Clearly, the desire in making an impact with money cannot be ignored. This concept has been adopted to the funding of public projects. In civic crowdfunding

a public institution or non-governmental organisation asks private donors to financially support public projects (Miglietta and Parisi, 2017).

Civic crowdfunding mechanisms increase financial transaction transparency and citizens' sensitivity towards public budgeting (Miglietta and Parisi, 2017). Yet, while it is interesting to observe civil society collaborating with government agencies, civic crowdfunding in its current form might reproduce or even widen social inequalities as wealthy neighbourhoods may benefit disproportionately from the combination of government funding and private financial support (Chambers and Kymlicka, 2002; Davies, 2015). However, a main goal of democratic society is the equality among its citizens and everyone should be able to participate in such processes independent of their own financial resources. New forms of participatory processes not only try to include underprivileged groups but generally aim for equality and balanced social representation (Shah, 2007).

Generally, institutions with the responsibility of allocating public budgets underlie a fiscal policy which aims for one general outcome: the increase of welfare of the corresponding society (Cabannes, 2004). In participatory budgeting, the institution provides the entire budget and lets citizens decide on its allocation. The added social value from funded projects, in particular, is considered an important aim, linking budget decisions to community welfare (Franklin et al., 2009).

Therefore, in order to maximise welfare, the (digital) process has to be well-designed in terms of user motivation and monetary outcomes. The impact of design parameters and incentives on participants' behaviours is crucial (Bigham et al., 2014). One important factor for participation processes is the information flow as information is the foundation for participation in general (Arnstein, 1969). A funding mechanism may, however, vary in that for example, the participant may or may not receive dynamic feedback, i.e., continuously updated informations on the status of the budgeting process. Whereas crowdfunding mechanisms continuously inform users about the project's current funding status and allow them to repeatedly invest in projects, participatory budgeting is usually implemented by static voting mechanisms. Here, individuals make a one-shot decision and are informed about the outcome only after everyone has made a decision (Shah, 2007).

As many participation platforms struggle to attract users, participation processes and mechanisms need to be carefully designed (Hellmanns et al., 2016). The mobilisation of users, their motivation to take part, and the motivation to participate in future processes are just a few requirements for successful processes. If participants enjoy the process, which means that they perceive a high hedonic value, and if the mechanism to allocate budgets is sufficiently engaging, they will consequently have an incentive to participate and it will draw enough attention and contribution to eventually succeed, since such schemes rely on critical mass to work properly.

In other domains of decision-making, such as auction bidding (Adam et al., 2015; Hariharan et al., 2016), risk taking (Heilman et al., 2010), or propensity to trust (Hawlitschek et al., 2016), researchers found that people's economic decision-making is highly dependent on their emotions and, in particular, their emotional arousal which reflects their excitement. First evidence shows that emotions also play an important role in participatory processes (Barros and Sampaio, 2016; Steiner, 2012). However, the interference of participatory budgeting mechanisms and emotions has not been evaluated yet.

In this thesis, mechanisms are investigated that support participatory decision-making. In particular, crowdfunding mechanisms are applied to participatory budgeting where the institution provides the entire funding. These mechanisms are designed to satisfy the call for participation (Eisner, 2005), combine the advantage of civic crowdfunding (Miglietta and Parisi, 2017), and foster social equality among participants (Shah, 2007). As the design of participatory processes and, in particular, the design of budget allocation mechanisms is crucial for the outcome, controlled laboratory experiments are conducted to investigate how different crowdfunding mechanisms affect the budget allocation as well as participants' emotions. In more detail, the thesis evaluates how different mechanisms increase participants' hedonic value and emotional arousal in order to make participation more exciting and, at the same time, achieve high individual payouts as well as welfare. Two possible design parameters that are important drivers of emotion and budget allocation in this regard are feedback and personal budget.

Personal budget in this context is defined as the share of the entrusted institutional budget that participants are allowed to keep privately. In the remainder of the thesis, governments and corporations will be referred to as institutions that provide the funding on crowdfunding platforms for users that are either citizens or employees. Offering personal budget, on the one hand, might increase the motivation to participate. On the other hand, personal budget bears the risk of losing parts of the budget to participants who keep it privately. It is therefore interesting to investigate if institutions could provide personal budget to participants and expect similar monetary results, regardless of whether they can keep the entire budget or have to return every share of the budget that was not invested in projects, and at the same time increase motivation.

Feedback in such crowdfunding mechanisms is investigated in two conditions. It can be either static, where participants only receive information about the funding of projects after the investments, or dynamic, where the funding status is continuously updated, similar to crowdfunding websites. Similar to voting, static feedback is only provided after everyone's decision is made. This might lead to coordination problems, since participants do not have any information on other investments or the overall funding status of projects. Dynamic feedback might help to overcome coordination problems by providing more detailed information and by enabling multiple investments (Dorsey, 1992). Hence, participants can react on other participants' investment behaviour and adjust their investment decision on the basis of the new level of information. As access to information is motivation to citizens (Shah, 2007), a more detailed information flow during the process might also increase the incentive to participate.

1.2 Research Questions

This thesis contributes to the field of participatory budgeting by experimentally evaluating design parameters applied to crowdfunding mechanisms. It thereby contributes to the challenge to find mechanisms that support the collaboration between people as well as their participative decision-making, by managing the information flow between participants. The objectives of such participatory processes in this work are twofold. On one hand, institutions aim to increase the

welfare of their constituents (Cabannes, 2004). On the other hand, constituents strive for excitement and want to enjoy the mechanisms, a desire that institutions want to realise (Steiner, 2012; Barros and Sampaio, 2016). Consequently, the impact of design parameters on both the monetary outcomes as well as the emotions of participants of such processes are evaluated. Figure 1.1 illustrates the research questions addressed that will be introduced in more detail in the following paragraphs.

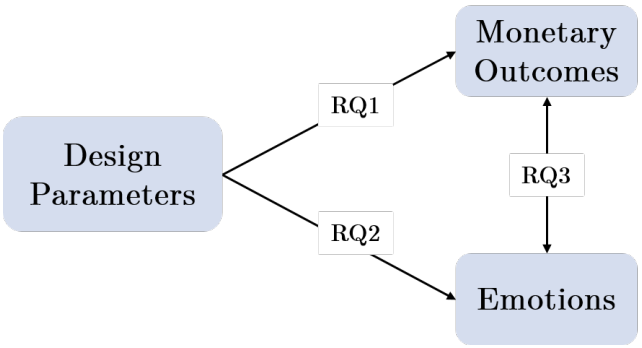

Figure 1.1: Structural Overview of Research Questions.

When budget allocation is not decided by representatives but open to the public via participatory processes, such as participatory budgeting, the initial purpose remains the same. Institutions still underlie a fiscal policy which aims for the increase of welfare of the corresponding society (Cabannes, 2004). This comes with challenges as well as opportunities. The loss of decision-making power of the institution needs to be compensated by carefully defined funding and participatory mechanisms to ensure public welfare and social equality. Therefore, such funding mechanisms need to be designed in a way that individual preferences are combined to achieve a group outcome that serves the initial goal of project funding in the interest of society but at the same time reflects the preferences of the individuals. The choice of the corresponding design parameters, e.g. dynamics of feedback or the share of personal budget, is crucial as minor changes of the parameters can possibly yield significant differences in the outcome and is therefore subject to research. Hence, the first research question, which is addressed and evaluated in Chapter 4 and 5 of this work, is:

RQ 1 **What effects do design parameters have on budget allocation when applied to participatory budgeting mechanisms?**

A well defined participatory process is, however, worthless without individuals who are actually participating. Successful public participation relies on voluntary involvement. Beside the intrinsic motivation to participate, the design of the participation mechanisms should be engaging to maximise the number of participants and further motivate individuals' commitment. In addition to the monetary outcomes, it has been revealed that emotions are important for participation processes, too (Barros and Sampaio, 2016; Steiner, 2012).

To ensure long-term success of the process and citizens' engagement, institutions rely on positive experiences that individuals associate with their participation. This will not only lead to recurrent participation but also to a network effect when participants talk about their experience. Participants want to enjoy the funding mechanisms and institutions want their constituents to take the decisions responsibly. This also depends on the design of the mechanism. Therefore, the second research question focusses on the impact of design parameters on the emotions of participants and is addressed and evaluated in Chapter 6.

RQ 2 **What effects do design parameters have on emotions when applied to participatory budgeting mechanisms?**

Having covered two possible outcome variables, the monetary outcomes of budget allocation and participants' emotions, as well as their respective dependences on the design parameters, naturally, the third research question arises.

RQ 3 **Do monetary outcomes and emotions influence each other in participatory budgeting mechanisms?**

Hereby, emotions are mostly considered as a resulting effect from a given framework. However, emotions have been found to influence decision-making in other contexts (Heilman et al., 2010; Adam et al., 2015). Their effect on individual investment behaviour in participatory budgeting, on the other side, has not been investigated so far. Furthermore, emotions are not only a result of the mechanism

itself but participants might also react emotionally to the monetary outcome of the process. Their influence on the individuals' behaviour during participatory processes must therefore not be neglected and complements the first part of the research question. The third research question is also addressed and evaluated in Chapter 6.

1.3 Structure of Thesis

The research outline described above guides the structure of this thesis. The thesis consists of four parts as summarised in Figure 1.2.

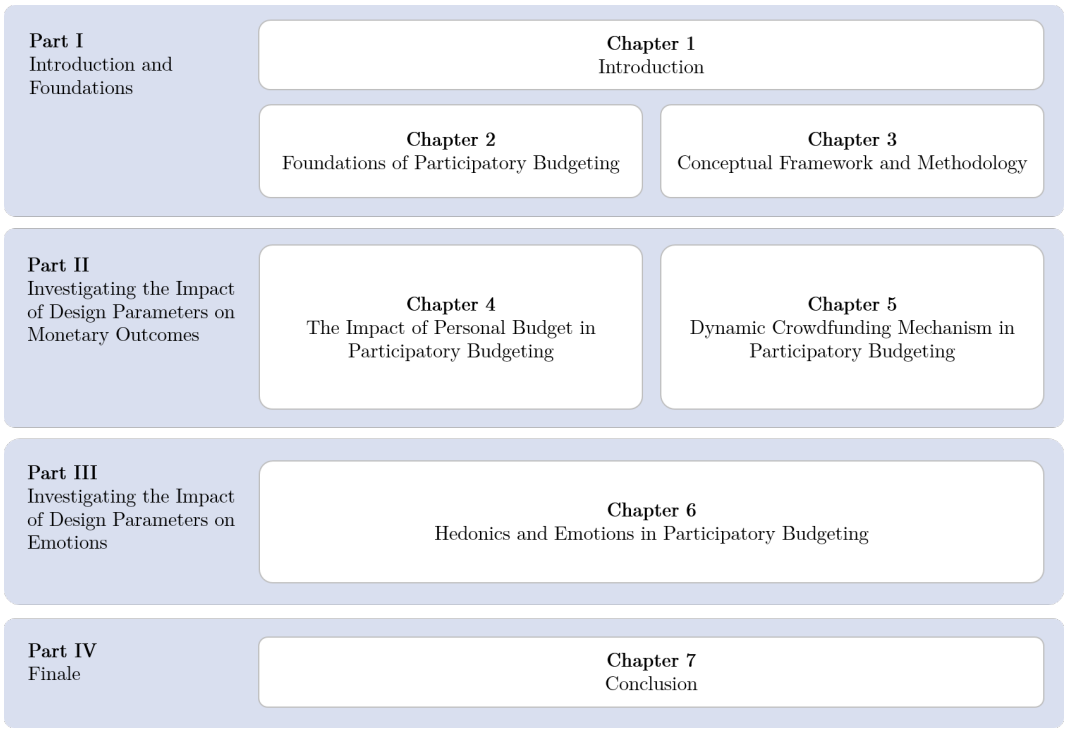

Figure 1.2: Structure of the Thesis.

Part I introduces the context of participation processes, in particular crowdfunding and participatory budgeting, and provides an experimental framework on the theory of threshold public goods. Chapter 1 motivates the need for online mechanisms for participation processes and introduces the concepts of participatory budgeting and crowdfunding mechanisms. Chapter 2 provides the foundations of online

participation and the two concepts of crowdfunding and participatory budgeting. Chapter 3 gives an economic framework of the evaluated mechanisms in the field of threshold public goods games. It further proposes an experimental design to model participatory budgeting as a crowdfunding mechanism and to test the impact of different design parameters in the laboratory. Additionally, Chapter 3 provides an overview on the methods that are applied in this thesis: laboratory experiments, questionnaires, and physiological measurements.

Part II focusses on Research Question **RQ1**, investigating the impact of design parameters on investment behaviour and allocation aspects. Two design parameters, dynamic feedback and personal budget, are evaluated. Chapter 4 presents the results and evaluation of a laboratory experiment which considers the impact of personal budget on allocation outcomes, such as individual payouts and welfare gain. Chapter 5 extends the experiment of the previous chapter and presents the results and evaluation of a second laboratory experiment. This considers the impact of personal budget and dynamic feedback on allocation outcomes such as investment behaviour, individual payouts, and welfare gain. The chapter closes with policy suggestions and implications.

Part IV concludes this thesis with Chapter 7 and summarises the contributions. It therefore provides an outlook on future work.

1.4 Research Development

Parts of this thesis have been presented and published at international peer-reviewed conferences and workshops and are under review for publication in international journals. This section provides an overview of the published material and simultaneously outlines the development of the work and the corresponding refinement and extension steps of the research.

The evaluation framework of online participation platforms presented in Section 2.1.1 is joint work with Astrid Hellmanns, Margeret Hall, Tom Zentek, and Christof Weinhardt. It was presented at the *Second Karlsruhe Service Summit 2016* and further published in the *Proceedings of the Second Karlsruhe Service Summit 2016*

(Hellmanns, Niemeyer, Hall, and Weinhardt, 2016). The framework is included in the foundations of online participation in Chapter 2.

The basic setup of combining crowdfunding with participatory budgeting was published in the proceedings of the *First Karlsruhe Service Summit 2015* (Niemeyer, Hellmanns, Teubner, and Weinhardt, 2015). The concept was further developed and resulted in a more detailed experimental design which is presented in Chapter 3.

Chapter 4 evaluates the first design parameter of the crowdfunding mechanism: personal budget, the initial budget that constituents can keep privately. First results of Research Question **RQ1** were investigated in collaboration with Thomas Wagenknecht, Timm Teubner, and Christof Weinhardt. The results were presented and published at the *49th Hawaii International Conference on System Sciences 2016 (HICSS)* (Niemeyer, Wagenknecht, Teubner, and Weinhardt, 2016). Results of the experiment in this paper are presented in Chapter 4 and 6 and are expanded by further analyses on welfare and efficiency.

Results on the effect of personal budget on emotional arousal (**RQ2**) were presented and published in the *Proceedings of the Second Karlsruhe Service Summit 2016* (Niemeyer, Wagenknecht, and Weinhardt, 2016). Section 6.3.3 extends the analysis.

An extended evaluation of the impact of personal budget and dynamic feedback on monetary outcomes (**RQ1**) is joint work with Timm Teubner, Margeret Hall, and Christof Weinhardt and is under review at the journal *Group Decision and Negotiation* (Niemeyer, Teubner, Hall, and Weinhard, 2017). It also contains a research model on hedonics and emotions based on data from a questionnaire (**RQ2** and **RQ3**).

Physiological considerations of the extended dynamic crowdfunding mechanisms and the impact of personal budget (**RQ2**) are submitted to the *25th European Conference on Information Systems 2017* and are currently under review (Niemeyer, Hariharan, Teubner, and Hall, 2017). This is joint work with Anuja Hariharan, Timm Teubner, and Margeret Hall.

Complementary research in progress (Chapter 7) on the interaction of Social Media and online participation platforms is joint work with Margeret Hall and Christof Weinhardt. It was presented at the *34rd Annual ACM Conference on Human Factors in Computing Systems* and is forthcoming as (Niemeyer, Hall, and Weinhardt, 2016). An analysis of communal well-being in institutions was evaluated with Andreas Lindner, Margeret Hall, and Simon Caton by means of 42 Facebook pages. It was presented at the *ACM Conference on Human Factors in Computing Systems* (Lindner, Hall, Niemeyer, and Caton, 2015) and is published in the *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems*. Considerations on group live biofeedback on participation platforms were developed with Ewa Lux, Florian Hawlitschek, Timm Teubner, and Marc Adam and are published in the *Information Systems and Neuroscience, proceedings of the Gmunden Retreat on NeuroIS* (Lux, Hawlitschek, Teubner, Niemeyer, and Adam, 2015).

Chapter 2

Foundations of Participatory Budgeting

"Democracy [...] is government by discussion."

(John Stuart Mill, 1859)

Generation Y is changing the landscape in the political as well as the working environment. People born between 1982 and 2000 ask to be integrated in collaborative and cooperative decision-making processes (Eisner, 2005). The traditional representative democracy, where citizens participate only indirectly in decision-making, is therefore no longer able to meet the new requirements for participation to activate constituents (Wagner, 2014). Therefore, new forms of (political) participation need to be developed. Governments already react to that need and use information and communication technology to provide services and introduce new processes for the cooperation between citizens, government, and administration (Mossberger et al., 2008; Carter and Bélanger, 2005).

There is a plethora of processes for the participation in institutional decision-making. This thesis focusses on participatory budgeting, a process that includes citizens in the budget allocation of an institution. The budget allocation mechanisms used for participatory budgeting will be adapted from crowdfunding. Therefore, this chapter provides the foundations of participatory budgeting and crowdfunding. First, online participation is introduced in Section 2.1 as an opportunity for collaborative decision-making. Online participation platforms give the basis for such processes, where participants can meet online, i.e., for discussion or votes,

independent of time and location. Participatory budgeting is described as a way to participate in an institution's budget allocation. Second, crowdsourcing is introduced. Two aspects are important when applying crowdfunding mechanisms to participatory budgeting: the crowdsourcing of decision-making that the institution outsources to their constituents and crowdfunding mechanisms as an instrument that gives constituents the possibility to fund projects. Section 2.2 therefore gives an overview and categorisation of crowdsourcing in general and describes the concept of civic crowdfunding in more detail. Last, in Section 2.3, hedonic value and emotions are introduced, as they may motivate participants to participate and influence decision-making in the context of participation.

Parts of this chapter have been published (Niemeyer, Hellmanns, Teubner, and Weinhardt, 2015; Hellmanns, Niemeyer, Hall, and Weinhardt, 2016). The publications contain the general idea of using crowdfunding mechanisms in the context of participatory budgeting and the evaluation framework of online participation platforms. They are expanded by foundations on both participatory budgeting and crowdfunding mechanism, as well as civic crowdfunding.

2.1 Participation in the Digital Era

Political participation is defined as behaviour designed to affect the choice of governmental policies (Verba and Nie, 1987). In more detail, it is action that influences the distribution of social goods and values (Rosenstone and Hansen, 1993). There are many ways to participate in political decision-making. Voting for representatives is one way to participate and delegate the decision-making. Another way is to communicate needs and interests to the elected representative or the government (Verba et al., 1995). Some institutions therefore offer consultation hours or online participation platforms to give individuals the opportunity for a uni-directional information flow or even provide platforms for individual bi-directional communication between institution and constituents. In contrast to these individual processes, there is a number of processes that formalise the information flow. Signing petitions, taking part in referenda, or participatory budgeting are more organised ways to participate. Additionally, participation in civil society includes volunteering or joining interest groups. Some of these activities are more

far-reaching than others. A typology of citizens participation was defined by Arnstein (1969), who classified eight levels of participation. **Manipulation** and **therapy** are levels of non-participation as their aim is to educate and cure participants. **Informing** and **consultation** are instruments to hear constituents and give them a voice. **Placation** adds the right to give advice. **Partnership** enables constituents to negotiate. And finally, **delegated power** and **citizen control** give constituents the full managerial power.

The usual instruments of citizen participation, like referenda, votes, and participation in civil society, do not include the highest levels of citizen control, as this contradicts the concept of a representative democracy in most scenarios. An OECD (2001) study therefore clustered the aforementioned levels to three central levels, i.e. types, of participation in the context of current discussions and process development. The levels refer to the interactivity between institution (government) and constituents.

Information affects all participation instruments that aim for supply and dissemination of information. The constituents-institution relationship is uni-directional, since constituents only receive information. This type of participation is a basic precondition for all other forms of participation.

Consultation is a central element of participation that aims for exchange of ideas and opinion of institution and constituents as well as interest groups. The constituents-institution relationship is bi-directional, since constituents cannot only receive information about the bearing and mindset of the institution but can also give feedback and improvement proposals. Official consultation hours or the personal contact to representatives and the institution are such processes.

Public participation is an active dialogue between institution and constituents. Both parties are equally and actively engaged in the policy making process. Constituents are involved in agenda setting and policy proposals by discussions, voting, and a commitment of the institution to realise outcomes.

Processes on the level of public participation include citizens in policy making. At the same time, they offer a way for governments to improve their policy performance. Not only enable such processes a better understanding of people's needs,

they also improve policy outcomes at lower costs by letting people take action in policy-making where success depends upon a change of individual behaviour (OECD, 2016).

In the public sector, good governance has been found to be a key factor for economic development and social well-being (OECD, 2016). Requirements for such good governance have been suggested by the OECD (2016). Mechanisms for consultation and participation should reinforce openness, transparency, and accountability and emphasises the importance of fairness and equity in the relationship between citizens, governments, and other stakeholders (OECD, 2016).

Internet-based solutions have proven to work as tools to organise such participatory procedures (Klein, 2012). Governments need to leverage the possibilities of information technology. Although the impact of internet use on citizens engagement has not been clarified so far (Boulianne, 2009), with the rise of digital solutions for participation, transparent governments profit in many ways. Citizens' trust in the institution was found to increase through the use of modern information management. At the same time, online participation processes ensure better outcomes at less costs and foster innovative and new economic activities (OECD, 2015).

The challenge for political as well as corporate institutions is to motivate their constituents to participate. Galston (2004) find civic knowledge as a key driver for political participation. The more knowledge people have, the more likely they are to participate in civic and political affairs (Galston, 2004). This emphasised the importance of the information flow between institution and individuals.

There is a wide range of participation processes. This section looks at two independent aspects of participation in the digital era. First, online participation platforms (OPPs) are introduced as a practical instrument for participation processes. As previously mentioned, the increasing digitalisation allows for participation in complex topics beyond regional limitations. Content, interactivity, and technical requirements are factors that need to be considered when implementing OPPs. Thereafter, participatory budgeting is introduced as a form of collaborative budget allocation.

2.1.1 Online Participation Platforms

Information and communication technologies are often used to support, complement, or even replace common offline participation instruments. The possibilities for public institutions to include citizens in decision-making are as diverse as developed technologies and software available (Kubicek et al., 2011). Online participation platforms are websites that provide information and instruments to include citizens in opinion making and decision-making processes. The level of interactivity depends on the intended level of participation. Information and consultation platforms require less interactivity than (public) participation platforms. The success of such technologies is evaluated differently by different researchers, suppliers, and users, since it can be measured from a number of perspectives (Kubicek et al., 2011; Escher, 2013). When evaluating online participation platforms, it makes sense to categorise requirements and evaluate which ones are fulfilled to support the success of the process.

Most research on the impact, correlation, and success of online participation platforms (OPPs) has a social or humanistic background and focusses on individual cases (i.e., Große et al. (2013) for enquetebeteiligung.de). More comprehensive studies that allow for comparative statements rarely focus on the technical concept and realisation of OPPs. For example, The Alexander von Humboldt Institute for Internet and Society investigates user expectations and behaviour of 13 political and enterprise OPPs in the German-speaking area (Send et al., 2014). Kubicek et al. (2011) compare twelve political OPPs worldwide and identify criteria for success. Important drivers are solution-relevant information, range, inclusivity, increase of acceptance of measures, democracy support, influence on result, efficiency, well-defined purpose, activity of decision-makers in the process, mobilisation of participants, transparency, connectivity, resources, and urgency of the topic. The authors do not focus on any technical aspects. However, the application of information and communication technologies offers additional requirements due to the OPPs' characteristics as websites. A number of research suggests evaluation procedures and criteria for websites (Levi and Conrad, 1997; Signore, 2005; Madan and Dubey, 2012). Signore (2005), for example, differentiates between five dimensions of requirement: correctness, presentation, layout, navigation, and interaction. Furthermore, there are special approaches for the usability of websites. While Levi and

Conrad (1997) suggest five categories for evaluation (attractiveness, controllability, efficiency, helpfulness, and learnability), Kirakowski and Corbett (1993) focus on user perception of software usability.

Hellmanns et al. (2016) developed and designed an interdisciplinary requirement framework that facilitates a holistic evaluation of OPPs. The focus lies on platforms implemented for civic participation processes of public institutions. The requirement framework includes suggested and validated dimensions by Signore (2005), Levi and Conrad (1997), Kubicek et al. (2011), Venkatesh et al. (2003), an others, and adapts them to a civic approach. The evaluation framework includes six literature-based and pretested criteria (usability, security, information, transparency, integration, and mobilisation) with subcategories. They are grouped in technical, content-related and interactivity requirements.

Technical requirements. The entire participation process is based on technical functionalities of an OPP, rendering these requirements necessary but not sufficient for platform success. Based on the interaction between users (citizens) and the website (OPP), requirements from technology acceptance models can be adapted (Davis et al., 1989; Venkatesh and Davis, 2000; Venkatesh et al., 2003, 2012). The requirements are extended by website quality, as the quality of website has been found to correlate with its usage (Aladwani and Palvia, 2002; Signore, 2005; Aladwani, 2006). The interaction between an initiating institution and the website requires special security and privacy policies that have been evaluated in the context of e-government (Yildiz, 2007; Mulgan, 2014). Summarising, technical requirements can be categorised into two subcategories, usability and security.

The *usability* of an OPP includes the navigation of the website, focussing on the menu and page structure and links; the design of text, pictures, the page layout, and the presentation on mobile devices; multimedia, which can include videos and sounds; and efficiency, i.e., the effort to find information and to actively participate at a voting or discussion; and lastly, a help system, guiding users who need help.

Security aspects include the security of information, i.e., integrity, authenticity, commitment, availability, and confidentiality. It also refers to privacy aspects including pseudonymisation and anonymisation (Yildiz, 2007; Mulgan, 2014).

Content-related requirements refer to content provided on the online participation platform, usually by the institution itself, but also by participants. Independent of the intended level of participation that the platform is designed for, the requirements are the same. They are divided into two subcategories, information and transparency.

Information on the OPP needs to be correct and complete, as information is the foundation of participation (OECD, 2001). Only well-informed users can successfully participate on OPPs. The relevant information should also be updated and target-oriented to address as many participants as possible. This involves multilingualism, accessibility, and gender neutrality.

The *transparency* of the platform refers to the participation processes as such. This includes the disclosure of different user groups, FAQs, and conditions of use. The transparent provision of information and data should also include a focus on readability, information set-up, and information structure. This might include, i.e., the number of headings and subheadings, paragraph length, etc. (Kubicek et al., 2011; Venkatesh and Davis, 2000; Signore, 2005).

Interactivity requirements include all requirements that relate to the interaction between institution, citizens, and website during the participation process. The higher the level of participation and therefore the interactivity, the more relevant is this part of the evaluation framework. Two subcategories are defined, integration and mobilisation.

The *integration* of the OPP within the institution needs to be institutionalised and automated to assure the possibility of continuation. This requirement mostly concerns the initiating institution and its dealing with the platform. Integration in the existing structures of the institution are crucial, e.g. when participatory budgeting is included.

Additionally, a *commitment* of the institution is necessary when processing decision outcomes (Venkatesh et al., 2003; Kubicek et al., 2011). The mobilisation of users concerns the marketing and public relations of the entire process, integration of online as well as offline actions, and topics that are relevant to the target group.

The evaluation framework by Hellmanns et al. (2016) can be extended by the impact of social media. Social media platforms are unavoidably connected to online participation. In their review paper Skoric et al. (2016) present a number of studies that examine the correlation between the use of social media and online participation. Besides some studies that do not show a link between the use of social media and online participation (Skoric and Poor, 2013), others came to the conclusion that Facebook (Bode, 2012; Vitak, 2012), blogs, and microblogs (Chan et al., 2012; De Zúñiga et al., 2009) are positively related to online participation. Still other research finds that participation is only increased when the movement is at scale (Mukkamala, 2013; Margetts et al., 2011).

2.1.2 Participatory Budgeting

Regardless of the choice between online or offline participation, the impact of a participatory process also strongly depends on the financial influence of the process itself. Besides the protection of civil liberties and the increase in public security, democratic institutions aim for social welfare (Wampler, 2012). As it is assumed that democratic institutions always strive for the improvement of their citizens' quality of life, one possibility to further increase the level of democracy, social inclusion, and social equity, as well as transparent administration, is participatory budgeting (Sintomer et al., 2008). Participatory budgeting is a process in which citizens (and civil society organisations) have the right to participate directly in institutional budget allocation. The process addresses all citizens of a community and focusses on financial issues with limited resources in limited time. It includes discussions on the budget allocation and a binding statement of the organisers on the proceeding with outcomes of the process (Herzberg, 2006; Sintomer et al., 2012).

The implementation and practices of participatory budgeting, however, vary widely. One reason is that the process has to be integrated in existing forms of local governance (Sintomer et al., 2008; Marquetti et al., 2012). However, there are three core phases of a participatory budgeting process: the information phase, the consultation phase, and finally, the accountability phase (Sintomer et al., 2012).

Information phase. In this first phase, constituents are informed about the fiscal system and the procedure of participatory budgeting. Especially town meetings and information supply in form of websites, leaflets, flyers, and information booths is provided. A transparent and understandable presentation of the budget is the focus of this phase and the basis for following steps.

Consultation phase. During this phase, constituents can suggest and discuss ideas, projects, and budget estimates. This phase often includes a voting on different alternatives. Some participatory budgeting processes include the whole budget, others only bring money-saving proposals up for discussions. The best way to implement this phase are online or offline citizens' meetings and participation platforms, where interested citizens can meet, discuss, end decide independent of time and location.

Accountability phase. In this phase, the feasibility of favoured projects is examined. The institution then decides on their realisation. Citizens are informed about the reasoned decision. A transparent presentation of the decision process is an important part of this phase.

Participatory budgeting was first conducted in Porto Alegre, Brazil, in the late 1980s. After twenty years of military dictatorship, the idea was to include citizens in decisions of the government that affected them directly (Abers, 1998). In neighbourhood-based forums, citizens were able to discuss and decide on the distribution of funds (Abers, 1998). The circumstances differed significantly from the situation we are facing in Western Europe today (Sintomer et al., 2008). Corruption and clientilism lead to a failure of the delegated democracy of Brazil which has one of the greatest income gaps in the world. Still, all variations on participatory budgeting are rooted in representative democracies (Cabannes, 2004). Hence, the municipal council is responsible for providing, as well as approving the financial resources and budget allocation.

Participatory budgeting processes can vary in the level of participation. Leaving the power with the executive and legislative branches is the simplest form of consultation. Deliberative processes, in contrast, give citizens (or respectively the participatory budgeting councillors) the decision-making power, which implies a binding decision for the municipal council (Cabannes, 2004). The decision on the

level of participation and the form of the participatory budgeting lies within the hands of the initiating institution. The challenges and success of participatory budgeting are closely related to the political system of the city. The more financially flexible a government is, the more influence citizens can have on the selection of new public projects (Cabannes, 2004). Governments which cannot provide large budgets to a participatory budgeting, transfer a more general discussion on the use of limited resources to citizens rather than the selection of specific public projects (Shah, 2007). Independent of characteristics of such processes, institutions and local governments increase transparency of the budget allocation when implementing participatory budgeting. This strengthens political support and social equality. Since everyone can participate in the distribution of resources, projects can be funded in all neighbourhoods, independent of their income level (Shah, 2007).

Several factors have been found to enhance participatory budgeting processes. Strong support from the institution and a generally supportive political environment, a civil society willing and able to contribute to current topics, and financial resources to fund the projects selected by citizens positively impact participatory budgeting (Shah, 2007). Participatory budgeting can change citizens' political and social consciousness and create awareness for limited resources (Shah, 2007).

In Germany, in 53 municipalities participatory budgeting processes were implemented in 2014 (Ermert et al., 2015). As the number of these participatory processes in local politics is rising continuously, enterprise participatory budgeting is also increasing in popularity. Enterprises adopt participatory budgeting to empower employees by participating in budget allocations (Barsky, 1999; Muller et al., 2013). The allocation mechanism used by Muller et al. (2013) generally known as crowdfunding, is the central topic of the following section.

However, there are also limitations to participatory budgeting. While citizens are engaged in the policy making of an institution, the institution or government remains the principal actor, which might be discouraging to some participants. Furthermore, objectives of institutions and citizens might vary, as citizens could be more interested in short-term public projects, whereas institutions aim for long-term planning (Shah, 2007).

	Participatory Budgeting	Crowdfunding	(Participation) Platforms	Dynamic Feedback	Personal Budget	Threshold Public Goods	Multiple Goods	Heterogeneous Utilities	Laboratory Experiment	Physiological Measurements
Cabannes (2004)	●	○	◑	◑	○	○	●	●	○	○
Wash and Solomon (2014)	●	●	○	●	○	●	●	●	●	○
Muller et al. (2014)	●	●	●	●	○	◑	●	●	○	○
Signore (2005)	○	○	●	○	○	○	○	○	○	○
Adam et al. (2012)	○	○	○	●	●	○	○	●	●	●
Hariharan et al. (2016)	○	○	○	●	●	○	○	●	●	●
Coats et al. (2009)	○	○	○	◑	●	◑	○	○	●	○
Cadsby and Maynes (1999)	○	○	○	○	●	●	○	○	●	○
Kölle (2015)	○	○	○	○	●	◑	○	●	●	○
Fischbacher et al. (2014)	○	○	○	○	●	◑	○	●	●	○
Corazzini et al. (2015)	○	○	○	○	●	●	●	○	●	○
This work	●	●	●	●	●	●	●	●	●	●
	○ not covered, ◑ partially covered, ● covered.									

Table 2.1: Literature overview of relevant research in the context of this thesis.

In the reminder of this thesis, research on participatory budgeting focusses on the consultation phase and mechanisms that support the allocation of an institutional budget. The most relevant related literature of this chapter and research introduced in the conceptual framework of the next chapter are summarised in Table 2.1 and put in the context of this thesis. The first three columns refer to the main topics participatory budgeting, which was already introduced in the previous section, crowdfunding, which will be introduced in the following section, and participation platforms. Column four and five refer to the design parameters evaluated in this thesis, dynamic feedback and personal budget. Columns six to eight categorise the

theoretical foundation of threshold public goods games which will be introduced in detail in Chapter 3, and finally the last two columns check the methods that were used, laboratory experiments and the measurement of participants' physiology. The methods will also be introduced in Chapter 3. But first, the next section introduces crowdfunding.

2.2 Crowd Science Perspective

Before taking a closer look at civic crowdfunding it is worth reviewing general definitions of crowdsourcing. Crowdsourcing, a combination of the words crowd and outsourcing, was introduced by Howe (2006) as "taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call". The crowd was defined as a non-hierarchical group of interested people. This first definition was expanded many times, the internet was included defining crowdsourcing as an online problem-solving model (Brabham, 2008) or a sourcing model in which organisations use predominantly advanced internet technologies to harness the effort of a virtual crowd to satisfy specific organisational needs (Saxton and Wang, 2013).

2.2.1 Crowdsourcing Categorisation

Crowds are as diverse as the problems they solve (Prpić et al., 2015). Prpić et al. (2015) therefore developed a typology of crowdsourcing. It classifies crowdsourcing tasks in two dimensions, (i) the type of contribution the crowd is required to make and (ii) the way these contributions are accumulated. The type of contribution varies from objective content like ReCaptcha, an automatised check for human instead of agent-based activity, which digitalises books at the same time, to subjective content like creative tasks (von Ahn et al., 2008). The contributions made by the crowd can be either aggregated to get the final solution from smaller tasks or it can be filtered so that, e.g., the best solution is used. This leads to the clusters presented in Figure 2.1.

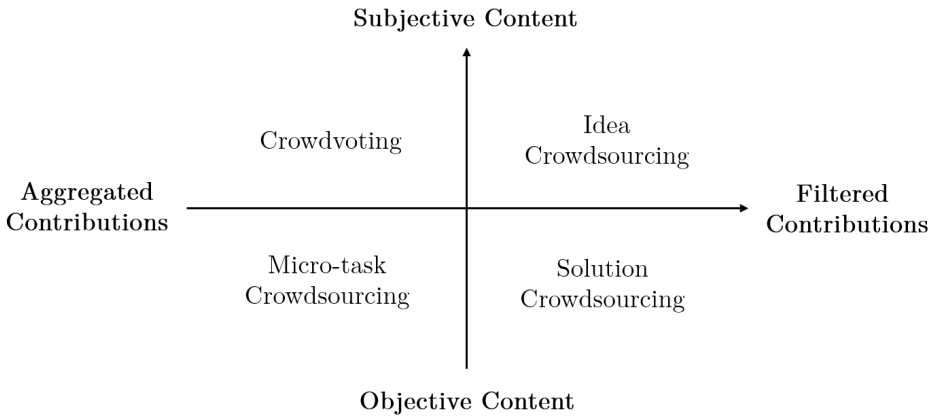

Figure 2.1: Crowdsourcing typology following Prpić et al. (2015), own representation.

For civic crowdfunding, a form of crowdsourcing, and in particular for its use in participatory budgeting the categorisation model introduced above is a strong simplification. The following section will look at crowdfunding in more detail and in a civic context. While crowdfunding in participatory budgeting can be seen as aggregated contributions, a categorisation in subjective or objective content is not pragmatic at this point as this aspect is still under investigation.

2.2.2 Civic Crowdfunding for Participatory Budgeting

One form of crowdsourcing is crowdfunding. It can be categorised as a form of micro-task crowdsourcing (Stemler, 2013). First mentioned by Howe (2006), crowdfunding has rapidly increased in popularity. The mostly used definition of crowdfunding is by Belleflamme et al. (2013):

"Crowdfunding involves an open call, mostly through the internet, for the provision of financial resources either in the form of donation or in exchange for the future product or some form of reward to support initiatives for specific purposes."

The overarching problem is the funding of an ambitious object or project, which is broken into smaller tasks. The individual tasks are small funds and therefore objective. These micro-task funds are aggregated to fund the bigger initial project (Prpić et al., 2015).

Civic crowdfunding is a specific way of participation in which the funding of a project benefits from private as well as government funds, assets, or sponsorship (Stiver et al., 2015). Public infrastructure, including New York's Statue of Liberty and London's Royal Albert Hall, have been funded through similar mechanisms (Harris, 1986).

Civic crowdfunding fosters citizens' financial involvement, while strengthening sensitivity towards the pursuit of efficient governance, sustainable resource management and financial transaction transparency (Miglietta and Parisi, 2017). Hence, two principal objectives for institutions are addressed: providing financial relief from shrinking local government budgets, and extending to citizens the juridical right to be more involved in the decision process. As a consequence, citizens' understanding of public resources management has shifted in favour of a more transparent, efficient, and smart approach, and favouring projects that are sustainable and efficient (Osborne et al., 2013).

Civic crowdfunding platforms offer several advantages over other funding mechanisms, such as building strong social interactions within communities and inducing citizens to take active roles in their communities while also pursuing other benefits. Moreover, the online range of platforms allows communities to overcome offline market barriers, which represented a obstacles to growth and developments of countless areas and neighbourhoods where the digital divide still hinders such approaches for long time (Choi and Bell, 2011). Lastly, civic crowdfunding fosters social responsivity to public expenditures and welfare, as well as increases transparency, reducing corruption, or misgovernment of public funds (Miglietta and Parisi, 2017).

While it is interesting to see civil society partnering with policy-makers, civic crowdfunding in its current form, however, has some major disadvantages. Civic crowdfunding might reproduce or even widen social inequalities as wealthy neighbourhoods may benefit disproportionately from the combination of government funding and private financial support (Davies, 2015). Any wider adoption of civic crowdfunding hence demands further exploration of the fundamental principles of crowd mechanisms, in which responsibilities are outsourced to a wider range of people (Prpić et al., 2015).

The use of crowdfunding mechanisms for participatory budgeting might overcome this disadvantage when only institutional budget is used to fund public projects. It is important to emphasise at this point that within this thesis the term crowdfunding is used in a technical description of the funding mechanism. Key motivators for participatory budgeting include social and economic benefits of interested citizens, or citizens directly interested in the potential profits of the project. On the other hand, citizens that have not agreed to finance the project do not suffer any negative consequences - thus increasing the risk of exposure and free-riding. In this context, of differing private utilities, transparency measures, such as dynamic information and feedback provided to citizens, spread a new sense of belonging and respect for common resources that can hardly be achieved when public resources expenditures management is hidden or hard to trace (Osborne et al., 2013). Hence, the kind of feedback provided to citizens, is likely to be a key determinant of both the level of participation, as well as the final group outcomes - such as whether a project is funded, or the overall social welfare.

There is already first evidence that crowdfunding mechanisms can be applied to participatory budgeting processes by employers and governments alike for the benefit of their employees or citizens. Most notably in the recent past, IBM employees were provided with a fixed budget that they could spend on projects proposed by their co-workers on an intranet-wide crowdfunding platform (Muller et al., 2013). Through collaboration across manager levels and departments, employees were able to address previously unmet needs, thereby removing some constraints of inflexible corporate processes. This crowdfunding mechanism enables individuals to communicate their preferences in form of investments.

In the case described above, the crowdfunding mechanism is not used in a microtask way but is categorised as crowd-voting, since individuals do not invest their (private) budget anymore but make a subjective choice between alternatives requested by an institution that aggregates the votes or investments (Prpić et al., 2015). The central mechanism investigated in this thesis is similar to the example provided above, however, with distinctly different design parameters. The larger objective in this work is to evaluate the impact of these design parameters academically and in a well-defined controlled laboratory experiment.

2.3 Hedonics and Emotions in Decision-Making

Decision-making in companies and local governments, is usually not associated closely with emotions, but fact-based, objective considerations. In particular, this applies when the focus lies on discussions with large impact on finances or infrastructure. In participatory processes, however, emotions have been found to be strongly correlated with participants' commitment and motivation (Glaser and Salovey, 1998; Jones et al., 2013; Valentino et al., 2011; Brader, 2005). It is therefore crucial to investigate design parameters in participatory processes not only with respect to their influence on monetary outcome or budget allocation, but also with regard to emotional arousal or hedonic value. Design parameters that purely focus on such objectives are examined in the context of gamification.

2.3.1 Hedonic Value and Agency

The term "hedonic" derives from the Greek term for "sweet" and denotes anything related to or characterised by pleasure, fun, and enjoyment (Higgins, 2006). Hedonic value is one of the classical motivational principles since people generally strive for the pursuit of pleasure as well as the avoidance of painful situations (Higgins, 2006). It is therefore closely related to perceived enjoyment or intrinsic motivation and has been found to influence decision-making (Davis et al., 1992; Fiore et al., 2005; Brosch and Sander, 2015).

Hedonic motivation has also been defined as the fun or pleasure derived from using a technology. Corresponding results from IS research show that hedonic value from using a technology has a positive effect on technology acceptance and use (van der Heijden, 2004; Brown and Venkatesh, 2005). Venkatesh et al. (2012) found that hedonic value can be used as a predictor of consumers' behavioural intention to use a technology.

In the consumer context, hedonic value has also been found to be an important determinant of technology acceptance and use (Brown and Venkatesh, 2005). Hedonic goods in this context are bought and consumed for pleasure, fun, and enjoyment. Its counterpart are utilitarian goods which are bought and consumed for their

practicability. Babin et al. (2004) find a positive correlation between positive affect and hedonic value in shopping behaviour.

In contrast to the pure hedonic value, the sense of agency during a participatory process refers to the sense of initiating and controlling actions in order to influence events (Moore and Obhi, 2012). Recent findings in cognitive and neuroscience support the notion that the sense of agency affects human motivation as people tend to prefer actions that seem to be or are under their control (Karsh and Eitam, 2015). Humans perceive an implicit as well as an explicit sense of agency (Synofzik et al., 2008). The implicit judgement is performed on a motor related, un-deliberate level (Karsh and Eitam, 2015). Numerous studies, in this regard, suggest that the brain responds particularly strong to events that signify actual or potential control (Synofzik et al., 2008). Karsh and Eitam (2015) suggested that, independent of the outcome, the perception of control over the environment motivates behaviour. Research on implicit agency is usually performed by testing the response time of individuals as humans select preferable, motivating results more frequently (Moore and Obhi, 2012; Karsh and Eitam, 2015; Synofzik et al., 2008). Contrarily, explicit sense of agency is partly independent from the implicit sense of agency as it requires a stronger, deliberate conceptualisation (Moore and Obhi, 2012). Therefore, explicit sense of agency can be tested using questionnaires. Nonetheless, Moore and Obhi (2012) suggested that the implicit sense of agency can influence the explicit aspect to some extent.

2.3.2 Emotions in Decision-Making

In contrast to the impact on hedonic value that can only be quantified by self-assessment, emotional arousal can directly be measured via the participants' emotions which are exhibited by quantifiable physiological changes. The impact of emotions has found its way to economic theory and experimental economics in the last decades. Emotions have been found to correlate with political participation in various ways (Glaser and Salovey, 1998; Jones et al., 2013; Valentino et al., 2011; Brader, 2005). This section aims to give a brief overview on what emotions are and how they affect our decision-making. The physiological measurements of emotions, especially arousal, will be introduced in Section 3.1.3.

Affect is a "neurophysiological state" consciously accessible as a simple primitive non-reflective feeling most evident in mood and emotion but always available to consciousness (Russell, 2009, p. 104). Affect can be categorised into emotion (short-term) and mood (long-term) (see Figure 2.3).

A mood is a general affect. It is "the appropriate designation for affective states that are about nothing specific or about everything-about the world in general" (Frijda, 2009, p. 259). Examples are an anxious mood, maybe even about the whole world or the future. Moods can last minutes, hours, or even days. In contrast, emotions are a collection of changes in body and brain states, a short-term physiological reaction in response to specific physical and social challenges and opportunities (Keltner and Gross, 1999; Bechara, 2004). Such prototypical emotional episodes are a "complex set of interrelated sub-events concerned with a specific object" (Russell, 2009, p. 809). This means that emotions are elicited by an external stimulus or reactions to an event with a subjective significance, such as gains and losses (Bechara and Damasio, 2005). Examples of emotions are anger, fear, pride, and love. Emotions, thus, usually last for shorter durations than moods and are more specific and event-related (Frijda, 2009).

Arousal and valence can help to differentiate emotions from other mental states (Elster, 1998). Arousal describes the intensity (quantity) of an emotion (Russell and Pratt, 1980; Russell, 1989), valence represents an emotion's quality which can range from very positive to very negative. Russell (1989) developed the circumplex model of emotion (see Figure 2.2) that represents emotions in a two dimensional space as combinations of arousal and valence.

Economic models assume that decision-makers choose between different actions by assessing the desirability (economically referred to as "utility") and likelihood of their consequences (Rick and Loewenstein, 2008). This information is then integrated in expectation-based decisions. The aim of such decisions in these models is to maximise the utility (Rick and Loewenstein, 2008). These conventional economic theories of decision-making (such as the Expected Utility Theory) have been criticised, since decision-making can be conceptually viewed as a cognitive as well as an affective process and not only the homo economicus' maximisation of

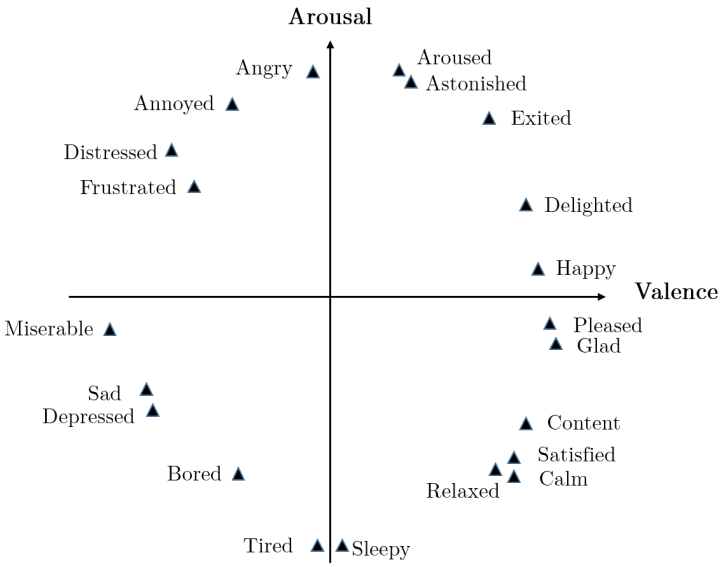

Figure 2.2: Circumplex model of emotion (Russell and Pratt, 1980). Own representation.

utility (Bechara and Damasio, 2005; Lieberman, 2007). This implies that a view of emotions is necessary to obtain a holistic understanding of decision-making.

Emotions can be further classified into expected and immediate emotions. Expected emotions are anticipated to occur as a result of the chosen action. For example, the action of buying stock can cause an expected disappointment when prices decline. Therefore, disappointment can be the expected emotion in such a decision situation. Expected emotions are in line with the consequentialist view of economics since they can be included in utility maximising by integrating a defined term in the expectation-based decision model (Rick and Loewenstein, 2008; Katok and Kwasnica, 2008)

Immediate emotions are experienced at the moment of decision-making. They are subjective experiences in response to a specific event. Immediate emotions are either integral emotions or incidental emotions. Integral emotions arise due to the context of decisions and from thinking about the future consequences of the decision. Still, they are experienced at time of decision-making. It has been argued that they might provide decision-makers with additional information about their own taste. This is in contrast with the assumption that people have an imperfect understanding of their own preferences (Rick and Loewenstein, 2008). Incidental

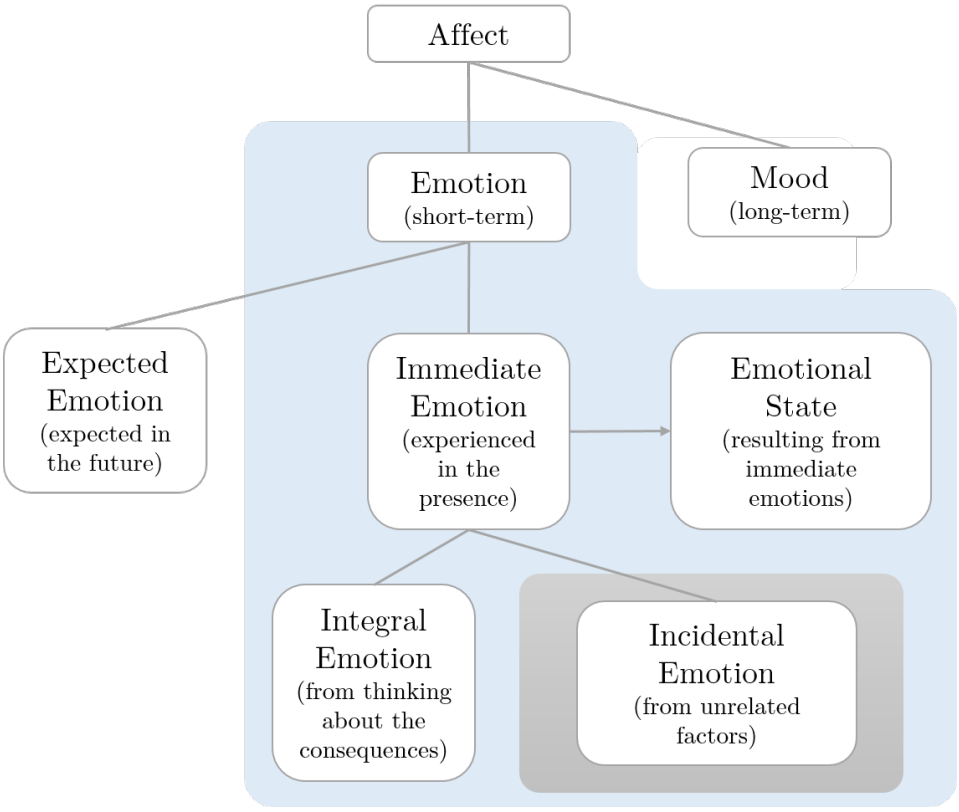

Figure 2.3: Structural presentation of arousal in the context of affect. Own representation.

emotions are experienced at the moment of decision-making but arise from sources unrelated to the task. Experimental economists try to control incidental emotions in the lab by creating controlled settings. Taking incidental immediate emotions into account would challenge economic theories and add the influence of unrelated factors to the model of decision-making (Rick and Loewenstein, 2008). Immediate emotions result in an emotional state, a "continuous construct that canalizes the influence of the volatile immediate emotions" (Adam et al., 2015, p. 470).

Recent research develops the influence of immediate emotions that expand first attempts that included anticipated emotions (Loewenstein and Lerner, 2003; Rick and Loewenstein, 2008). Physiological measurements can help to better understand decision behaviour (Thaler, 2000; Adam et al., 2011). This extension of the methodology of experimental economics by physiological measurements is now commonly referred to as NeuroIS and Neuroeconomics. This new method of investigating economic decision-making enables insights in different fields.

Through experiments with physiological measurements it has been found that attraction to chance can be indicated by differences in arousal based on the choices made by people for different types of lotteries (Adam et al., 2012). Adam et al. (2015) were also able to show that people were emotionally aroused in auctions. They increased social competition and demonstrated that "auction fever" leads to higher bids. These results on the competitive auction task were validated by Teubner et al. (2015). They found that emotional arousal also depends on whether participants face human or computerised agents (Teubner et al., 2015). Higher levels of arousal were found for unfair offers in the ultimatum game, associated with their rejection, however, only when playing against human opponents, not computer agents (van 't Wout et al., 2006).

This chapter provided the foundations of participatory budgeting. It classified it as a participatory process which can be implemented by the use of crowdfunding mechanisms. To understand and experimentally evaluate different mechanisms a theoretical framework is needed as basis for experimental investigations.

Consequently, the next chapter will introduce the methods of this thesis and provide a conceptual framework of participatory budgeting as threshold public goods game. This will motivate the second design parameter that is investigated in the work at hand, the share of personal budget, and facilitate the experimental design presented in the last section of the next chapter.

Chapter 3

Conceptual Framework and Methodology

"Each piece, or part, of the whole of nature is always merely an approximation to the complete truth, or the complete truth so far as we know it. In fact, everything we know is only some kind of approximation, because we know that we do not know all the laws as yet. Therefore, things must be learned only to be unlearned again or, more likely, to be corrected. [...] The test of all knowledge is experiment. Experiment is the sole judge of scientific 'truth'."

(Richard Feynman, 1977)

People want to be involved in the decision-making of institutions (Eisner, 2005). Institutions can comply with that demand by giving their constituents the opportunity to get involved in the institution's budget allocation. Therefore, institutions need to find mechanisms that on the one hand foster their financial objectives and on the other hand motivate people to participate. Mechanisms that have been introduced in the last chapter that might fulfil these requirements are crowdfunding mechanisms. Since the design of crowdfunding mechanisms might influence the outcome significantly, the impact of design parameters on the monetary as well as non-monetary outcomes has to be tested first. This will be done by means of experiments, as "experiment is the sole judge of scientific 'truth'" (Feynman et al., 1977).

Therefore, the methodology is introduced before the conceptual framework in which the research of this thesis is rooted. The methods used to investigate the

addressed research questions in the experimental framework are described in Section 3.1. Most importantly, laboratory experiments are introduced that form the basis for all investigations. Experiments enable the observation of behaviour when investing in participatory budgeting. Additionally, questionnaires and physiological measurements are described.

In this thesis, crowdfunding mechanisms are applied to participatory budgeting. A budget of an institution is allocated to a crowd of individuals. Individuals can then invest their budget in multiple projects of public interest. These projects are represented by threshold public goods assuming that a realisation of the project is beneficial to all individuals. Section 3.2 introduces participatory budgeting as multiple threshold public goods game with heterogeneous cost thresholds and heterogeneous utilities and presents related literature. This is the theoretical foundation of the experiments in the context of crowdfunding mechanisms and participatory budgeting. In Section 3.3 the experimental framework is further specified by a number of design choices.

Five publications are based on the general experimental framework that is introduced in this chapter (Niemeyer, Hellmanns, Teubner, and Weinhardt, 2015; Niemeyer, Wagenknecht, Teubner, and Weinhardt, 2016; Niemeyer, Wagenknecht, and Weinhardt, 2016), two are currently under review (Niemeyer, Hariharan, Teubner, and Hall, 2017; Niemeyer, Teubner, Hall, and Weinhardt, 2017). This chapter expands the published basic foundations and experimental design by a detailed description of methods and related literature in the theoretical basis of crowdfunding mechanisms, threshold public goods games, including the coordination problem.

3.1 Methodology

All research questions are addressed in controlled lab experiments including incentivised investment decisions, a questionnaire, and the measurement of participants' physiological data. This section introduces laboratory experiments as a method of experimental economics to investigate human behaviour in a controlled situation with incentives to behave as in situations outside the lab (Smith, 1976). Second,

questionnaires are introduced as a method to gain additional knowledge about self-reported emotions and perception that cannot be directly measured and observed by the investment behaviour. In addition to the self-report in questionnaires, measuring physiological data of participants is introduced as a third method used in this thesis.

3.1.1 Laboratory Experiments

Laboratory experiments are used in experimental economics to investigate human behaviour in economic decision situations (Davis and Holt, 1993). Since the 1960s, small pieces of the real world are taken to the lab to be better understood (Cassar and Friedman, 2004). Today, experiments are firmly fixed in game theory, industrial organisation, finance, public choice, and other microeconomic fields (Friedman and Sunder, 1994).

The explanatory power of experimental results highly depends on the internal and external validity of the experiment. Guala (2002, p. 262) defines internal and external validity formally as follows, "an experiment result is internally valid if the experimenter attributes the production of an effect B to a factor (or set of factors) A, and A really is the (or a) cause of B in the experiment setup E. Furthermore, it is externally valid [...] if A causes B not only in E, but also in a set of other circumstances of interest F, G, H, etc."

Since internal and external validity counteract each other, experiment designers have to priorise and focus on one of these constraints. Laboratory experiments simplify and abstract situations from the real world to gain undoubted causal conclusions (Loewenstein, 1999). This leads to a high internal validity but comes at costs of external validity (Schram, 2005). Online and field experiments have a higher external validity compared to lab experiments, but usually exhibit higher variance and participants fail to deal with more challenging tasks as they are, i.e., more distracted by their environment (Anderhub et al., 2001; Hergueux and Jacquemet, 2015).

The design of a laboratory experiment usually motivates participants by induced monetary rewards. The induced value theory by Smith (1976) defines a set of

requirements for experiments, where decisions are incentivised by an induction of preferences and an appropriate choice of the payout structure (Smith, 1976). Friedman and Sunder (1994) developed practical advice for experimenters from the induced value theory. This requires monotone preferences, so that more payout is better. The payout is depending on the performance and participants understand this correlation (salience). Each utility change is caused by payout, which means that other impacts cannot be investigated (dominance). Participants should then be paid in cash straight after the experiment to prevent time-wise consideration. The average payout should be larger than the opportunity costs. Optimally, participants have low opportunity costs and a fast learning behaviour. Students are therefore often invited to experiments (Friedman and Sunder, 1994).

According to Friedman and Sunder (1994), simple settings and practice rounds enable the full understanding that is necessary for the success of an experiment. Hence, it is common practice to test the understanding of the experimental setup with a short quiz. This also includes neutral wording and only telling the truth. Behaviour, payout, and research aim should stay private information (Friedman and Sunder, 1994). All these rules contribute to the advantage of replicability. They help to rerun experiments to gain the same controlled situation and therefore similar results (Davis and Holt, 1993).

Participants are usually recruited via recruitment platforms to ensure a random selection of participants. Since most experimental labs are located at universities, a high number of students is registered on platforms like ORSEE or hroot (Greiner, 2015; Bock et al., 2014). Participants are then invited to computer laboratories where they make decisions in controlled settings.

In the context of this thesis, laboratory experiments are conducted to ensure a high internal validity when investigating different design parameters. This allows to trace behaviour changes to differences in the design parameters rather than outside influences such as distraction during the experiment or preferences for specific projects. Participants are recruited on the platform ORSEE and invited to the Karlsruhe Decision and Design Lab (KD^{2}Lab)[1]. Brownie is used as experimental software (Hariharan et al., 2015). Brownie is a software for experiments in the

[1] `https://www.kd2lab.kit.edu`, last accessed on January 30th, 2017

field of experimental economics. In contrast to similar software such as z-tree (Fischbacher, 2007), it provides the opportunity to include physiological measurements and thus obtain data on the physiological state of participants at the same time as their (investment) behaviour during the experiment. Participants are incentivesed by monetary payouts that depend on their behaviour during the experiment. The design of the experiment is as simple as possible to prevent confusion and distraction from the task and contains a detailed instruction and a quiz that ensures the understanding of the experiment of all participants.

3.1.2 Questionnaires

In contrast to laboratory experiments, questionnaires can elicit information about the attitudes of participants that are difficult to measure by observational techniques (McIntyre, 2013). There are two different types of questions in terms of the expected answer. Open-ended questions ask for ideas and thoughts and leave space for detailed answers (Salant and Dillman, 1994). Closed-ended questions, in contrast, only allow answers from a given set of alternatives (McIntyre, 2013). Closed-ended questions with ordered choices give participants a list of responses that each has to be evaluated independently. Likert scales provide a numerical scales to evaluate these possible responses (Likert, 1932). These types of questions are easier to answer and also easier for researches to analyse.

In this thesis, a questionnaire is implemented with Google Forms[2]. Constructs on stated emotions and the perception of hedonic value are implemented as Likert scales and complemented with open-ended questions on field of study and binary questions on gender.

3.1.3 Physiological Measurements

Physiological measurements enable experimenters to record participants' physiological state during the experiment. This section aims to give an overview what arousal is and what kind of emotions are measured in an experiment. Elster (1998) identifies six features that differentiate emotions from other mental states. Besides

[2] `https://docs.google.com/forms`, last accessed on January 30th, 2017

cognitive antecedents, intentional objects, action tendencies, and physiological expressions, arousal and valence can identify and categorise emotions. This research quantifies emotional arousal as has been done by previous research described in Section 2.3.2. This can be done by measuring participants' heart rate or skin conductance. The heart rate has been shown to be an accurate proxy for a person's arousal and reflects the current physiological and emotional state (Günther, 2010; Thayer et al., 2012). Additionally, it is affected by stress and influenced by (economic) decision-making (Adam et al., 2015).

The autonomic nervous system (ANS) reacts largely unconsciously on our environment and regulates body function such as the digestion and heart rate (Langley, 1903; Kapa et al., 2010). The two branches, the sympathetic and the parasympathetic nervous system innervate an electrical excitation that leads to a contradiction of the cardiac muscle. The sympathetic fibres increase the activity of the cardiac muscle whereas the parasympathetic fibres cause a deceleration of the heart activity (Jänig, 1989; Kapa et al., 2010). In the experiments of this work, physiological data of participants' heart rate is collected using electrocardiography as has been done by several studies in the field of NeuroIS (Riedl et al., 2010; Adam et al., 2012, 2015). The heart's electrical conduction system directs the electrical information to stimulate cardiomyocytes. The change in the heart's electrical voltage can be measured on the body surface. It is therefore a painless and non-invasive procedure. Electrocardiograms (ECG) record the electric activity of the heart over time by electrodes placed on the skin. By placing multiple electrodes on different parts on the chest (see Figure 3.1, the magnitude of the heart's electrical potential can be recorded from different angles and the whole cardiac cycle is recorded.

The ECG can be decomposed into characteristic deflections, the P, Q, R, S, and T waves. Since the R-wave peak is the most characteristic peak in the ECG signal, which corresponds to the majority of ventricular myocardium activity, i.e., the activity of the heart chamber muscles, it is usually used to quantify the heart rate (Bernston et al., 2007; Adam et al., 2012). The time intervals between successive R-wave peaks are referred to as interbeat intervals (IBIs). The heart rate can be quantified by measuring the time between successive R-wave peaks in the ECG (Jennings et al., 1981).

In the experiments in the context of this work, physiological data of participants' heart rate is collected using electrocardiography. For measurement of heart rate, three Ag/AgCl electrodes are connected to the Bioplux (2007) sensor system and data is transmitted via Bluetooth and stored on the participants' PC. The sampling frequency was 1 kHz, which enables a reliable detection of interbeat intervals. After participants arrived in their assigned cubicles, they were wired before the beginning of the experiment (see Figure 3.1) in case physiological measurements were collected in that session.

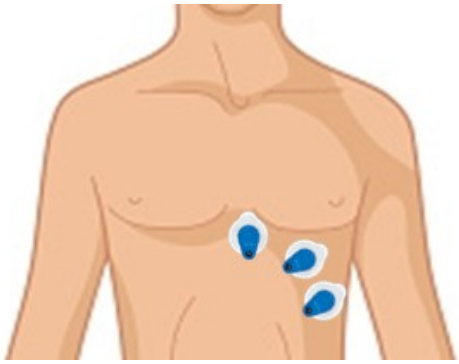

Figure 3.1: Placement of ECG electrodes for the measurement of participants' physiology during laboratory experiments.

All experiments in this thesis are implemented in Brownie (Hariharan et al., 2015). Heart-rate data from different participants are acquired using the sensor acquisition functionalities provided on the platform. After getting instructions on the procedure and experiment as well as control questions, a 5-minute initial cool down phase (ICD) provides data of a calm situation that can be used to normalise, e.g., the heart rate during the course of the following experiment. Pre-processing of data, filtering, and R-wave peak detection was done using Matlab (Bernston et al., 2007), and heart rate was computed by measuring the time between successive R-wave peaks in the ECG (Jennings et al., 1981).

3.2 Participatory Budgeting as a Threshold Public Goods Game

Participatory budgeting as described in Section 2.1.2 is implemented by institutions to give their constituents a voice and let them decide on the budget allocation of an institutional budget (Shah, 2007). For this budget allocation process there are usually a number of projects suggested that had been initiated by the institution or the constituents themselves. These projects are usually beneficial to not only one constituent but a whole group. In this thesis a crowdfunding mechanism for participatory budgeting is investigated. This means that the institution divides the budget under all constituents, who can than decide on whether and how much to invest in the suggested projects. Since such mechanisms can be seen as a form of threshold public goods (Corazzini et al., 2015), they are described in detail in this section. After a general introduction of public goods games, threshold public goods games are specified and the coordination problem that arises in this context.

3.2.1 Public Goods Games

Each individual can profit from a public good and one individual can consume the good without reducing the availability for others (Ledyard, 1994). In economics, these characteristics of public goods are defined as non-excludability and non-rivalry (Malkin and Wildavsky, 1991). A private good, in contrast, is excludable and rivalrous. Only one individual can profit from and consume the good.

Economists have developed an experimental game to model and evaluate contribution behaviour related to public goods: the public goods game (Andreoni, 1988; Ledyard, 1994). In the basic setting of this game, a group of n participants receives a budget b_i and each one of them simultaneously decides individually on how much of their initial budget they want to invest in the public good (z_i). Uninvested budget goes to the private good. All investments are summed, multiplied by a given factor γ and distributed among all n participants. The factor $\alpha := \gamma/n$ is called the marginal per capita return (MPCR) (Ledyard, 1994).

The payout of individual i in public goods games includes the benefit from a private good (endowment minus investments) and the benefit from the public good (utility). It is given by:

$$\Pi_i = (b_i - z_i) + \alpha \cdot \sum_{i=1}^{n} z_i \tag{3.1}$$

As long as $\frac{1}{n} < \alpha < 1$, the formula above describes a public goods problem. If $\alpha > 1$, it is always beneficial for an individual to invest in the public good independent of the others. If $\alpha < \frac{1}{n}$, it is not beneficial for anyone to invest in the public good but to maintain the budget for the private good.

Standard public goods games face individuals with the decision of how much to invest in the public good. Investing leads to a higher common payout of the group. Therefore, if everyone invests their entire budget, the outcome is welfare optimal. However, free-riding (not investing anything but still profiting from the public good) increases the personal payout and even leads to a higher payout than those receive who funded the public good. This leads to the social dilemma between free-riding and investing, since participants profit from the public good, even if they do not invest personally (Ledyard, 1994).

Participants profit from the public good independent of the own investment. If there is no possibility to hold back (parts of) the budget in the private good, because the private good does not exist, there is no incentive to not invest (parts of) the budget. The dominant strategy is to invest everything.

There has been a large number of public goods experiments in the past. In his survey, Ledyard (1994) gives an overview on the experimental research regarding public goods. Typical results are the following. In one-shot games, participants invest about half of their budget. Most experiments on public goods games, however, consider repeated decisions and therefore several periods of public good funding (Ledyard, 1994). Typically, investments in the public good decrease over time. This observation is sometimes called cooperative decay. Especially the last round is characterised by an end-game effect (Andreoni, 1988). The effect can be explained by the lack of future interaction and hence, no motivation for strategic cooperation (Croson, 1996; Reuben and Riedl, 2009). Repeated games allow for matching of

participants. Participants can be assigned to the same group (partner matching) or to a new group of participants (stranger matching) in each new round. Partner matching leads to higher contributions than contributions in stranger matching (Keser and Van Winden, 2000; Fehr and Gächter, 2000b). If a new period of the game starts without participants knowing in advance (unexpected restart), significantly higher contributions are observed in the first round of the new set of periods. Contributions in the following periods are declining over the course of the experiment as before (Andreoni, 1988; Ambrus and Pathak, 2011). The restart effect induces participants in partner matchings, where participants stay in the same group composition, to the contribution of the initial level (Croson et al., 2005). This effect is weaker for participants in stranger matchings, where participants are in different group compositions in each round (Croson, 1996).

Focus of most research in the field of public goods is the question whether and to what extend different modifications and design parameters influence contribution behaviour. Theoretically as well as experimentally, the size of the MPCR has a positive effect on the contribution since cooperation pays more (Reuben and Riedl, 2009). Other factors that have been found to enhance contributions are communication (Bochet et al., 2006) and punishment (Fehr and Gächter, 2000a). The experience of participants with public goods games from former experiments has a negative effect on the level of contributions.

The game-theoretic prediction is that no one contributes anything since free-riding is pareto-optimal. However, as the large number of experiments shows this is not seen in the laboratory. Social preferences can explain the deviation from the game-theoretic prediction: altruism, warm glow, efficiency-seeking motives, conditional cooperation, and reciprocity are just a few that might explain the contribution behaviour in public goods games (Palfrey and Prisbrey, 1997; Keser and Van Winden, 2000; Sonnemans et al., 1999; Fischbacher and Gächter, 2010).

3.2.2 Threshold Public Goods Games

Projects of public interest with a certain cost threshold can be seen as threshold public goods (Corazzini et al., 2015), because a project is funded if the threshold is met and, hence, all constituents profit from its realisation. For the provision

of threshold public goods, a certain cost threshold is predetermined for the good, i.e. project, to be realised. Individuals thus only profit if this threshold is reached (Croson, 2000). This theoretical description gives the foundation for crowdfunding in a civic context.

Most experiments on threshold public goods investigate binary contributions, an all-or-nothing contribution to the good (van de Kragt et al., 1983; Rapoport and Eshed-Levy, 1989). However, allowing participants to invest any share of their initial budget better represents raising money for threshold public goods outside the lab (Cadsby and Maynes, 1999). In real world situations, one can always decide on how much to spend when funding projects, for example on crowdfunding websites.

There is a broad theoretical foundation of threshold public goods games analysing player strategies and equilibria. For threshold public goods without refunds, only strategy combinations that exactly meet the threshold represent Nash equilibria (Nash, 1951). This means that no player can improve from this outcome by changing their strategy and therefore each player is happy with their decision retrospectively. However, this entails the coordination challenge to meet the threshold, and not to exceed the threshold unnecessarily.

One design parameter of threshold public goods games is the refund rule (Cadsby and Maynes, 1999). Any investment that was made to a good that is not funded will be refunded to the individual. The availability of refunds expands the Nash equilibria space by all combinations of investments that surpass the threshold and are therefore refunded. Hence, it also facilitates coordination. Applying the refund rule leads to higher investments (Isaac et al., 1989). Wash and Solomon (2014) find significant effects on productivity when using an all-or-nothing return rule rather than having a direct donation mechanism.

A second design parameter is the rebate rule that proportionally refunds investments exceeding the threshold(Marks and Croson, 1998). A rebate rule can weaken the risk of overfunding. Marks and Croson (1998) report that rebate rules have no influence on the number of funded goods.

The extend of how individuals benefit from the threshold public good in case of a successful funding is represented by utilities. Kölle (2015) investigated heterogeneous utilities of individuals and found no significant difference to homogeneous utilities, where everyone profits equally from a funded good. Fischbacher et al. (2014), in contrast, for linear public goods, found two different behaviour types when investigating heterogeneous utilities. Unconditional contributors, who make their investment decision independently of the other group members invested less when having different utilities, whereas, conditional contributors did not behave differently compared to the case of homogeneous utilities.

3.2.3 The Coordination Problem

The funding of multiple projects bears a coordination problem. The better participants coordinate their investments between projects the higher is the outcome for all participants. Corazzini et al. (2015) compared investment behaviour with one public good to that of four public goods and found that more public goods lead to more severe coordination problems and lower investments in general. This is not surprising since the coordination problem occurs in cooperative games when players simultaneously make a decision. This section introduces the coordination problem more general and presents several solutions and methods to simplify coordination.

Coordination games are games with multiple pure strategy Nash equilibria where the payouts are highest when players are able to coordinate their strategies (Goeree and Holt, 2002). There exist two types of coordination games. Games of conflict are characterised by contradicting interests (Goeree and Holt, 2002). This leads to coordination problems when individuals prefer different equilibria outcomes (Goeree and Holt, 2002). Games with common interests are characterised by players who choose to play the same strategies since the they prefer the same equilibrium (Goeree and Holt, 2002).

The two-person game "the battle of the sexes" is a classic example that demonstrates the coordination problem (Luce and Raiffa, 1957). The rules are the following. Two players, a girl and a boy, want to spend an evening together but forgot to agree on a location. Two locations are possible, they could watch a football match or go to the

opera. Both players have to make their decision independently and simultaneously. The boy prefers the football match, the girl the opera. The payoff matrix is given by:

Boy / Girl	Football	Opera
Football	(3,1)	(0,0)
Opera	(0,0)	(1,3)

Table 3.1: Payoff matrix of the battle of the sexes. Player 1 (boy) and player 2 (girl) have to choose between location A (football) and location B (opera). Players face a coordination problem since payouts are only given when both players choose the same location.

The battle of the sexes as described above has two Nash equilibria with pure strategies, (Football, Football) and (Opera, Opera). In both cases neither the boy nor the girl can improve by changing their strategy. The challenge for the players to end up in the same Nash equilibrium lies in the coordination (Luce and Raiffa, 1957). This is here, both deciding to go to the same location, which results in the highest utility. In threshold public goods games without refunds, the challenge is to exactly meet the threshold where no one can improve by deviating from their strategy. In case of multiple threshold public goods, the challenge is not only coordinating to meet the threshold of one good, but also to coordinate which goods to fund, if there is not enough budget to fund all of them.

Across all coordination games, several approaches can simplify the coordination problem and enhance cooperation. The following selection has been applied to threshold public goods games.

Explicit Communication. The maybe easiest way to overcome the coordination problem is explicit communication. If two players in the "battle of the sexes" are allowed to talk about the location, it is quiet intuitive that they will not face the problem of beeing at the same location. In public goods games, face-to-face communication as well as communication through an anonymous chat room have been found to have strong effects on the outcome efficiency (Bochet et al., 2006). However, numerical communication via computer terminals had no net effect on contributions or efficiency (Bochet et al., 2006). This suggests that only communication with some kind of social interaction enhances cooperation.

Refunds and Rebates. The refund rule determines the refund of investments made to goods that are not sufficiently funded, whereas the rebate rule refunds investments that exceed the cost threshold. A positive effect on the contribution behaviour is found when applying the refund rule (money-back guarantee) (Cadsby and Maynes, 1999). This is, if investments to goods that are not sufficiently funded are refunded, individuals invest more. However, somehow counter-intuitive, neither refund nor rebate rules improve coordination in multiple public goods games (Marks and Croson, 1998; Wash and Solomon, 2014). When there is only one good to fund, the refund rule increases efficiency as well as the success of meeting the threshold (Coats et al., 2009). A negative effect is found for high thresholds in the absence of refunds (Cadsby and Maynes, 1999). Applying the refund rule, however, there is no effect on the contribution when changing the level of the threshold (Cadsby and Maynes, 1999). These results suggests that refunds generally enhance contributions.

Timing and Order of Movement. A problem that arises in coordination games is that players might be willing to contribute but do not want to invest more than the other players and be "free-ridden" (Kurzban et al., 2001). One solution to overcome this challenge is allowing sequential commitments of small contributions (Schelling, 1960). This can prevent players from unequal contributions. Hence, having more detailed information on the current funding status of a good improves coordination and result in a higher rate of successful provision of threshold public goods (Dorsey, 1992). A sequential order of contributions to threshold public goods outperforms simultaneous contributions in terms of efficiency and success rate of funding (Coats et al., 2009; Erev and Rapoport, 1990). This effect is found to be even greater when no refund rule is applied (Coats et al., 2009).

Focal Points. Focal points are equilibrium points which are psychologically prominent or salient by semantic or physical distinction from other strategies (Schelling, 1960; Camerer, 2003). Even in pure coordination games where multiple mathematically symmetrical strategies cannot be distinguished by conventional game theoretic models, players have been observed to achieve high levels of coordination (Mehta et al., 1994). According to Schelling (1960) this is due to the way strategies are labelled or named. Social or cultural norms and experience can influence individual preferences and make certain strategies focal (Myerson, 2009). In the context

of threshold public goods the threshold itself can serve as focal point (Cadsby and Maynes, 1999). This might lead to focal investments of an equal share of the required amount. Also, groups of ten are more prominent investments than other numbers.

Repetition and Signalling. While one-shot coordination games usually do not result in an efficient equilibrium, repeated games with partner matching are more likely to reach the efficient outcome (Clark and Sefton, 2001). Two possible explanations are the opportunity to learn and adapt the other players' strategies as well as forward-looking behaviour by recognising the efficient outcome and using early signalling strategies (Clark and Sefton, 2001). Signalling, as an action to convey unobservable information has to fulfil two requirements (Camerer, 2003). First, is has to be affordable, that is, the costs of the signal should not exceed the expected benefit and, second, it should be too expensive for a player of the wrong type to afford (Camerer, 2003). In the context of coordination games, a player might use early rounds of a repeated game in order to signal cooperation (Clark and Sefton, 2001). This might lead to lower benefits in the first rounds but an efficient equilibrium in later rounds (Clark and Sefton, 2001).

Summarising, there are several ways to overcome the coordination challenge in threshold public goods games that should be considered by mechanism designers as well as participants. The work at hand focusses on three aspects. Refunds and rebates will be implemented in all mechanisms to reduce the coordination problem in a realistic setting. Repetition is implemented by repeating the funding multiple times in the experiment. However, it is important to notice that such repetitions might be unrealistic when offering participatory budgeting.

The impact of timing will be investigated by comparing static to dynamic feedback during the investment phase. This is an important design parameter of crowdfunding mechanisms and main focus of this work. Dynamic feedback on the funding status might not only simplify the coordination problem by means of timing and order of movement but also contain some kind of numerical communication. It is subject to following research to investigate this impact in the context of participatory budgeting.

3.3 Experimental Framework and Design Choices

The employed crowdfunding mechanisms within the scope of this thesis are investigated in the context of participatory budgeting and are based on the theory of threshold public goods. Multiple threshold public goods and individuals with different utilities are the basis for participatory budgeting. This section provides the framework of the following experiments and puts them in a formal context. After a formal description of the general mechanism, the mechanism is specified for the implementation of the laboratory experiment. The last part of the section describes the treatment variables *personal budget* and *feedback* in detail and presents the implemented experimental process.

3.3.1 Formal Description of the Mechanism

An institution gives individuals ($i,k \in I = \{1,...,n\}$) the possibility to decide on the funding of projects ($j \in J = \{1,...,m\}$). Therefore, each individual (k) is given a budget (b_k) to invest in projects (j) with costs (c_j). Individuals simultaneously allocate their budget (b_k) to the projects (j). The investments of individual k to project j are denoted by (z_{kj}). In total, the sum of all budgets (b_k) is not sufficient to fund all projects ($\sum b_k < \sum c_j$). If the cost threshold of a project is met, each individual profits from the project realisation with a utility (u_{kj}) that is in this experimental context exogenously given. All utilities are private information and only known to the individual, whereas the number of projects and their costs are common knowledge.

In the described setting, a group of individuals can gain additional welfare W by funding projects. Welfare gain is defined as the additionally created utility from realised projects. An indicator variable $\mathbb{1}_j$ signs projects j that are sufficiently funded and takes the value $\mathbb{1}_j = 1$ if $\sum_{i \in I} z_{ij} \geq c_j$ and $\mathbb{1}_j = 0$ otherwise. Welfare gain is therefore denoted by:

$$W = \sum_{j \in J} (\sum_{i \in I} u_{ij} - c_j) \cdot \mathbb{1}_j \tag{3.2}$$

Following Coats et al. (2009), efficiency is defined as "percent of the maximum feasible surplus for public good provision" (Coats et al., 2009, p. 328). Consequently, in this thesis, the efficiency of multiple threshold public goods is defined as the percent of achieved welfare gain of the maximum welfare gain:

$$E = \frac{W}{\max(W)} \tag{3.3}$$

Concerning the payout of individuals, a refund and rebate rule are applied. The refund rule for underfunding if investments do not meet the cost threshold ($\sum_{i \in I} z_{ij} < c_j$). Investments are refunded to individuals. This is consistent with most crowdfunding platforms like Kickstarter[3] or Indiegogo[4], where investments to projects that do not reach the cost threshold are refunded after the investment phase. The refund rule has been implemented in laboratory experiments such as Wash and Solomon (2014).

The rebate rule is applied, when investments exceed the cost threshold. In contrast to provision points, where overfunding creates additional utility, here, overfunding is refunded via proportional rebate (Marks and Croson, 1998). The proportional rebate rule can be demonstrated by a simple example. Person 1 invests 75 MU in project A, person 2 invests 50 MU in the same project. The cost threshold of this project is 100 MU. Therefore, the total investments exceed the threshold by 25 MU. This amount is proportionally refunded. Person 1 gets $75/125 * 25 = 15$ MU, Person 2 receives a refund of $50/125 * 25 = 10$ MU.

Applying these two refund rules, the payout in the standard setting is given in two parts. It always contains the initial budget minus investments. Additionally, there are three scenarios. The first scenario applies to all projects that are underfunded. This is, the sum of investments to that project does not reach the cost threshold. Here, investments to this project j are refunded. If the cost threshold is exactly met, individuals receive the corresponding utility from the funded project. The third scenario applies to all projects that are sufficiently funded and exceed the threshold. In this case, the individual receives a given utility from the funded project and proportional rebate of the overfunding.

[3] `www.kickstarter.com`, last accessed on January 30th, 2017
[4] `www.indiegogo.com`, last accessed on January 30th, 2017

Hence, the payout function of the standard setting can be formalised by the following formula.

$$\Pi_k = b_k - \sum_{j \in J} z_{kj} + \begin{cases} \overbrace{z_{kj}}^{\text{refund}} & \forall j \text{ with } \sum_{i \in I} z_{ij} < c_j \\ u_{kj} & \forall j \text{ with } \sum_{i \in I} z_{ij} = c_j \\ \underbrace{u_{kj}}_{\text{utility}} + \underbrace{\frac{\sum_{i \in I} z_{ij} - c_j}{\sum_{i \in I} z_{ij}} \cdot z_{kj}}_{\text{proportional rebate}} & \forall j \text{ with } \sum_{i \in I} z_{ij} > c_j \end{cases} \tag{3.4}$$

Equation 3.4 can be simplified by an indicator variable $\mathbb{1}_j$ that takes the value $\mathbb{1}_j = 1$ if j is funded and the cost threshold is met or exceeded. If the sum of investments does not reach the cost threshold, $\mathbb{1}_j = 0$. Hence, the payout function can be rewritten as:

$$\Pi_k = b_k + \sum_{j \in J} (u_{kj} - z_{kj} + \frac{\sum_{i \in I} z_{ij} - c_j}{\sum_{i \in I} z_{ij}} \cdot z_{kj}) \cdot \mathbb{1}_j \tag{3.5}$$

with $b_k \geq \sum_{j \in J} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i \in I} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

With this formal description of a threshold public goods game, a crowdfunding mechanism for participatory budgeting is provided. To test the motivated design parameters in a laboratory experiment, several design choices and specifications need to be done. The next subsection provides specific choices and formalises the experimental design.

3.3.2 Experimental Procedure and Design

The theoretical game explained above is transformed to a laboratory experiment in the following section and the experimental procedure is described. The choice of design variables of endowments, thresholds, and utilities is guided by Wash and Solomon (2014). Two design variables are investigated in this thesis, the share of personal budget and the dynamics of feedback. The share of personal budget mainly affects the payout structure, since the funding power of the institutional

budget stays the same and only the share of the budget that can be kept privately differs. Feedback does not affect the payout but only the funding mechanisms during the investment. The implementation of feedback and personal budget will be explained in more details after the general experimental procedure.

Each session consists of 12 participants. In case of physiological measurements during the experiment, respective participants are attached to ECG sensors. Instructions are then handed out to participants and read out loud. The understanding of the procedure described in the instructions is tested in a quiz, which is followed by an initial cool down phase (ICD) of five minutes. The 12 participants of each session then play 24 periods of project investment (see Figure 3.2). In each period they are assigned to two groups of six participants ($n = 6$) who are exposed to four projects ($m = 4$) for funding. This is similar to stranger matching, as a participant is never in the same group twice.

The project funding consists of two phases, the investment phase and the result phase. In the investment phase, participants are endowed with $b_k = 150$ monetary units (MU). The total budget of the group is therefore $\sum_{i=1}^{6} b_i = 900\,\text{MU}$.

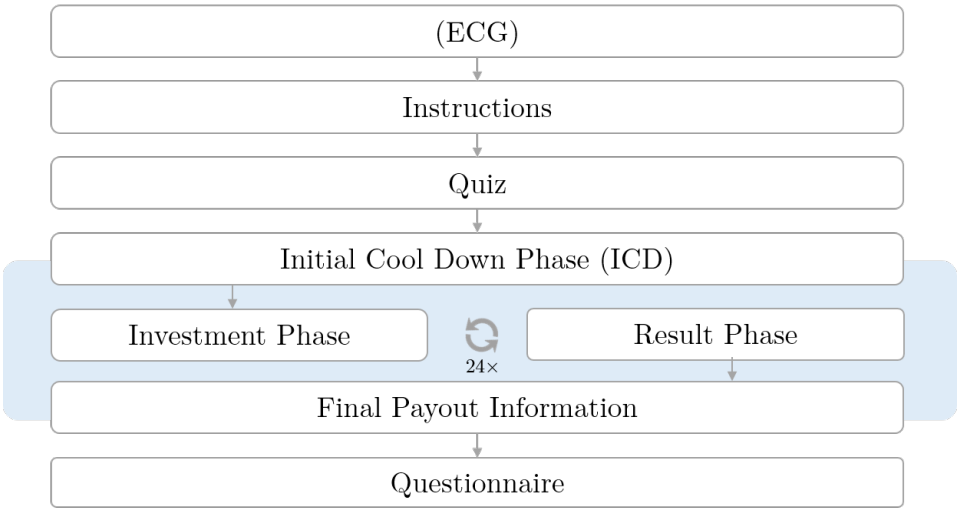

Figure 3.2: Experimental procedure: In case of physiological measurements, the experiment starts with the placement of ECG electrodes. Next, instructions are given and a quiz tests the understanding of the experiment. After an initial cool down phase (ICD) 24 rounds of investment and result phase are played, followed by final payout information, and a questionnaire.

Participants can then invest their budget in four projects (A, B, C, and D) that differ in their given utilities of funded projects j with costs $c_j \in \{100, 200, 300, 400\}$ MU, respectively. The investment phase lasts 60 seconds. If the cost threshold of a project is met ($\sum_{i=1}^{6} b_{ij} \geq c_j$), participants profit in form of individual given utilities u_j. These utilities are provided as private information (Table 3.2, $u_{ij} \in \{50, 100, 150, 200\}$ MU), independent of their own investment to the project. To avoid sequence effects participants are assigned to different utility types in each round. Each period consists of two groups. Within one group there are six participants who are assigned to one of the six utility types, which are displayed in Table 3.2. This ensures a consistent total utility of each project of $\sum_{i=1}^{6} u_{ij} = 750$ MU.

type/ project	A	B	C	D
1	200	150	100	50
2	50	200	150	100
3	100	50	200	150
4	150	100	50	200
5	200	100	150	50
6	50	150	100	200
total utility	750	750	750	750

Table 3.2: Utility types with heterogeneous utilities. In each round, participants are allocated to a new group and to one of the six utility types.

The investment phase is followed by a result phase, where participants are informed about their round payout according to the payout function. After 24 rounds of investment and result phase, payouts are summarised on a final payout information screen. Four of the 24 rounds are randomly chosen to be payout relevant. This encourages participants to take the decisions seriously as each period could be a quarter of the final payout. The four round payouts are then added and converted into Euro.

3.3.3 Treatments

The motivated research questions which are targeted on two design parameters result in an experimental design with two treatment variables. For the share of

personal budget (PB), three different levels were investigated. Correspondingly, the *feedback dynamics* (FB) can either be static or dynamic.

FB/PB	PB_0	PB_{50}	PB_{100}
FB_{stat}	S0	S50	S100
FB_{dyn}	D0	D50	D100

Table 3.3: Treatment design. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

In each treatment session, participants repeatedly face a two-stage investment process. In the **investment phase**, participants are asked to state their investments to the four projects. This phase lasts 60 seconds. The investment phase, participants see the same investment screen over all three levels of personal budget. However, it differs between static and dynamic feedback. Figure 3.3 shows exemplary screenshots of the investment phase in the static and dynamic feedback treatment.

The second treatment variable captures *feedback* dynamics (FB). Here, two treatment conditions are considered: static and dynamic mechanisms. In the static feedback treatments, participants face one quasi-simultaneous decision in each period. They decide once if and how much they want to invest in each project, not knowing about the other participants investment decisions.

In the dynamic feedback treatment, participants can observe what the other participants have invested in the projects. At the same time, they repeatedly face the funding decision whether and how much they want to invest in the projects. This information is continuously updated in a progress bar for each project. Exemplary screenshots from the experiment (Figure 3.3) show the investment phase in the dynamic feedback treatment with integrated progress bar. Repeated funding decisions can be made in a set time interval of one minute.

Both investment screens are kept as similar as possible. The only difference lies in the progress bar. The one in the dynamic feedback treatment is continuously updated as any of the six participants of the group make an investment. This information about the current funding status is common knowledge to all participants of the group. In the static feedback treatment, the progress bar is visible too,

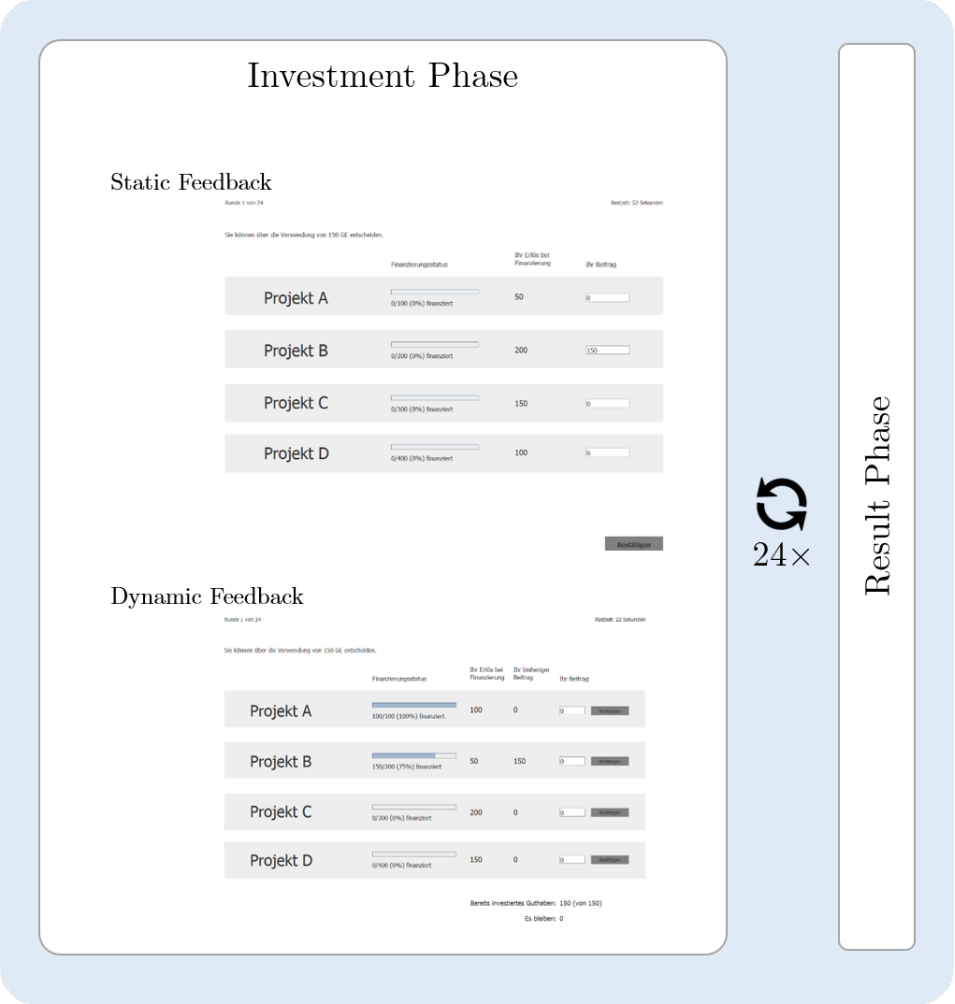

Figure 3.3: Exemplary screenshots of the investment phase. The static feedback treatment (top screenshot) offers the one-shot decision of the budget allocation to four projects. The dynamic feedback treatment (bottom screenshot) gives participants the opportunity to invest multiple times while observing the current funding status of all four projects.

but it is always empty and there is no feedback about any investment of the other participants. Feedback is only given after the investment phase.

After the investment phase, participants receive information on their round payout in the **result phase**. The payout functions depend on the share of personal budget. However, they are the same for static and dynamic feedback. The result screen summarises the outcomes of the investment phase and gives detailed information on the payout calculation. The result screens of 0% personal budget treatment, 50% and 100% personal budget treatment are all depicted in Figure 3.4.

The treatment variable *personal budget* (PB) represents the budget share which can, besides spending it on projects, be kept privately (in a separate account). Three levels of personal budget are differentiated and therefore three treatments.

In the 100% personal budget treatment, the entire budget b_k can be invested or kept. The payout is given by

$$\Pi_k = b_k + \sum_{j \in J} (u_{kj} - z_{kj} + \frac{\sum_{i \in I} z_{ij} - c_j}{\sum_{i \in I} z_{ij}} \cdot z_{kj}) \cdot \mathbb{1}_j \tag{3.6}$$

with $b_k \geq \sum_{j \in J} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i \in I} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

In the 50% personal budget treatment, only half of the budget is given to participants. This part can is personal budget and can be either invested or kept. Therefore, 50% of the initial budget is personal. Each investment is then doubled by the institution, i.e. experimental software. The payout Π of each individual i is given by:

$$\Pi_k = \frac{1}{2} b_k + \sum_{j \in J} (u_{kj} - z_{kj} + \frac{\sum_{i \in I} 2z_{ij} - c_j}{\sum_{i \in I} 2z_j} \cdot 2z_{kj}) \cdot \mathbb{1}_j \tag{3.7}$$

with $b_k \geq \sum_{j \in J} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i \in I} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

In the 0% personal budget treatment, in the absence of a personal budget, the payout Π of each individual k is given by:

$$\Pi_k = \sum_{j \in J} u_{kj} \cdot \mathbb{1}_j \tag{3.8}$$

with $\mathbb{1}_j = 1 \iff \sum_{i \in I} z_{kj} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

This chapter concludes the theoretical framework of this thesis. In Chapters 4 and 5 the corresponding experiments are introduced, conducted, and evaluated.

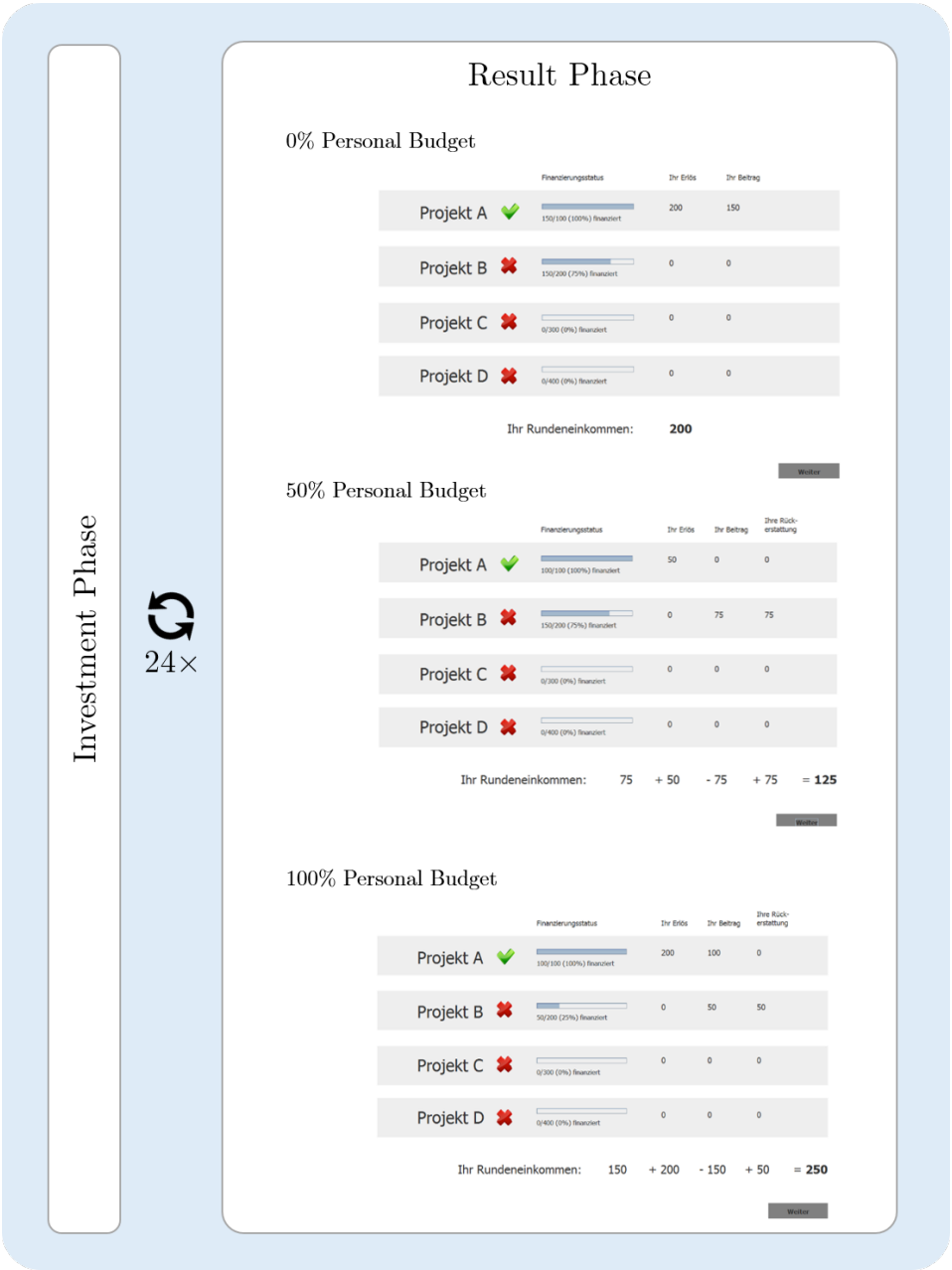

Figure 3.4: Exemplary screenshots of the result phase. In the 0% personal budget treatment (top screenshot), participants only profit from utilities from funded projects. In the 50% personal budget treatment (middle screenshot), participants can only invest half of the institutional budget, while any investment is doubled by the second half. Besides utilties, participants profit from personal withholdings and refunds. In the 100% personal budget treatment (bottom screenshot), the entire budget is handed out to participants who can either invest or keep the budget privately. Participants profit from the utilities form funded projects as well as personal withholdings and refunds.

Part II

Investigating the Impact of Design Parameters on Budget Allocation

Chapter 4

The Impact of Personal Budget in Participatory Budgeting

"No amount of experimentation can ever prove me right; a single experiment can prove me wrong."

(Albert Einstein, 1879-1955)

Participatory processes are ever increasing in popularity and citizens as well as employees ask for collaborative decision-making (Eisner, 2005; Shah, 2007). Institutions, such as governments, enterprises, and local authorities, comply with the demand for participatory processes. However, attendance numbers of processes such as referenda or participatory budgeting are small. Reasons are time-consuming processes, as well as time and location boundedness (Macintosh, 2008). This emphasises the need for suitable processes that overcome such obstacles and support participatory decision-making.

The rise of information and communication technologies (ICT) has been conductive to overcome multiple challenges of participation processes (Weber et al., 2003). It enables participants to take part in discussions, vote on local decisions, and participate in budget allocations, independent of their location and in short time. Examples like the Enquete Commission Internet and Digital Society of the German Bundestag[1] show that participatory decision-making can be implemented online

[1] `www.enquetebeteiligung.de`, last accessed on January 30th, 2017

and lead to valuable outcomes. This shows the success of such ICT-driven processes (Große et al., 2013; Harraß, 2015). There still remains the question of how to design participatory processes and mechanisms that motivate more people to take part in collaborative decision-making and expand the idea of liquid democracy. This new form of democracy combines representative democracy with elements of direct democracy and therefore enables more participation of citizens (Harraß, 2015).

In the context of civic crowdfunding it has been shown that people are interested in public projects and are even willing to invest their own money (Davies, 2015). While civic crowdfunding fosters social responsibility and increases transparency of public funds (Miglietta and Parisi, 2017), it might not be desired that citizens invest their private budget in some contexts, e.g., for projects in the responsibility of the public sector or employers (Davies, 2015). However, due to the fact that people like to invest money in public projects, a personal budget, that individuals can dispose freely, might be a motivation and increase the interest in public decision-making. As this is, however, risky to institutions who give out the budget to their constituents, it is necessary to evaluate the impact of personal budget in participatory budgeting first.

To experimentally investigate the impact of personal budget it is worth looking at threshold public goods games since the participatory budgeting of public projects can be modelled as such games. As introduced in Section 3.2, in (threshold) public goods games, a group of participants is endowed with a personal budget and each participant decides individually whether to invest in a public good from which they all profit or to keep (parts of) the budget privately as private good (Ledyard, 1994; Marks and Croson, 1998). Investments in the private goods are directly converted into utility and go into the individual payout, whereas everyone profits from the public good independent of their own investment. The decision whether to invest into the public good or keep the budget and free-ride is called the social dilemma (Andreoni, 1988). In the absence of a private good, participants do not face a social dilemma since there is no option to free-ride: there is no personal budget that can be kept in the private good, but only public budget to invest in the public good.

In the context of participatory budgeting the institution provides the entire budget and needs to make several choices on the mechanism design. Allowing for a personal budget that can be kept in a private account might on the one hand be a motivation to participants, but on the other hand be risky, since participants might just keep everything. In this case the institution would lose its budget. Therefore, it is important to evaluate both mechanisms, with and without personal budget, to find out which implications this design parameter has on the investment behaviour of participants. These insights are of great interest to all stakeholders. Individuals might just aim for a high payout, whereas an institution on the one hand wants its constituents to profit from the realisation of public projects, but on the other hand might want to minimise the risk of losing a large share of its budget to individuals. A third perspective is a global view on the outcome. Therefore, welfare gain and the efficiency of different mechanisms is evaluated.

Summarising, this chapter contributes to the grand challenge of finding mechanisms that support participatory decision-making. In more detail, it focusses on the monetary outcomes of the budget allocation when offering personal budget to participants in participatory budgeting. The research question addressed in this chapter is:

RQ 1 **What effects do design parameters have on budget allocation when applied to participatory budgeting?**

In the experiment of this chapter, two crowdfunding mechanisms for participatory budgeting are tested. Participants allocate an institutional budget on public projects. The institutional budget is therefore divided into small budgets and given to participants, who then have the opportunity to invest it in projects by a crowdfunding mechanism. If the costs of a project are reached, the public project is realised and all participants profit from its realisation. Hence, the mechanism can be modelled as a multiple threshold public goods game, where individuals have heterogeneous utilities (see Section 3.3). The investigated design parameter is *personal budget*, the share of the entrusted budget that participants can invest but also keep privately. Focus of this chapter are the differences in monetary outcomes in the presence and absence of personal budget. In the presence of a personal budget, participants benefit from the public good as well as the private good and

have the opportunity to keep 100% of their budget privately. In the absence of a personal budget, participants have no private good (0% personal budget) and only profit from the public good. In this case, unused budget as well as refunds and rebates will fall back to the institution. The conceptual framework is introduced in more detail in Chapter 3.

This chapter is organised as follows. First, hypotheses on the impact of personal budget on investments, individual payouts, and welfare gain are developed and presented in Section 4.1. Section 4.2 specifies the experimental design that was introduced in Section 3.3 in a more general way. Hypotheses-based as well as explorative results are presented in Section 4.3. Section 4.4 evaluates these results, and Section 4.5 summarises the insights gained from the experiment.

Parts of this chapter have already been published (Niemeyer, Wagenknecht, Teubner, and Weinhardt, 2016). This discussion is expanded by a more detailed analysis and insights gained from the experiment for future experiments in this context.

4.1 Hypotheses

In this section, monetary target variables of participatory budgeting mechanisms are introduced. The level of investments reflects the investment behaviour of participants and is therefore relevant when comparing different mechanisms. Individual payouts mostly affect participants as they reflect the benefits of participants. Welfare gain is one of the initial goals of initiating institutions and allows for a global measurement of the outcome. Hence, the expected impact of personal budget on these target variables is explained.

Investments

The first target variable is investments. In participatory budgeting modelled as a threshold public goods game, individuals decide over an institutional budget and invest (parts of) their initial budget in projects. The level of their investment is of great interest since it is first, the most direct variable to measure the behaviour of individuals, and second, relevant to institutions especially when personal budget is

given to individuals that they might keep privately. Personal budget, a budget that can be kept privately, reflects the existence of a private good in addition to the public goods. Having such an additional investment option leads to a social dilemma as introduced in Section 3.2. Previous research on linear public goods games has shown, that in experiments, about 30% of participants have been found to practise free-riding behaviour and decide to keep their private budget instead of investing it in the public goods (Fischbacher et al., 2001). For threshold public goods this free-riding behaviour depends on the level of the threshold and the corresponding utility. In the absence of a private good, however, there is never an option to keep the budget privately and therefore there is no incentive to free-ride and no opportunity to free-ride but only to invest. Since utility can only be generated by funded projects there is no incentive to let parts of the budget go to waste, i.e. back to the institution. In contrast, personal budget offers the opportunity to free-ride and keep (parts of) the budget privately. It is hence expected that:

H4.1 *The absence of a personal budget leads to higher investments than the presence of a personal budget.*

Individual Payouts

Payouts are defined as the sum of monetary profit from the budget and utility from funded projects. If there is no personal budget, the individual payout of participants is generated only by the utility from funded projects, whereas in the case of personal budget personal withholdings and refunds from underfunding and overfunding are added. In the scenario of this thesis, the total budget is not sufficient to fund all projects. Therefore, the number of funded projects depends on the coordination of participants between the projects (Corazzini et al., 2015). However, it is not expected that personal budget has an influence on the coordination because it does not have an impact on the level of communication, refunds, focal points, etc. (see Section 3.2). Hence, the absence of a personal budget leads to more funded projects than the presence of a personal budget, because higher investments are expected.

This leads to two contradicting conclusions. Payouts in case of personal budget include lower utility from funded projects, since less projects are funded. But additionally, personal withholdings are added to the payout. In contrast, in the absence of personal budget, higher utility from funded projects is expected, since more projects are funded. However, no personal withholdings and refunds are added. These contradicting argumentations will be tested with the following hypothesis:

H4.2 *The absence of a personal budget leads to lower individual payouts than the presence of a personal budget.*

Welfare Gain and Efficiency

The next monetary target variable is welfare gain. Recalling the definition of welfare gain from Section 3.3, welfare gain is the difference between gained utility from funded projects and their respective costs.

From Hypothesis *H4.1* it follows that the absence of personal budget leads to higher investments and therefore more funded projects are expected. If all projects had the same costs and utilities this would already lead the conclusion, that welfare gain is higher in the absence of personal budget and hence, to Hypothesis *H4.3*. If projects have heterogeneous cost thresholds, as it is in the context of this thesis, the successful funding of profitable projects depends on the level of coordination. Since personal budget does not affect the level of coordination, there is no difference expected. This leads to the following hypothesis:

H4.3 *The absence of a personal budget leads to a higher welfare gain than the presence of a personal budget.*

Recalling the definition of efficiency as "percent of the maximum feasible surplus for public good provision"(Coats et al., 2009, p. 328), see Chapter 3, it is expected that efficiency is higher in the absence than in the presence of personal budget.

The hypotheses will be tested in a laboratory experiment based on the experimental framework introduced in Section 3.3. The next section further specifies the experimental design of this first experiment.

4.2 Experimental Design Specifications

Building on the experimental framework and design choices in Section 3.3, the first experiment tests the design parameter *personal budget*. The treatments are further defined, as well as the measurement of collected data and the detailed procedure of the conducted experiment.

Treatments

This first experiment investigates the impact of personal budget, the budget share that can be kept privately, on the investment behaviour and other monetary target variables. Personal budget is modelled in two different levels. The S100 treatment includes 100% personal budget, which means that participants can keep the entire budget ($b_k = 150$ monetary units (MU)) privately if they choose. In contrast, the S0 treatment does not offer this outside option but 0% personal budget. Participants can also invest the budget ($b_k = 150$ MU) in projects, but cannot keep it privately. In the S0 treatment, all unused budget shares goes back to the institution.

This experiment does not consider dynamic feedback but only static feedback. This means that participants make a one-shot decision without the knowledge about the other participants' investments. Feedback about the funding status and funding success is only given after the investment phase, when all participants have made their investment decisions.

The payout scheme includes refunds of investments to unfunded projects as well as proportional refunds (rebates) from overfunded projects. This was already defined in detail in Section 3.3. Hence, two of the six treatments from Section 3.3 are investigated. The treatments are between-subject, i.e. one participants is only participating in one treatment. The results and evaluation of the questionnaire and the physiological data measured during the experiment will be presented in Chapter 6.

In the **S100 treatment** with 100% personal budget, the payout of participant k is the sum of the initial budget ($b_k = 150$ MU), and in case of a successfully funded project the personal utilities (u_{kj}) of this project, minus investments to the funded project,

Session-ID	Treatment	Participants	Physio data
1	S100	12	yes
2	S0	12	yes

Table 4.1: Session plan: Session id, treatment abbreviation, the number of participants, and the measurement of physiological data.

and plus the proportional refunds. Recalling the payout function from Section 3.3.2 leads to:

$$\Pi_k = 150 + \sum_{j=1}^{4}(u_{kj} - z_{kj} + \frac{\sum_{i=1}^{6} z_{ij} - c_j}{\sum_{i=1}^{6} z_{ij}} \cdot z_{kj}) \cdot \mathbb{1}_j \tag{4.1}$$

with $b_k \geq \sum_{j=1}^{4} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i=1}^{6} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

In the **S0 treatment**, in the absence of a personal budget, each participant profits from all funded projects (marked by $\mathbb{1}_j = 1$) in the form of their given individual utility (u_{kj}) for that project, independent of personal investments. There are no personal withholdings, refunds, nor rebates.

$$\Pi_k = \sum_{j=1}^{4} u_{kj} \cdot \mathbb{1}_j \tag{4.2}$$

with $\mathbb{1}_j = 1 \iff \sum_{i=1}^{6} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

Measurement

Participants of the experiment make repeated investment decisions. The investments of a participant (summed over all four projects A to D in one period) are the behavioural target variable that further leads to the other outcome-related variables of individual payout, welfare gain and efficiency. A questionnaire on the sense of agency (Moore and Obhi, 2012) and demographics completes the experiment. All participants are attached to ECG sensors to collect physiological data. Results from non-monetary outcomes are presented in Chapter 6.

Procedure

The experiment was run with 24 students in the Laboratory of the Institute of Information Systems and Marketing at the Karlsruhe Institute of Technology. For each of the two treatments, one session was run with 12 participants. Participants were mostly students of economics and industrial engineering and were recruited using ORSEE (Greiner, 2015). 16 participants were female. Participating students were between 19 and 29 years old (21.3 years on average). The experiment was implemented and conducted using the experimental software Brownie (Hariharan et al., 2015). After all 24 participants were attached to ECG sensors to record their physiology, the experimental sessions started with instructions that were handed out to all participants in paper and were read out loud (see Figure 3.2). To assure that participants understood the investment task, they had to answer ten control questions, followed by a five minute initial cool down phase. 24 periods of project funding were played. A questionnaire on the sense of agency (Moore and Obhi, 2012), demographics, and field of study completed the experiment. The experiment took on average 75 minutes per session. Average payouts were 13.87 EUR.

4.3 Results

The following results focus on investments and the implicating effects on the individual payout, welfare gain, and efficiency. Non-monetary results from the questionnaire and physiological measures are presented in Chapter 6.

Investments

The most direct factor to observe behaviour in the experiment are investments. Investments (averaged over participants and periods) reveal a mean of 149.60 MU with a standard deviation of 4.97 MU for the S0 treatment without personal budget. Investments of the S100 treatment with personal budget are on average 145.98 MU with a standard deviation of 15.62 MU (see Table 4.2). Looking at the average investments of each participant, summed over all four projects shows that, except for the first period, there occur only small differences in the amounts the

participants invest in projects. However, in the first rounds, there is a difference of 24.58 MU between the two treatments. Participants in the S0 treatment almost always invest the entire endowment. This was expected since participants do not have an additional use for the budget. The possibility to free-ride in the S100 treatment, however, is not often taken. Participants in the S100 treatment invest more than 90% of the initial budget after the first round on average (see Figure 4.1).

Investment	S0	S100	overall
Mean	149.60	145.98	147.79
Std. dev.	(4.97)	(15.62)	(11.72)

Table 4.2: Average investments (and standard deviation) in monetary units (MU) in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget.

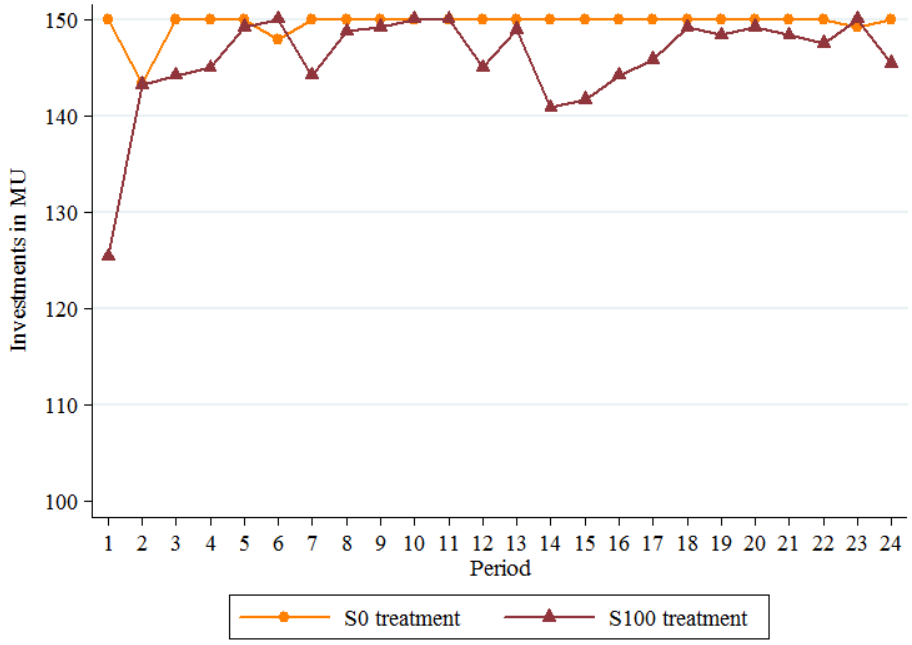

Figure 4.1: Average investments in MU per period of participants in the S0 treatment with 0% personal budget and in the S100 treatment with 100% personal budget.

To better understand the investment behaviour of participants, two generalised least-squares (GLS) mixed effects regressions are conducted (see Table 4.3). The regressions control for participant properties and the 24 periods of the experiment.

They are each based on 576 observations (24 participants playing 24 periods). The dependent variable is the sum of all investments across the projects A through D made by one participant in one period. The independent variables are a treatment dummy for the share of personal budget PB_{100} that takes the value 1 if the participant is in the S100 treatment and $PB_{100} = 0$ otherwise, and the period variable ranging from 1 to 24 in Regression (1). As summarised in Table 4.3, Regression (1) ($R^2 = 0.034$) reveals a significant treatment effect on the investment. Participants in the S100 treatment invest significantly less to the projects (coef. $= -3.625$, $p = 0.045$). With respect to treatment, participants tend to invest more over the course of the experiment (coef. $= 0.169$, $p = 0.010$). Regression (2) additionally includes $female$ as gender dummy variable. Gender has no effect on the investment, as Regression (2) shows (coef. $= 1.962$, $p = 0.309$) as Regression (2) shows ($R^2 = 0.040$). Summarising, this confirms Hypothesis *H4.1* and leads to:

Result 1: Investments are lower with 100% personal budget than with 0% personal budget.

	Investment	
	(1)	(2)
PB_{100}	-3.625*	-3.298^{+}
	(1.792)	(1.819)
period	0.169*	0.169*
	(0.066)	(0.066)
$female$		1.962
		(1.929)
intercept	147.486***	146.014***
	(1.511)	(2.092)
N	576	576
R^2 overall	0.034	0.040

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4.3: GLS mixed effects regression on investments. PB_{100}: 100% personal budget, *period*: period 1-24, $female$: female participants. Both regressions are based on 576 observations: 24 participants and 24 periods.

Individual payouts

Payouts of participants in the S0 treatment only include utilities from funded projects. In the S100 treatment, additionally, personal withholdings are allowed and investments that do not meet the cost threshold (underfunding) or exceed it (overfunding) are refunded. Participants in the S0 treatment fund more projects that they profit from but cannot keep personal withholdings. It is therefore interesting to look at payouts and how these contradicting effects are reflected in the individual payouts.

Participants in the S0 treatment earned on average 320.31 MU with a standard deviation of 93.50 MU, whereas the payout of participants in the S100 treatment were on average 366.15 MU with a standard deviation of 84.60 MU. Tabel 4.4 summarises means and standard deviations of payouts. Figure 4.2 depicts the composition of payouts in the two treatments.

Payout	S0	S100	overall
Mean	320.31	366.15	343.23
Std. dev.	(93.50)	(84.60)	(91.98)

Table 4.4: Average payouts (and standard deviation) in monetary units (MU) in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget.

	Payout	Welfare Gain
PB_{100}	45.83**	-127.08^{+}
	(13.843)	(70.60)
period	2.74**	13.82*
	(1.00)	(5.10)
intercept	286.01***	1251.132***
	(1.511)	(80.96)
N	96	96
R^2 overall	0.166	0.102

Table 4.5: GLS mixed effects regression on payout and welfare gain. PB_{100}: 100% personal budget, *period*: period 1-24. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Both regressions are based on 96 observations: 2 treatments with 2 groups in each of the 24 periods.

Since payouts depend on the investment behaviour of all six group members, a generalised least-squares (GLS) regression is run on payout aggregated on group

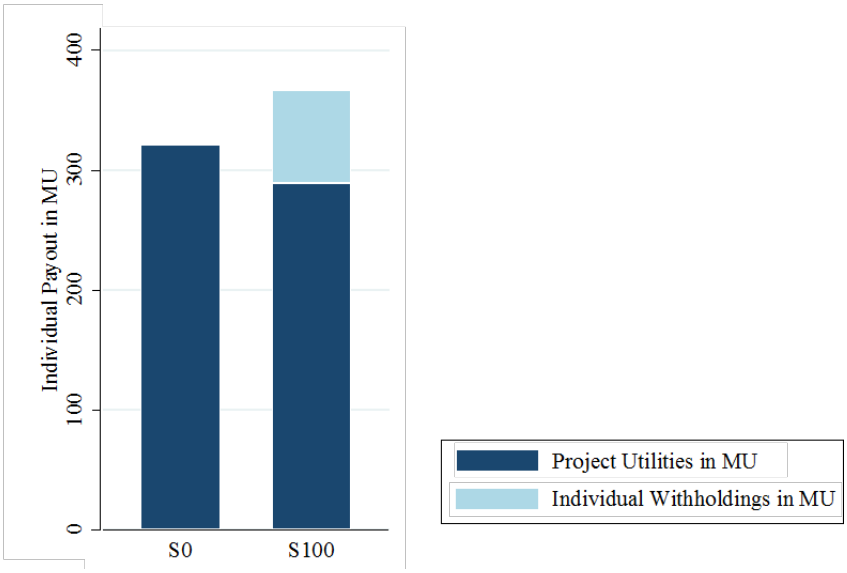

Figure 4.2: Average payout per treatment. The payout in the S0 treatment consists of utilities from funded projects. The payout in the S100 treatment consists of utilities from funded projects but also individual withholdings from uninvested budget and refunds.

level. With two groups per period and 24 periods in both treatments, this yields 96 observations. The regression on payout as dependent variable, treatment dummy variable PB_{100} as independent variable, as well as *period* as time variable shows that payouts are significantly higher in the S100 treatment than in the S0 treatment (coef. $= 45.83$, $p = 0.001$). Over time, the payout increases with respect to the treatment (coef. $= 2.74$, $p = 0.007$). The regression ($R^2 = 0.166$) is displayed in Table 4.5. These results confirm Hypothesis *H4.2* and lead to:

Result 2: Individual payouts are higher with 100% personal budget than with 0% personal budget.

Welfare Gain and Efficiency

The view on individual payouts revealed higher results in S100 treatment. How does the more general view on welfare gain perform? Welfare gain, the additionally generated utilities per period, is evaluated in order to have a more general look at the monetary outcomes. Welfare gain is therefore quantified by the generated utility of a group minus the respective costs for the successfully funded projects. The

additionally gained welfare from funded projects is on average 1423.96 MU with a standard deviation of 298.18 MU for groups in the S0 treatment (see Figure 4.3). In the S100 treatment, groups were able to gain a welfare of 1296.96 MU with a standard deviation of 402.57 MU.

Welfare Gain	S0	S100	overall
Mean	1423.96	1296.96	1360.42
Std. dev.	(298.18)	(402.57)	(359.56)
Efficiency	86.30%	78.60%	82.45%

Table 4.6: Average welfare gain (and standard deviation) in monetary units (MU) in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget.

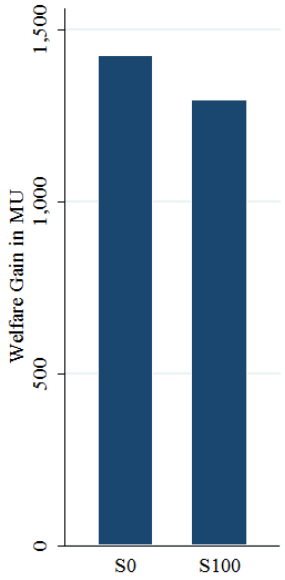

Figure 4.3: Average welfare gain per group in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget in MU. Welfare gain is calculated per group in one period as the sum of utilities from funded projects minus respective costs.

Since welfare gain is a group outcome and cannot be analysed on an individual level, a generalised least-squares (GLS) regression is conducted on a group level (see Table 4.5). Welfare gain is significantly higher in the S0 treatment than in the S100 treatment (coef. $= -127.08$, $p = 0.075$). It increases over time (coef. $= 13.83$, $p = 0.008$). Since the maximum possible welfare gain is the same for both mechanisms, consequently, the S0 mechanism reveals a higher efficiency of

86.30% compared to that of the S100 mechanisms of 78.60%. These results confirm Hypothesis *H4.3* and lead to:

Result 3: The overall welfare gain and efficiency is higher with 0% personal budget than with 100% personal budget.

Additional Results

Looking at the reaction time between participants seeing the investment screen and the time submitting their investments, a treatment effect can be observed (Figure 4.4). Participants in the S100 treatment have a markedly higher mean reaction time of more than 8 seconds compared to participants in the S0 treatment (coef. $= 8.815, p = 0.066$). This is about 13% of the available time per period. The reaction times decline in both treatments towards the end of the experiment (coef. $= -0.385$, $p < 0.001$).

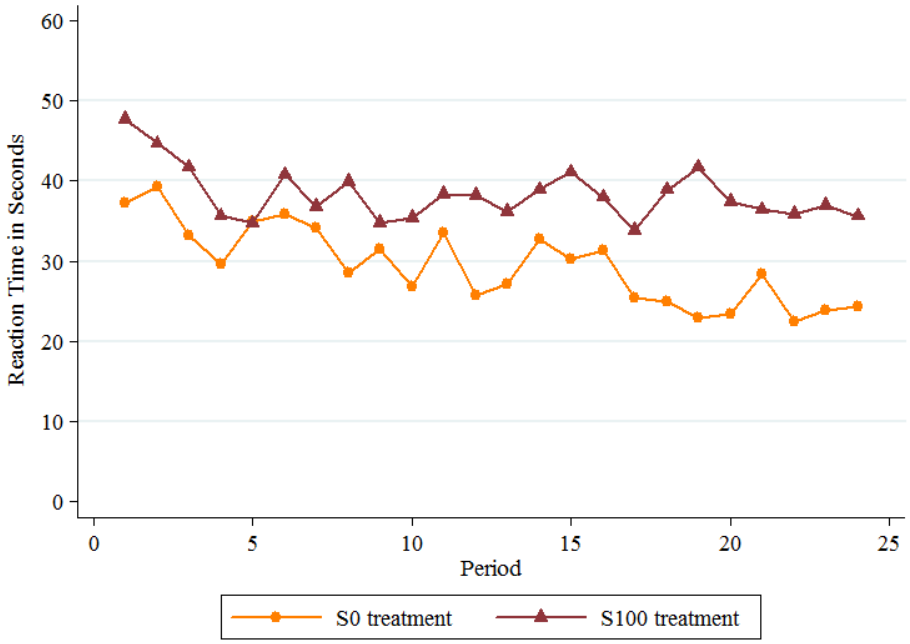

Figure 4.4: Average reaction time per period between seeing the investment screen and the submission time of investments in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget.

4.4 Evaluation

The results demonstrate several differences between the two treatments. This suggests that personal budget is an important design variable for participatory budgeting mechanisms. The results show that all investigated target variables are affected. This section evaluates the results and gives corresponding explanations.

Investments

Investments are lower in the S100 treatment, where participants are able to keep parts of the budget (*Result 1*). Unsurprisingly, participants mostly applied the dominant strategy in the S0 treatment whereby they invested their entire endowment, as unused budget would be returned to the institution. This effect is more pronounced under laboratory conditions, as there is no outside option to invest and no distraction. Under field conditions, engagement and decisions in participatory budgeting will have to compete against other leisure and work time activities and will most certainly not experience as much attention as in the laboratory. However, participants in the S100 treatment also ended up investing almost their entire endowment. Especially when considering the learning effects that occurred with more repetitions of the game, the invested sum was almost as much and at least 90% of that of their peers in the other treatment. Results show that the treatment difference vanishes in the second half of the experiment (coef.$= -3.93$, $p = 0.127$). Nevertheless, it has to be noted, that a funding process in the field will not contain 24 similar periods but only few funding decision. And therefore, the difference in the level of investments still comprises the risk to institutions that participants keep parts of the budget if they are allowed to, which is then lost to the institution. Even when expecting that investments will be generally lower in the field, this effect will probably still remain and bear a higher risk to institutions when offering personal budget.

Individual Payouts

For individuals, especially their personal payouts are of great interest when looking at monetary outcomes. Results show that individuals earn more in the S100 treatments where the mechanism allows to keep parts of the budget (*Result 2*). This result is more pronounced in the first half of the experiment, but still significant in the second half. Although less projects are funded in the S100 treatment and consequentially less utility is gained from these projects, the fact that personal withholdings are allowed and underfunding as well as overfunding is refunded, leads to overall higher payouts. In the field, this result applies in particular to free-riders and individuals with a low utility from a funded project. This is the case if individuals barely profit from the project because it might not affected their lives in a way other projects would. Hence, keeping parts of the budget and only funding the projects with higher utility will still lead in sum to a higher utility than if no budget could be kept privately.

Welfare and Efficiency

The third target variable of the evaluation of the mechanisms is welfare gain, the additionally generated utility of a group in one period. Maximising individual payouts seems to happen at the dispense of overall welfare gain as it is significantly higher in the S0 treatment, where participants generate a 10% higher mean welfare gain than their peers in the S100 treatment (*Result 3*). On the basis of welfare gain and the maximum possible welfare gain, the mechanisms can be evaluated by their efficiency. The S0 mechanism generates an efficiency of 86.30%, whereas the efficiency of the S100 is on average only 78.60%. This means that on average less than 80% of the possible welfare gain were generated by groups in the S100 treatment which were allowed to keep parts of the budget privately. This seems to happen on cost of the welfare gain and efficiency. Institutions aiming for high welfare gains might therefore prefer mechanisms without personal budget as they lead to higher efficiency and welfare gain. The fact that the welfare gain increases over time, however, cannot be transferred into policy suggestions but provide useful insight for experimenters. While it is unrealistic that participatory budgeting decisions will be repeated 24 times in such a short time, the fact that welfare increases in

the experimental setting clearly states that coordination between group members improves over time. This confirms research results from other domains such as coordination games (Clark and Sefton, 2001). The declining reaction time leads to the conclusion that participants experience a learning effect over the course of the experiment. With more experience, participants make their decisions faster.

4.5 Summary and Design Requirements

In summary, two different crowdfunding mechanisms in participatory budgeting were investigated and the experiment was conducted with students of the Karlsruhe Institute of Technology. The research is based on the literature on threshold public goods games. Based on first positive results from trials on enterprise crowdfunding, this approach for participatory budgeting in governments and public agencies was investigated in this first experiment. The experimental design is built on two main treatments. In both settings, an institution provides the funding for the process. Yet, in the S0 treatment, participants are strongly inclined to invest their entire endowment on all available projects as they would have to return unused budget at the end of each round, including rebates for overfunding or underfunding. Participants in the S100 treatment are free to keep the entrusted budget. The results suggest that these mechanisms induce notable differences. Investments and the overall welfare gain are found to be higher in the S0 treatment (*Result 1 and 3*). As a preliminary result, this suggests that institutions should choose such a mechanism in order to obtain high investment value and limit their risk. However, payouts to individuals are higher in the S100 treatment which makes it more attractive to participants (*Result 2*).

To answer Research Question **RQ1**, this experiment provides first evidence that the design parameter *personal budget* affects the monetary outcomes of the participatory budget allocation significantly. Personal budget leads to lower investments but higher individual payouts at cost of the overall welfare gain.

When engaging citizens or employees in a crowdfunding platform for budget allocation, governments and enterprises can limit their risks of losing parts of the budget to their constituents by applying a mechanism in which the funding provided

as an initial endowment can only be used on that platform. The experiment shows that by using such a mechanism, an institution can generate greater welfare, increase participants' investments and realise a higher number of projects. However, differences between the treatments are small. Thus, an institution could venture to suggest higher trust in its constituents by granting them full responsibility over the budget. Therefore, motivational, hedonic, and emotional factors need to be further investigated.

The experiment in Chapter 5 will build on these results and insights. In order to investigate the effects of a compromise, a share of 50% personal budget is investigated in which participants get half the budget, while the institution doubles every investment. This, on the one hand, will reduce the risk of the institution compared to the S100 treatment while keeping some of the individual aspects of the S100 treatment compared to the S0 treatment. Additionally, the experiment will include more participants to increase the number of data sets and the validity of results. Furthermore, other mechanism designs are addressed that help to overcome the coordination problem. Providing dynamic feedback during the investment phase of the experiment will be investigated where participants continuously invest and are informed about the current funding status, rather than only investing round-by-round. This represents a much more realistic scenario as it depicts the actual design of platforms such as Kickstarter. It can be expected to significantly increase coordination among participants and might lead to a higher number of realised projects and therefore higher levels of welfare.

Chapter 5

Dynamic Crowdfunding Mechanisms in Participatory Budgeting

"Experiment is the only means of knowledge at our disposal. Everything else is poetry, imagination"

(Max Planck, 1858-1947)

With the emerging demand for participation, new processes for the cooperation between citizen, governments, and administration need to be introduced and evaluated (Sæbø et al., 2008). One instrument to include constituents in the decision-making of an institution is participatory budgeting. It allows citizens to collaboratively participate in the allocation of public finances (Sintomer et al., 2008). Participatory budgeting is a participatory process which complements representative democracies. Hereby, citizens and civil society organisations have the right to participate directly in determining fiscal policy (Marquetti et al., 2012). In particular, citizens have the opportunity to determine the use of resources in their communities. The implementation of such processes varies widely between different institutions, as participatory budgeting always has to be integrated in existing structures of the local government and will develop over time (Marquetti et al., 2012).

Participatory budgeting processes are facilitated by the digital transformation of government services, and at the same time supported by information, social media,

and digital technology (Bekkers et al., 2011). The occurring challenge is to make use of these trends and introduce mechanisms that enable all stakeholders to participate in decision-making. Generally, there are two main incentives to participate. On the one hand participatory budgeting facilitates the access to information on budgets and policy-making, on the other hand, participants benefit from the realisation of preferred public projects (Shah, 2007). Just as in civic crowdfunding approaches it is expected that discussions over long-term policy issues and projects are potentially reduced.

A high degree of civil participation and mobilisation is mandated, which is often challenging to achieve in the short term (Miglietta et al., 2013). Offering participants a personal budget that they can keep privately if not invested in public projects during the process might facilitate the mobilisation and motivate participants. However, it bears the risk for the institution that the entrusted budget will actually be kept. It is therefore crucial to test the effects of personal budget on the investment behaviour and the targeted monetary objectives, such as welfare gain.

As access to information is motivation to citizens (Shah, 2007), a more detailed information flow during the process might increase the incentive to participate. But which implications does the provision of information on the funding status during the decision-making have on monetary outcomes and investment behaviour? Today, people are used to a high level of information access. Including information of the funding status which reflects the investment behaviour of their peer, might not only be a natural situation to well-informed citizens, but also simplify coordination of investments between projects.

To address the grand challenge of providing institutions and individuals with mechanisms that enable participatory problem-solving and decision-making, this chapter focusses on two specific design parameters and their impact on monetary outcomes. It hereby contributes to the following research question, as introduced in Chapter 1.

RQ 1 **What effects do design parameters have on budget allocation when applied to participatory budgeting?**

The conducted experiment in this chapter is based on results and conclusions of Chapter 4. It hereby extends the previous chapter's experiment. In addition to the treatments of the experiment in Chapter 4, this chapter expands the design parameter *personal budget* by the compromise case of 50% personal budget. Only half of the initial budget is handed out to individuals. This entrusted budget can be kept privately or invested in the projects. Each investment is doubled by the institution with the second half of the initial budget. This ensures that individuals can only keep half of the budget but still have the same funding power as the cases of 100% personal budget and 0% personal budget. The result of Chapter 4 showed that personal budget increases individual payouts at the cost of welfare gain. The compromise of 50% personal budget might still lead to high levels of individual payouts but on the other hand increase the incentive to invest and support the overall welfare gain.

As the results from the experiment in Chapter 4 also showed, coordination between participants is difficult. In case of successful funding, projects were overfunded on average by 28% and both mechanisms revealed on average an efficiency of 82%.[1] One way that suggests to overcome coordination problems is to give participants more information on the current funding status of projects and enable multiple investments to react on other participants investment behaviour. Aim of this chapter is to investigate the influence of dynamic feedback experimentally. Consequently, *feedback* dynamics is evaluated in two variations. During the investment phase, feedback can be given after everyone's decision is made. This is similar to voting and called static feedback. Individuals only receive information on the investment decisions of the other participants after they made their decision on whether and how much to invest themselves. In contrast, dynamic feedback offers a continuous update of current investments during the decision process. Consequently, this enables individuals to make multiple small investments and adjust their investment decision on the basis of the new level of information.

This chapter is organised as follows. Hypotheses on both design variables, feedback dynamics and personal budget, are introduced in Section 5.1. The experimental design is then further specified in Section 5.2, building on the design framework

[1] Further information on the coordination problem and dynamic feedback can be found in Section 3.2.3.

introduced in Section 3.3. Subsequently, results of the experiment are presented in Section 5.3. The impact of the two design parameters on monetary outcomes of the budget allocation are then evaluated in Section 5.4. Finally, insights of the evaluation and implications are presented and Research Question **RQ1** is answered.

Parts of this chapter are under review in an international journal (Niemeyer, Teubner, Hall, and Weinhard, 2017). This includes a first analysis of the experimental results. In this chapter, additional analyses and evaluations are included, such as the impact of physiological measurements and gender on investment behaviour.

5.1 Hypotheses

Hereafter, the hypotheses on the economic and monetary target variables and their expected correlation with the design parameters are introduced. The target variables focus on mechanism outcomes that impact individuals as well as global outcomes such as welfare gain.

Investment

The investment behaviour in participatory budgeting is of great interest to several parties. Institutions providing the budget want to know how much of the initial budget is invested by participants and project initiators want their projects to be funded. The aim of this experiment is to shed light on the investment behaviour depending on different mechanism designs. The first design parameter is feedback. It can be either static or dynamic (see Chapter 3). Static feedback replicates the design of Wash and Solomon (2014) where no feedback is provided during, but only after the investment phase. In the dynamic case, participants can observe the sum of investments made by other participants. During the entire investment phase feedback about the current funding status is updated. This mechanism is similar to standard crowdfunding schemes where the funding status is visibly updated at all time.

Generally, if the cost threshold of a project is met, there is no incentive to further invest in that project. Dynamic feedback does not lead to investments above the

cost threshold, by design, as the current sum of investments can be observed and participants can react on the provided information. With static feedback, however, this information is not given and participants do not know if a project is already funded. All mechanisms include a refund rule for underfunding as well as overfunding. If the sum of investments exceeds the cost threshold, there is no risk of losing parts of the budget since overfunding is refunded proportionally (Marks and Croson, 1998). Investments made with static feedback will therefore be higher to make sure that the cost threshold is met.

H5.1 *Static feedback leads to higher investments than dynamic feedback.*

The second design parameter is personal budget, that is, the share of the initial budget that can be kept privately, i.e., as private good. Free-riding describes the strategy of holding back budget and hoping for others to fund the public goods projects. Everyone profits from a realisation, independent from their investments (Ledyard, 1994). In the absence of a personal budget, free-riding is meaningless since, by design, unused budget falls back to the institution. Hence, the dominant strategy in the absence of personal budget is to invest the entire budget to maximise the chances project thresholds are surpassed. This lead to Hypothesis *H4.1* in the previous chapter: The absence of personal budget leads to higher investments that the presence of personal budget. This hypothesis was supported in Chapter 4. It is now extended by the case of 50% personal budget to gain insights in the compromise between the two extreme cases of only personal budget an no personal budget. It is therefore expected that the investment level will be between those two cases.

H5.2 *The smaller the personal budget shares, the higher are the investments.*

Individual Payouts

Payouts are the target variable that individuals are most interested in. Individuals profit from successfully funded projects, however, coordination problems are implied in threshold public goods games with multiple goods (Corazzini et al., 2015). The number of funded projects is dependent on how well participants coordinate

their investments to reach the cost thresholds. Especially mechanisms with static feedback that do not allow to observe the other participants' investments imply coordination problems (see Section 3.2.3 for further information on the coordination problem). This challenge is simplified by dynamic feedback, where participants constantly observe the current funding status. A sequential order of contributions that is possible with dynamic feedback has been found to outperform simultaneous contributions in terms of efficiency and success rate of funding (Erev and Rapoport, 1990; Coats et al., 2009). Thus, it is expected that dynamic feedback leads to more funded projects than static funding. More funded projects lead to a higher utility from their realisation and therefore higher individual payouts.

H5.3 *Dynamic feedback leads to higher individual payouts than static feedback.*

The coordination problem of multiple threshold public goods games (Corazzini et al., 2015) is not affected by personal budget. Since personal budget might only affect the decision of how much to invest and not where to, it is expected that the number of funded projects only depends on the level of investments. Hence, smaller personal budget shares lead to more funded projects. The more projects are funded, the higher is the individual payout. Consequently, payouts would be expected to be highest with 0% personal budget. However, results from the previous chapter show that payouts are higher in the case of 100% personal budget than with 0% personal budget (see Section 4.3). This is traceable to the personal withholdings that are only allowed with personal budget and exceed the effect of higher utilities from funded projects. It is therefore expected:

H5.4 *The smaller the personal budget shares, the lower are the individual payouts.*

Welfare Gain and Efficiency

One of the main objectives of democratic institutions is to increase social welfare (Wampler, 2012). Consequently, the third criterion to evaluate the mechanisms is welfare gain. In the context of this thesis, welfare gain is defined as the sum of created utilities from funded projects minus their corresponding costs. Welfare gain is therefore closely related to the number of funded projects but also depends

on the ratio of costs and utilities of the funded projects. Funding less expensive projects leads to the same utilities with less cost and consequently higher payouts. Hence, participants have the incentive to choose less costly projects. One solution to overcome the challenge of coordinating among projects is allowing sequential commitments of small contributions (Schelling, 1960). Having more detailed information on the current funding status of a good improves coordination and result in a higher rate of successful provision of threshold public goods (Dorsey, 1992). The coordination of funding less costly projects is therefore easier in the mechanisms with dynamic feedback, where the funding status is continuously updated. These insights leads to:

H5.5 *Dynamic feedback leads to higher welfare gains than static feedback.*

It is therefore also expected that mechanisms with dynamic feedback will be more efficient than those with static feedback. As argued above, the created utilities are only dependent on the number of funded projects. Funding projects with low costs are a matter of coordination. Since coordination is expected to be the same over all levels of personal budget, it is expected that the welfare gain is positively related to the level of investments (see Hypothesis *H5.2*), which means that allowing for personal budget will not only lower investments, but therefore also imply lower welfare gain. Formally:

H5.6 *The smaller the personal budget shares, the higher is the welfare gains.*

In line with the definition of efficiency in Chapter 3, it is expected that smaller shares of personal budget lead to higher efficiency than those with higher shares of personal budget. This is due to the maximum welfare gain that can be achieved, which is the same for all mechanisms.

5.2 Experimental Design Specifications

The employed mechanisms are based on the theory of threshold public goods games as introduced in Chapter 3. This section formalises the experimental design and describes the application in detail.

Treatments

The two treatment dimensions *personal budget* (PB) and *feedback* dynamics (FB) are operationalised using a 3 x 2 full factorial treatment design. The share of personal budget can be 0% of the entrusted budget (PB_0), 50% (PB_{50}), or 100% (PB_{100}) of the budget that participants receive at the beginning of each round. The feedback can be either static (FB_{stat}) or dynamic (FB_{dyn}). Each participant is randomly assigned to one of the six treatment conditions (between-subjects design), where there are 36 participants in each condition (see Table 5.1).

FB/PB	PB_0	PB_{50}	PB_{100}
FB_{stat}	S0: 36	S50: 36	S100: 36
FB_{dyn}	D0: 36	D50: 36	D100: 36

Table 5.1: Treatment design: Label and number of participants in each condition. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

As in Chapter 4, the S0 and D0 treatments do not offer any outside option to invest the budget but 0% personal budget. Participants can only invest the budget ($b_k = 150\,\text{MU}$) in projects and cannot keep it privately. Each unused budget share goes back to the institution. Each participant k profits from all funded projects (if the sum of investments meets the cost threshold) in the form of a given individual utility (u_{kj}) for that project, independent of their personal investment. There are no personal withholdings, refunds nor rebates. The payout is formally given by:

$$\Pi_k = \sum_{j=1}^{4} u_{kj} \cdot \mathbb{1}_j \tag{5.1}$$

with $\mathbb{1}_j = 1 \iff \sum_{i=1}^{6} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

The additional S50 and D50 treatments offer a personal budget share of 50%. This means, participants are only endowed with half the initial budget ($\frac{1}{2} b_k = 75\,\text{MU}$). Each investment, however, is then doubled by the institution. This ensures that the funding power of the initial budget stays the same over all treatments. Participant k therefore profits from the initial budget and in case of successful funding of a project, the given utility for that project, minus the investments to the project, plus

proportional refunds from overfunding. Formally, the payout function is given by:

$$\Pi_k = 75 + \sum_{j=1}^{4}(u_{kj} - z_{kj} + \frac{\sum_{i=1}^{6} 2z_{ij} - c_j}{\sum_{i=1}^{6} 2z_{ij}} \cdot 2z_{kj}) \cdot \mathbb{1}_j \tag{5.2}$$

with $b_k \geq \sum_{j=1}^{4} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i=1}^{6} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

The S100 and D100 treatments include 100% personal budget, which means that participants can keep the entire budget ($b_k = 150$ MU) privately if they want, just as in Chapter 4. The payout of participant k is given by the sum of the initial budget $b_k = 150$ MU, and in case of a successfully funded project, the given personal utilities u_{kj} of this project, minus investments to the funded project, plus the proportional refunds. This leads to the payout function:

$$\Pi_k = 150 + \sum_{j=1}^{4}(u_{kj} - z_{kj} + \frac{\sum_{i=1}^{6} z_{ij} - c_j}{\sum_{i=1}^{6} z_{ij}} \cdot z_{kj}) \cdot \mathbb{1}_j \tag{5.3}$$

with $b_k \geq \sum_{j=1}^{4} z_{kj}$ for each individual k, and $\mathbb{1}_j = 1 \iff \sum_{i=1}^{6} z_{ij} \geq c_j$, $\mathbb{1}_j = 0$ otherwise.

Measurement

Participants of the experiment make investments decisions. These investments are the behavioural target variable that further leads to other outcome-related variables, such as payouts, welfare gain, and efficiency. A questionnaire and physiological measures complete the experiment. Results from these non-monetary outcomes are presented in Chapter 6.

Procedure

The experiment was run with 216 students of the Karlsruhe Institute of Technology (KIT). Participants were recruited via ORSEE (Greiner, 2015) and were mostly

Session-ID	Treatment	Physio	Physio correct
1	S100	yes	12/12
2	D100	yes	11/12
3	S100	yes	10/12
4	S100	no	-
5	D100	yes	11/12
6	D100	no	-
7	S50	yes	11/12
8	S50	no	-
9	S0	yes	11/12
10	D50	yes	11/12
11	D50	no	-
12	D0	yes	12/12
13	D0	no	-
14	S50	yes	11/12
15	S0	yes	10/12
16	S0	no	-
17	D50	yes	11/12
18	D0	no	-

Table 5.2: Session plan: Session number, treatment abbreviation, measurement of physiological data, and the number of usable physiological data sets.

students of economics and industrial engineering. Participants were on average 22.4 years old (between 18 and 39 years). 56 of 216 (30%) participants were female[2], which reflects the ratio of the Karlsruhe Institute of Technology. The experiment was conducted using Brownie (Hariharan et al., 2015). Sessions which included the recording of the physiology of participants, began with the attachment of physiological sensors. A session plan (see Table 5.2) gives an overview on all 18 sessions. It contains information on the corresponding treatment and whether or not physiological measurements were recorded. The procedure of sessions with and without physiological measures were identical from here on to assure the comparability. A structural procedure of the experiment is displayed in Figure 3.2. Next, instructions were handed out to all participants and were read out aloud.

[2]Two participants did not state their gender.

After a five minute rest period, participants had to answer 10 control questions to assure task comprehension. 24 periods of project funding were played, each one separated by a five second rest period. A questionnaire on excitement (Liu et al., 2013), hedonic value (Venkatesh et al., 2012), demographics, and field of study completed the experiment. The experiment took on average 75 minutes per session. After the experiment, participants were paid in cash. Payments were on average 14.60 EUR. The evaluation of physiological data and results from the questionnaire will be presented in Chapter 6.

5.3 Results

The experimental results obtained from the experiment described above are summarised in the subsequent paragraphs. Here, the focus lies on the target variables investments, individual payouts, and welfare gain.

Investments

In each round, participants have a funding power of 150 MU. For a fair comparison of investments, investments in treatments with 50% personal budget are doubled, where participants invest up to 75 MU that are doubled by the experimental software. The sum of all averaged investments per participant across projects A to D is summarised per treatment in Table 5.3. Investments of participants who receive static feedback have a mean of 137.89 MU with a standard deviation of 29.07 MU, whereas participants receiving dynamic feedback invest on average 119.07 MU with a standard deviation of 42.89 MU. Participants with 0% personal budget invest on average 146.41 MU of their entrusted budget of 150 MU with a standard deviation of 18.90 MU. The average investment of participants with 50% personal budget is 128.20 MU with a standard deviation of 37.09 MU. Participants who have 100% personal budget and are allowed to keep the entire budget privately, invest on average 110.79 MU with a standard deviation of 43.85 MU, which equals 74% of their initial budget of 150 MU. Figure 5.1 shows the average investments over 24 periods for all treatments.

FB/PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	148.73	137.65	127.30	137.89
	(12.96)	(27.32)	(37.32)	(29.07)
FB_{dyn}	144.09	118.74	94.38	119.07
	(23.16)	(42.76)	(43.74)	(42.86)
Overall	146.41	128.20	110.79	128.47
	(18.901)	(37.09)	(43.85)	(37.80)

Table 5.3: Average investments per treatment (and standard deviations) in monetary units (MU). PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

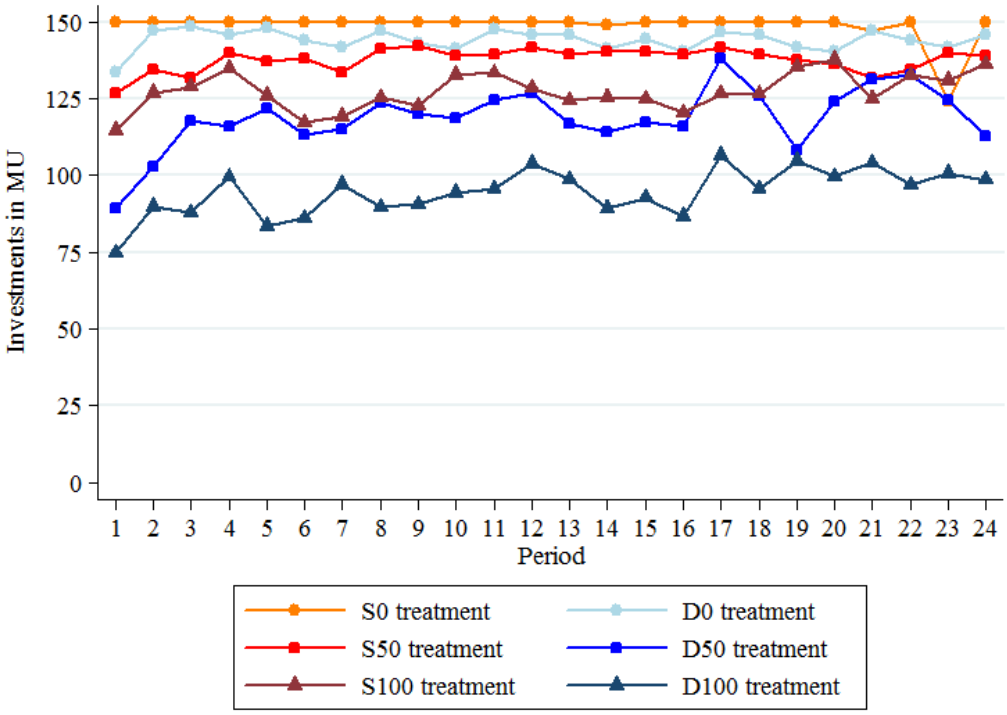

Figure 5.1: Average investment per period 1-24 for each treatment. S0 (S50 and S100 respectively) denotes the treatment with static feedback and 0% personal budget (50% and 100% personal budget respectively). D0 (D50 and D100 respectively) denotes the treatment with dynamic feedback and 0% personal budget (50% and 100% personal budget respectively).

First, investments are averaged per period and participant over sessions, which produces three completely independent observations of each of the six treatments. This is a very conservative analysis to leave out possible time effects and interaction effects. An ordinary least-squares regression is run based on these 18 independent observations (Table 5.4 Regression (1)). The dependent variable is the averaged sum of all investments per participant per period over all participants and periods. Independent variables are the treatment variable indicators dynamic feedback FB_{dyn} (with $FB_{dyn} = 1$ if the session was in a dynamic feedback treatment and $FB_{dyn} = 0$ if it included static feedback), 0% personal budget PB_0 (with $PB_0 = 1$ if the session was in a treatment with 0% personal budget and $PB_0 = 0$ otherwise) and 100% personal budget PB_{100}. The regression uses static feedback and 50% personal budget as baseline. The results are summarised in Table 5.4, Regression (1). Significant treatment differences are observed for all treatment variables. Investments made with static feedback are on average higher than those made by participants receiving dynamic feedback (coef.$= -18.81$, $p < 0.001$). This confirms Hypothesis *H5.1*.

Investments are on average significantly highest in the 0% personal budget treatments (coef.$= 18.16$, $p = 0.003$), followed by 50% personal budget treatments and 100% personal budget treatments (coef.$= -17.40$, $p = 0.003$) having the lowest investments on average. Therefore, Hypothesis *H5.2* can also be confirmed. Similar effect direction with smaller effect sizes were found when only looking at those participants whose physiology was measured and those who were not attached to sensors. The smaller effect sizes are due to the low number of observations in this conservative analysis. However, these results assures that participants react similarly to the design parameters and do not change their investment behaviour as a reaction to the physiological measurement. This is an important result for further experimental evaluations.

Second, a set of generalised least-squares (GLS) regression is run to evaluate the effects in more detail. Regressions (2)-(4) are based on 5184 observations with 216 participants playing 24 periods (see Table 5.4). Column (2) reports the results of an generalised least-squares regression of the sum of investments made by one participant in one period as dependent variable and the three treatment dummy variables as independent variables as well as a period variable. The results show highly

	Investments			
	(1)	(2)	(3)	(4)
PB_0	18.16**	18.16***	19.53***	18.07***
	(4.949)	(3.332)	(3.301)	(4.713)
PB_{100}	-17.40**	-17.40***	-16.65***	-11.85*
	(4.949)	(3.332)	(3.270)	(4.713)
FB_{dyn}	-18.81***	-18.81***	-17.77***	-24.20***
	(4.041)	(2.721)	(2.687)	(4.614)
period		0.284***	0.284***	0.253*
		(0.0555)	(0.0555)	(0.111)
$female$			-9.105**	-8.978**
			(2.993)	(2.871)
physio			4.017	5.954*
			(2.786)	(2.693)
$FB_{dyn} * PB_0$				17.84**
				(6.305)
$FB_{dyn} * PB_{100}$				-12.06
				(6.252)
$FB_{dyn} * period$				0.377***
				(0.111)
$PB_0 * period$				-0.572***
				(0.135)
$PB_{100} * period$				0.0979
				(0.135)
Intercept	137.6***	134.1***	133.0***	132.9***
	(4.041)	(2.808)	(3.463)	(3.924)
N	18	5184	5184	5184
R^2	0.212	0.212	0.226	0.256

Table 5.4: Regressions of the sum of investments per participant per period averaged over sessions. PB_0: 0% personal budget, PB_{100}: 100% personal budget, FB_{dyn}: dynamic feedback, *period*: period 1-24, $female$: female participants, *physio*: participants attached to physiological sensors. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

significant differences in treatment variables. Compared to the baseline of static feedback and 50% personal budget, investments in the treatment with 0% personal budget are significantly higher (coef.$= 18.16$, $p < 0.001$) and those in the treatments with 100% personal budget significantly lower compared to 50% personal budget (coef.$= -17.40$, $p < 0.001$) confirming previous results from Regression (1) and

Hypothesis *H5.2*. Dynamic feedback leads to lower investments (coef.$= -18.81$, $p < 0.001$) in support of Hypothesis *H5.1*. Additionally, the increase of investments per period (coef.$= 0.284$, $p < 0.001$) is highly significant.

Regression (3) adds a gender dummy and a second dummy variable for those participants who were attached to physiological sensors. Two participants did not state their gender. In these cases, the gender dummy *female* takes the value 0.5. The presence of physiological sensors does not have an effect on the level of investments. Female participants invest significantly less (coef.$= -9.105$, $p = 0.002$) then male participants. The treatment and period effects are the same as in Regression (2) concerning effect direction and effect size.

Regression (4) takes interaction effects into account. Results show that this weakens the period effect, since it is driven by dynamic feedback treatments $FB_{dyn} * period$ (coef.$= 0.377$, $p < 0.001$), where investments increase faster than in static ones and weakened by 0% personal budget treatments $PB_0 * period$, where the decline is slower compared to 50% personal budget (coef.$= -0.572$, $p < 0.001$). $FB_{dyn} * PB_0$ appears to have a significantly positive effect on investments (coef.$= 17.84$, $p = 0.005$) which means that investments in the dynamic feedback treatment are especially high when 0% personal budget is given. Interestingly, the attachment of physiological sensors affects investment behaviour in Regression (4). Participants attached to sensors invest more than those who's physiology was not measured (coef.$= 5.954$, $p = 0.027$).

Summarising the results on investments, dynamic feedback has a significant effect on the level of investments. Investments are higher when participants receive dynamic feedback than when only static feedback is given, which confirms Hypothesis *H5.1*.

Result 1: Dynamic feedback leads to lower investments than static feedback.

The share of personal budget impacts the level of investments as expected. Participants in the 0% personal budget treatment invest more than those in the 50% personal budget treatment than those in the 100% personal budget treatment, confirming Hypothesis *H5.2*.

Result 2: The smaller the share of personal budget, the higher are the investments.

Additionally to the hypothesised impact of the design variables on investment behaviour, the impact of gender is investigated. The data from the experiment suggests that female participants invest less than male participants. This contradicts findings in other cooperative games (Charness and Rustichini, 2011), but is in line with others (Rapoport and Chammah, 1965; Brown-Kruse and Hummels, 1993) that suggest that females initially contribute significantly more than males, but significance vanishes as the game evolves (Cadsby and Maynes, 1998).

Result 3: Female participants invest less that male participants.

A subgroup of participants was attached to ECG sensors during the experiment to measure their physiology. Independent of the actual results from collected physiological data, the attachment of sensors itself might lead to a change in behaviour. The analysis above suggests that the attachment of physiological sensors during the experiments leads to higher investments.

Result 4: Physiological sensors might lead to higher investments.

Individual Payout

The payouts are defined in Section 3.3. It should be noted that the maximum possible payout differs between levels of personal budget. Due to the possibility to free-ride in the case of 50% and 100% personal budget, payouts can be higher than in the 0% personal budget treatments. With 0% personal budget the maximum payout is achieved when the three projects are successfully funded that lead to a participants maximum utilities of $200 + 150 + 100 = 450$ MU. In the case of 50% personal budget, a participant can achieve a higher payout, when the same three optimal projects are funded by the other participant. The maximum payout is then $450 + 75 = 525$ MU. With 100% personal budget and perfect free-riding, $450 + 150 = 600$ MU can be earned. The evaluation of the different mechanisms will not treat the payouts differently, because the absolute payout is what matters to individuals in the end.

Overall, the static feedback treatment reveals an average payout of 337.96 MU with a standard deviation of 87.53 MU, whereas participants exposed to dynamic feedback during the funding earn on average 360.55 MU with a standard deviation of 77.72 MU. Looking at the share of personal budget, the average payouts with 0%

FB/PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	336.69	333.60	343.60	337.96
	(90.11)	(87.12)	(85.10)	(87.53)
FB_{dyn}	366.38	352.96	362.33	360.55
	(74.31)	(78.91)	(79.32)	(77.72)
Overall	351.53	343.28	352.96	349.26
	(83.89)	(83.65)	(82.77)	(83.53)

Table 5.5: Average payouts per treatment (and standard deviations) in monetary units (MU). PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

personal budget are 351.53 MU with a standard deviation of 83.89 MU, with 50% personal budget participants earn on average 343.28 MU with a standard deviation of 83.65 MU, and participants with 100% have an average payout of 352.96 MU with a standard deviation of 82.77 MU. Payouts of all treatments are summarised in Table 5.5.

Figure 5.2 reports the averaged individual payouts per treatment. They are divided in two sources. The payout share from project utilities (u_{ij}) is depicted in dark blue. Personal withholdings, refunds, and rebates are only part of the payout if the share personal budget is greater than 0%. This part of the payout is depicted in light blue.

A first look at Figure 5.2 suggest that payout differences between different levels of personal budget are rather small but dynamic feedback might lead to higher payouts. Hence, an ordinary least-squares regression is run with 18 independent observations, one per session. The individual payouts are the dependant variable. Static feedback and 50% personal budget serve as baseline. The results are summarised in Table 5.6 (1). Payouts are significantly higher with dynamic feedback (coef.= 22.591, $p < 0.001$), confirming Hypothesis *H5.3*.

Result 5: Dynamic feedback leads higher individual payouts than static feedback.

For the share of personal budget, however, there is only one significant difference in the payouts. Participants in the 100% personal budget treatment earned significantly more than in the 50% personal budget share (coef.= 9.679, $p = 0.063$).

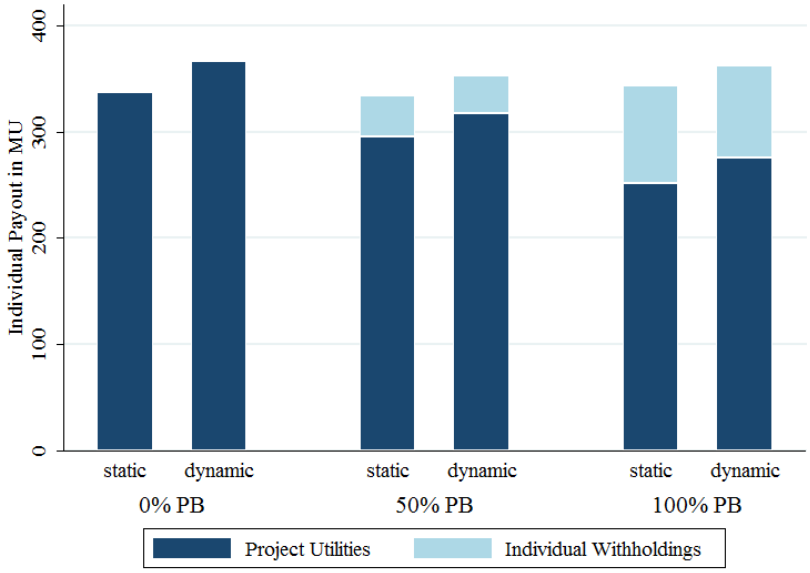

Figure 5.2: Average individual payout in MU divided by source. Payout from project utilities is depicted in dark blue, payout from personal withholdings and refunds in light blue.

To analyse the difference between the payouts in the 0% personal budget treatment and the 100% personal budget treatment, a second OLS regression is run (see Table 5.6, Regression (2)). This difference is not significant (coef.$= 1.427$, $p = 0.770$).

Result 6: There is no evidence that personal budget has an effect on individual payouts, except that participants with 100% personal budget have a significantly higher payout than those with 50% personal budget.

Welfare Gain and Efficiency

Welfare gain is defined as the additionally generated utility from the mechanism (see Chapter 3). It is measured as the sum of gained utilities from funded projects minus respective costs. This requires that unused budget in the 0% personal budget treatment does not expire or forfeits but goes back to the institution. The same holds for unused institutional budget in the 50% personal budget treatment that is not used to double investments. Efficiency is measured as the percent of the maximum feasible surplus (welfare gain) of 1650 MU, as introduced in Chapter 3.

	Payout	
	(1)	(2)
PB_0	8.251	
	(4.79)	
PB_{50}		-8.251
		(4.79)
PB_{100}	9.679*	1.427
	(4.79)	(4.79)
FB_{dyn}	22.591***	22.591***
	(3.91)	(3.91)
intercept	331.987***	340.238***
	(3.91)	(3.91)
N	18	18
R^2	0.732	0.732

Table 5.6: OLS regressions of individual payouts per period averaged over sessions. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{dyn}: dynamic feedback. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The welfare gain generated by groups of six participant in one period is on average 1509 MU when participants have to personal budget, with a standard deviation of 249 MU, this equals an efficiency of 91%. A mean of 1347 MU is achieved with a standard deviation of 321 MU from those with 50% personal budget. This mechanisms has therefore an efficiency of 81%. 100% personal budget leads to a welfare gain of 1173 MU on average with a standard deviation of 373 MU. The efficiency is therefore 71%. Mechanisms with static feedback lead to a welfare gain with a mean of 1291 MU and a standard deviation of 381 MU, which equals an efficiency of 78%. Groups who receive dynamic feedback, in contrast, generate on average a welfare gain of 1395 MU with a standard deviation of 299 MU. This mechanism therefore reveals a higher efficiency of 85% than that with static feedback. Welfare gain and efficiency are summarised in Table 5.7 and displayed in Figure 5.3.

The highest welfare gain of 1540 MU was reached in the 0% personal budget treatments with dynamic feedback yielding the highest efficiency of 91% among all mechanisms. An ordinary least-squares regression with welfare gain averaged over group and period as dependant variable is run on session level with 18 independent observations. The results are displayed in Table 5.8. The welfare gain in

FB / PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	1478.47	1301.39	1093.40	1291.09
	(291.41)	(346.31)	(398.52)	(381.42)
	[89.6%]	[78.9%]	[62.3%]	[78.25%]
FB_{dyn}	1540.28	1392.71	1253.47	1395.49
	(193.36)	(287.86)	(328.15)	(298.94)
	[93.4%]	[84.4%]	[76.0%]	[84.57%]
Overall	1509.38	1347.05	1173.44	1343.29
	(248.79)	(321.15)	(373.11)	(346.44)
	[91.45%]	[81.64%]	[71.11%]	[81.41%]

Table 5.7: Average welfare gain per treatment (and standard deviation) in monetary units (MU) and [efficiency]. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

the dynamic feedback treatments is significantly higher than in the static feedback treatments (coef.$= 9.679$, $p = 0.063$). This result confirms Hypothesis *H5.5*.

Result 7: Dynamic feedback leads higher welfare gain than static feedback.

As for the share of personal budget, welfare gain in the 100% personal budget treatment is lower than in the 50% personal budget treatment (coef.$= -173.61$, $p < 0.001$), whereas welfare gained in the 0% personal budget treatment is significantly higher than in the baseline of 50% personal budget (coef.$= 162.33$, $p < 0.001$). Therefore, Hypothesis *H5.6* can be confirmed.

Result 8: The smaller the personal budget share, the higher is the welfare gain.

Summarising, investments with static feedback are significantly higher than in mechanisms with dynamic feedback. However, they do not lead to more, but significantly less funded projects and lower welfare. Investments and funded projects decrease with the personal budget. However, privately kept personal withholdings increase opportunistically.

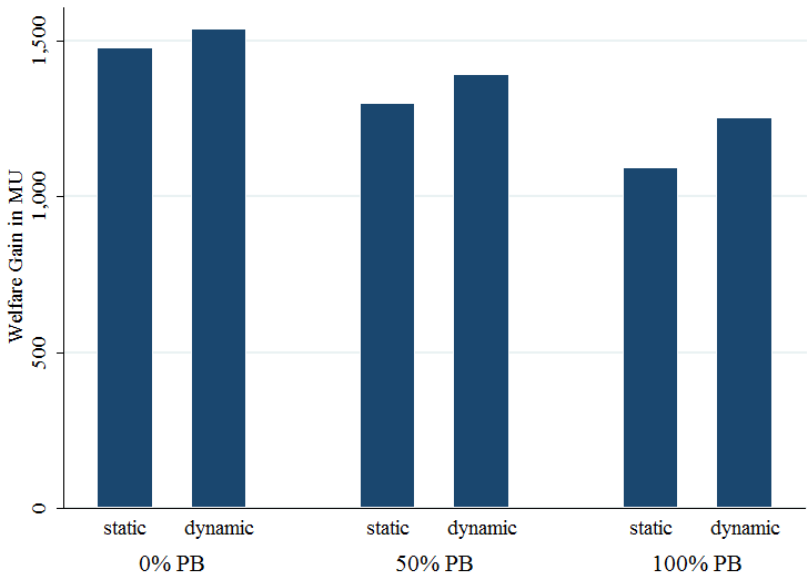

Figure 5.3: Average welfare gain per group averaged over periods in monetary units (MU) for all treatments.

5.4 Evaluation and Implications

In contrast to the previous chapter, the results shown above were obtained by investigating two design parameters simultaneously. In summary, there are clear trends for the choice of dynamic feedback. On the other hand, the choice of personal budget share is more complex. The following paragraphs address the two design parameters from different perspectives.

Investments

Participants exposed to dynamic feedback invest significantly less than those who received static feedback (*Result 1*). This can be explained by the fact that overfunding did not occur since participants could observe the current funding status at all times and there was no incentive to invest in already successfully funded projects. Additionally, participants coordinate better between projects so that underfunding is lower than in the static feedback treatments. This means that observable investments by the dynamic feedback increase the awareness of how promising the

	Welfare Gain
PB_0	162.33***
	(30.25)
PB_{100}	-173.61***
	(30.25)
FB_{dyn}	104.40**
	(24.70)
intercept	1294.85***
	(24.70)
N	18
R^2	0.910

Table 5.8: OLS regression of welfare gain per per group and period averaged over sessions. PB_0: 0% personal budget, PB_{100}: 100% personal budget, FB_{dyn}: dynamic feedback. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

funding of a project is. For example, observing that no one else invests in project D except one's own small investment, will lead a participant to not invest in this projects again, or not even start investing in this project but first fill up the ones where investments are already made. The different levels between investments due to dynamic feedback are more pronounced, when participants are allowed to keep (parts of) the budget privately, i.e., in the 50% and 100% personal budget treatment. This can be seen in Table 5.4, Regression (4), were the interaction term of dynamic feedback and 0% personal budget reveals a significant coefficient reversed to the coefficient of dynamic feedback in general. Hence, dynamic feedback leads to lower investments only if there is the outside option to profit from personal withholdings.

The impact of personal budget interferes the effects of dynamic feedback. Both, for static and dynamic feedback, investments in the 0% personal budget treatments are highest (*Result 2*). This is not very surprising, since participants cannot keep (parts of) the budget privately and therefore there is no inventive to no invest. Investments in the 100% personal budget treatment are lowest. This effect of investments being higher with less personal budget, is stable over different analyses, as Table 5.4, Regressions (1)-(4) shows (*Result 2*). In the case of 0% personal budget, free-riding cannot occur since there is no possibility to keep budget in a private account. However, in the other cases, participants have that possibility and results

show that they do. Free-riding behaviour is more pronounced with 100% personal budget, where participants have full access to the budget and free-riding is more "profitable". Interestingly, pure free-riding, where participants keep their entire budget is very rare. Over all sessions, only in 30 periods a participant does not investments at all.

Individual Payout

Across all levels of personal budget, individual payouts are higher when participants receive dynamic feedback than if static feedback is given (*Result 5*). This is a clear indicator for better coordination, since participants manage to fund more projects with less investments. This result is independent of the level of personal budget.

As for the level of personal budget, there is only a small difference found (*Result 6*). Interestingly, participants in the 50% personal budget treatment have on average the lowest payouts. Still, only the comparison of participants with 100% personal budget earning more than those with 50% personal budget is significant (*Result 6*). The result, however, is very interesting, since the maximum possible payouts are different over the three levels of personal budget. So when comparing the percent of the maximum payout that a participant can achieve together with the other group members, the 0% personal budget mechanisms performs better (78.12%) than that with 50% personal budget (65.39%) than that with 100% personal budget (58.83%). The better performance in the S0 and D0 treatments is also reflected in the amount of project utilities that represent the entire payout. This part is conspicuously smaller with 50% and 100% personal budget, where individual withholdings, refunds, and rebates are added to the project utilities. Overall, when looking at individual payouts, individuals might not care where the payout came from, since payouts are about the same over all levels of personal budget (except payouts from 100% personal budget being slightly above those from 50% personal budget).

Welfare Gain and Efficiency

Surprisingly, the maximum welfare gain of 1650 MU was achieved by the same number of groups in the dynamic feedback as well as with static feedback treatment, which was in 44.44% of the groups. However, mechanisms with dynamic feedback lead on average to significantly higher welfare gains, independent of the level of personal budget (*Result 7*).[3] This shows that participants invest their budget meaningfully and manage to coordinate investments across projects.

Welfare gain in the case of 0% personal budget is significantly higher than with 50% personal budget and the maximum welfare gain wisas achieved in 63.54% compared to 44.10%. 50% personal budget lead to higher welfare gain 100% personal budget (with only 25.60% achieving the maximum welfare gain). This shows that welfare gain decreases the higher the share of personal budget is (*Result 8*).

The emerging concept of participatory budgeting was investigated by means of a laboratory experiment, based on the fundamental design variables feedback dynamics and personal budget. The first design parameter and treatment variable of this research is the dynamics of feedback used to crowdfund projects of public interest with an institutional budget. The results can be discussed from three different angles: the view of constituents, of the institution, and a global view on all stakeholders.

Constituents' Perspective

Constituents, who are exposed to a dynamic mechanism, benefit from higher payouts and a better coordination. This means less frustration due to coordination issues or unexpected results and indicates higher participation in following processes. The outcomes from low personal budget mechanisms show that constituents face higher total utility from funded projects. However, there is a tendency that total payouts are lowest when constituents can only keep half of the budget privately.

[3] Since the ordinary least-squares regression in Table 5.8 is only based on 18 independent observations, it does not include interaction effects. Additional regressions per level of personal budget confirm that the differences in payouts by feedback hold true for all three levels.

Institution's Perspective

Institutions that crowdsource their budget allocation to their constituents profit from dynamic feedback mechanisms in terms of more funded projects and higher welfare gain. Additionally, less budget is "lost" to their constituents by personal withholdings compared to static feedback mechanisms. Institutions generally benefit from lower levels of personal budget. This decreases the risk of losing budget to personal withholdings.

Global Perspective

Mechanisms with dynamic feedback fund more projects and lead to a higher welfare gain with less investments. This can be explained by a better coordination due to the additional information provided during the investment process. The information on the funding status enables participants to immediately react on investments and adjust their investment strategies. From a global perspective a lower share of personal budget is preferred when it comes to welfare gain. The less personal budget participants can keep, the higher is the overall welfare gain produced by the realisation of public projects.

Governments and corporations can use crowdfunding mechanisms to allocate budgets by a crowd. The results on monetary outcomes of the experiment show that dynamic feedback stimulates the funding of projects and results in overall higher welfare gains. Maximising welfare represents a main goals of enterprises and governments (Wampler, 2012). Dynamic feedback mechanisms address and fulfil these requirements, satisfying the call of Generation Y for being integrated in collaborative and cooperative decision-making processes. Institutions focussing their decision on these target variables should design crowdfunding mechanisms with dynamic feedback properties for participative budget allocation.

The decision on the share of personal budget must be made carefully, since constituents might not reinvest the institutional budget but rather keep it privately if personal budget is given. Giving out personal budgets is a risk for the institution, because constituents may actually keep parts of it privately. The evidence shows that governments and corporation should balance these effects, but be careful

when choosing the compromise of the 50% personal budget when deciding on a mechanism for a participatory budget allocation.

To answer Research Question **RQ1**, this second experiment confirms first evidence that the design parameter *personal budget* impacts the monetary outcomes of the participatory budget allocation in the following way: personal budget leads to lower investments but higher individual payouts at cost of the overall welfare gain. Additionally, the design parameter *feedback* affects the monetary outcomes: dynamic feedback leads to better coordination and higher welfare gain than static feedback.

There are several limitations to this study. First, a laboratory experiment necessarily creates an artificial environment. In particular, inducing specific utility values for projects certainly limits the results generalisability. There, expected project values can usually not exactly be assessed and the individual utility scores for potential supporters are blurry even (or especially) to them (see Mateos et al. (2015) for incomplete preferences). This suggests the need for experiments with actual projects with personal preferences rather then induced ones or field experiments, e.g., for crowdfunding on-campus projects.

However, hedonic and emotional factors play a prominent role not only in investment decision-making generally but in the context of participatory budgeting. Especially when it comes to real-world projects, emotions are closely attached to other factors of influence. It is therefore necessary to first measure hedonics and emotions in the closed setting of an abstract lab experiment in order to investigate their influence on investment decisions. Physiological measures and the questionnaire are investigated in the next chapter.

Part III

Investigating the Impact of Design Parameters on Emotions

Chapter 6

Hedonics and Emotions in Participatory Budgeting

"I don't want to be at the mercy of my emotions. I want to use them, to enjoy them, and to dominate them."

(Oscar Wilde, 1845-1900)

It has been established that feelings and emotions are important for participation processes (Barros and Sampaio, 2016; Steiner, 2012) from at least two perspectives. First, only when and if a crowd-based mechanism for budget allocation is sufficiently emotionally engaging, it draws enough attention and contribution to eventually succeed and enhance emotional contagion (Barsade, 2002). Such schemes rely on a critical mass to properly work (Margetts et al., 2011). Second, research in the realm of consumer e-commerce found that people's economic decision-making processes highly depend on their emotional states (Adam et al., 2015; Hariharan et al., 2016; Heilman et al., 2010; Hawlitschek et al., 2016). Beyond the understanding of individual behaviour resulting in group outcomes, it is particularly important to assess emotions in this context.

In order to achieve similar objectives as civic crowdfunding, the design of participatory budgeting is proposed by means of designing emotionall engaging mechanisms. Two design parameters are suggested as important drivers of emotion and behaviour in this regard. The first one relates to the feedback information provided

to participants during the funding process. Participants may or may not receive dynamic feedback on the status of the current funding progress of the projects. Most consumer-based crowdfunding platforms like Kickstarter allow users to repeatedly invest in projects and to observe other users' investments and the projects' funding statuses. The occurring interaction with other participants, time pressure, and a more complex decision might lead to higher emotional arousal compared to decisions made without that dynamic feedback. The dynamic feedback property is evaluated in the context of participatory budgeting processes. The second design parameter relates to the fiscal policy of the institution. The institution may allow for different levels of personal budget. Budgets can either only be transferred to the participants, who can then allocate it to projects on behalf of the institution, where non-allocated budget remains with the institution. Or budget can actually be transferred to the participants with the aim of allocation to projects. Non-allocated budget, in this case, remains with participants. Such personal budgets create inherent conflict between funding public projects and private retention, yielding social dilemma situations. While previous research (Muller et al., 2013) does not consider personal budgets, this thesis extends this stream of research in this regard.

Measurement of aspects like engagement and excitement are current research lacunae, and are addressed by this thesis focussing on the impact of dynamic feedback and personal budget. This research addresses that gap using an experimental approach. The results from the experiments introduced in Chapter 4 and 5 are extended with data from a questionnaire after the experiment and physiological measurements recorded during the experiment. Thus, in this chapter, the following research question is addressed.

RQ 2 **What effects do design parameters have on emotions when applied to participatory budgeting?**

Two design parameters are evaluated. The first one is personal budget, the share of an entrusted budget that participants are allowed to keep privately. The second design parameter evaluated in this chapter is feedback, which can either be static or dynamic.

Lastly, the hedonic and emotional factors are combined with investment behaviour. This leads to the question:

RQ 3 Do investment behaviour and emotions influence each other in participatory budgeting?

The outline of this chapter focussing on the effect of personal budget and feedback on hedonics and emotions, is as follows. First, hypotheses on the effect on hedonics and emotional arousal are developed in Section 6.1. Section 6.2 gives an overview of the experimental procedure and measurements. Results from both the questionnaire and physiological measurements are presented in Section 6.3. Section 6.4 evaluates the results and states implications.

Parts of this chapter have been published (Niemeyer, Wagenknecht, Teubner, and Weinhardt, 2016; Niemeyer, Wagenknecht, and Weinhardt, 2016) or are currently under review (Niemeyer, Hariharan, Teubner, and Hall, 2017; Niemeyer, Teubner, Hall, and Weinhardt, 2017). The impact of emotions on investment behaviour is additionally analysed with physiological measurements in this chapter.

6.1 Hypotheses

Besides the evaluated monetary target variables in Chapter 4 and 5, design parameters might influence participants perception of hedonic value, sense of agency, and emotional arousal. In this section, hypotheses are established to investigate whether different levels of personal budget and dynamic rather than static feedback in a participatory budgeting setting affect the sense of agency (Moore and Obhi, 2012), hedonic values (Venkatesh et al., 2012), and emotional arousal (Liu et al., 2013). The constructs of the questionnaire were already introduced in Section 2.3.

The Effect of Personal Budget on the Sense of Agency

Given that an institution provides the entire funding for participatory budgeting, the mechanism by which participants can allocate their entrusted budget is

expected to have crucial effects on the sense of agency, the sense of initiation and controlling actions (Moore and Obhi, 2012). Constituents should have a stronger feeling of exerting control over their environment if they are free to use their entrusted budget in any way they prefer. Thus, it can be argued that if an institution entrusts its constituents with the full responsibility over the budget and, equally important, with the benefits from funded projects, participants will perceive higher explicit and implicit agency. However, if participants can only benefit from successfully funded projects and have no outside option to keep parts of the budget privately, they are limited in their control and will experience a lower sense of agency and motivation. Thus, with regard to the design parameter of personal budget, the following hypothesis can be stated:

H6.1 *Personal budget leads to a higher sense of agency than investing institutional budget that cannot be kept privately.*

The Effect of Dynamic Feedback on Emotional Arousal and Hedonic Value

In a funding process with static feedback, participants submit their investments quasi-simultaneously, neither knowing the contributions of other participants nor the overall funding status. Participants transmit a single investment to each project. In dynamic feedback processes, anyone can make any desired number of publicly displayed investments over a given period of time. Such dynamic processes inherently bear the potential of evoking excitement and arousal due to the interaction of demanding inputs and presenting (intermediate) results. This reasoning applies to funding processes with dynamic feedback, which is supported by empirical evidence from related domains, including suspense and surprise (Adam et al., 2012) and time pressure (Finucane et al., 2000; Ku et al., 2005; Malhotra, 2010). Given that funding processes with dynamic feedback involve elements of surprise and time pressure, the second hypothesis states:

H6.2 *Dynamic feedback leads to higher levels of arousal than static feedback.*

Dynamic feedback in crowdfunding represents a subtle form of social interaction, offering a mode of communicating with other investors via investment-based signals. The possibility for social interactions was found to be a potent driver of hedonic value and adoption of online applications such as social network sites (Gosling and Mason, 2015) and sharing platforms (Hawlitschek et al., 2016). This dynamic nature offers a way to express intentions and strategies by signalling intended investments and even trying to lure others into funding one's own preferred project. It is suggested that this game-like character of funding processes with dynamic feedback causes higher levels of hedonic value. The third hypothesis is:

H6.3 Dynamic feedback leads to higher levels of hedonic value than static feedback.

The Effect of Personal Budget on Emotional Arousal and Hedonic Value

Personal budget offers participants the option of a private withholdings. When making investment decisions, participants have to decide on how much of the initial budget they want to keep privately for themselves and how much they want to invest into projects. High personal budget shares lead to a more complex decision and higher risks, as all participants have the option of keeping parts of the budget. Since risky decision-making, such as gambling, increases subjective excitement and arousal (Eadington, 1976), it is suggested that

H6.4 The higher the share of personal budget, the higher is the levels of arousal.

High personal budget shares offer participants more choices and therefore meaningful decisions. In the case of no personal budget, there exists no social dilemma as the dominant strategy is to invest the entire budget (see Section 3.3). If a personal budget exists, the strategy space is larger because investing or not represents a "real" decision. Having a real choice is typically considered as being more engaging than making a decision that is actually already made by the institution. This leads to the following hypothesis:

H6.5 *The higher the share of personal budget, the higher is the perceived hedonic value.*

The Effect of Personal Budget on Emotional Arousal and Hedonic Value

In line with Holbrook and Hirschman (1982) hedonic value is defined as drawing out more fun and playfulness from the mechanism than from the task itself. Babin et al. (2004) find a positive correlation between positive affect and hedonic value in shopping behaviour. Since excitement is considered as positive emotional arousal (Russell and Pratt, 1980), it is proposed:

H6.6 *The higher the level of arousal, the higher is the perceived hedonic value.*

The Effect of Dynamic Feedback and Personal Budget on Investments

The effects of the two design parameters, personal budget (PB) and feedback dynamics (FB), on the investment behaviour were already evaluated in the previous chapter (see Hypothesis *H5.1* and Hypothesis *H5.2*). While this is a revision of Chapter 5, it is crucial to recall these implications here in order to complete the entire picture.

H6.7 *Dynamic feedback leads to lower investments than static feedback.*

and

H6.8 *The higher the share of personal budget the lower are investments.*

All hypotheses are tested in the controlled laboratory experiments introduced in Chapter 3 by means of a questionnaire and physiological measurements. The next section describes how the sense of agency, hedonic value, and arousal were measured in detail.

6.2 Experimental Procedures and Instrumentalisation

The experimental design introduced in Chapter 3 was implemented in two experiments. Both these experiments were evaluated in Chapter 4 and 5 with a focus on monetary outcomes and budget allocation. In both cases, a subgroup of participants was attached to ECG electrodes to measure their physiological data during the experiments. A questionnaire was handed out to all participants at the end of each session.

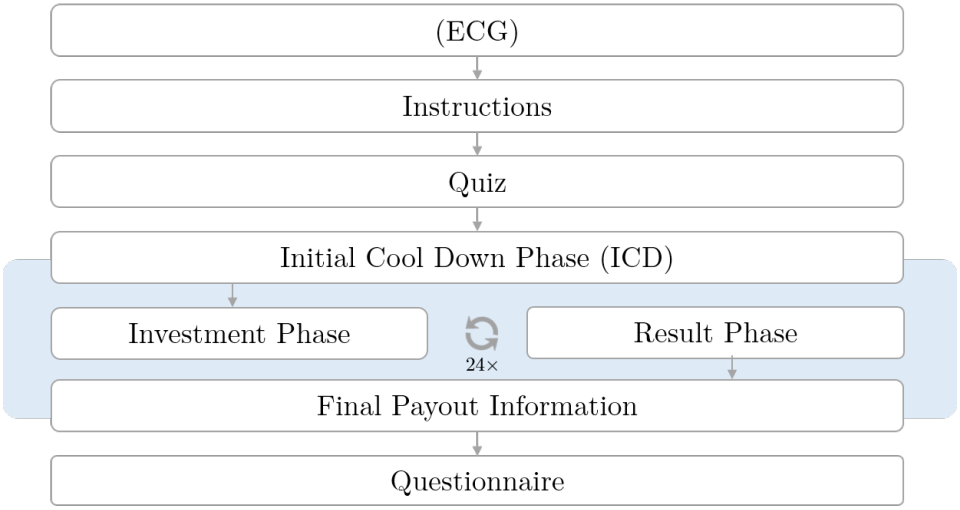

Figure 6.1: Recall: Experimental procedure. In case of physiological measurements, the experiment starts with the placement of ECG electrodes. Next, instructions are given and a quiz tests the understanding of the experiment. After an initial cool down phase (ICD) 24 rounds of investment and result phase are played, followed by final payout information, and a questionnaire.

Questionnaire

In both experiments a questionnaire was answered by all participants after 24 rounds of project funding. Both questionnaires contain demographic questions on age, gender and field of study as control variables. The questionnaire can be found in Appendix B.

In the first experiment which investigated the effect of personal budget on investment behaviour, the questionnaire included constructs on the sense of agency. The

sense of agency was measured by a self formulated 3-item construct. Since there was no validated construct found on the sense of agency, it was developed and formulated as 3-item construct based on the definition by Moore and Obhi (2012). All constructs were answered on a Likert scale with seven items.

The second experiment does not consider the sense of agency. It focusses on the investigation of the effect of dynamic feedback (DYN) and personal budget (PB) on perception of hedonic value (HED) and individual arousal (AR) is a key factor to consider in this regard. Figure 6.2 presents the research model which combines Hypotheses *H6.2*-*H6.6* and completes the analysis with investment behaviour (INV). To analyse investment behaviour (*H6.7* and *H6.8*), investments are measured as the sum of investments to project A to D by one person averaged over all 24 periods.

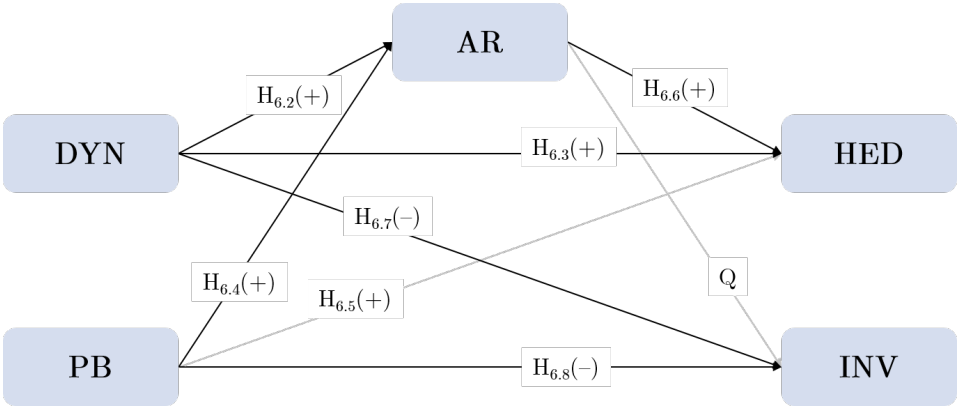

Figure 6.2: Research model: Hypotheses. AR: arousal, HED: hedonic value, DYN: dynamic feedback, PB: personal budget, INV: investment.

Physiological Measurements

In both experiments emotions are experimentally investigated in the economic context of investment decision-making. The theoretical and applied framework was already introduced in Section 3.1. Building on this foundation, the experiments presented in this thesis collected physiological data of 132 participants in total to gain insights on the emotional arousal of participants during the participatory budgeting process.

The physiological measurements allow to gain deeper insight in the emotional arousal of participants throughout the entire experiment. In contrast to self-

reported arousal in the questionnaire, physiological measurements reveal less biased data.

The arousal level of participants was measured with the help of the electric activity of the heart recorded by electrocardiograms (ECG) as described in Section 3.1. Participants were equipped with ECG sensors before the start of the experiment (see Figure 3.2). After the last part of the experiment, the questionnaire, sensors were removed and participants proceeded with collecting their payment. After a data conversion process the time between successive R-wave peaks in the ECG is transformed to obtain the heart rate. It is provided in units of beats per minute (bpm) (see Chapter 3).

The data set contains outliers that can be explained by loose sensors due to movement or other technical problems, such as network connectivity. Errors and artefacts in the measured heart rate data are usual (Jennings et al., 1981). It occurs that heart beats are missed or that extra "triggers" produce artificially short beats. Since these errors impact statistical analyses, they must be detected and corrected (Jennings et al., 1981). Jennings et al. (1981) suggests to declare errors as "missing data" and replace them by statistical estimates. To remove these outliers and avoid interference of the results, on an individual level data points above the personal 99% percentile and below the personal 1% percentile are removed. Missing values are replaced by a moving median with a subset size of 5 seconds. Heart rates are then normalised by taking the ratio of the heart rate (HR) at time t and the mean of the individual HR during the initial cool down phase (ICD).

$$HR_{\text{norm}}(t) = \frac{HR(t)}{\overline{HR}(\text{ICD})}, \text{ with } \overline{HR}(\text{ICD}) = \frac{1}{300}\sum_{t=1}^{300} HR(t),\ t \text{ in sec} \tag{6.1}$$

This enables a comparison between participants independent of the individual absolute level of their heart rate. The normalised HR can then be used as proxy for emotional arousal as described in Section 3.1.

6.3 Results

The results of the questionnaires and physiological measurements as they were described above, are presented in four parts. First, the questionnaire results on the sense of agency from the first experiment are presented testing Hypothesis *H6.1*. Second, the research model on Hypotheses *H6.2-H6.8* is investigated. Third, emotional arousal is investigated in more depth using physiological data from the first experiment testing *H6.4* and fourth, testing *H6.2* and Hypothesis *H6.4* with physiological data from the second experiment.

6.3.1 Sense of Agency

The first experiment investigates the effect of personal budget on the sense of agency (*H6.1*). It was conducted with 24 participants. The sense of agency was measured in a questionnaire by a 7-item Likert scale. Participants in the S0 treatment stated their level of agency with on average 5.81 out of 7 with a standard deviation of 0.77, whereas participants in the S100 treatment who were allowed to keep the budget privately reported on average a higher sense of agency and stated a mean of 6.02 with a standard deviation of 0.64.

The Cronbach's alpha value is 0.738 and therefore larger than the suggested 0.70 which supports the construct reliability. For the analysis and evaluation of the sense of agency, a t-test is run. It reveals no difference in the sense of agency of participants with personal budget in the S100 treatment and those who had no personal budget that they could keep privately in the S0 treatment ($p = 0.043$). Hypothesis *H6.1* can therefore be neither confirmed nor disproved.

It is therefore crucial to have a larger number of participants in order to allow for statistically significant results. Furthermore, it is recommended to first validate the questionnaire construct of the sense of agency in a separate study.

Result 1: There is no evidence that personal budget has an effect on the sense of agency.

6.3.2 Research Model on Questionnaire Data

The proposed research model presented in Figure 6.2 is based on Hypotheses *H6.2 - H6.8*. Besides the design parameters personal budget (PB) and dynamic feedback (DYN), the model includes the investments (INV) made by participants during the experiment and two questionnaire constructs. The questionnaire was handed out to the participants at the end of the second experiment that was introduced in Chapter 5. It includes the questionnaire constructs hedonic value (HED) and arousal (AR), which were both measured by a 7-item Likert scale.

The research model is validated using Structural Equation Modelling (SEM). The sample size of the second experiment with 216 participants is sufficiently large to validate the model in partial least-squares (PLS) (Gefen, 2000). The model is evaluated following a two-stage approach following Chin (2010) and Götz et al. (2010).

Before the analysis of the research model itself, the two constructs are summarised and the measurement model is tested in the first stage. All 216 participants of the experiment answered the questionnaire. Table 6.1 and Table 6.2 summarise means and standard deviations of hedonic value and arousal for all treatments. A first look at these statistics shows that participants who received dynamic feedback reported on average higher values for hedonic value (mean $\mu = 5.59$, standard deviation $\sigma = 1.30$) than those receiving static feedback (mean $\mu = 4.81$, standard deviation $\sigma = 1.13$). The same holds for arousal, where participants in dynamic feedback treatments state on average higher values (mean $\mu = 5.02$, standard deviation $\sigma = 1.17$) than those receiving static feedback (mean $\mu = 4.20$, standard deviation $\sigma = 1.38$).

Hence, the measurement model is tested. The reliability of the construct items is verified by applying an exploratory factor analysis and checking for item loadings (Table 6.3). The highest cross-loading is as low as 0.139 (see Table 6.3 for cross-loadings of HED3 with AR), comfortably below the standard threshold of 0.4. Testing the construct reliability reveals Cronbach's alpha values larger than 0.70. The composite reliability takes values larger than 0.60. Therefore all constructs have values larger than the suggested thresholds (Nunnally and Bernstein, 1994; Bagozzi and Yi, 1988) (Table 6.4).

FB/PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	4.77	4.88	4.79	4.81
	(1.49)	(1.16)	(1.30)	(1.31)
FB_{dyn}	5.08	5.71	5.97	5.59
	(1.64)	(1.06)	(0.97)	(1.30)
Overall	4.93	5.30	5.38	5.20
	(1.56)	(1.18)	(1.29)	(1.36)

Table 6.1: Average values of hedonic value per treatment (and standard deviations) measured on a 7-item Likert scale. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

FB/PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	3.80	4.52	4.29	4.20
	(1.34)	(1.39)	(1.35)	(1.38)
FB_{dyn}	4.89	5.00	5.17	5.02
	(1.23)	(1.32)	(0.93)	(1.17)
Overall	4.34	4.76	4.73	4.61
	(1.39)	(1.37)	(1.23)	(1.34)

Table 6.2: Average values of arousal per treatment (and standard deviations) measured on a 7-item Likert scale. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

Next, convergent validity is established by examining each construct's Average Variance Extracted (AVE). Results show that this value exceeds the suggested threshold of 0.5 (Au et al., 2008). This criterion is met by all the constructs in the model (Table 6.4). Discriminant validity was assessed by verifying that the square root of the AVE for each construct was larger than correlations between that construct and any other construct (Fornell and Larcker, 1981). The next step in evaluating discriminant validity is to check whether the item loadings on their theoretical constructs were larger than their loadings on other constructs. A difference of at least 0.10 is recommended (Chin, 2010). All adapted measures met the criteria for discriminant validity, as shown in Tables 6.5 and 6.6.

The structural model presented in Figure 6.2 is assessed. First, the R^2 values of the endogenous constructs of the model are examined. Although there is no specific threshold for this measure, Gefen (2000) suggest that larger values are better. Falk and Miller (1992) recommend R^2 values of at least 0.10. As can be seen in Figure 6.3,

		Item loadings	
Construct	Item	AR	HED
AR	AR1	0.724	0.087
	AR2	0.807	0.057
	AR3	0.993	-0.053
HED	HED1	-0.044	0.970
	HED2	-0.010	0.902
	HED3	0.139	0.756

Table 6.3: Item reliability assessment (exploratory factor analysis). AR: arousal with three items (AR1-AR3), HED: hedonic value with three items (HED1-HED3).

Construct	Composite reliability	Cronbach's alpha	AVE
AR	0.933	0.892	0.823
HED	0.949	0.920	0.862

Table 6.4: Construct reliability assessment. AR: arousal , HED: hedonic value.

all R^2 values exceed this threshold. The antecedents of hedonic value (HED) explain 34.2%, and the antecedents of investment behaviour (INV) explain 43.3% of the respective construct's variance.

As shown in Figure 6.3, all except one of the hypothesised relationships are supported by the data. Effect sizes of all paths are displayed in Table 6.7. The non-significant paths fall short of the threshold of .02 and thus have effect sizes below "small", following common guidelines (Rosenthal, 1991).

The model reveals a highly significant effect of dynamic feedback on the arousal level of participants compared to static feedback with a small effect size, confirming Hypothesis *H6.2*. Participants who receive continuously updated information during the funding of public projects experience this mechanism as being more exciting than those exposed to only aggregated feedback.

Result 2: Dynamic feedback leads to higher perceived arousal than static feedback.

Dynamic feedback (DYN) also has a significantly positive effect on hedonic value (HED) with a small effect size. This confirms Hypothesis *H6.3*. Participants not

	DYN	PB	AR	HED	INV
DYN	-				
PB	0.000	-			
AR	0.306	0.118	0.907		
HED	0.288	0.137	0.567	0.928	
INV	-0.358	-0.552	-0.17	-0.267	-

Table 6.5: Construct correlation matrix. Values on the diagonal indicate the square root of AVE. AR: arousal, HED: hedonic value, DYN: dynamic feedback, PB: personal budget, INV: investment.

	AR	HED
AR1	0.873	0.501
AR2	0.905	0.521
AR3	0.942	0.519
HED1	0.508	0.943
HED2	0.503	0.925
HED3	0.563	0.917

Table 6.6: Loadings and cross-loadings of measurement items. AR: arousal with three items (AR1-AR3), HED: hedonic value with three items (HED1-HED3).

only are more excited when getting feedback, but also enjoy the funding process more.

Result 3: Dynamic feedback leads to higher levels of perceived hedonic value than static feedback.

When looking at the impact of the second design variable, personal budget, in the model, it can be seen that a higher share of personal budget leads to a higher perception of arousal. Therefore, Hypothesis *H6.4* can be confirmed. Investing a budget that can also be kept privately is experienced as more exciting.

Result 4: The higher the share of personal budget, the higher is the level of perceived arousal.

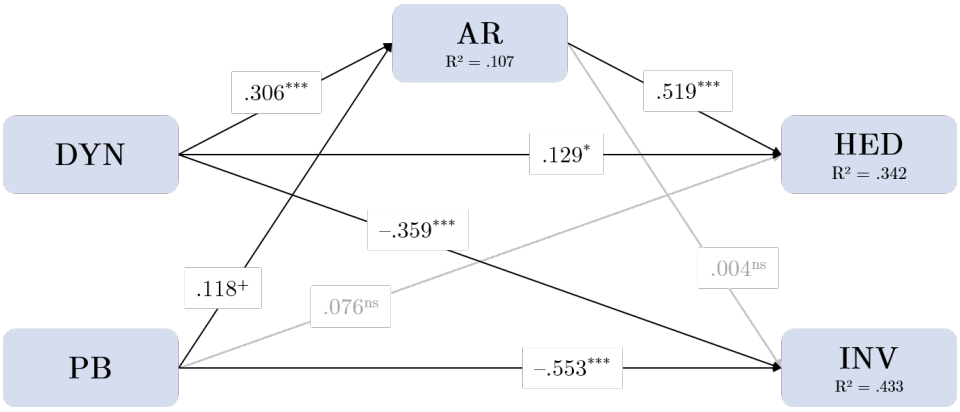

Figure 6.3: Research model. AR: arousal, HED: hedonic value, DYN: dynamic feedback, PB: personal budget, INV: investment.

Testing Hypothesis *H6.5*, there is no significant relationship found between personal budget (PB) and hedonic value (HED). The effect size is found to be below the threshold of small effects (Rosenthal, 1991).

Result 5: The share of personal budget does not affect the perceived hedonic value.

The research model reveals that the effect of personal budget on hedonic value is mediated by the perception of arousal. Arousal is found to positively affect hedonic value. This confirms Hypothesis *H6.6*. Participants who are more excited, i.e. who perceive higher levels of emotional arousal also experience higher levels of hedonic value, enjoying the funding process more.

Result 6: The higher the level of perceived arousal, the higher is the perceived hedonic value.

The experimental results concerning the impact of both design variables on the investment behaviour confirm the results from Chapter 4 and Chapter 5. Moreover, there was also no significant effect from perceived arousal (AR) to INV.

Result 7: There is no effect found of the level of perceived arousal on the investment behaviour.

Path			f2	Effect size
DYN	→	AR	0.11	small
DYN	→	HED	0.02	small
DYN	→	INV	0.21	medium
PB	→	AR	0.02	small
PB	→	HED	0.01	-
PB	→	INV	0.53	large
AR	→	HED	0.37	large
AR	→	INV	0.00	-

Table 6.7: Construct correlation matrix. Values on the diagonal indicate the square root of AVE. AR: arousal, HED: hedonic value, DYN: dynamic feedback, PB: personal budget, INV: investment.

6.3.3 Physiological Response

In two experiments, participants' physiology was measured during the funding decisions. Foundations on emotions were introduced in Section 2.3, the method of measuring participants' physiology to gain insights in their emotional arousal was presented in Section 3.1.

Physiological Measurements of the First Experiment

In the first experiment, all 24 participants were attached to ECG electrodes to record participants' heart rate during the entire experiment. Heart rates (HR) are derived from the ECG data. Physiological data of 5 of 24 participants could not be used due to technical problems during the recording. A session plan is provided in Table 6.8. The HRs of all other participants were normalised by taking the ratio of the HR and the averaged individual HR during the initial cool down phase as defined in Equation 6.1. This normalisation yields values between 0 an 1. Figure 6.4 shows the normalised HR per treatment averaged over periods and participants. Participants in the S0 treatment, where they invest a budget that they are not allowed to keep privately, have an average normalised heart rate of 0.991 with a standard deviation of 0.069. Those participants in the S100 treatment, where they are allowed to keep budget privately, have a normalised heart rate of 0.968 on average with a standard

deviation of 0.050 (see Table 6.11). The statistical analysis is based on average values per participant per period.

Session-ID	treatment	Physio	Physio correct
1	S100	yes	10/12
2	S0	yes	9/12

Table 6.8: Session plan. Treatment abbreviation, measurement of physiological data and the number of usable physiological data sets.

nHR	S0	S100	overall
Mean	0.991	0.968	0.980
Std. dev.	(0.069)	(0.050)	(0.061)

Table 6.9: Average normalised heart rates (and standard deviation) in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget.

To statistically test the difference in the level of emotional arousal between the treatments, a generalised least-squares mixed effects regression is conducted (Table 6.10, Regression (1)) controlling for participant properties and periods. The average normalised HR is used as dependent variable, a treatment dummy PB_{100} as independent variable which is $PB_{100} = 1$ if the participant was in the S100 treatment. Additionally, the regression includes a period variable (1-24). The regression (R^2=0.0659) shows no significant treatment effect (coef. $= -0.0236$, $p = 0.283$). This leads to the conclusion that emotional arousal is not correlated with the opportunity to keep the budget privately as it was designed in the S100 treatment with 100% personal budget.

Result 8: There is no correlation found between the level of emotional arousal and personal budget.

However, a significant period effect is observed (coef.$= -0.00151$,$p < 0.001$), participants' average normalised HR significantly decreases over the course of the experiment. This is in line with the literature (Hariharan et al., 2016).

Running the same regression with an additional gender dummy $female$ (Table 6.10, Regression (2)) does not show any differences for the treatment nor period variable and reveals the same effect size and direction of the treatment variable and does

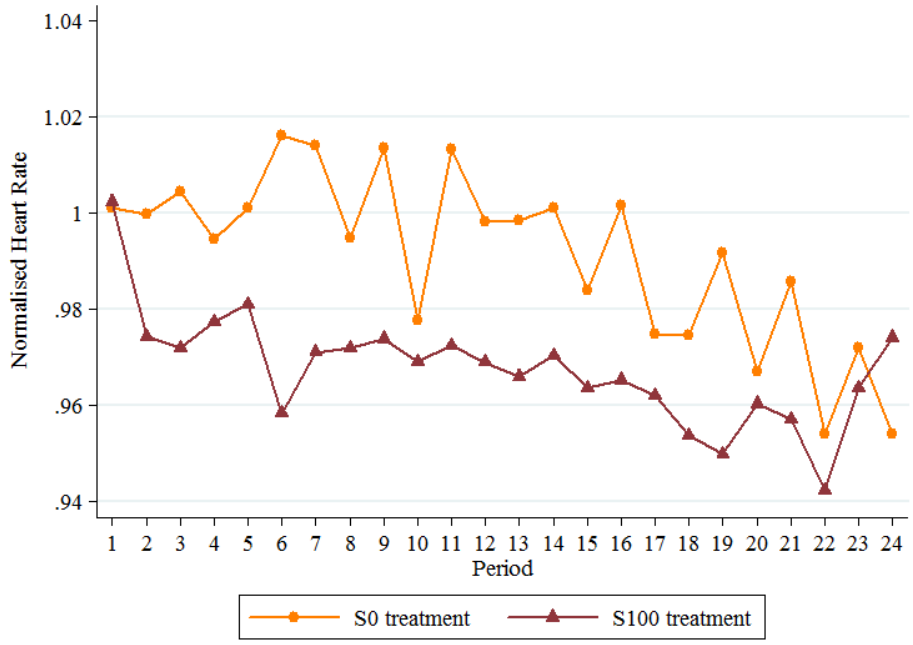

Figure 6.4: Average normalized HR by treatment in the S0 treatment with 0% personal budget and the S100 treatment with 100% personal budget in MU over 24 periods.

	normalised HR		
	(1)	(2)	(3)
PB_{100}	- 0.0236	-0.0243	-0.0240
	(0.0220)	(0.0229)	(0.0236)
period	-0.00151***	-0.00151***	-0.00153***
	(0.000275)	(0.000275)	(0.000276)
female		-0.00517	-0.00528
		(0.0237)	(0.0244)
investment			0.0000966
			(0.000181)
intercept	1.010***	1.014***	0.999***
	(0.0155)	(0.0230)	(0.0357)
N	455	455	455
R^2	0.0659	0.0674	0.0668

Table 6.10: Regressions of averaged normalised HR per participant per period. PB_{100}: 100% personal budget, *period*: period 1-24, *female*: female participants, *investment*: investment level. $^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

not show a gender effect in the level of normalised heart rate (coef. $= -0.00517$, $p = 0.827$).

Result 9: There is no gender effect found for the level of emotional arousal.

The correlation between emotional arousal and investment behaviour is investigated in Table 6.10, Regression (3). The independent variable "investment" is added to the previous regression. Investment is defined as the sum of investments to projects A to D of one participant in one period. The regression does not reveal any correlation between the average normalised heart rate of participants and their respective investments (coef.$= 0.000097$,$p = 0.593$).

Result 10: There is no effect found of the level of investments on emotional arousal.

These results present a first attempt to investigate emotions in participatory budgeting in a controlled experimental setting. There is no measurable evidence for an endowment effect in terms of emotional arousal when investing money that could or could not be kept as an outside option. As the sample size of 19 participants was quite small, the following conduction of more sessions in the second experiment with more than 120 physiological data sets of participants further investigates the conjectures.

Physiological Measurements of the Second Experiment

The second experiment on crowdfunding in the context of participatory budgeting (described in Chapter 5) was conducted with 216 participants at the Karlsruhe Decision and Design Lab (KD^2Lab) in March 2016. In addition to the treatment variable *personal budget*, the experiment investigates the effect of dynamic *feedback*. 132 of 216 participants were equipped with ECG sensors to record their physiology during the experiment. This allows the investigation of the impact of physiological measurements on the investment behaviour and assures that effects not only hold for participants attached to sensors but also for those without sensors.

Physiological data sets of 10 of 132 participants could not be used due to technical problems during the recording. This is due to loose or defective ECG sensors. A session plan is provide in Table 5.2. Outliers were removed by replacing the

individual 1% and 99% percentile of a participants' heart rate values. A moving median method with an interval size of 5 seconds was then applied to all data to substitute missing values. To make heart rates comparable between participants with physiological ranges, the individual mean heart rate during the initial cool down phase (ICD) at the beginning of the experiment is used to normalise heart rate values.

The normalised heart rates by treatments are presented in Figure 6.5 and Figure 6.6. The average normalised heart rates per treatment are summarised in Table 6.11. It can be seen that normalised heart rates are on average higher if dynamic feedback is given for participants with 0% and 50% personal budget.

FB/PB	PB_0	PB_{50}	PB_{100}	Overall
FB_{stat}	0.990	0.979	1.006	0.992
	(0.046)	(0.060)	(0.061)	(0.057)
FB_{dyn}	1.012	1.014	1.004	1.010
	(0.062)	(0.071)	(0.054)	(0.063)
Overall	0.998	0.997	1.005	1.000
	(0.053)	(0.068)	(0.058)	(0.061)

Table 6.11: Average normalised heart rates per treatment (and standard deviations). PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{stat}: static feedback, FB_{dyn}: dynamic feedback.

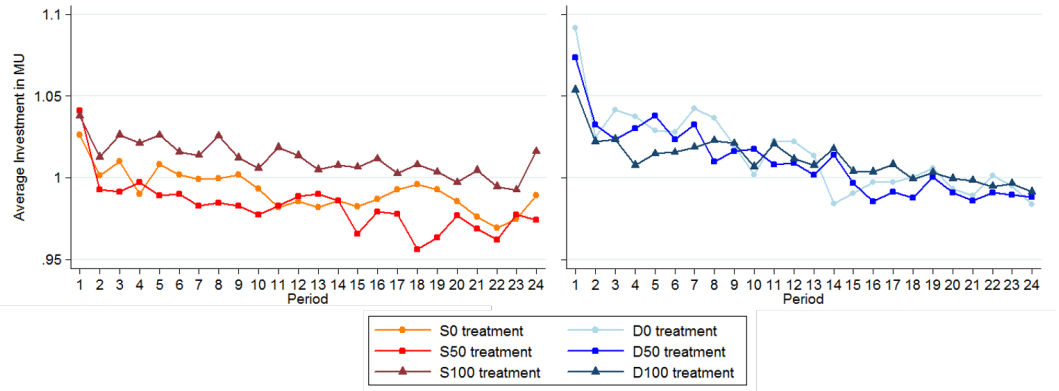

Figure 6.5: Average normalized HR by feedback treatments.

To analyse the impact of dynamic feedback and personal budget on arousal, a generalised least-squares (GLS) mixed effects regression, controlling for participants' properties and the 24 periods of the experiment is conducted. The regression is

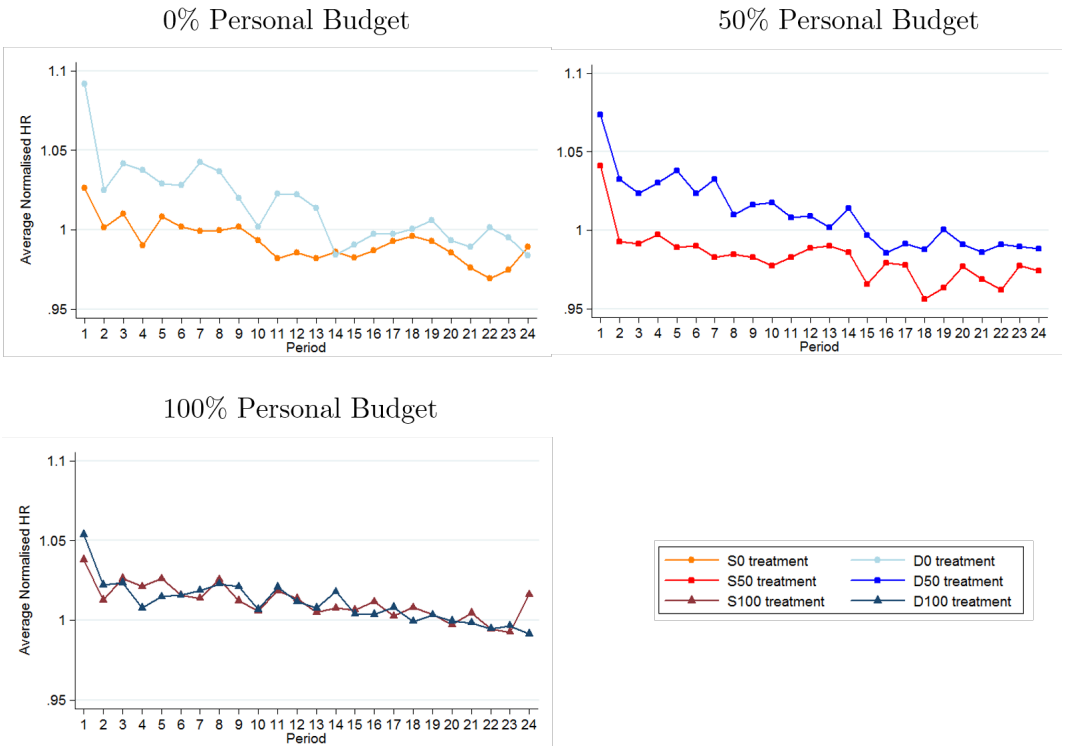

Figure 6.6: Average normalized HR by personal budget treatments.

based on 2928 observations (122 participants and 24 periods). The dependent variable is the average normalised heart rate, treatment dummy variables for dynamic feedback (FB_{dyn}), 50% personal budget (PB_{50}), and 100% personal budget are used as independent variables as well as a period variable. This leaves static feedback and 0% personal budget as baseline of the first regression. Results are summarised in Table 6.12, Regression (1). Dynamic feedback (FB_{dyn}) has a positive effect on the normalised heart rate of participants (coef.= 0.0176, $p = 0.050$), confirming Hypothesis *H6.2*.

Result 11: Dynamic feedback leads to higher arousal.

However, there is no impact of personal budget found on the normalised heart rate. Neither the difference between 0% and 50% personal budget is significant (coef.= -0.00410, $p = 0.718$) nor the difference between 0% and 100% personal budget (coef.= 0.00416, $p = 0.712$). Supplementary analysis (see Table 6.12, Regression (2)) revealed no difference between 50% and 100% personal budget (coef.= 0.00827, $p = 0.427$).

	normalised HR			
	(1)	(2)	(3)	(4)
PB_0		0.00410		
		(0.0114)		
PB_{50}	-0.00410		-0.00448	-0.00423
	(0.0114)		(0.0114)	(0.0115)
PB_{100}	0.00416	0.00827	0.00475	0.00539
	(0.0113)	(0.0104)	(0.0114)	(0.0114)
FB_{dyn}	0.0176*	0.0176*	0.0181*	0.0186*
	(0.00897)	(0.00897)	(0.00903)	(0.00908)
period	-0.00189***	-0.00189***	-0.00189***	-0.00190***
	(0.0000902)	(0.0000902)	(0.0000902)	(0.0000903)
female			-0.00636	-0.00616
			(0.0104)	(0.0104)
investment				0.0000211
				(0.0000227)
intecept	1.016***	1.012***	1.017***	1.014***
	(0.00921)	(0.00872)	(0.00950)	(0.0102)
N	2928	2928	2928	2928
R^2	0.0729	0.0729	0.0729	0.0729

Table 6.12: Regressions of averaged normalised HR per participant per period. PB_0: 0% personal budget, PB_{50}: 50% personal budget, PB_{100}: 100% personal budget, FB_{dyn}: dynamic feedback, *period*: period 1-24, *female*: female participants, *investment*: investment level. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Result 12: There is no effect found of personal budget on the normalised heart rate.

Over the course of the experiment, the normalised heart rate decreases, a negative coefficient for period is significant (coef.$= -0.00189$, $p < 0.001$). This finding is in line with previous research, where the heart rate was measured during experiments (Hariharan et al., 2016).

To investigate gender effects, the same GLS mixed effects regression is conducted with an additional gender dummy *female* (Table 6.12, Regression (3)). It reveals the same effect size and direction of the treatment variable and does not show any gender effect in the level of normalised heart rate (coef. $= -0.00636$, $p = 0.540$).

Result 13: There is no gender effect found for the level of emotional arousal.

Regression (4) in Table 6.12 investigates the impact of investment levels on the normalised heart rate. The independent variable *investment* is added to the previous regression. Investment is defined as the sum of investments to projects A to D of one participant in per period. The regression does not reveal any correlation between the average normalised heart rate of participants and their investment levels (coef. $= 0.0000211$, $p = 0.353$).

Result 14: There is no evidence that investment behaviour has an effect on emotional arousal.

To complete the analysis for Research Question **RQ3**, the impact of arousal on the investment behaviour is investigated. This analysis expands the results from perceived arousal from the questionnaire by physiological heart rate data that was collected during the experiment. Table 6.13 expands the generalised least-squares mixed effects regressions in Table 5.4. The dependent variable is the sum of investments A to D by one participant made in one round. The independent variables are three treatment dummy variables PB_0 for 0% personal budget, PB_{100} for 100% personal budget, and FB_{dyn} for dynamic feedback. Additionally nHR denotes the normalised heart rate (between 0 and 1), *period* is used as time variable (from 1 to 24). Regression (1) displays the result of the first regression with these variables. It shows the same effect directions and similar effect sizes as the regressions without the normalised heart rate in Chapter 5. The normalised heart rate and therefore the emotional arousal does not have a significant effect on investments (coef.$= 13.17$, $p = 0.354$). Similar results are revealed by Regression (2). Adding a gender dummy variable $female$ does not reveal an impact of the normalised heart rate on the investment behaviour (coef.$= 12.32$, $p = 0.384$).

Result 15: There is no evidence that emotional arousal has an effect on investment behaviour.

6.4 Evaluation and Implications

In summary, the effect of the sense of agency, i.e. the sense of initiating and controlling actions, in participatory budgeting was investigated by means of a questionnaire. There is no significant evidence for an effect of personal budget

	Investments	
	(1)	(2)
PB_0	10.99*	11.58**
	(4.328)	(4.244)
PB_{100}	-19.42***	-17.99***
	(3.942)	(3.091)
FB_{dyn}	-23.80***	-23.00***
	(3.414)	(3.358)
nHR	13.17	12.32
	(14.21)	(14.16)
period	0.236**	0.235**
	(0.079)	(0.079)
$female$		-9.754*
		(3.857)
Intercept	134.1***	133.0***
	(2.808)	(3.463)
N	2947	2947
R^2	0.226	0.237

Table 6.13: Regressions of the sum of investments per participant per period averaged over sessions. Standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001. PB_0: 0% personal budget, PB_{100}: 100% personal budget, FB_{dyn}: dynamic feedback, nHR: normalised heart rate, *period*: period 1-24, $female$: female participants. $^+$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

on the level of agency (*Result 1*). However, the self-formulated construct based on the definition of the sense of agency, was not found to be a valid construct. Results are therefore based on the 3-item construct. Results suggest that participants who are able to keep the entrusted budget perceive their decision-making as controlling as those who cannot keep it privately.

The perception of hedonic value and emotional arousal in participatory budgeting were investigated in more depth in the second experiment. A research model proposed the impact of dynamic feedback and personal budget on hedonic value, mediated by perceived arousal, as well as investment behaviour. Results show that dynamic feedback leads to a higher perception of hedonic value (*Result 2*). Participants enjoy dynamic investment mechanisms with a higher level of interaction more.

Self-reported arousal is higher when participants are exposed to dynamic feedback (*Result 3*). The interaction created by dynamic feedback during the funding and the possibility to fund multiple times is perceived to be more exciting. Furthermore, perceived arousal leads to higher hedonic value (*Result 6*). This result shows that dynamic feedback not only has a direct effect on hedonic value but is also partially mediated by arousal.

Dynamic feedback leads to lower levels of investments than static feedback, which was already investigated in detail in Chapter 5. By the additional feedback during the investment process, participants can better coordinate their investments between projects. Investments are, however, not affected by the level of perceived arousal (*Result 7*).

Dynamic feedback is implemented by a continuously updated funding status of projects and enables some kind of social interaction. Results of the evaluated research model suggest that dynamic feedback impacts both target variables hedonic value and the level of investments. Participants have more fun when investing in mechanisms with dynamic feedback and, at the same time, invest more. This is desired by institutions and platform designers who want to motivate their constituents to participate and encourage the funding of public projects.

The second design variable, personal budget, does not affect hedonic value directly. Participants with a higher share of personal budget do not have a different perception of hedonic value than those with a lower share of personal budget (*Result 5*).

Participants with a higher share of personal budget tend to have a higher perceived arousal when investing budget that can also be kept privately (*Result 4*). This effect is not found when investigating arousal by means of physiological measurements. The share of personal budget has no significant influence on the average normalised heart rate and therefore on the emotional arousal during the investment process (*Result 12*). Participants with higher shares of personal budget, however, report higher levels of arousal when asked at the end of the experiment. There are two explanations for the behaviour. Either participants with a high share of personal budget perceive their arousal higher than it actually was during the investment process, or, participants with low shares of personal budget perceive the level of arousal lower than it actually was, when asked after the experiment .

Perceived arousal is found to lead to a higher perceived hedonic value (*Result 6*). Therefore, personal budget does not impact hedonic directly, but is mediated by perceived arousal.

The level of investments is affected by the share of personal budget, which was already investigated in Chapter 5. Participants with higher shares of personal budget invest less to the public projects.

The evaluation of arousal measured by physiological measurements enables an unbiased look at the arousal and excitement of participants. Participants who receive dynamic feedback have a higher normalised average heart rate, therefore, it leads to a higher level of emotional arousal (*Result 11*). This is in line with the results of the research model that included self-reported arousal from a questionnaire.

Policy makers who aim for excited constituents need to decide if they want to base the decision of which mechanism to choose on the actual excitement of participants experienced during the funding process or on the perceived excitement they remember after the funding process. The share of personal budget does not affect the level of arousal, however, it is perceived differently. When aiming for excitement during the process, policy makers can therefore base their decision on other objectives. If perceived arousal is aimed for when looking back on the process, policy makers and institutions should choose higher shares of personal budget.

In this chapter, hedonics and emotions were investigated in the context of participatory budgeting. Two design parameters, feedback dynamics and personal budget, were applied to a crowdfunding mechanism for the participatory allocation of an institutional budget. The effect of the design parameters on hedonics and emotions of participants can not only be discussed from participants' perspective who experience the funding mechanisms but also from the institution's perspective and a global view on the process.

Constituents' Perspective

Constituents experience more excitement when exposed to funding mechanisms with dynamic feedback and enjoy the funding process more. Since this is a driver

for motivation, constituents are more likely to participate again. Being entrusted with a personal budget that constituents can keep privately leads to a higher perception of fun. Self-reported emotional arousal is also higher for those being able to keep the budget. However, this is not found in the physiological data collected during the process. Constituents are more excited about the funding with personal budget ex post, than they are during the process. In contrast, constituents are as excited when investing budget that they cannot keep but experience it less exciting ex post.

Institution's Perspective

Institutions solely aiming for excited constituents who enjoy the funding process, should chose mechanisms with dynamic feedback. These mechanisms lead to higher levels of observed as well as self-reported emotional arousal and hedonic value. The choice whether to provide personal budget or not is more complex. While personal budget leads to higher self-reported excitement and constituents state that they enjoy the process more ex post, there is no evidence for a higher emotional arousal found in the physiological data. If institutions aim for ex post excitement and hedonic value, personal budget can help to achieve that. A difference in emotional arousal during the funding process between different levels of personal budget, however, is not seen. Institutions are free to focus on other objectives such as monetary outcomes investigated in Chapter 5.

Global Perspective

A global view on emotions is always difficult as it is such a personal experience. It can generally be said that excitement and enjoyment enhances motivation to participate and leads to further participation in later processes. Dynamic feedback leads to higher levels of emotional arousal and hedonic value and can therefore be recommended. Since there is no correlation found between investments and arousal, emotions do not impact the investment behaviour and are therefore not

relevant for monetary outcomes in this scenario. From a global perspective monetary objectives might be more relevant than small differences in self-reported hedonics.

The evaluations of hedonics and emotions in the context of participatory budgeting contributes to the grand challenge of finding appropriate mechanisms that support participatory decision-making. More specifically, two research questions were investigated. The evaluation of Research Question **RQ2** revealed that design parameters impact the perception of hedonic value and emotions. Especially the support of a continuous information flow during the decision-making process increases excitement and enjoyment of the mechanisms, which is an indicator for participation in future participation processes. The evaluation of Research Question **RQ3** did not reveal any significant effects of emotions on investments or vice versa. Neither do more excited people invest more in the context of participatory budgeting, nor do they react emotionally on monetary outcomes during the process.

Part IV

Finale

Chapter 7

Conclusion

"The best way to predict the future is to invent it."

(Alan Curtis Kay, 1985)

In this thesis, mechanisms were evaluated that satisfy the call for participation by supporting collaborative decision-making. In particular, crowdfunding mechanisms were applied to participatory budgeting where the institution lets participants decide over the allocation of an institutional budget. These mechanisms combine the advantage of civic crowdfunding and also foster social equality among participants. As the design of such processes is crucial for the outcome, the impact of design parameters was investigated by means of controlled laboratory experiments. In particular, it was evaluated how different design parameters increase participants' hedonic value and emotional arousal and, at the same time, achieve high individual payouts as well as welfare gain. Two design parameters that were shown to be important drivers of emotions and budget allocation are feedback and personal budget.

7.1 Contributions

This thesis contributes to the challenge of designing mechanisms that support participatory decision-making. In particular, it contributes to the domain of participatory budgeting by evaluating the impact of design variables of crowdfunding

mechanisms on the budget allocation and participants' emotions. Two design parameters, the share of personal budget in funding processes and the dynamics of feedback during the funding of public projects are investigated. In regard of the proposed research questions in Section 1.2, the thesis contributes to the understanding of outcome-related effects, such as welfare gain, individual payouts, hedonic value, and emotions, of participatory mechanisms for budget allocation.

The following three subsections summarise the contributions to the respective research questions. In particular, the impact of design parameters on budget allocation (**RQ1**), on emotions (**RQ2**), and the relationship between monetary outcomes and emotions (**RQ3**) are presented. Furthermore, implications for policy makers are given.

7.1.1 The Impact of Design Parameters on Monetary Outcomes

The first part of this thesis investigated the impact of two design parameters on the allocation of an institutional budget. Therefore, two controlled laboratory experiments were conducted based on the following research question (see Chapter 4 and 5).

RQ 1 **What effects do design parameters have on budget allocation when applied to participatory budgeting?**

Institutions that offer participatory budgeting in order to satisfy the call for collaborative and cooperative decision-making can vary in a variety of design parameters. Two important ones were evaluated in this thesis, the impact of dynamic feedback and the share of personal budget. When striving for a general welfare increase, institutions should employ dynamic feedback mechanisms in participatory budget allocation. Results show that dynamic feedback stimulates the funding of projects. Participants receiving continuously updated feedback on the current funding status of projects are able to coordinate better than those who only receive static feedback after the investment. Therefore, dynamic feedback results in overall higher welfare gains which represents a main goal of enterprises and governments.

On the one hand, institutions profit from dynamic feedback mechanisms in terms of higher welfare gain when including individuals in their budget allocation. On the other side, individuals benefit from increased utility and better coordination when exposed to a dynamic mechanism. This results in less frustration due to coordination issues or unexpected outcomes which in turn indicates higher participation in subsequent processes. These aspects need to be considered by institutions and platform designers implementing such processes. If aiming for a high welfare gain in participatory budgeting, the application of dynamic feedback will increase these outcomes.

Besides feedback mechanisms, the impact of personal budget was investigated. While civic crowdfunding requires private donors to invest in public projects, what can lead to social inequalities, participatory budgeting is purely based on the allocation of institutional budget (Davies, 2015; Shah, 2007). The decision on the share of personal budget must be made carefully, since constituents might keep and not reinvest the institutional budget. This poses as a risk for the institution. The results of two laboratory experiments in Chapter 4 and 5 showed that higher personal budget shares lead to a decrease in investments. The results reveal that people who are allowed to keep parts of the budget privately take that opportunity.[1] Consequently, welfare gains from successfully funded projects were lower. Thus, institutions can achieve high welfare gain by implementing mechanisms which do not offer a personal budget share. However, participants were able to produce higher individual payouts with the help of personal withholdings. Hence, personal budget is individually more profitable but at the cost of the social surplus of the community.

7.1.2 The Impact of Design Parameters on Emotions

The impact of feedback dynamics and the share of personal budget on the hedonic value and emotions of the individuals was addressed by Research Question **RQ2**.

[1] However, only less than 1% of decisions were found to be pure free-riding, where a participant kept the entire budget.

RQ 2 What effects do design parameters have on emotions when applied to participatory budgeting?

Results of two experiments with physiological measurements and corresponding questionnaires were presented and evaluated in Chapter 6. Results do not reveal a significant difference in hedonic value or emotional arousal across different levels of personal budget regardless of the feedback characteristics. Only the perceived arousal after the experiment is found to be marginally higher for larger shares of personal budget. This implicates that participants find these mechanisms equally engaging but might remember larger shares of personal budget as more exciting and more enjoyable. Platform designers can therefore safely choose between mechanisms, keeping objectives such as welfare gain or maximising institutional budget in mind when focussing on the actual arousal level during the process. Care must however be taken when aiming for a perception of enjoyment and excitement after the process since higher shares of personal budget might be remembered as more exciting.

Furthermore, dynamics of feedback are investigated as a design parameter in mechanisms where projects of public interest were funded with an institutional budget. The evaluation of Chapter 6 showed that participants who receive dynamic feedback during the investment phase have a significantly higher emotional arousal level than those who only receive static feedback. The opportunity to invest multiple times and react on other group members' investments expands the strategy space leading to a more complex decision process and interaction between participants. Dynamic feedback, hence, increases the hedonic value and, therefore, seems to create a situation that is more exciting and engages participants with the decision-making process. In other words, constituents are happier, an objective targeted by institutions as they benefit from the constituents' motivation (Lindner et al., 2015).

Summarising the contributions derived from answering Research Question **RQ1** and **RQ2**, both design parameters affect the budget allocation as well as emotions of participants. Dynamic feedback supports the institutional objective of welfare gain while providing participants not only monetary advantages but also an enjoyable and exciting experience. These factors are potential drivers for the success of

participatory budgeting and the participatory process it is embedded. The choice of the share of personal budget given to participants is more complex. While there is no difference in emotional arousal, low levels of personal budget lead to higher welfare gains and do not bear the risk of losing parts of the budget to private withholdings, whereas higher levels of personal budget lead to a higher perception of hedonic value and arousal after the funding process.

7.1.3 The Relationship between Investment Behaviour and Emotions

While the impact of the design parameters on budget allocation and emotions was investigated in the previous research questions, the relationship between the two outcomes is evaluated by the third research question. This research question was addressed and evaluated in Chapter 6.

RQ 3 Do monetary outcomes and emotions influence each other in participatory budgeting?

First, the impact of emotions on the investment behaviour is addressed. The emotional arousal measured by participants' physiology, however, does not affect the level of investments. Hence, more excited participants are not found to invest more (or less) in participatory budgeting. Policy makers and platform designer can therefore freely decide between more exciting mechanisms, e.g. dynamic feedback mechanisms, and less exciting ones, when worrying about the correlated change in investment behaviour. Second, the impact of investment behaviour on emotions was addressed. Evaluations show that the level of investments does not affect the emotional arousal of participants during the funding of public projects. More excited participants do not invest more, as it might appear in the context of auctions (Adam et al., 2015). Although the design parameter of feedback dynamics affects the investment behaviour as well as the emotional arousal of participants, the two outcomes are not related. While the share of personal budget affects the monetary outcomes and investment behaviour, but not the emotional arousal during the funding. Emotions can not explain the investment behaviour.

7.1.4 Policy Suggestions

Governments and corporations can adapt the concept of crowdfunding mechanisms to allocate budgets by a group, such as citizens or employees. The results show that dynamic feedback leads to more excitement and higher perception of hedonic value than static feedback. Constituents will therefore be more intrinsically motivated to participate in such participatory processes. At the same time, dynamic feedback stimulates the funding of projects and results in overall higher welfare gains. Institutions focussing their decision on these target variables rather than other strategic considerations should design crowdfunding mechanisms with dynamic feedback properties for participative budget allocation. Maximising welfare and constituents' contentment represent two main goals of enterprises and governments (Lindner et al., 2015). Dynamic feedback mechanisms address and fulfil these requirements, satisfying the desire of Generation Y for being integrated in collaborative and cooperative decision-making processes (Eisner, 2005). Therefore, dynamic feedback mechanisms are recommended over over static feedback in participatory budget processes when focusing on the target variables of payouts, welfare, excitement, and hedonic value. Other factors that might lead to contradicting recommendations could be privacy concerns and political reasons that were not considered in this research.

The decision on the share of personal budget must be made carefully, since a larger share of personal budget leads to more excitement but constituents can keep it privately rather than reinvesting in the project funding. On the one hand, institutions aim for excitement and hedonic value of the constituents, which can be realised by offering them a personal budget that they could also keep. On the other hand, the opportunity of individuals to keep the personal budget poses also as a risk for the institution, as mentioned previously. The evidence shows that governments and corporations should consider these opposing trends. Care must be taken when deciding on a personal budget share as a balance of the corresponding effects is not trivial.

7.2 Outlook and Future Work

In this section, an outlook is given on possible applications to real projects, in particular on online participation platforms. Furthermore, future work that addresses the limitations of this thesis is discussed and solutions are outlined.

7.2.1 Application to Real Projects on Online Participation Platforms

This thesis contributes to the understanding of design parameters in participatory budgeting. The abstract level of the laboratory experiments allowed to understand the mechanism and the investment behaviour with a high internal validity. However, laboratory experiments always create an artificial environment. In the context of this thesis, preferences in form of utility values were exogenously given to participants. This limits the generalisability since private utilities for real public projects will be different and not observable. Arousal levels, too, cannot be generalised easily. When funding projects with real involvement, participants' emotions towards the content might interfere with the emotions caused by the mechanism. The consequent next step is to take this understanding in the field and test its external validity with real projects. This extends the controlled setting of given preferences by insights on the investment behaviour based on personal preferences. Furthermore, the success of online participation platforms depends on several stakeholders and their relationships. The online participation platform has to be designed to attract users and guide them through a well-defined process. The institution as initiator and policy maker is responsible for the transparency and actuality of the website and the utilisation of results. Users, i.e. citizens or employees, provide their discussions and decisions as necessary content on the website. The interaction of these three stakeholders, institution, individuals, and website, need to be further evaluated to gain a complete picture of online participation.

7.2.2 Ethical, Legal, and Social Implications of Online Participation Platforms

Online participation platforms designed for participatory budgeting have special needs and requirements are prerequisite. A supportive legal framework should be integrated in existing government practices and regulate the terms of all stakeholders' actions (Shah, 2007). The necessity for a well-defined process of budgeting outcomes within the institutions is higher and participants make more far-reaching decisions when it comes to financial decisions rather than discussions and project proposals on such platforms. Additionally, social implications need to be considered. Beside giving all citizens the right to participate, policy makers and platform designer should consider if all citizens also have the possibility to make use of this right. These factors require a profound revision and extension of the existing evaluation framework introduced by (Hellmanns et al., 2016).

7.2.3 Online participation and Social Media.

Social media impact the usage behaviour on online participation platforms in many ways (Niemeyer et al., 2016). Not only can social media help to attract participants to the platform, it can also enhance the bi-directional information flow between citizens and institutions. These factors should consistently and profoundly be taken into account when linking a new or an existing online participation platform to social media. The challenge is to make use of the positive opportunities by including technical, content-related, as well as interactivity requirements to obtain digitally native online participation platforms.

7.2.4 Live Biofeedback for Group Decisions

Emotions influence our health, decision-making, and social interactions. Hence, modern forms of opinion building and exchange, e.g., on online participation platforms, should consider the effects of emotions on individual and group level. Previous research on group interactions demonstrated that providing the members

with information about the affective state of the entire group, reciprocally influences the affective states of the individuals and can even increase group performance. Groups can benefit from live biofeedback. First research has examined how group live biofeedback based on the participant's heart rate impacts participation behaviour (Lux et al., 2015). This should be further investigated in the context of participation platforms.

In conclusion, the emerging concept of participatory budgeting was combined with crowdfunding mechanisms within this thesis and investigated by means of two laboratory experiments, based on the fundamental design variables of dynamic feedback and personal budget. This examination is not of purely academical interest but should be seen as a guideline on the pursuit of higher social welfare. In our time, participation in both public institutions and enterprises cannot be limited to simple polls anymore but more advanced processes of collaborative decision-making have to be implemented. Design parameters have to be well-chosen in order to achieve an efficient participatory budgeting process.

Within this work, it has been shown that both welfare and participants' excitement, two essential objectives, can be increased significantly by introducing dynamic feedback. This central conclusion is also reflected in the current trend of progressing digitalisation and drastically increased information flow. Therefore, on the basis of this thesis, future participatory processes can be optimised, thus helping to prosper social welfare both in municipal communities as well as enterprises. The thesis further suggests that participatory processes will need to adapt to future developments in information and communication technologies and corresponding effects on society. With the theoretical framework introduced within this thesis, the evaluation process will nevertheless stay the same but the recommended choice for policy makers will vary. While the commitment of personal budget is still a novel concept in governmental institutions today, companies with more freedom in their fiscal policy will be able to profit from the findings within this thesis. In particular, enterprises can decide on the share of personal budget to increase hedonic value at the cost of lower welfare. Nevertheless, with changing laws and progressing trends in society, personal budget will find its way into participatory budgeting processes of public institutions.

List of Figures

List of Tables

List of Symbols

$i, k \in I = \{1, ..., n\}$	individual
$j \in J = \{1, ..., m\}$	good or project
Π_i	payout of individual i
b_i	initial budget of individual i
α	marginal per capita return
n	number of individuals
γ	multiplication factor of public goods
c_j	cost threshold for project j
z_{ij}	investment of individual i in project j
u_{ij}	utility of individual i from funding of project j
W	welfare gain
E	efficiency

List of Abbreviations

ANS	Autonomic Nervous System
AR	Arousal
AVE	Average Variance Extracted
bpm	Beats per Minute
Brownie	Behavioral Research of groups using Web and NeuroIS Experiments
DYN	Dynamic Feedback
ECG	Electrocardiogram
FB	Feedback
GLS	Generalised Least-Squares Regression
HED	Hedonic Value
HR	Heart Rate
hroot	Hamburg Registration and Organization Online Tool
IBI	Interbeat Interval
ICD	Initial Cool Down Phase
ICT	Information and Communication Technology
INV	Investment
KD^2Lab	Karlsruhe Decision and Design Laboratory
KIT	Karlsruhe Institute of Technology
MPCR	Marginal per Capita Return
MU	Monetary Unit
nHR	Normalised Heart Rate
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least-Squares Regression
ORSEE	Online Recruitment System for Economic Experiments
PB	Personal Budget
PG	Public Good
RQ	Research Question

STA	Static Feedback
TPG	Threshold Public Goods

Part V

Appendix

Appendix A

Experimental Instructions

A.1 S0 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. In each round you will decide over the use of 150 monetary units (MU). You may use parts of it or the entire sum to invest in the funding of various projects.

Please note: the amount of your endowment that is not invested expires in this round.

You may choose from four different projects (A, B, C, and D). Each project is characterised by its threshold and the utility that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU, and Project D 400 MU. If one or more participants sufficiently funded a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also a participant who did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the different projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

In each round you have the **one-time** opportunity to invest in the funding of several projects. Please note: The total of your investments may not exceed your endowment.

Period earnings

After 60 seconds the investment phase ends, entered investments are automatically confirmed, and the round incomes are computed. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project
- Any amount from your endowment that was not invested expires

Thus, your round income in each round is computed as follows:

Your round income	=	utilities from funded projects

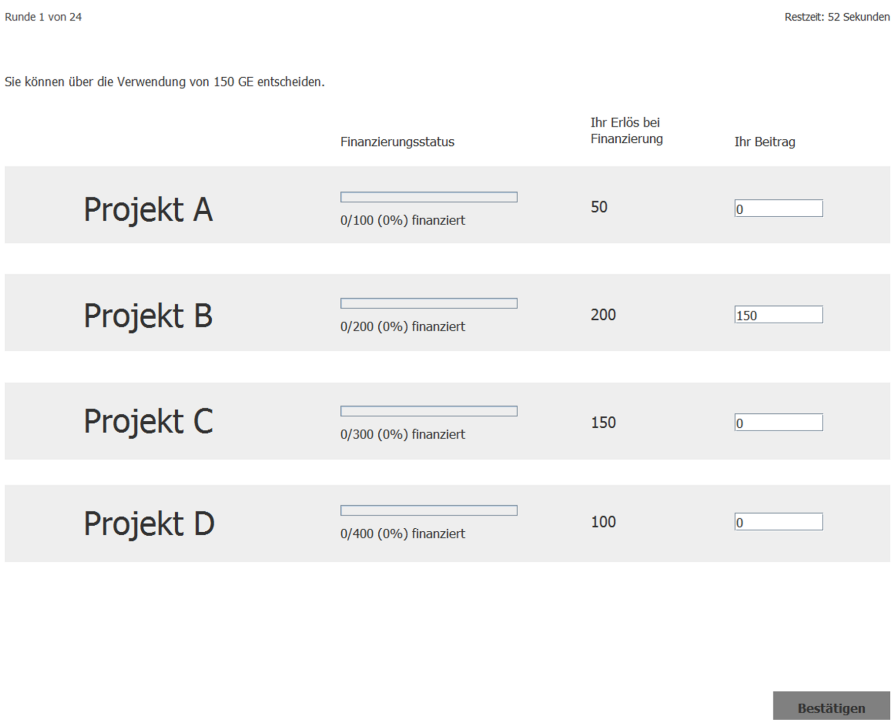

Figure A.1: Screenshot: Input phase S0

At the end of each round you will see the following result screen:

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round incomes are not transferred into the next round.

Total earnings

After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

Overall process

Before we begin the experiment you will answer several comprehension questions

Figure A.2: Screenshot: Result phase S0.

regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules

Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

A.2 S50 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. Each round you will decide over the use of 75 monetary units (MU). You may keep the entire sum or use part of it or the entire sum to invest in the funding of various projects.

Please note: the amount not invested from your endowment will go directly towards your round return.

You may choose from four different projects (A, B, C, and D). Each project is characterized by their threshold and the utilities that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU and Project D 400 MU. In case of one or more participants sufficiently fund a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also if a participant did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the various projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

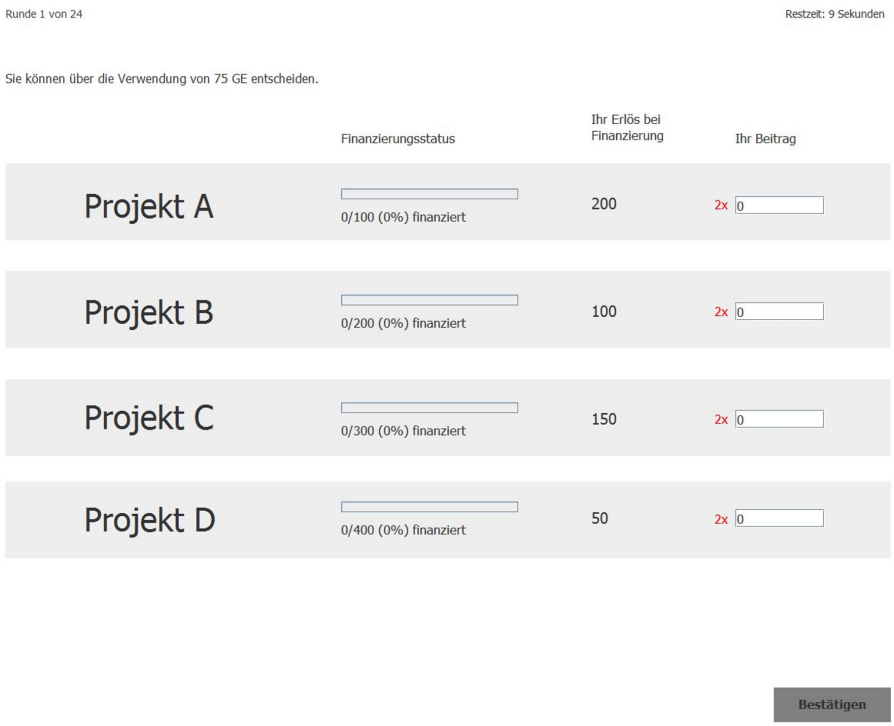

Figure A.3: Screenshot: Input phase S50.

Each round you have the **one-time** opportunity to invest in the funding of several projects. Please note: The total of your investments may not exceed your endowment. All of your investments will be doubled by the experiment software

Period earnings

After 60 seconds the investment phase ends with entered investments automatically confirmed, and the computation of the round income. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project.
- Investments for not sufficiently funded project will be refunded.
- Investments which exceed the project threshold will be refunded proportionately. For example you have invested 50 MU in a project and another participant has invested 75 MU. The threshold is 200 MU. Note: all investments from participants are being doubled by the experiment software. The excess investment thus is 2*50 + 2*75 - 200 = 50 MU. Half of this are participant investments. This will be refunded to each participant with a ratio of (50 : 75): You will be refunded 10 MU and the other participant will be refunded 15 MU.

Thus, your round income in each round is computed as follows:

Your round income	=	endowment of 75 MU
	−	project investments
	+	utilities from funded projects
	+	refunds from not funded project
	+	refunds from overfunded projects

At the end of each round you will see the following result screen:

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round income is not transferred into the next round.

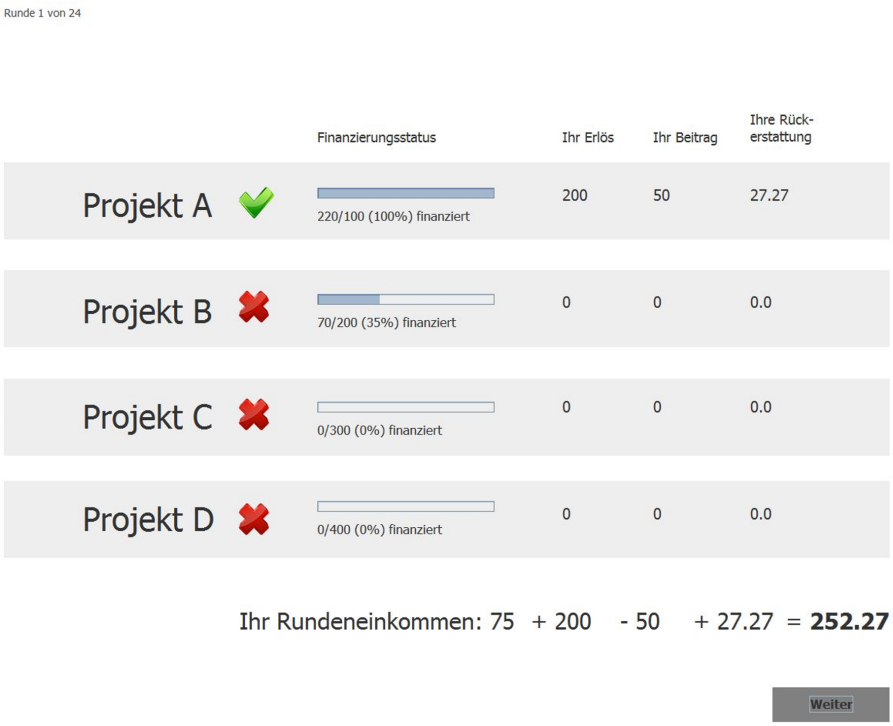

Figure A.4: Screenshot: Result phase S50.

Example

Let us look at a simple example with just 3 participants and a single project. The investment threshold is 100 MU. In case of sufficient funding the participants would achieve utilities of 50, 100 or 150 MU, respectively.

Participants 1 and 2 invest 15 and 35 MU, respectively and participant 3 contributes nothing. The investments are being doubled by the experiment software. The project now is fully funded.

This results in the following round income:

P1: 75 - 15 + 50 = 110
P2: 75 - 35 + 100 = 140
P3: 75 - 0 + 150 = 225

Total earnings
After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

Overall process
Before we begin the experiment you will answer several comprehension questions regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules
Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

A.3 S100 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. Each round you will decide over the use of 150 monetary units (MU). You may keep the entire sum or use part of it or the entire sum to invest in the funding of various projects.

Please note: the amount not invested from your endowment will go directly towards your round return.

You may choose from four different projects (A, B, C, and D). Each project is characterized by their threshold and the utilities that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU and Project D 400 MU. In case of one or more participants sufficiently fund a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also if a participant did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the various projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

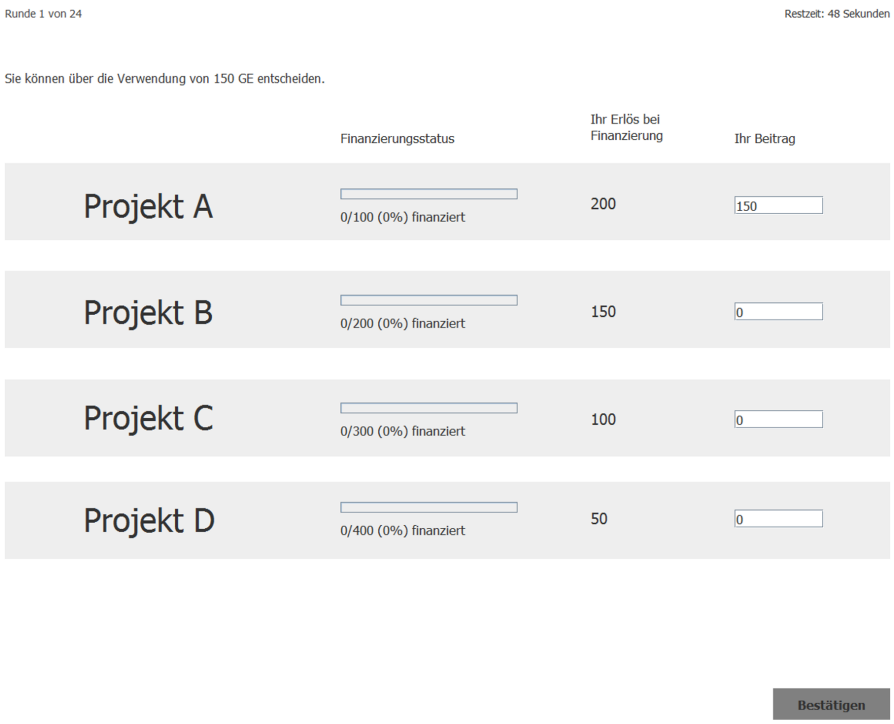

Figure A.5: Screenshot: Input phase S100

Each round you have the **one-time** opportunity to invest in the funding of several projects. Please note: The total of your investments may not exceed your endowment.

Period earnings

After 60 seconds the investment phase ends with entered investments automatically confirmed, and the computation of the round income. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project.
- Investments for not sufficiently funded project will be refunded.

- Investments which exceed the project threshold will be refunded proportionately. For example you have invested 100 MU in a project and another participant has invested 150 MU. The threshold is 200 MU. The excess investment of 100 + 150 - 200 = 50 MU will be refunded to each participant with a ratio of (100 : 150): You will be refunded 20 MU and the other participant will be refunded 30 MU.

Thus, your round income in each round is computed as follows:

Your round income	=	endowment of 150 MU
	−	project investments
	+	utilities from funded projects
	+	refunds from not funded project
	+	refunds from overfunded projects

At the end of each round you will see the following result screen:

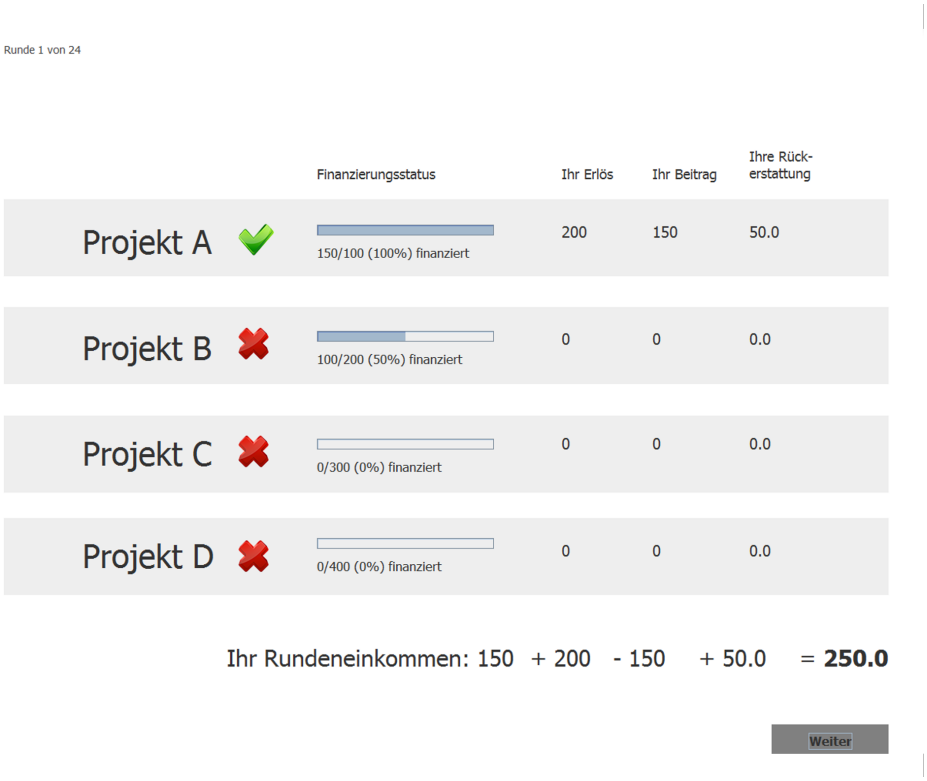

Figure A.6: Screenshot: Result phase S100.

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round income is not transferred into the next round.

Example

Let us look at a simple example with just 3 participants and a single project. The investment threshold is 100 MU. In case of sufficient funding the participants would achieve utilities of 10, 100 or 150 MU, respectively.

Participants 1 and 2 invest 30 and 70 MU, respectively and participant 3 contributes nothing. The project now is fully funded.

This results in the following round income:

P1: 150 - 30 + 50 = 170
P2: 150 - 70 + 100 = 180
P3: 150 - 0 + 150 = 300

Total earnings
After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

Overall process
Before we begin the experiment you will answer several comprehension questions regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules
Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

A.4 D0 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. Each round you will decide over the use of 150 monetary units (MU). You may use part of it or the entire sum to invest in the funding of various projects.

Please note: the amount not invested from your endowment expires in this round.

You may choose from four different projects (A, B, C, and D). Each project is characterized by their threshold and the utilities that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU and Project D 400 MU. In case of one or more participants sufficiently fund a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also if a participant did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the various projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

The investment phase is dynamic. You now have the opportunity to invest in the funding of various projects. The total of your investments may naturally not exceed your endowment. After each input (from you or other participants) the screen will be updated and the current project investment states will be displayed in the progress bar.

Period earnings

After 60 seconds the investment phase ends and your round income will be computed. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project
- Any amount from your endowment that was not invested expires

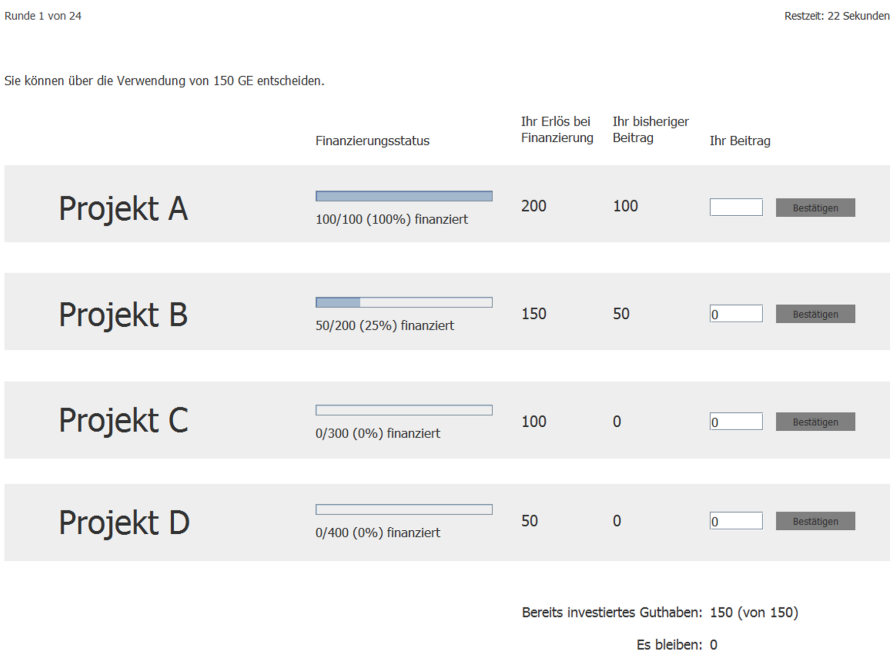

Figure A.7: Screenshot: Input phase D0.

Thus, your round income in each round is computed as follows:

Your round income = utilities from funded projects

At the end of each period you will see the following result screen:

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round income is not transferred into the next round.

Total earnings

After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

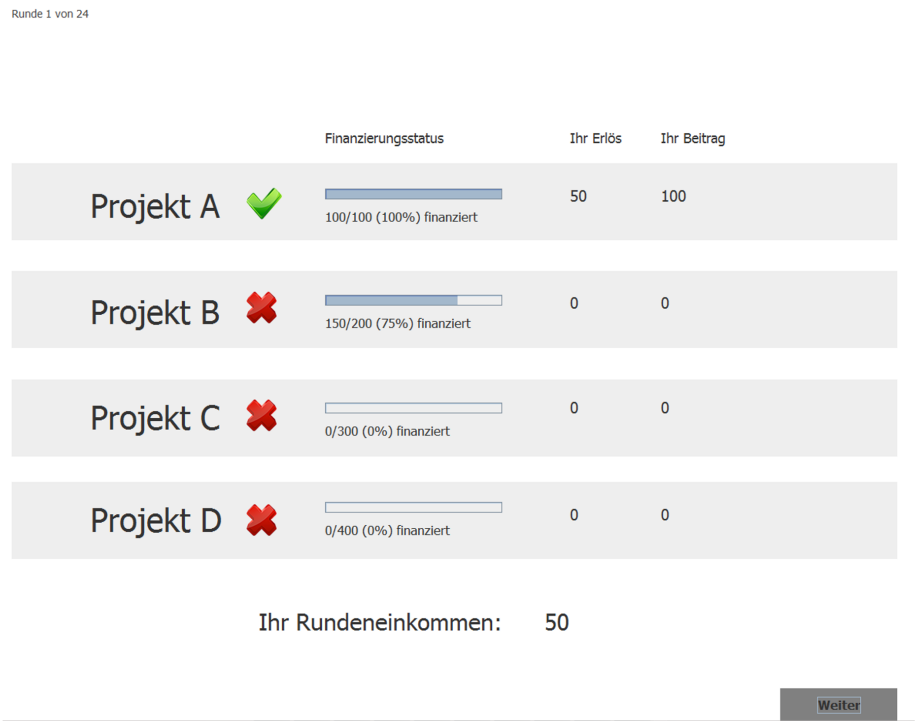

Figure A.8: Screenshot: Result phase D0.

Overall process

Before we begin the experiment you will answer several comprehension questions regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules

Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

A.5 D50 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. Each round you will decide over the use of 75 monetary units (MU). You may keep the entire sum or use part of it or the entire sum to invest in the funding of various projects.

Please note: the amount not invested from your endowment will go directly towards your round return.

You may choose from four different projects (A, B, C, and D). Each project is characterized by their threshold and the utilities that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU and Project D 400 MU. In case of one or more participants sufficiently fund a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also if a participant did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the various projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

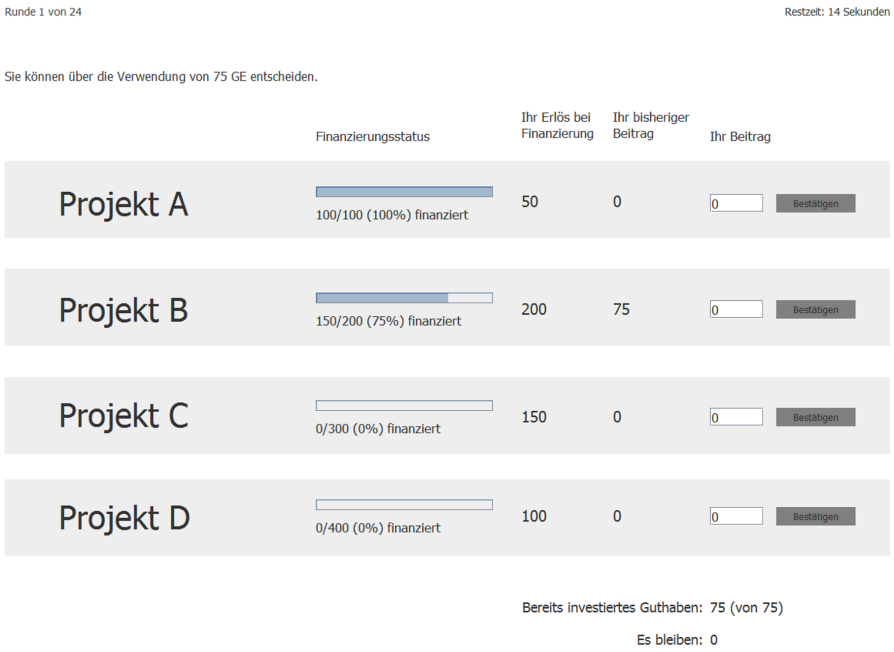

Figure A.9: Screenshot: Input phase D50.

The investment phase is dynamic. You now have the opportunity to invest in the funding of various projects. The total of your investments may naturally not exceed your endowment. After each input (from you or other participants) the screen will be updated and the current project investment states will be displayed in the progress bar.

Please note: All of your investments will be doubled by the experiment software. The progress bar already includes the doubled investments of all participants.

Period earnings

After 60 seconds the investment phase ends and your round income will be computed. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project.
- Investments for not sufficiently funded project will be refunded.

Thus, your round income in each round is computed as follows:

Your round income	=	endowment of 75 MU
	−	project investments
	+	utilities from funded projects
	+	refunds from not funded project

At the end of each round you will see the following result screen:

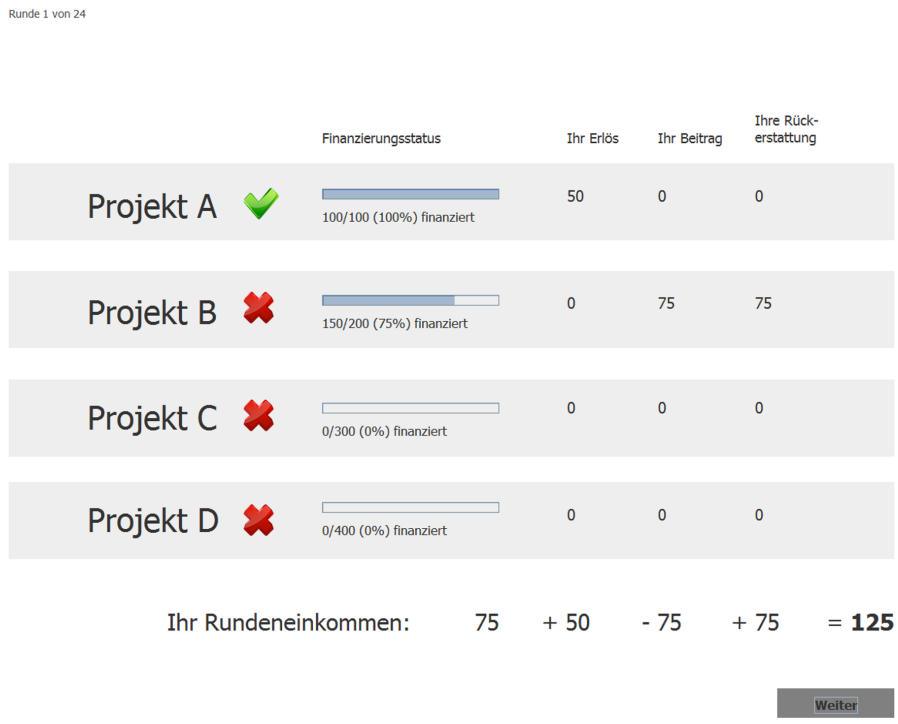

Figure A.10: Screenshot: Result phase D50.

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round incomes are not transferred into the next round.

Example

Let us look at a simple example with just 3 participants and a single project. The investment threshold is 100 MU. In case of sufficient funding the participants would achieve utilities of 100, 50 or 150 MU, respectively.

To start, participant 1 enters 25 MU. Then participant 2 enters 20 MU. The investments are being doubled by the experiment software. Finally, participant 1 closes the "investment gap" of 10 MU, therefore investing 5 MU. The project now is fully funded. Participant 3 contributed nothing.

This results in the following round income:

P1: 75 - (25+5) + 100 = 145
P2: 75 - 20 + 50 = 105
P3: 75 - 0 + 150 = 225

Total earnings
After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

Overall process
Before we begin the experiment you will answer several comprehension questions regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules
Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

A.6 D100 Treatment

Welcome and thank you for your participation in this experiment.

General information
You are participating in an economic experiment today and can earn real money. How much you earn depends on the decisions you and the other participants make. During the experiment we will be using monetary units (MU) which subsequently will be converted to Euro. Here, 100 MU are equivalent to 1.00 €.

This experiment deals with **the funding of project by multiple persons**. You and the other participants are repeatedly confronted with the decision whether and how much to invest in different projects. If a project is sufficiently funded, i.e. the sum of all investments exceeds a certain project-specific threshold, you will receive a utility from this project. This is also the case if you did not invest in this particular project yourself.

This experiment consists of 24 rounds in total. In each round you and the 11 other participants will be randomly divided into two groups of 6. The composition of your group changes in each round and will not be communicated to you.

The procedure of the experiment is the same in all rounds. Each round you will decide over the use of 150 monetary units (MU). You may keep the entire sum or use part of it or the entire sum to invest in the funding of various projects.

Please note: the amount not invested from your endowment will go directly towards your round return.

You may choose from four different projects (A, B, C, and D). Each project is characterized by their threshold and the utilities that you will receive in case of sufficient funding. The thresholds are as follows: Project A 100 MU, Project B 200 MU, Project C 300 MU and Project D 400 MU. In case of one or more participants sufficiently fund a project **all participants** receive utilities regardless of how much each participant invested in the project's funding and notably also if a participant did not invest in this project at all.

Please note that you and the other participants may achieve different utilities from the various projects. The respective utilities range from 50 MU to 200 MU. The amount of potential project utilities is determined for each participant individually and varies in each round. Each participant only knows their own potential project utilities.

The core of each round is the investment phase. This phase lasts for 60 seconds where you will see the following input screen.

The investment phase is dynamic. You now have the opportunity to invest in the funding of various projects. The total of your investments may naturally not exceed your endowment. After each input (from you or other participants) the screen will be updated and the current project investment states will be displayed in the progress bar.

Period earnings

After 60 seconds the investment phase ends and your round income will be computed. Please note the following:

- If a project has been sufficiently funded you will be credited with utilities from this project, regardless of whether you invested or how much you invested in this project.
- Investments for not sufficiently funded project will be refunded.

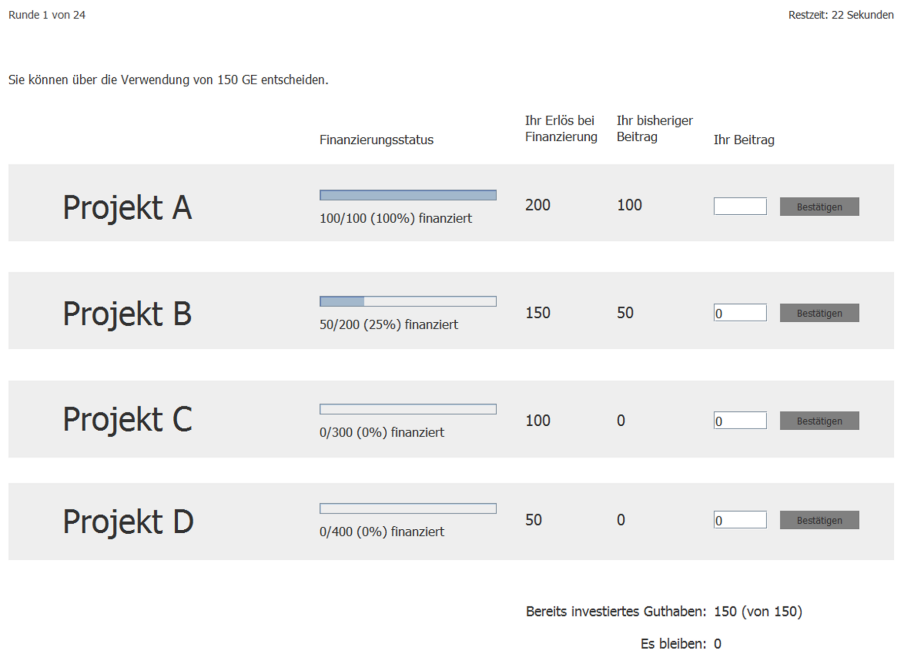

Figure A.11: Screenshot: Input phase D100.

Thus, your round income in each round is computed as follows:

Your round income	=	endowment of 150 MU
	−	project investments
	+	utilities from funded projects
	+	refunds from not funded project

At the end of each round you will see the following result screen:

A red cross indicates that this particular project was not funded successfully. A green check indicates successful funding. You will receive utilities for this project, regardless of whether you invested or how much you invested in this project. The round income is not transferred into the next round.

Example

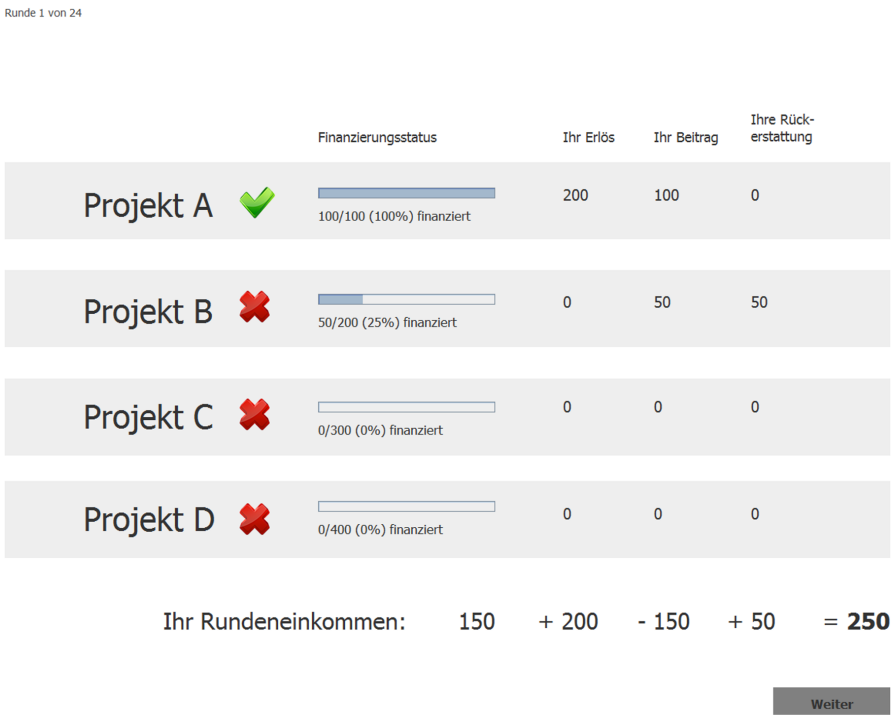

Figure A.12: Screenshot: Result phase D100.

Let us look at a simple example with just 3 participants and a single project. The investment threshold is 100 MU. In case of sufficient funding the participants would achieve utilities of 100, 50 or 150 MU, respectively.

To start, participant 1 enters 50 MU. Then participant 2 enters 40 MU. Finally, participant 1 closes the ”investment gap” and invests 10 MU. The project now is fully funded. Participant 3 contributed nothing.

This results in the following round income:

P1: 150 - (50+10) + 100 = 190
P2: 150 - 40 + 50 = 160
P3: 150 - 0 + 150 = 300

Total earnings

After 24 rounds your round incomes from **four randomly chosen** rounds are added up and converted to Euro, where 100 MU are equivalent to a payment of 1.00 €.

We will provide an overview of round results at the end of the experiment.

Overall process

Before we begin the experiment you will answer several comprehension questions regarding the rules of the experiment. Please fill in these questions on your computer. After a rest period of 5 minutes the experiment as described above will run for 24 rounds. Finally, we request you to complete a short questionnaire.

Procedural rules

Communication with other experiment participants is not permitted and will lead to exclusion from the experiment and the corresponding payments.

If you have any questions about the experimental process or if anything is unclear to you during the experiment, please remain seated quietly and open your door to inform the experiment supervisor. The experiment supervisor will then come to you. Please ask your question as quietly as possible as to avoid disturbing any other participants.

Appendix B

Questionnaire

B.1 Sense of Agency

The questions on the sense of agency are self-formulated and based on the definition by Moore and Obhi (2012).

I had the feeling that my decisions influenced the outcome of the experiment.

I had the feeling that my decisions influenced the project funding.

I had the feeling to be crucial for the outcome of the experiment.

I had the feeling that my action made a difference.

B.2 Hedonic Value

The questions are based on the suggested items by Voss et al. (2003) and Venkatesh et al. (2012).

The experiment/ the project funding was fun.

I enjoyed the experiment/ the project funding.

The experiment/ project funding was entertaining.

B.3 Arousal

The questions are based on the suggested items by Li (2013).

During the experiment/ project funding I felt active.

During the experiment/ project funding I felt activated.

During the experiment/ project funding I felt excited.

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