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Front Pages

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The current issue is the fourth of the ninth volume of the *Athens Journal of Business & Economics (AJBE), published by the Business & Law Division and the Economics Unit of ATINER.*

Gregory T. Papanikos
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- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **13 June 2024**

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KaPIL – Karlsruher Platform Innovation Lab: A Validation Environment to Design Digital Platform Business Models and Test Related Tools and Methods

By Patrick Brecht[*], Jacqueline Reinbold[±], Manuel Niever[°], Carsten H. Hahn[•], Felix Pfaff[♦] & Albert Albers[♠]

In the past decade, digital platform business models have gained significant worth as they differ in creating and capturing value compared to traditional linear business processes. Previous research developed the SPEC – Smart Platform Experiment Cycle, a process to validate digital platform business models to ensure their successful implementation. In this context, it is intriguing to investigate whether and how step (1) of SPEC can be expanded by other platform design tools. This study developed a Live-Lab, namely KaPIL – Karlsruher Platform Innovation Lab, to design digital platform business models and test related tools and methods. Applying the Design Research Methodology, the designed Live-Lab is created by implementing ProVIL – Product Development in a Virtual Idea Laboratory combined with the Smart Education Concept and digital platform business knowledge. KaPIL was applied with students from the Karlsruhe University of Applied Sciences in cooperation with the company STIHL to assess its efficacy, applicability, and validity. KaPIL can be used to design digital platforms and shows that the Platform Canvas, the Platform Business Model Canvas, and the Platform Design Canvas can expand step (1) of SPEC. In future research, more applications of KaPIL are required to validate its robustness and extend it to other digital platform methods and tools.

Keywords: *digital platform business model, live-lab, design research methodology, innovation process, validation environment*

Introduction

Over the last few years, it has become visible that digital platforms tend to dominate markets. The world's most valuable brands, such as Google, Amazon, Microsoft, and Apple, are based on digital platform business models. In contrast to many traditional pipeline companies, whose brand value has declined during the

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COVID-19 pandemic, digital platforms are recording positive, double-digit growth rates in their brand value (Interbrand 2021). Furthermore, platforms such as Alibaba, Facebook, and Airbnb have been founded in Asia and the United States of America, while Europe lags in creating platform businesses (Hosseini and Schmidt 2022).

One way to gain a foothold in the platform economy might be to transform existing pipeline business models of technology- and knowledge-based companies into platform business models. This transformation is trending as a recent study by the Federation of German Industries revealed: Many companies in the business-to-business (B2B) market are trying to transform their business model (Bundesverband der Deutschen Industrie e.V 2021). This focus on B2B business models might allow European companies to enter the platform business model realm competitively by using their expertise from their market segment to create new and powerful digital platforms. Research on this topic has further shown platforms fail before they achieve significant relevance (Yoffie et al. 2019). It shows that a systematic approach to designing platforms could help practitioners.

This paper is a response to Brecht et al. (2021), who deal with validating digital platform business models in their work. The authors designed the SPEC – Smart Platform Experiment Cycle, which requires practitioners to already have an existing platform business model mapped out to validate or refute through the smart experiment design and execution. To make the process more accessible to practitioners not meeting the requirement yet, the authors requested research on how they can reach the state of mapped out digital platform business model. The authors have highlighted the relevance of B2B platform business model creation. However, they did not indicate how creating those digital platforms can be fostered systematically. As a starting point for research, the authors recommend considering a streamlined process to ideate and design digital platforms and a suitable choice of tools and methods. This current research aims to develop and test a Live-Lab that fosters creating platform business models and verifying which available tools are best suited for the platform design. A Live-Lab is a research method enabling researchers to test methods and processes in a realistic setting while controlling specific conditions (Walter et al. 2016). Therefore, this paper answers the following research questions:

> RQI: Whether and how can step (1) of the SPEC - Smart Platform Experiment Cycle be expanded by other Platform Design Tools?
> RQ II: How can a Live-Lab be designed and executed with the objective to design digital platforms and test digital platform tools and methods?

The answer to these research questions was found by analyzing the Live-Lab ProVIL and the Smart Education Concept to design a validation environment. Based on these findings, KaPIL was designed and demonstrated with the challenges the company STIHL faced during digital platforms design. This paper is structured as follows. The first section shows relevant digital platform methods and tools as well as the structure of the Live-Lab ProVIL and the Smart Education Concept. The next section elaborates on the research design based on the Design Research Methodology (DRM) and the dimensions, variables, and evaluation metrics of the

quantitative interviews. The consecutive result section shows how the Live-Lab requirements were applied in KaPIL and how the platform tools and methods fulfill their purpose as a designing tool for digital platforms. Finally, this research concludes with a discussion and future implications for researchers and practitioners aiming at designing digital platforms.

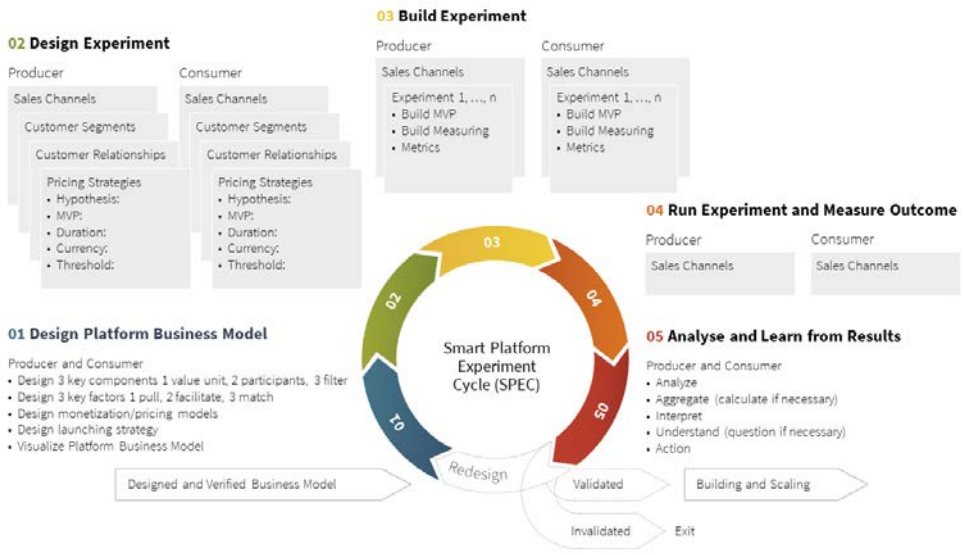
Literature Review

The following section provides a basic understanding of relevant theoretical aspects essential to this research. Therefore, it briefly introduces the validation framework SPEC and elaborates on platform design tools and different types of platform canvases. Finally, it also explains the Live-Labs method by introducing the ProVIL Live-Lab in detail.

SPEC – Smart Platform Experiment Cycle

The SPEC – Smart Platform Experiment Cycle is a validation process specifically for digital platforms tested in the Business-to-Consumer (B2C) sector (Brecht et al. 2021). It is an aggregated process based on the build-measure-learn feedback loop of the Lean Startup approach (Ries 2011), the Customer Development Process (Blank and Dorf 2012), the Four-step Iterative Cycle (Thomke 2003), and the core principles of platform design (Parker et al. 2016). The SPEC is divided into five steps, which are illustrated in Figure 1.

Figure 1. *SPEC – Smart Platform Experiment Cycle (Brecht et al. 2023)*



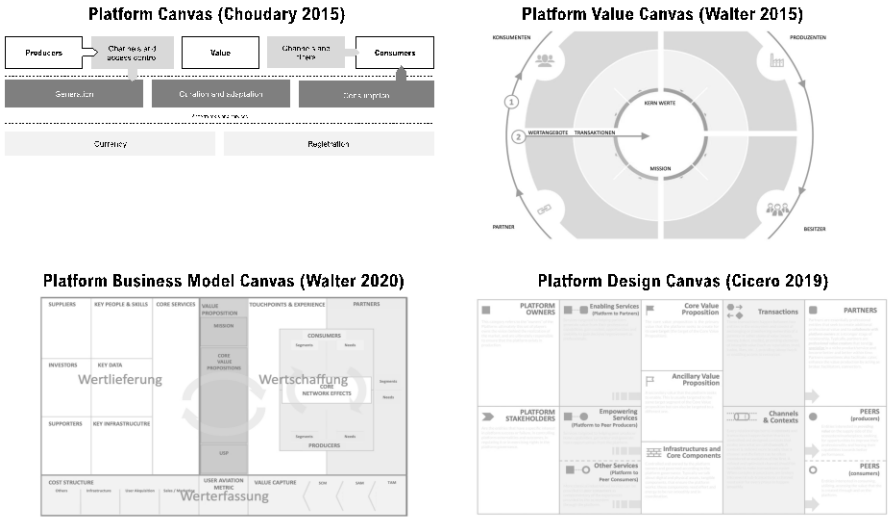
The starting point for applying SPEC is a verified business model. The first step consists of designing a platform business model. Here, the participants functions, and strategies for monetization should be defined and visualized. In the second step, experiments must be designed for the individual platform business

model components to validate the hypotheses from the previous step. When designing the experiments, the order in which the building blocks are validated is determined and scheduled. In the context of digital platform business models, the designed experiments validate the platform user side, namely the sales channels, customer relationships, and pricing strategies. In step three, a minimal viable product (MVP) is built, for instance, as a landing page. The MVP represents the first solution to the customer's problem and should contain essential functions. Next, the experiments are conducted in the specified order. The results are measured, and observations on the specified measurement metric are collected. In the last step, observations are analyzed and learned lessons are collected. After this final step and depending on the results, the SPEC can be exited, leading to build and scale the platform or discard the business model entirely. Alternatively, the SPEC can be cycled through again to gain deeper insights into digital platforms.

Platform Design Tools

The following section presents platform design tools: (1) Platform Canvas by (Choudary 2015), which is part of the holistic toolset, (2) Platform Value Canvas and (3) Platform Business Model Canvas, which are part of the Platform Innovation Kit by (Walter 2015/2020) and, (4) Platform Design Canvas (Cicero, 2019), which is part of the Platform Design Toolkit (Cicero 2019). Figure 2 shows an overview of the four canvases. These four canvases were selected to be tested in KaPIL as suggested by (Brecht et al. 2021) to initially design digital platforms with SPEC. In 2021, an update of the Platform Design Toolkit and Platform Innovation Kit was available. This research was done with the older version of the tools, prior to the update.

Figure 2. *Digital Platform Tools based on Choudary (2015), Cicero (2019), Walter (2015, 2020)*



Platform Canvas (PC)

Choudary's Platform Canvas visualizes the most relevant components of a digital platform, divided into ten building blocks. Accordingly, the three decisive activities are defining a value-creating interaction, constructing an infrastructure to realize this interaction, and mapping the strategies for value capture (Choudary 2015). Platform design with the Platform Canvas works as follows: Building blocks are used to represent the core interaction. The platform building block describes an infrastructure for value exchange between participants. Next, the role and the motivation of the two participants, producer and consumer, are defined. The fourth step identifies the offered value exchanged via the platform. The next step uses channels to enable participant access to the platform, for example, via a website or app. The platform controls producer access, so only producers with desirable behavior create content. While filters ensure relevant content displayed to consumers, the platform should provide producers special developer tools to facilitate creating value units. Once interaction and access mechanisms are determined, the infrastructure is built by defining tools, services, and platform activities. Tools and services are, for example, recommendation services and efficient search functions. The content should be curated and the display adapted to the user's individual need. Furthermore, a monetary or non-monetary currency used in the value exchange must be defined. Lastly, value capturing mechanisms concerning monetization strategies or pricing models should be described. (Choudary 2015).

Platform Value Canvas (PVC)

The Platform Value Canvas (PVC) is part of the Platform Innovation Kit by Matthias Walter and Simon Torrance. The toolkit encompasses a collection of seventeen canvases and tools. The Platform Value Canvas is a methodical approach to visualize a platform business model (Walter 2020). The canvas focuses on the platform stakeholders and the value propositions. The canvas has a circular structure and is divided into four quadrants. Producers represent the supply side, creating and offering value units via the platform. Consumers are the demanding entity who want to use value units. The owner owns the platform, provides the infrastructure, and defines all essential business model components. The fourth stakeholder group are partners such as suppliers and business partners who determine the successful implementation of the platform. The stakeholder group names at least one positive value proposition the platform delivers from their viewpoint. The next step defines value-generating transactions. At the center of the canvas, key components such as filters, algorithms, curation tools, main functions, and the mission of the business model are described (Walter 2020).

Platform Business Model Canvas (PBMC)

The Platform Business Model Canvas (PBMC) corresponds to a one-page dashboard mapping all essential building blocks of a platform business model. In addition to design, it can track the progress of the validation process. The PBMC is divided into three sections and fifteen building blocks. First, on the right side of the Canvas, six building blocks define how value creation takes place in the

business model. Therefore, the three external participant groups, consumers, producers, and partners, must be identified, and their needs recorded. Then, a value proposition is created for each segment and adapted to their needs. It is divided into three components: (1) the core value unit, which is exchanged between consumers and producers. (2) the core mission of the platform, which states why the platform exists. (3) the unique selling proposition (USP), which differentiates the value proposition from alternative product solutions. Once the external participants and their value propositions are defined, the next step determines the touchpoints and experiences through which the platform participants are reached and connected in the ecosystem. Thus, it identifies the core network effects between producers and consumers and determines how the platform stimulates and promotes one-way and cross-side network effects (Walter 2020).

After all value creating elements are described, the canvas continues by defining the seven elements of value delivery on the left side of the PBMC, including the platform core services that support stakeholders in onboarding, matching, and exchange. Notably, it highlights how these services differ from the competition. In addition, it must identify which people and skills (e.g., employees) are needed to build and operate the platform. Another significant element is data. Data should be analyzed and determined which data flows represent the platform core and how they should be processed. Next, the canvas builds an infrastructure and identifies which core elements are required for the platform to function. Finally, it identifies key stakeholders relevant to creating, operating, and financing the business strategy, including key suppliers, investors, and supporters. The third area of the PBMC represents the value capture. In this area, it documents the cost structure with its essential cost drivers, accumulating about 80 percent of the costs, all revenue sources, and value-generating units such as sales and data. The last element is the core metrics, which defines the applied metrics to measure the platform's success. One criticism is that filling out the PBMC can be overwhelming due to the many details, especially at the beginning of the business model development. Therefore, it is recommended to use PVC before the PBMC. (Walter 2020).

Platform Design Canvas (PDC)

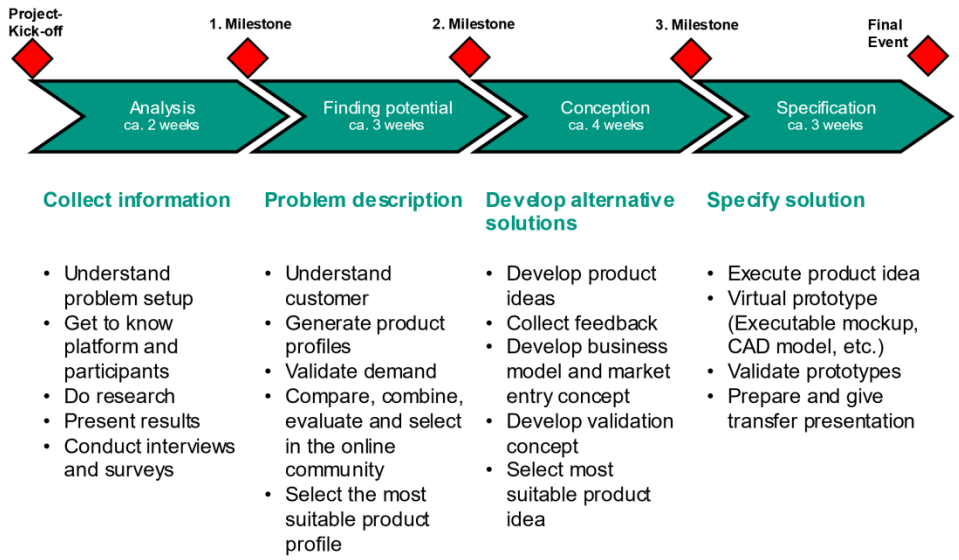
The Platform Design Canvas (PDC) belongs to the Platform Design Toolkit by Simone Cicero. The toolkit contains a step-by-step guide for creating a platform business model, listing eight steps and seven modeling tools as aids (Cicero 2019). The canvas can be used alone or together with the auxiliary canvases of the toolkit's 8-step guide. The PDC structure is like Osterwalder and Pigneur's Business Model Canvas. Like the PBMC, it serves as a dashboard for quickly summarizing platform strategy and identifying platform and ecosystem potential (Cicero 2019). The PDC is divided into thirteen building blocks. The right side of the canvas depicts the partners, peer producers, and peer consumers. In the middle, the value propositions are elaborated. Cicero (2019) differentiates between the core value proposition and auxiliary value propositions. The core value proposition represents the primary benefit to the peer segments and defines the problem solutions. In contrast, auxiliary value propositions represent the secondary benefit relating to

existing or new user groups. Simultaneously, coordination and transaction costs should be minimized. Therefore, the next building block defines what constitutes a good transaction and how high volume can be promoted. Additionally, the infrastructure and core components are listed, which are controlled by the platform owner and managed via policies. The PDC's left sides lists the services and capabilities the platform offers to partners, producers, and consumers. Lastly, other platform stakeholders and owners should be named. Cicero (2019) distinguishes two roles for platform owners: the owner role and the designer role. While owners manage the platform infrastructure, designers take responsibility for strategy design and sustainable business model development (Cicero 2019).

The Live-Lab: ProVIL – Product Development in a Virtual Idea Laboratory

Live-Labs are a research method based on applications in real-world scenarios and are classified between traditional methods such as field studies or laboratory studies. The method's main advantage is participants perceiving themselves as product developers, making them more critical of new processes and methods while focusing on the project's success (Walter et al. 2016). Live-Lab concepts usually provide results more easily transferable to the actual situation of the business partner (Walter et al. 2016). In contrast, field studies are case-specific, and thus, generalizing results is difficult (Walter et al. 2016). According to Albers et al. (2018a), by creating a Live-Lab focused strongly on real-world application, the research results gain external validity (Albers et al. 2018a). Hence, Live-Lab was chosen to answer the research question about the suitability of platform design canvases. The Live-Labs IP – Integrated Product Development and ProVIL – Product Development in a Virtual Idea Laboratory have been used for cooperative product development in academia in cooperation with the industry at Karlsruhe Institute of Technology (KIT) (Albers et al. 2018b). ProVIL was run for the first time in 2016 for four months. 32 students worked on a new product development challenge given by the project partner Porsche AG in the Smart Mobility field. Ten innovation coaches who were students from the study program "Industrial Engineering and Business [Administration]" at Karlsruhe University of Applied Sciences supported the students. These innovation coaches moderated virtual meetings, evaluated the students' results, and supported students using an innovation platform (Walter et al. 2016). To this day, ProVIL run seven times. Figure 3 shows an overview of the process model ProVIL.

Figure 3. *Process Model of ProVIL (Walter et al. 2016)*

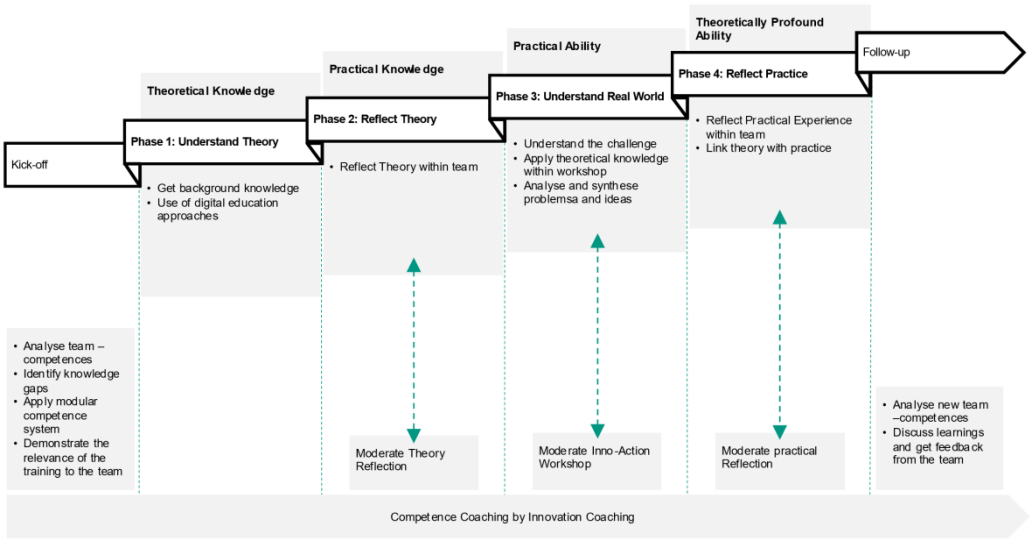


ProVIL included phases, in which the teams acted agile and independent with guidance from innovation coaches: First, there was a planning phase. Second, a two-week research phase allowing students to familiarize with the topic and the innovation platform. Third, in a three-week profiling phase the goal was to gain a comprehensive picture of the customers' needs and desires. Thus, the persona-method describing customers was used to derive product profiles matching potential solutions to the respective customers. Fourth, a four-week idea phase followed those generated ideas for the intended product development. Lastly, a three-week specification phase realized first product concepts by translating the ideas into presentable mock-ups (Walter et al. 2016).

Smart Education Concept

The hybrid learning concept incorporates the three elements of theory, practice, and reflection with the goal of transferring knowledge into ability (Niever et al. 2020). During the concept application, Massive Open Online Courses (MOOCs) are used to deliver theoretical knowledge to the students. The lecturer and discussion stimulated among the students provided practical knowledge. Then, students applied the newly gained knowledge to a practical, real-life problem (Niever et al. 2020). Niever et al. (2020) suggested a four-step process when implementing a hybrid learning concept (see Figure 4). The authors emphasized the benefits of promoted and moderated learning communities and the implementation of innovation coaches (Niever et al. 2020). They further highlight the importance of multidisciplinary teams.

Figure 4. *Smart Education Concept Based on Hybrid Learning (Niever et al. 2020)*



Research Design

Design Research Methodology

This section describes the process of designing KaPIL with the objective of testing platform design tools in the context of a real-world problem setup. This process is based on the Design Research Methodology (DRM) by (Blessing and Chakrabarti 2009). The stages are described in the following.

Research Clarification (RC)

The objectives of the research clarification (RC) are to help researchers gain insights into the current understanding, identify the research goals, and derive a research plan through literature reviews (Blessing and Chakrabarti 2009). Blessing and Chakrabarti (2009) refer to the output of each DRM stage as deliverables. Describing existing and the desired situation are modeled as networks of influencing factors in so-called reference models (Blessing and Chakrabarti 2009). Success criteria measuring the research outcome to evaluate the research need to be formulated. If it is not feasible to use those criteria in the research scope (e.g., if the effect happens after the research timeframe), other *measurable success criteria* are selected to serve as indicators of these success criteria (Blessing and Chakrabarti 2009). The research plan for this paper is displayed in Table 1. The initial reference model (IRM) describes the existing situation.

Descriptive Study I (DS I)

The Descriptive Study I aims at "identifying and clarifying in more detail the factors that influence the preliminary Criteria and the way in which these factors influence the Criteria" (Blessing and Chakrabarti 2009, p. 32). It is achieved through

reviewing the literature about empirical research, undertaking empirical research, and through additional reasoning. In DS I, the Live-Lab, ProVIL is analyzed. The IRM from the RC phase and the preliminary criteria are used as a basis to generate an updated impact model, success and measurable success criteria. Success criteria refer to the ultimate research goal (Blessing and Chakrabarti 2009).

Table 1. *Research Plan Based on the Design Research Methodology (Blessing and Chakrabarti 2009)*

	Descriptive Study I	**Prescriptive Study**	**Descriptive Study II**
Research question (RQ)	*RQ* 1: Whether and how step (1) of the SPEC – Smart Platform Experiment Cycle can be expanded by other Platform Design Tools?* *RQ* 2: How can a Live-Lab be designed and executed with the objective to design digital platforms and test digital platform tools and methods?*		
Guiding question	What are requirements and key factors in implementing a Live-Lab to design platform business models?	How can we design and execute a Live-Lab that meets the necessary requirements?	How applicable is the derived process model and the four platform design canvases to solve real world challenges?
Methods	Literature review of the SPEC - Smart Platform Experiment Cycle	Action Research in the Live-Lab ProVIL – Product Development in a Virtual Idea Laboratory, Smart Education Concept and platform tools	Application of KaPIL process model and conducting of two surveys among KaPIL participants
Main outcomes	Reference Model derived (see section results)	KaPIL – Karlsruher Platform Innovation Lab a process model derived from ProVIL and Smart Education Concept (see section results)	Insights about conducting the Live-Lab KaPIL and the use of platform design canvases (see section results)

Prescriptive Study (PS)

The Prescriptive Study aims to systematically develop support regarding the DS I results (Blessing and Chakrabarti 2009). The support can take on many forms (e.g., guidelines, methods, or equations) and mediums (e.g., paper, software, or workshops) (Blessing and Chakrabarti 2009). It is limited in functionality but sufficiently developed to test the research contribution (Blessing and Chakrabarti 2009). In this research, the prescriptive study developed a process model describing the design and implementation of KaPIL.

Descriptive Study II (DS II)

The objectives of the Descriptive Study II is to identify through empirical evaluation "whether the support can be used for the task for which it is intended and has the expected effect on the Key Factors" (Blessing and Chakrabarti 2009, p. 38). Criteria are usability, applicability, and usefulness. The deliverables are success evaluation results and suggestions to improve the support, reference and impact models (Blessing and Chakrabarti 2009). For this research, the Live-Lab is conducted with a project partner resulting in students participating in surveys to evaluate the application of KaPIL and its influencing factors, such as the design canvas choices.

Empirical Method

Quantitative interviews are conducted with digital platform developers to investigate the suitability of the four canvases for platform design as part of the DS II. The research question is operationalized by deriving dimensions, variables, and evaluation metrics regarding each dimension. The first survey contained 30 questions, and the second survey 20 questions. Table 2 outlines the dimensions and variables of the two questionnaires. The reason for conducting two survey is twofold. Firstly, initial findings can be derived from the first survey and integrated into the next. Secondly, a second survey is necessary later to gain insights into the actual use and deployment of the tools. Another advantage is repeatedly investigating the same characteristics with the same participants, increases the representativeness of the results. This approach is a panel or longitudinal study (Goldstein et al. 2018).

The first dimension contains closed questions about the study participants' prior knowledge and usage behavior. To ensure the evaluation of only unbiased answers the first two questions contain two fictitious tools as response options. The second category analyzes individual preferences and ratings. The first survey assesses the learnability and evaluates according to the use purpose. The second survey investigates the reasons. The third dimension examines the participation, use, and collaboration with the modeling tools in the challenge context. Fourth, the design tools limitation are surveyed exploratively through the variables exploring the boundaries and specifics in the B2B environment. The last dimension contains demographic, for instance, the subjects' age, gender, and degree program. In the follow-up assessment, it is necessary to assess the results' external validity.

Table 2. *Dimensions, Variables, and Evaluation Metrics of the Quantitative Interviews*

Dimension	Variables	Question type	Scale	Evaluation	Survey 1	Survey 2
Knowledge & application	Knowledge	Multiple selection	Nominal	Frequency	X	X
	Frequency of use	Multiple selection	Nominal	Frequency	X	X
	Frequency of intensity	Scale (labeled)	Ordinal	Mean	X	X
	Time of application	Multiple selection	Nominal	Frequency	X	X
	Application context	Multiple selection	Nominal	Frequency	X	
Individual preference & evaluation	Favorite	Single selection	Nominal	Frequency	X	X
	Reasons for Favorite	Open question	Nominal	Text analysis		X
	Easy to use	Single selection	Nominal	Frequency	X	X
	Easy to understand	Single selection	Nominal	Frequency	X	X
	Ability to learn	Input number	Metric	Mean	X	
	Evaluation	Scale (labeled)	Ordinal	Mean	X	
Challenge	Challenge-participation	Single selection	Nominal	Frequency	X	X
	Selection Canvas in challenge	Multiple selection	Nominal	Frequency	X	X
	Selection Canvas regarding to challenge	Open question	Nominal	Text analysis		X
	Rating teamwork	Scale (labeled)	Ordinal	Mean	X	X
Limitation & critic	Limitation	Open question	Nominal	Text analysis	X	X
	B2B Specifications	Open question	Nominal	Text analysis	X	X
	Tools (Platform Design Toolkit)	Multiple selection	Nominal	Frequency	X	
	Tools (Platform Platform Innovation Kit)	Multiple selection	Nominal	Frequency	X	
Demographics	Course	Single selection	Nominal	Frequency	X	X
	Age	Single selection	Nominal	Frequency	X	X
	Gender	Single selection	Nominal	Frequency	X	X

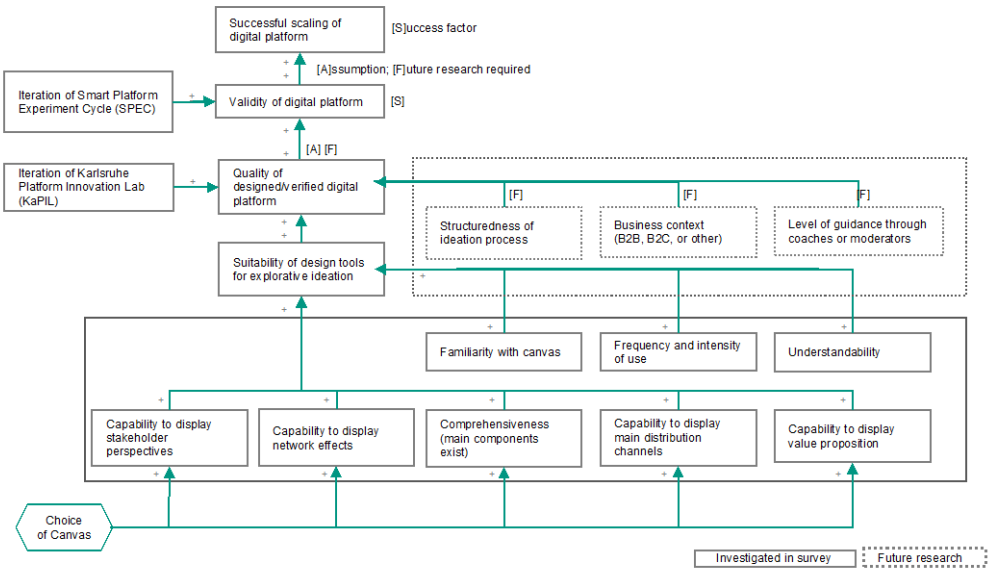
The sample of the surveys consists of 22 students from the master's programs International Management, Industrial Engineering, and Technology Entrepreneurship at the Karlsruhe University of Applied Sciences. The participants are between 20 and 29 years old. Since students participating in KaPIL are taught in platform business model design and are familiar with the four platform design tools presented in the theoretical part of this paper, they are suitable survey participants. Data analysis is done manually using statistical metrics. Nominal variables are evaluated using relative frequencies. The arithmetic means are calculated for metric variables and preference values with an ordinal scale. A quantitative content analysis evaluates the exploratory questions containing open-ended answers. This method assigns responses with the same text parts to a common category and evaluates frequencies (Döring et al. 2016).

Results

Live Lab – Requirements, Challenges, and Potentials

The reference model is mainly based on research by Brecht et al. (2021) and assumptions about the possible factors impacting the quality of designed business models (see Figure 5). It describes how key factors can influence other components towards scaling a platform. The research started with Brecht et al. (2021) regarding the SPEC, a process applied to validate a platform business model. Here, research can address how practitioners can evolve from a validated business model to a successfully scaled digital platform or how one gets a verified business model to enter the SPEC.

Figure 5. *Updated Reference Model Including Success and Measurable Success Criteria*

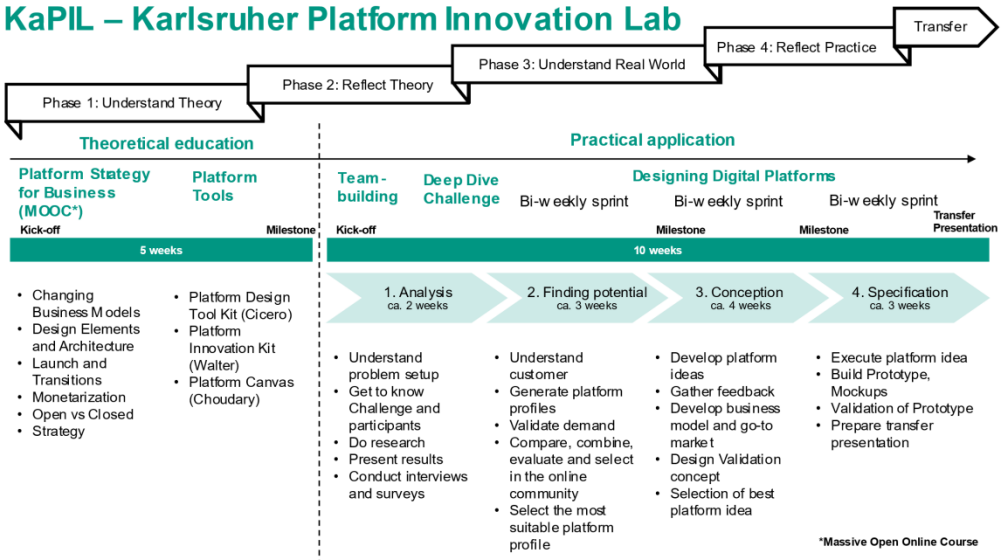


To investigate this matter, assume that the quality of a designed and verified platform business model depends on several factors such as suitable design tools for explorative ideation, structure of the ideation process, the business context of the application (B2B or B2C), and the level of guidance through coaches or moderators. The focus lies on the first factor – the suitability design tools. The authors defined several measurable key factors such as familiarity with canvas, comprehensiveness, and capability to display certain platform elements to investigate this factor in detail (see Figure 5). These key factors are used as a basis for the survey design.

Design and Implementation of KaPIL – Karlsruher Platform Innovation Lab

The authors adapted the Live-Lab concept and added elements from the Smart Education approach and special digital platform design tools as described in the theoretical part of this paper. Workshops and discussions among the researchers resulted in a process model (see Figure 6). The authors tested KaPIL empirically by collaborating with the company STIHL. The researchers collected quantitative and qualitative feedback data throughout the complete Live-Lab execution via digital surveys among participating students. It helped the researchers derive possibilities for improving the concept and validating parts of it.

Figure 6. *Process Model of the Karlsruhe Platform Innovation Lab (KaPIL)*



KaPIL ran for 15 weeks with 22 students from the master's program Industrial Engineering, International Management, and Technology Entrepreneurship. Students were divided into five project teams working on real-world challenges, supported by two coaches. Three of the five project teams worked on an exploration case and two project teams worked on a digital platform about to enter the market. KaPIL consisted of five and one-half theoretical sessions and ten and one-half practical sessions, each lasting about three hours. Students received homework

after each session and were graded based on the final presentation regarding the designed digital platform and written report.

In contrast to other Live-Labs, KaPIL was run entirely digitally due to the COVID-19 pandemic. The researcher used software such as Microsoft Teams, Google Jamboard, Lime Survey, and Mentimeter. The teaching was supported by the Massive Open Online Course (MOOC) "Platform Strategy for Business" by Marshall van Alstyne (Van Alstyne 2020) and external speakers. Surveys among the students evaluated the course comprehensibility and other aspects of the lab. Students were taught the following contents: The importance of platform business models, their design and architecture, launching strategies, network effects, monetarization strategies, and advantages of closed vs. open design.

Survey Results Regarding Platform Tools and Methods

The first survey was conducted on December 16, 2020, and the second on February 3, 2021.To gain unbiased results, the first two questions contained two fictitious platform tools as test variables. In the familiarity study, the test variables were selected, leading to the exclusion of these data sets from the data analysis. Thus, the evaluation included 20 valid data records in the first survey. The second sample was composed of 18 valid data records with the same demographic characteristics. Four design phases are distinguished concerning the use of the canvases. These are based on the design phases of the Platform Design Toolkit by (Cicero 2019). It differentiated between the stages of development: exploration, strategy design, validation, prototyping, and scaling and growth. Exploration is the initial phase where developers first create a context to identify the digital platform and collect different ideas. In the second phase, strategy design takes place. A concrete platform strategy needs to be developed and gradually validated with the network participants. In the validation phase, the riskiest business platform strategy hypotheses are tested using an MVP, interviews, or surveys. After successful validation, the scaling and growth phase follows. Here, participants are acquired and activated while network effects are initiated and promoted between and within participant groups (Cicero 2019). The PBMC is most frequently applied in the first three phases. With existing platform business models, all canvases are used relatively frequently: 90% of the surveyed use the PVC, 85% the PBMC, and 80% the PC. Only the PDC was used by every second person. A statement on the earlier design phases was only meaningful in the second survey since test persons were in earlier design stages as part of the challenge.

Examining specifics in the B2B environment provided a clear picture in the first dataset. The following characteristics for customers in B2B market were mentioned: a smaller number of customers, the presence of direct and indirect customers, heterogeneous requirements, a different way of addressing customer(-s) and -acquisition, multi-personnel decisions, higher quality standards, and personal contact. According to the students, a particular challenge was accumulating enough customers to generate network effects in B2B markets. Another remark was relevant data protection, which is more crucial in the B2B than in the B2C context.

In addition, other decisive factors were collected. The most frequently mentioned challenge was identifying customers. Furthermore, there were difficulties in choosing a monetization strategy, collecting sufficient information in the B2B market, generating network effects, the strong competitive environment, and a lack of knowledge about players and value-added processes in the timber industry.

The evaluation of the results gives the following picture. The PBMC by (Walter 2020) was the favored tool among users and was considered the easiest to understand and use. It had the highest use frequency and the second-highest use intensity. At the time of the first survey, 80% of the sample was familiar with it. After that, the PVC was used second most frequently for mapping existing platform business models. On average, Choudary's PC received the lowest rating for all test characteristics. Based on the investigation results, the PBMC will initially be evaluated as the most suitable modeling tool for platform design. Table 3 shows an overview of the main results of the dataset.

Table 3. *Survey Results Regarding the Platform Design Canvases*

Variables	Scale	Metric	PBMC[1]	PVC[2]	PDC[3]	PC[4]
Preferred Canvas	Nominal	Frequency	67%	11%	17%	6%
Easy to use	Nominal	Frequency	50%	11%	28%	11%
Comprehensibility	Nominal	Frequency	61%	6%	28%	6%
Phase 1: Exploration	Nominal	Frequency	50%	33%	28%	22%
Phase 2: First Draft	Nominal	Frequency	44%	39%	11%	28%
Phase 3: Comprehensive Strategy	Nominal	Frequency	44%	28%	6%	0%
Phase 4: Existing Business Model	Nominal	Frequency	67%	67%	44%	61%
Stakeholder perspective	6-Value-Scale	Mean	4	3.8	3.2	3.5
Completeness	6-Value-Scale	Mean	5	3.5	4.1	3.7
Hypothesis collection	6-Value-Scale	Mean	4.5	3.6	3.8	3.6
Key Stakeholders	6-Value-Scale	Mean	4.8	4.5	3.9	3.3
Key Channels	6-Value-Scale	Mean	4.9	3.7	4,2	4.3
Value Proposition	6-Value-Scale	Mean	5	4.8	4.2	4
Network effects	6-Value-Scale	Mean	4.8	4.5	3.9	2.9

[1]Platform Business Model Canvas [2]Platform Value Canvas [3]Platform Design Canvas [4]Platform Canvas.

Discussion, Limitation, and Future Research

The research was set out to expand the first step of the SPEC – Smart Platform Experiment Cycle and develop a Live-Lab as a validation environment to design and test digital platform tools and methods. The method used for empirical research were online surveys. The advantage of this method is surveys took place independent of place and time during the COVID-19 pandemic. In addition, the standardized survey enabled a statistical evaluation of quantitative data to measure frequencies. The combination of closed and open questions enabled collecting quantitative and qualitative data. However, it was disadvantageous that no questions

regarding the specific response behavior were recorded. Another difficulty was recruiting enough subjects (Bortz and Döring 2006, p. 260 f.). The subjects' characteristics and compliance with the scientific quality criteria of quantitative research determined the validity and quality of the survey results (Goldstein et al. 2018, p. 123). The research results were based on the knowledge gained from two time-delayed, quantitative surveys with students. However, in practice, the target group of the platform tools should include platform developers and entrepreneurs. Accordingly, it is necessary to examine to what extent test person characteristics match the target group characteristics to make a statement about the reliability and transferability of the test results. The study subjects were students. If one compares the student characteristics with the entrepreneurial characteristics, the following can be established: The students represent most of the entrepreneurial age group. A study by Statista GmbH about "Distribution of company founders in Germany by age group in 2019" showed around half of the entrepreneurs are between 18 and 34 years old (Statista GmbH 2020). Another entrepreneurial characteristic was working in a start-up or a company's innovation department, little time and money at hand but having capacities (Hell and Gatzka 2018). Students in the Technology Entrepreneurship master's program fulfilled these characteristics. They required to apply with a business idea or an existing company and were supported in starting or expanding their business throughout their studies. Furthermore, all the students in the challenge take on the role of a digital platform developer. However, due to the repeated, slightly modified survey implementation, the result reliability could be increased.

The following recommendations for future research can be derived. The findings, including the platform design, should be further validated concerning applicability in business practice, directly in startups for B2B platforms, or in the context of Live-Lab studies. According to Albers and Rapp (2022) the model of SGE – System Generation Engineering describes the development of new systems. Future research should investigate the interaction between the development of mechatronic systems and the development of digital B2B platform business models. Running KaPIL for the first time revealed the following insights. The applied software tools helped the researchers organize the lab, conduct polls, and collect feedback regularly. Students criticized separating theoretical and practical parts of the lab. Consequently, the practice part should commence earlier to create an overlay between theory and practice. Future research should show which canvases and platform design tools are adequate to design an initial platform business model and whether certain problem cases are more suitable for this setting.

Conclusion and Outlook

This research shows the Live-Lab KaPIL – Karlsruher Platform Innovation Lab can be used to design digital platform business modles through cooperation between academia and corporates and test related tools and methods. Furthermore, the Platform Design Canvas, the Platform Business Model Canvas by Walter (2020), and the Platform Design Canvas by Cicero (2019) can expand step (1) of

SPEC – Smart Platform Experiment Cycle. In the future, a more structured approach is needed to design digital platforms during the practical application of KaPIL. One possible solution might be to implement an explorative, quickly paced design sprint, for instance, the rapid platform exploration method called SPDS - Smart Platform Design Sprint (Brecht et al. 2023). Additionally, it should be supplemented by innovation coaching activities to guide the development teams (Albers et al. 2020). In future research, more applications of KaPIL are needed to validate its robustness and extend it to other digital platform tools and methods.

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Conceptualization of a Cooperative Company Builder for Systematic Transfer of University Research and Innovation in the German Mittelstand

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Universities lack a systematic transfer from research and innovation projects into practice. German Mittelstand firms have limited resources to pursue explorative innovation, which is required to realize business opportunities and remain competitive. Since current collaborations do not fully unlock innovation potential, this research aims to conceptualize a company builder to bring these two parties together in an entrepreneurial ecosystem. In line with this research's exploratory nature, a multi-method analysis was followed, applying two approaches for data analysis. The company builder information was analyzed via a qualitative document analysis. Seven guided expert interviews were conducted with employees in innovation-related positions in German Mittelstand firms and the university. Findings suggest the company builder's core activity is the venture creation process, ensuring systematic access to university-relevant research and innovation and facilitating valuable interactions among the ecosystem partners. The company builder's value lies in connecting relevant ecosystem partners through a comprehensive company-building environment to exchange knowledge and expertise and meeting the partners' needs equally regarding the new venture. Thereby, it is independent of bureaucratic university structures. Future research should validate current findings with higher sample size and focus on other relevant aspects, such as generating revenue and participation requirements for other potential ecosystem partners.

Keywords: *company builder, entrepreneurial ecosystem, the German Mittelstand, ambidextrous organization*

Introduction

In recent years, firms have experienced increasing pressure to be innovative. Partly, it may be attributed to the growing complexity resulting from globalization and the rapid emergence of new technologies. These developments push organization to become ambidextrous, demanding the ability to simultaneously balance exploitative and explorative activities (March 1991). In today's fast-paced economy, it is crucial to engage in both activities to mitigate the risk of business disruption (Alpkan and Gemici 2016). For the German Mittelstand companies, in particularly, it is a major challenge to engage in explorative innovation due to

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limited resources (Massis et al. 2018). Nonetheless, the German Mittelstand is a significant driver of the German economy as they offer secure jobs and generate sustainable revenues (BMWI 2018). This characteristic stems from their ability to globally exploit the markets they are specialized in (Massis et al. 2018). Thus, Mittelstand firms are required to leverage their limited resources in a profitable manner. A potential solution to leverage their research activities and gain access to adequate talents may be cooperations with universities. A cooperation between Mittelstand firms and universities would not create a new phenomenon. Successful and beneficial university-industry collaborations already exist, which transfer research findings into business practice (Stagars 2015, Apa et al. 2020). These collaborations are primarily formed with large corporations or small-and medium sized enterprises (SMEs), which have the necessary absorptive capacity and apply a similar problem-solving method common in scientific research (Apa et al. 2020). With the German Mittelstand representing SMEs seeking to extent their innovative capacities, the Karlsruhe University of Applied Sciences (HKA) is an example for a university holding valuable scientific based knowledge for SMEs. Currently, the HKA experiences a lack of a systematic transfer of research and student innovation projects into business practice (Hochschule Karlsruhe 2019). Therefore, this research attempts to conceptualize a company builder (CB) to leverage this unused potential by bridging these two parties together. A CB would act as an intermediary connecting relevant university research, innovation, and potential entrepreneurs with Mittelstand firms to systematically transfer knowledge into practice. CBs systematically support entrepreneurial processes of new venture (NV) creation over the long term by accumulating and centrally managing knowledge and resources (Rathgeber et al. 2017). However, to the authors' knowledge, there is a gap in academic research on the engagement of Mittelstand firms in CBs. Hence, the success of existing CBs and the unique requirements of the German Mittelstand make it relevant to investigate how a CB should be designed in a scalable and transferrable manner aimed at contributing to the improvement of systematic transfers of academic research and innovative student ideas into practice and strengthening the Mittelstand firms' competitive position by enhancing their explorative innovation capabilities.

This research aims to contribute to the research on CBs, which to date has only been limitedly investigated from an academic perspective. Previous studies have focused on the types of company builders, the organizational structure of a single case case-study, and the company builders' processes. Since this research only focuses on the analysis of larger independent CB or corporate CBs, the focus on designing an independent company builder with ties to a university that meets the Mittelstand firms' requirements will contribute to closing a research gap. Based on this focus, the following research question is formulated:

> How should a company builder be designed to achieve systematic transfers from research and innovation projects into practice?

Based on two independent approaches, the answer to the research question was derived though a qualitative document analysis and expert interviews. The

qualitative document analysis targeted ten existing CBs and provided first insights into structures, services, and offerings of CBs. Subsequently, the findings of seven guided interviews identified the Mittelstand firms' and innovation researchers' requirements for the collaboration on a CB and relevant services and offerings deemed valuable for the participants. The company builder's core activity is the venture creation process that is enriched by relevant research, practical experience of experts, and entrepreneurial and organizational support towards the NV. The CB should mediate the interest of each actor (the German Mittelstand, potential founders, and researchers), provide networking activities and other events, and ensure good communication between the parties.

This paper is structured as follows. The next section introduces essential concepts and elaborates on current research findings. It introduces entrepreneurial ecosystems, assesses innovation and collaboration in the German Mittelstand, and briefly defines the company builder concept. Section three reveals the methodological approach chosen for this study. Section four presents the analysis and results concerning the primary and secondary data on existing CBs and the expert interviews. Section five highlights interesting findings and points out limitations encountered in this study, giving rise to suggestions for future research.

Literature Review

Entrepreneurial Ecosystem

Entrepreneurial Ecosystems (EE) started developing in the 1980s and are defined as a set of multiple regional actors who bring resources into an ecosystem and collaborate with each other, ultimately leading to the creation and support of NVs. Potential actors include entrepreneurs, firms, investors, universities, and others supporting entrepreneurship (Spigel and Harrison 2018). Company builders as a relatively new actor within this ecosystem (Rathgeber et al. 2017). EEs develop organically as their significant characteristics such as culture, entrepreneurs, mentor networks, and entrepreneurial wisdom emerge from entrepreneurs (Spigel and Harrison 2018). Spigel and Harrison (2018) emphasize that the development of a culture takes time and can hardly be influenced by outside actors. Therefore, other outside actors can only assist in establishing a good foundation for such an entrepreneurial culture to develop, for instance, by connecting entrepreneurs with each other (Spigel and Harrison 2018). These actors bring in resources, which typically suit the unique requirements of start-ups. These resources represent, among others, the knowledge on entrepreneurial processes, such as business planning or funding. In general, EEs develop a broad knowledge base since they connect entrepreneurial networks with a variety of different backgrounds without igniting competitiveness among participants. Hence, it enhances collaboration, particularly with respect to the adoption of similar technologies and similar challenges faced (Spigel and Harrison 2018).

Within EEs it is crucial to ensure that entrepreneurs can access resources. Usually, start-ups are not part of an ecosystem immediately due to their novelty.

Therefore, it is decisive that start-ups actively engage in developing their network to achieve a good reputation that allows them to access an EE and its resources. It requires sufficient connections and mutual trust to build a powerful network. Functioning connections are crucial for participants of the ecosystem to access existing resources. Hence, it requires time for networks and EE to develop. Besides establishing strong connections, the need for time can be attributed to the timely process of accumulating resource variety. As Spigel and Harrison (2018, p. 160) put it: "Key ecosystem resources, such as entrepreneurial knowledge, financial capital, successful mentors, and skilled workers, are created or attracted over time by entrepreneurial activity and public investment. As successful entrepreneurs exit the ecosystem, the resources are "recycled" throughout the ecosystem and can be used by others." This statement suggests that experiences remain within the ecosystem over the long run. Their accessibility depends on the resource flows, hence, on the connectivity within the EE. However, some resources can leave the ecosystem creating disruptions, such as leaving participants or interactions outside the ecosystem. The stronger and more resilient an ecosystem becomes, the better it can absorb disruptions. Experiences regarding entrepreneurial failures can be passed on as well, enabling entrepreneurs to learn from past mistakes of other entrepreneurs within the EE. It shows that an entrepreneur's participation in EEs can be beneficial as they access a variety of valuable resources (Spigel and Harrison, 2018).

Innovation and Collaboration in the German Mittelstand

The German Mittelstand is a major driver of Germany's the economic performance though high employment rates and economic value (Berlemann and Jahn 2016, BMWI 2018, Pahnke and Welter 2019). This economic importance can be attributed to many Mittelstand firms competing on a global scale (BMWI 2018). The German Mittelstand firms are categorized as small- and medium-sized enterprises (SME), which are family-owned and managed with a maxium of 499 employees (Berlemann and Jahn 2016, Klodt 2018, Massis et al. 2018, Pahnke and Welter 2019). Thus, Mittelstand firms tend to possess relatively strong equity shares with the owner or family maintaining significant influence on the strategic and operational management (BMWI 2018, Welter et al. 2015). The firm's mindset stems from being owner-managed and translates into feeling a sense of belonging to the firm (Pahnke and Welter 2019). Key attributes are a conservative attitude towards external financing, long-term orientation over generations, a high level of specialization, local ties and embeddedness, and their close relations with their employees (Berghoff 2006, Massis et al. 2018). Due to their size, Mittelstand firms deal with resource constraints, resulting in limitations in product and service developments and commercialization (Massis et al. 2018). Therefore, they focus on niche markets and stand out with their customer-centric innovativeness (Berlemann and Jahn 2016, Massis et al. 2018). This focus on specialized innovation leads to a competitive advantage, providing the opportunity to leverage expertise, capabilities, and networks to achieve high innovation output (Duran et al. 2016). Mittelstand firms pursue globalization strategies to internationally

exploit their expertise, allowing them to minimize risk and increase revenues while focusing on their core resources and strengthening their competitive advantage (Berghoff 2006, Massis et al. 2018).

Massis et al. (2018) emphasized that Mittelstand firms can overcome resource constraints by strategically engaging with their business environment, network, and ecosystem. The study of Narula (2004) found that SMEs with a certain internal absorptive capacity can benefit from innovation-related activities in their network as they understand and adopt results. In addition, Mittelstand firms have access to a local talent pool due to their established position as an attractive employer offering stable jobs (BMWI 2018, Massis et al. 2018). Employees are highly satisfied as the firm takes responsibility for the employees, the ecosystem, and promotes flat hierarchies and high employee involvement (BMWI 2018, Massis et al. 2018, Pahnke and Welter 2019). It results in low employee turnover rates, supporting the retention of know-how and tacit knowledge in the firm (Sirmon and Hitt 2003). Furthermore, another constraint is unrealized growth opportunities due to the owner's reluctance to share control and declining capital investments from external parties (Massis et al. 2018). The conservative mindset limits internationalization strategies to exports and foreign subsidies instead of exploiting opportunities with joint ventures or other financial collaboration (Massis et al. 2018). The study by Miller et al. (2013) found that a long-term orientation would create resilience that overcomes resource constraints and facilitates long-term innovation. Schlepphorst and Schlömer-Laufen (2016) observed that family-owned businesses actively engaging in research and development (R&D), improved their growth likelihood. These findings provide opportunities for traditional Mittelstand firms.

Berlemann and Jahn (2016) found that owner-managed SMEs achieve above-average innovation output, which is attributed to the owner's strong and fast decision-making (power). It contradicts the perception of Mittelstand firms as "low growth, low-tech and non-innovative" (Pahnke and Welter 2019, p. 346). However, this perception seems to be driven by a narrow perspective on innovation. The Mittelstand pursues a different approach to innovation than modern firms that are perceived as highly innovative (Pahnke and Welter 2019). For Mittelstand firms, formal R&D activities are less important due to their limited resource pool, instead they tend to focus their innovative capacity on continuing to develop their offerings (Pahnke and Welter 2019). Interestingly, evidence showed an increased risk-aversion by family-owned businesses with each generation, even when they actively engage in innovation (Decker and Günther 2017). Furthermore, the relative number of owner-managed SMEs has a significant positive impact on a region's innovativeness since more innovation activities are performed (Berlemann and Jahn 2016). In addition, Mittelstand firms establish strong connections with their stakeholders, including the local banking system, local institutions, such as school and research centers, and the local community. They interact with these stakeholders and establish mutually valuable relationships. Thereby they overcome persisting resource constraints, leverage their competitive advantage, and support innovativeness in the long run (Massis et al. 2018). This traditional long-term oriented model is increasingly challenged by today's volatile fast-changing

environment that dissolves organizational boundaries (Pahnke and Welter 2019). Competing in globalized economies is aggregated due to competition and faced-paced technological developments as their strategic disadvantage in size significantly limits their resources for R&D (Narula 2004).

University-Mittelstand Collaborations

In literature, these collaborations are referred to as university industry collaborations (UIC), providing established firms access to a considerable amount of accumulated knowledge, strong scientific research, and extensive university networks (Stagars 2015). UIC occur in several different forms. Ankrah and Al-Tabbaa (2015) differentiate between the formal and informal, and the focused/ targeted and non-targeted UIC organization. In this light, joint ventures represent the formal targeted agreement characterized through a high level of organizational involvement that both parties capitalize on while a more informal form of UIC are joint lectures (Ankrah and Al-Tabbaa 2015). Thus, UICs provide both parties the opportunity to benefit from each other's resources – firms giving universities access to their practical experiences and universities sharing their innovations and human capital, which may enhance R&D (Caloghirou et al. 2001). As UICs are primarily aligned towards innovation, they benefit larger firms more than European SMEs that do not meaningfully engage in innovation (Community Innovation Survey, in Apa et al. 2020). Universities prefer long-term collaborations with larger consortia or firms with sophisticated R&D (Caloghirou et al. 2001), although UIC significantly improve the innovative capacity of SMEs (Lasagni 2012). Therefore, they are essential for SMEs in traditional industries, which lack the absorptive capacity required to benefit from such collaborations with universities (Spithoven et al. 2011). Notably, these collaborations are organic and typically evolve and improve over time (Steiber and Alänge 2020). Absorptive capacity is a requirement to effectively leverage a firm's network and the resulting innovation, allowing a firm to leverage its position by identifying and capitalizing external knowledge and adopting it as an impactful innovation (Cohen and Levinthal 1990). SMEs with good absorptive capacity achieve more technologically impactful innovations by investments in R&D and openness, which captures and processes external created value (Messeni Petruzzelli and Murgia 2021, Cohen and Levinthal 1990, Spithoven et al. 2011). Thus, if a firm possesses a certain absorptive capacity, it can benefit from engaging in open innovation activities such as UIC (Spithoven et al. 2011). Apa et al. (2020) found evidence that SMEs involved in informally organized UICs benefit in their innovation performance. The informal exchange of tacit knowledge and establishing a mutual relationship are essential, indicating their relevance in formal collaborations as well. Another finding suggests adopting internal R&D structures supports innovation regardless of UIC. It improves the absorptive capacity by enhancing the general innovation performance and supporting knowledge transfers of more formal collaborations (Apa et al. 2020). It is in line with Messeni Petruzzelli (2011) who found that UICs between universities and firms led to complementary technological competencies and long-term, lasting relationships. In support, Messeni Petruzzelli and Murgia

(2021) identified that technological relatedness improved the technological impact of spillovers.

Company Builders

Company builders have existed since 2007 and were developed to create new ventures and establish companies, mainly by making available dispensable company internal resources (Rathgeber et al. 2017, Scheuplein 2017). CBs are defined as a type of organization more heavily involved in building, financing, and supporting start-ups with a systematic process (Peter 2018, Rathgeber et al. 2017). CBs are categorized into two types, classic and corporate CBs (Rathgeber et al. 2017). Companies facing the challenge of being innovative in the fast changing, competitive environment adapt the corporate CB type by developing strategic relevant business division or models to integrate them into the existing business (Alpkan and Gemici 2016, Peter 2018). In contrast, a company pursuing the classic CB type aims at establishing new ventures or developing business models to sell them profitably (Peter 2018).

Generally, CBs independently support the ideation processes, guide founders, and help raise funds. In return, CBs hold majority shares and control the new venture's capital and consequently, greatly influence its development beyond the initial start-up phase (Rathgeber et al. 2017). The CB aims at creating new ventures and selling them in the market with a high return on investment (Steinbrenner 2021). Compared to start-up incumbents or accelerators, CBs distinguish themselves in the time horizons they actively are involved with new ventures (Peter 2018). While accelerators provide shorter support between three and six months and incumbents six to up to five years, some CBs support more than five years. Accelerators provide start-ups with the access to infrastructures and resources. Similarly, incumbents make available infrastructures and venture creating resources to ensure economics support (Peter 2018). Beyond providing start-ups with an infrastructure and relevant resources, CBs create independent companies and get actively involved in development processes, marketing, scaling, and selling of the startup (Peter 2018). Conclusively, all three types follow the goal of venture growth and generating a return on investment, however, the CB is more heavily involved (Peter 2018).

Methodology

In the manner of Albers et al. (2013) a qualitative research approach was chosen to gain a deeper understanding of this new research field. More precisely, a multi-method qualitative analysis was conducted to answer the research question in a holistic manner. Thus, it entailed a multiple case study with ten selected German CBs and seven expert interviews, which underline the explanatory nature of this research (Niederberger and Wassermann 2015, Yin 2017).

The case study analyzed existing CBs regarding their organizational structure and offerings on the platform and was based on a qualitative internet document

analysis. Regarding the CB selection, this work identified only relevant German CBs since this research focuses on the cooperation between German Mittelstand firms and universities in Germany. The search terms used in the selection process were 'Company Builder Germany', 'Venture Builder Germany', 'Venture Studio Germany' and 'Start-up Factory Germany'. The selection process was enhanced with additional criteria to assess each CB's relevance for the analysis. Based on this selection, a sample of ten CB was constructed, encompassing six independent, three corporate, and one university backed CB. The three corporate CBs were wattx by the Viessman Group, BEAM by the Beumer Group and lastly Xpress Ventures by Fiege Logistics. The independent CBs included Rocket Internet, 1648 factory, Mantro, etventure, Fostec Ventures, and Bridgemaker. The university backed CB was UnternehmerTUM by the Technical University Munich. The primary data on the CBs was collected on the respective CB website. In some cases, additional secondary data was collected as no sufficient information on all criteria were found in the initial search. The data collected was analyzed regarding general information on the CB, the role of the German Mittelstand, organizational structures, the support duration of new ventures, the ecosystem, offerings, provided services, and resources. Regarding the organizational structures, the framework proposed by Köhler and Baumann (2015) was applied. It assessed the CB's organizational structure based on four characteristics, namely: NV ownership, decision-making, incentives, and collaboration. The collaboration characteristic was assessed with the ecosystem analysis as it focuses on the CB network and collaboration potential.

The guided expert interviews were conducted with experts to gain a primary understanding of the Mittelstand firms' expectations and requirements, the collaboration potential, and CB suitability from an academic perspective. The interviewees were contacted via LinkedIn and e-mail. The final sample size for the guided expert interviews amounted to seven in total as these were the only available after initial contact. Five experts held a job position in a German Mittelstand firm. The criteria for being considered a German Mittelstand firm were family-owned or family-managed firm, the pursuit of high equity ratio, local integration, and long-term strategic focus. Each selected expert was well versed in digitalization, innovation, and new business management. The other two experts were researchers in innovation coaching and radical innovation, respectively, and were academic employees at the HKA. Almost all interviews were conducted via video calls due to COVID-19 pandemic and lasted between 52 and 95 minutes. Only one interview took place in person at one of the firms. The interviewees consented to recording and taking notes during the conversation. Subsequently, the interviews were transcribed and used for the analysis. The interview questions were categorized in general questions on the firm and interviewee position, followed by question on the topic of innovation, collaboration, and ecosystems. Concerning innovation, it was inquired whether the expert regarded the company as innovative and what approaches to innovation the company engaged in (radical or incremental). Furthermore, it was asked how close innovation related to their core business, whether innovation took place in collaboration with external partners, and what innovation challenges were encountered. The final interview

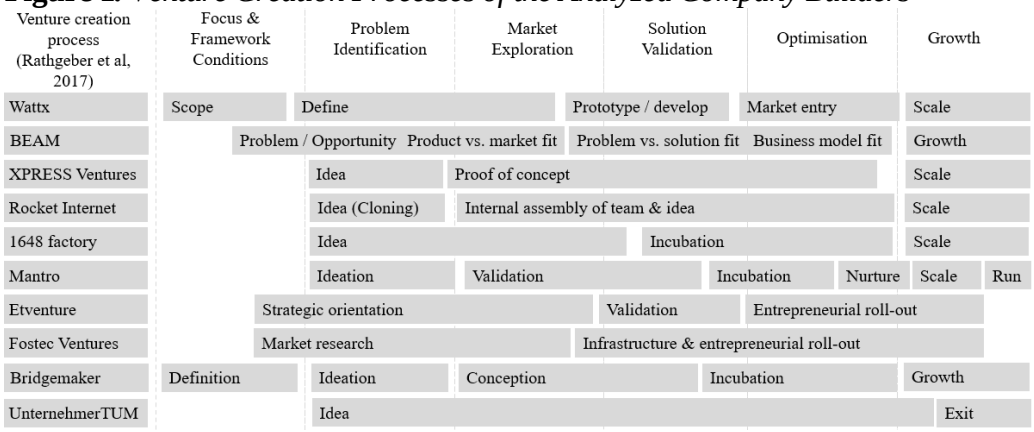
section questioned the interviewees on the CB requirements and the offerings, and a potential interest in a collaboration.

Analysis & Results of the Analyzed Company Builders

Organizational Structure

The analysis focusing on the organizational structure according to Köhler and Baumann (2015) derived the following results. The corporate CBs and the university CB appear more transparent in disclosing ownership structures (primary sourced) while the information on the independent CBs was found in a secondary search. The corporate CBs give their NS different share portions. XPRESS Ventures (2021) stated that NV founders receive the majority share ownership. Wattx holds between 25 to 50 percent of shares whereas the founding team owned at least 50 per cent of shares (Gruenderszene 2016, WiWo Gründer 2018). Beam (2020a) follows a more elaborate approach towards ownership. Founders receive between 15 and 80 percent of shares, depending on whether the NV operates in the intra-logistics industry (the core business) or the logistics industry. In the latter case, BEAM provides the founders with more than 50 percent of shares prior to the third funding stage, known as the Series A funding stage (Beam 2020a). The university-driven CB UnternehmerTUM supports the NVs through neutral partnerships, leaving the majority share ownership with the founding team (UnternehmerTUM 2021a). Derived from secondary data, the independent CBs follow two different approaches. Rocket Internet follows a hierarchical approach as it owns the NV's majority shares while the founding team receives an attractive salary next to the minority share ownership (Köhler and Baumann 2015). In contrast, Bridgemaker provides the founding team with the majority shares (Hombach 2018). Concerning the decision-making structures for the NVs, wattx (2020d) mentioned having simple and pragmatic structures to achieve independent and suitable decision-making for their NVs. 1648 factory (2021d), etventure (2020a) and mantro (2021a) left their NVs with agile decision-making structures. Only Rocket Internet stood out with its highly standardized and data-driven approach towards decision-making (Köhler and Baumann 2015). Moreover, half of the CBs centrally managed the idea- and knowledge management (1648 factory 2021b, Beam 2020b, Köhler and Baumann 2015, mantro 2021b, wattx 2020d). Most CBs focus on incentivizing by providing shares (Hombach 2018, Köhn 2019, UnternehmerTUM 2021a, wattx 2020d, XPRESS Ventures 2021). Only BEAM and Rocket Internet provide additional monetary compensation via a salary, which might stem from BEAM's close relationship with the Mittelstand firm Beumer Group and Rocket Internet's data-centric performance monitoring (Beam 2020a, Köhler and Baumann 2015).

Figure 1. *Venture Creation Processes of the Analyzed Company Builders*



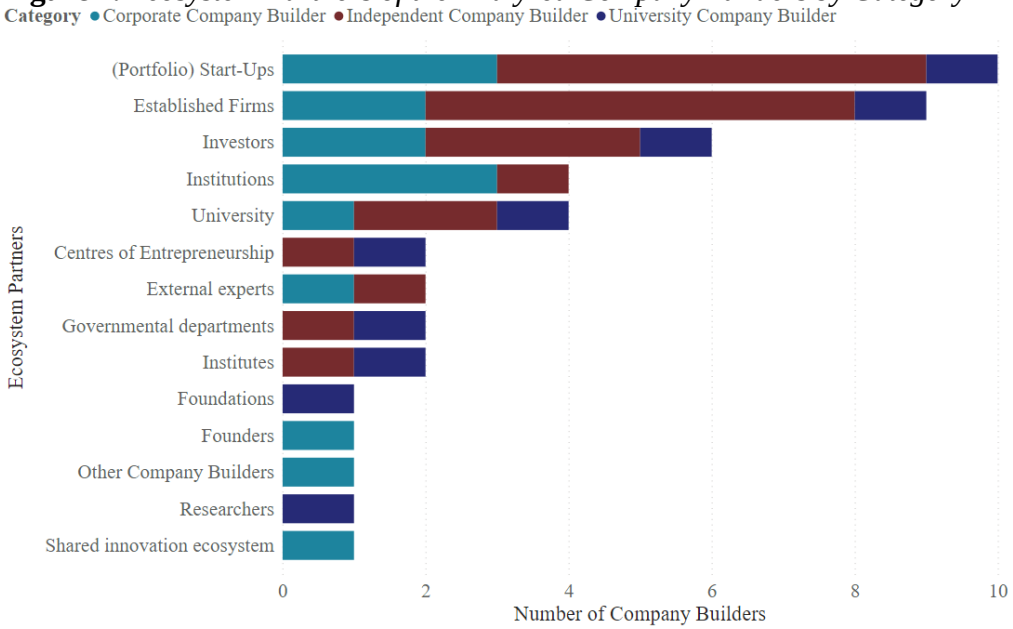
The CBs indicate a long-term support duration of three to five years or more as they seek a long-term partnership with the NVs (1648 factory 2021d, Beam 2020c, 2020d, Bridgemaker 2021b, etventure 2020a, FOSTEC Ventures 2017a, Köhler andBaumann 2015, mantro 2021b, UnternehmerTUM 2021b, wattx 2020d, WiWo Gründer 2018, XPRESS Ventures 2021). The long-term orientation is in line with previous findings as CBs tie their support to their venture creation process, including the scaling or growth phase. As seen in Figure 1, which maps the venture creation processes of the analyzed CB platforms according to Rathgeber et al. (2017), the CBs tend to continue collaborating with successfully scaled ventures by moving them into their portfolio as ecosystem partners (1648 factory 2021d, Beam 2021, Bridgemaker 2021b, etventure 2020a, FOSTEC Ventures 2017b, KI Berlin 2021, mantro 2021c, Rocket Internet SE 2021, XPRESS Ventures 2021). Only the university CB UnternehmerTUM (2021c), does not mention a portfolio of start-ups but considers NVs an integral part of their ecosystem.

Ecosystem Partners

Figure 2 shows the CBs' ecosystem partners. Next to the NVs integrated into the ecosystem as partners, all CBs collaborate with established firms. More precisely, FOSTEC Ventures (2017b) collaborates with SMEs, the corporate CB wattx focuses on Mittelstand firms (KI Berlin 2021). Unlike the other CBs, the corporate CB BEAM collaborates with their partnering institution the Beumer Group and even provides the NVs access to their B2B customers via their ecosystem (Beam 2020c). The university CB has established firms as their ecosystem partners and only offers the venture building to Mittelstand firms (UnternehmerTUM 2021c, 2021d). In addition, some CBs collaborate with universities, external experts, and researchers, which are considered essential ecosystem partners. XPRESS Ventures (2021), for instance, collaborates with legal experts to create legally sound NVs. Beam (2020b) mentors and advises NVs, which highlights their advisory network of experts supporting the NVs. XPRESS Ventures (2021) has universities and research institutes as their ecosystem partners. 1648 factory maintains close collaboration with universities,

which gives access to high-potential talent for their projects (Dortmund Startups 2020).

Figure 2. *Ecosystem Partners of the Analyzed Company Builders by Category*

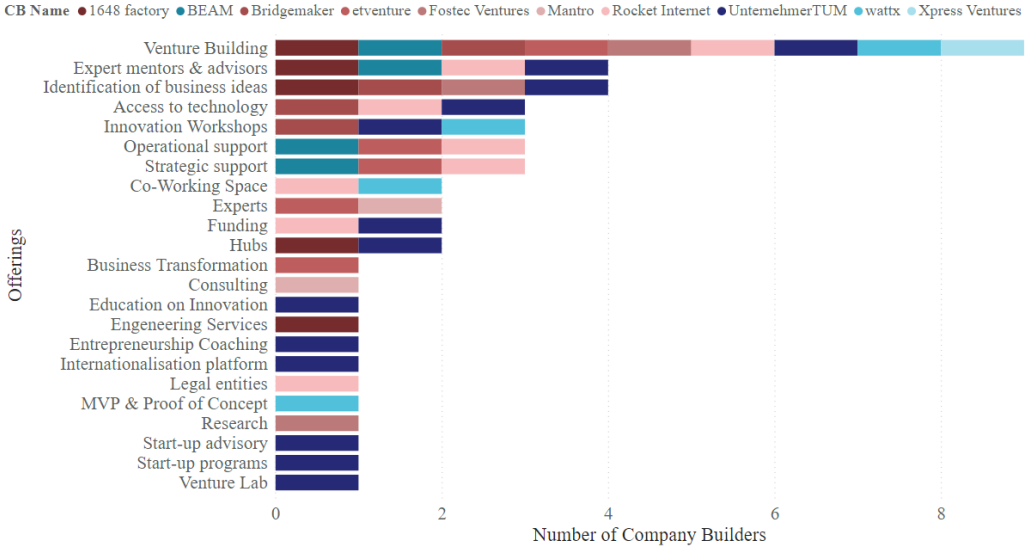


Offerings

As illustrated in Figure 3, all CB types offer venture building. The analysis shows that the CBs offer a different combination of services concerning venture building, such as identifying business ideas for the NVs (1648 factory 2021c, Bridgemaker 2021c, FOSTEC Ventures 2017a, UnternehmerTUM 2021b). In line, Beam (2020d) strategically matches ideas or identified business opportunities to suitable prospective founders. UnternehmerTUM (2021b) offers different services that provide entrepreneurial support to founders, including entrepreneurship workshops, competencies trainings, and entrepreneurship courses. Concerning the entire venture building process, Beam (2020d), etventure (2021) and Rocket Internet SE (2021) offer operational and strategic support for the NVs and potential partners. Another common offering is the access to a network of multi-disciplinary experts fully supporting the NVs (etventure 2020b, mantro 2021b) or mentoring and advising them with their skilled employees, such as senior experts in case of Rocket Internet (1648 factory 2021a, Beam 2021, Köhler and Baumann 2015, UnternehmerTUM 2021d). The CBs offer innovation workshops, which take place independently from venture creation (Bridgemaker 2021c, wattx 2020c, UnternehmerTUM 2021b). Wattx (2020c) offers this service as a measure to methodologically develop and validate a business idea. The university CB supports new product creations and strengthens the capabilities of entrepreneurs and executives regarding entrepreneurship and innovation (UnternehmerTUM 2021b). Lastly, services include the access to different additional material resources for the NVs, such as technological tools, software, and new technologies, which

assist the NVs in establishing an infrastructure for their business (Bridgemaker 2021a, UnternehmerTUM 2021c, Köhler and Baumann 2015). UnternehmerTUM (2021b) allows access to a garage equipped with machinery and software to assist NVs and start-ups. Additionally, the CBs provide a co-working space (wattx 2), a campus with a shared office space (Köhler and Baumann 2015), or innovation and focus area hubs (1648 factory 2021a, UnternehmerTUM 2021b). Conclusively, the CBs offer a variety of services that provide a systematic access to experts, their know-how and resources essential in new venture creation.

Figure 3. *Offerings of the Analyzed Company Builders*



Analysis & Results of the Expert Interviews

Innovation in the German Mittelstand

Innovation in the German Mittelstand is cloud-based software products based on subscription model (Interviewee 2), AI recognition in self-service areas in supermarkets, the smart service adoption to automate inventory management, the minimization of down-times due to remote support, and networked modular production systems, decentralized profiling system, and uniquely customized metal profiles for electric vehicles (Interviewee 2, 2021; Interviewee 4, 2021; Bizerba Innovations 2021). Adapting to new technologies as an integral part of new product development, nurturing ecosystem thinking, and meeting future needs with innovative activities embedded throughout the business, contributes to innovativeness (Interviewee 1, 2021, Interviewee 2, 2021; Interviewee 3, 2021). As a B2B business and part of the critical infrastructure, maintaining continuity is crucial (Interviewee 3, 2021). Being able to satisfy a customer's individual need and solve concomitant problems with individual product customizations developed from scratch shows a company's innovation capabilities (Interviewee 5, 2021). Within the sample of Mittelstand firms, only one company was not innovative as

the internal structure focused on past successes instead of utilizing opportunities (Interviewee 4, 2021).

Approach to Innovation

Two Mittelstand firms follow an organic approach towards innovation as innovation stems from internal activities (Interviewee 2, 2021; Interviewee 3, 2021). In contrast, in an inorganic approach suitable new technologies are acquired externally (Interviewee 1, 2021). Concerning exploitative and explorative innovation, it was considered an integral part of business by most firms. Thus, the majority engaged in both innovation activities. They dedicate business units or positions to screen new technologies and adopt them into the business (Interviewee 1, 2021; Interviewee 2, 2021; Interviewee 3, 2021). Although, balancing exploration and exploitation is an integral part of business (Interviewee 5, 2021), within the B2B environment exploitative activities and incremental innovation weight more due the necessity for continuity (Interviewee 3, 2021). From an academic perspective, the researchers emphasized that firms need to balance exploitative and explorative, and incremental and radical innovation to manage organizational ambidexterity (Researcher 1, 2021). There is evidence of the Mittelstand's tendency to innovate incrementally (70 to 80 percent) as they focus on existing business models and only have limited resources. The Mittelstand lacks a suitable way to innovate radically (Researcher 2, 2021). Regarding open or close innovation, three firms engage in close innovation close to their core business but also exerted innovation potential beyond the core business by implementing separate business units (Interviewee 1, 2021; Interviewee 3, 2021). Interviewee 2 (2021) believes innovation occurs close to the core business as it encompasses strategic software services that supported their products. Research showed firms must consider innovations close and beyond the core business to maintain a sustainable and successful business model (Researcher 1, 2021). Concerning the collaborative innovation potential, the researchers stressed the importance of collaborative innovation to better understand today's complex environment. Researcher 1 believed that collaborative innovation with universities is a source of inspiration and creativity for firms, which provides access to free thinking students, new opportunities, and diverse participants. Thus, engaging in open innovation represents a potential measure for a collaborative approach towards innovation. Researcher 1 (2021) stressed the co-creational nature of open innovation could leverage the participants' competencies. However, Researcher 2 (2021) claimed that the Mittelstand was reluctant in participating in these initiatives as they traditionally worked on their own, although offering higher efficiency and suitability and fostered radical innovation. A glance into practice showed that collaborative innovation and approaches were adapted within the firms. Interviewee 1 reported participating in accelerator programs and external open innovation initiative such as Hackethons. However, these initiatives were considered PR measures without proof of success. Interviewee 5 (2021) claimed collaborating with different partners within their network and participating in European research projects and open innovation initiates, which generate multiplication effects

(Interviewee 5, 2021). Interviewee 2 (2021) reported participating in external collaborative innovation initiatives with publicly sponsored proof of concept programs and pursuing cooperation and firm acquisitions. Engaging in open innovations appears to be a good measure for the future (Interviewee 2, 2021). Interviewee 3 (2021) disclosed predominantly investing and collaborating with start-ups and consultants, and proactively participating in initiatives such as the SAP and Microsoft innovation labs as an early adopter within the Mittelstand.

Challenges and Constraints to Innovation in the Mittelstand

The researchers held two opposing views on challenges and constraints to innovation within the Mittelstand. Researcher 1 (2021) claimed the Mittelstand has limited resources to engage in open innovation and collaboration despite a high potential in such initiatives. Contradicting, Researcher 2 (2021) pointed out the Mittelstand possessed sufficient resources but lacked the knowledge and competencies required for innovation. Both researchers argued that personnel/ human resources as the main constraint. Furthermore, resource management was not ideal, which created a risk-averse attitude towards innovation (Researcher 1, 2021). In this light, Researcher 2 (2021) referenced studies claiming smaller firms having higher employee efficiency compared to Mittelstand firms. The challenges caused through inefficient resource management and personnel was reported by the firm representatives as well. Due to lacking expert knowledge, for instance, in distribution and utilization channels, resources were not managed efficiently leading to capacity shortages (Interviewee 2, 2021; Interviewee 3, 2021). Interviewee 4 (2021) experienced the challenges from employees as the firm's incentive structure and mindset does not promote innovative thinking. Furthermore, internal structures and decision-making processes were not designed for innovation and future-orientation (Interviewee 4, 2021). Further challenges albeit manageable were achieving successful go-to-market with inventions, employee resistance, ensuring feasibility, accessibility, and value of future innovations (Interviewee 2, 2021; Interviewee 3, 2021). Lastly, Interviewee 5 (2021) viewed innovation naturally as a challenge due to the necessity of courage, willingness, and money to implement it.

Collaborations & Ecosystem

All interview expert agreed their firm/university belonged to an entrepreneurial ecosystem. Regarding the Mittelstand firms, the interview partners indicated different participation forms and tasks within the entrepreneurial ecosystems. Interviewee 1 (2021) shared they established their own ecosystem by participating in acceleration programs and acquiring start-ups. In comparison, interviewee 2 (2021) reported that they focused on establishing an internal start-up culture and participating in publicly sponsored projects. The other firms partnered with different actors like research, start- ups, and other projects (Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021).

The reasons for participating in EE were to gain mutual benefits with the partners resulting from knowledge exchange and developing solutions together (Interviewee 1, 2021; Interviewee 4, 2021). Furthermore, it provided access to a new generation of founders, process structures, and technologies, which can be transferred and leverage to the own business (Interviewee 1, 2021). Similarly, it is deemed beneficial in generating new ideas and valuable business opportunities (Interviewee 5, 2021). Interestingly, EE participation created an indirect benefit by establishing a positive reputation and networking opportunities (Interviewee 2, 2021).

From a research perspective, a university's role in an entrepreneurial ecosystem comprised three core tasks: research, education, and innovation (Researcher 1, 2021). The research task provides recent academic insights while the educational task includes transferring research findings via lectures and developing student competencies (Researcher 1, 2021). The innovation task fosters an innovative and entrepreneurial culture by integrating it into education and research (Researcher 1, 2021; Researcher 2, 2021). Thus, universities give their students valuable opportunities by leveraging the exchange with other ecosystem participants, such as firms and start-ups, and building a sound academic knowledge base (Researcher 2, 2021). In return, the university's reputation, entrepreneurship, and the acquisition of prospective students and projects is positively influenced (Researcher 1, 2021).

Collaboration with Start-ups

Within the sample, collaborations with start-ups were highly pursued and created positive and negative experiences. Interviewee 1 stated that relevant start-ups were acquired by applying a majority shareholding strategy without any exit strategies (Interviewee 1, 2021). In contrast, Interviewee 4 and 5 followed a cooperative strategy, which entailed business relationships and partnerships with relevant start-ups. Collaboration with start-ups was deemed positive as start-ups work professionally and have know-how, which diminished the firm's weaknesses and advanced its scalability through network effects, decentralization, and globalization (Interviewee 1, 2021; Interviewee 4, 2021). Furthermore, it increased firm reputation and served as motivation for existing employees to adapt innovative thinking (Interviewee 4, 2021). However, collaborations with start-ups were experienced as challenging. Externally, global start-up scouts and current approaches towards collaborations were limitedly successful due to the COVID-19 pandemic (Interviewee 1, 2021). Moreover, it was challenging to mediate the collaborating partners' requirements, needs, and goals (Interviewee 1, 2021; Interviewee 4, 2021). Lastly, the interviewees stated start-ups suffer from overconfidence, leading to falsely assessing their strengths and weaknesses due to their lack of experience (Interviewee 1, 2021; Interviewee 5, 2021). More precisely, Interviewee 5 (2021) commented "[...] there are great illusions present". From a start-up perspective, it was reported that start-ups had difficulties in finding and contacting a firm representative. Thus, Interviewee 2 (2021) shared the firm only indirectly collaborates with start-ups via publicly sponsored projects.

The researchers collaborated with start-ups in lectures and innovation teaching projects, which provides start-ups with methodological support. Nonetheless, it can be challenging as such innovation projects lack followed up after a semester of collaboration (Interviewee 1, 2021).

University – Mittelstand Collaboration

University-Mittelstand collaborations are experienced within the sample. The researchers claimed they mostly consisted of guest lectures, theses collaborations, workshops including problem solutions by students, and transferring educational formats and research findings into practice (Researcher 1, 2021; Researcher 2, 2021). It was highlighted that the access to the management of Mittelstand firms is alleviated, which in turn leads to a higher level of support for collaboration projects (Interviewee 2, 2021). Especially for research, firm collaboration is an opportunity to transfer research findings into practice and reveal the founding potential embedded in research (Researcher 1, 2021). The experts from Mittelstand confirmed collaborations with universities through guest lectures, collaborations for theses and dissertations, and participating in research and innovation projects (Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021). The Mittelstand favored the collaboration as it increased reputation, offered opportunities for talent acquisition and PR activities, and provided access to new external ideas outside firm boundaries (Interviewee 1, 2021; Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021). In addition, the exchange between scientific research and experts based on methodological knowledge and high-quality frameworks gives insights at an early stage of product development (Interviewee 3, 2021; Interviewee 4, 2021).

Although collaborations between university and the Mittelstand are common, the interviewees disclosed aspects deemed challenging. The different structures between the participants, managing intellectual property (IP) and other rights, and the high level of bureaucracy were viewed as obstacles in the fast-paced innovation environment (Researcher 2, 2021; Interviewee 3, 2021; Interviewee 5, 2021). The Mittelstand, specifically, experienced a lack of precision in tendering, a tendency of universities to pursue non-binding project, and difficulties finding relevant universities, study programs, and contact persons (Interviewee 5, 2021; Interviewee 1, 2021). It was further highlighted that the usability of research results was limited as researchers were reluctant to share their data sets, especially regarding artificial intelligence and machine learning (Interviewee 3, 2021). Furthermore, it was criticized that the project scopes were too broad, instead of focusing on developing specific services or solving concrete issues (Interviewee 3, 2021). Lastly, interviewee 4 (2021) believed students suffer from false self-assessments regarding their strengths and weaknesses. They lacked work experience, which impacted the quality of project results.

Requirements to Participate in a Company Builder

The interviewed researchers were familiar with the concept of company builders (researcher 1, 2021; researcher 2, 2021). However, more than half of the experts at the Mittelstand firms had not heard about company building prior to the interview (Interviewee 1, 2021; Interviewee 2, 2021; Interviewee 5, 2021). The remaining interviewees indicated to achieve multiple goals when participating in a CB. Firstly, it should enhance employer branding and recruiting regarding generative thinking, and promote social responsibility (Interviewee 1, 2021). Secondly, it must generate value to compensate for the time invested, such as knowledge, additional services or products, or the access to new markets (Interviewee 4, 2021). In case of acting as strategic investors, the experts expect matching with teams that solve a specific issue, which in turn creates NVs (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021). Lastly, participating in the network should lead to exchanging ideas on innovative topics and accessing the respective innovation power (Interviewee 2, 2021; Interviewee 5, 2021). The researchers would contribute with their research, which builds the foundation of NVs (researcher 1, 2021; researcher 2, 2021). It includes to systematically follow up on research results and innovation projects as a university aims to attract students and researchers (researcher 1, 2021; researcher 2, 2021).

The experts mentioned several factors influencing their decision to participate in a CB. One crucial factor is the clear definition of expectations and responsibilities of the different parties (Interviewee 1, 2021; Interviewee 2, 2021; Interviewee 4, 2021). More precisely, it was deemed essential that a NV maintains its freedom rather than being forced into the established firm structure (Interviewee 2, 2021). A good collaboration requires a balance between benefits and the associated costs, a reliable and formal framework with assigned contact persons across projects, and sufficient support (Interviewee 4, 2021). Unsurprisingly, the appropriate match between the founding team's idea and the firm's issue was crucial (Interviewee 3, 2021). In this regard, the experts require experience, competencies, and expert knowledge in the respective business area, especially within the B2B segment and process optimization (Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021).

The desired benefits by the experts at the Mittelstand firms varied. Interviewee 1 (2021) claimed participating in a CB would only be desirable when scouting and access to start-ups at the growth stage would be offered as they only are interested in investing (Interviewee 1, 2021). The others desire access to new ideas, innovation, know-how, new methods, and access to potential founders, talent, experts, and networks (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021). Considering networks, quality indicators incentivizing participation would be participants and ideas, an active alumni network, and the reputation of the sponsoring university (Interviewee 2, 2021). Most profoundly, the expert emphasized that the pursuit of an actual business with the intention of establishing a NV instead of mere research results should be focused on. Thus, an accurate match with prospective founders with a mature business idea with the appropriate Mittelstand firm within the CB that goes beyond research and analysis

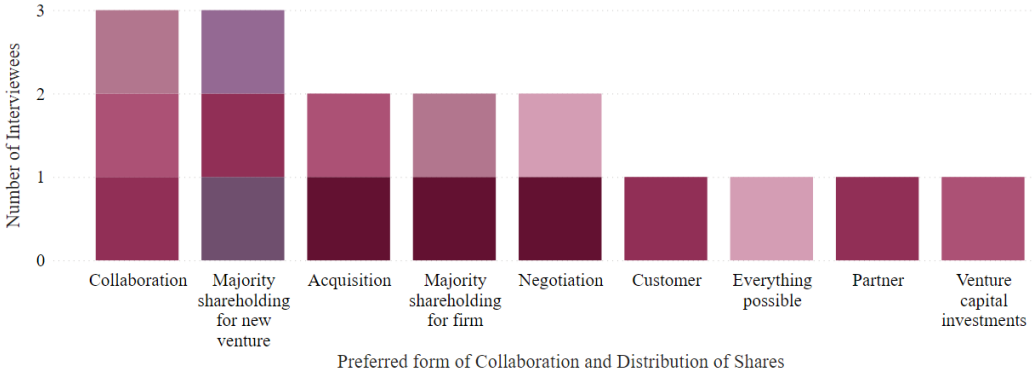
activities was the determining factor for the experts to participate (interviewee 3, 2021; Interviewee 4, 2021; interviewee 5, 2021). In comparison, the researchers desire to utilize their research results, distribute with, and market them (researcher 2, 2021). The CB's independence from universities makes participation more attractive as bureaucratic structures are avoided (Researcher 2, 2021).

The researchers and Mittelstand firms expressed some concerns regarding platform participation. Notably, the sample believed matching relevant academic insights with the company or prospective founders with the firm and identifying potential founders among students forming a well-functioning teams based on their personalities and skills would be challenging (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021; Researcher 2, 2021). From a structural perspective, the CB's close collaboration with the university may aggravate transparent access for firms due to their different structures and processes (Researcher 1, 2021). Thus, university should not hold NV shares due to its bureaucratic and slow structures (Researcher 2, 2021). Moreover, Mittelstand firms saw a challenge in harmonizing their business processes, infrastructure, rules, and procedures with the emerging NVs (Interviewee 2, 2021). Lastly, managing IP was deemed difficult; particularly, attributing and compensating contributors or protecting data since public offerings or participating in projects of a CB may result in a competitive disadvantage (Interviewee 3, 2021; Researcher 2, 2021).

Relevant Services, Offerings, and Features of a Company Builder

The firms have different preferences for the collaboration with a NV and share distributions. Figure 4 presents the preference of each interview partner. The Mittelstand experts are depicted in pink while the researchers are shown in purple. Most prefer a collaboration form, which depends on case-specific negotiations with each NV (Interviewee 1, 2021; Interviewee 5, 2021). Both researchers emphasized the founders should receive the majority shares as they put in the effort to establish the NV and the responsibility lying with the CB to mentor the firm and protect the NV from a takeover by the firm (Researcher 1, 2021; Researcher 2, 2021). Some Mittelstand firms prefer to hold majority shares to gain a higher level of control (Interviewee 1, 2021; Interviewee 4, 2021), especially if the NV performs close to the firm's core business (Interviewee 3, 2021). One expert prefers share distribution according to the effort put into a NV, associated risks and competencies (Interviewee 5, 2021).

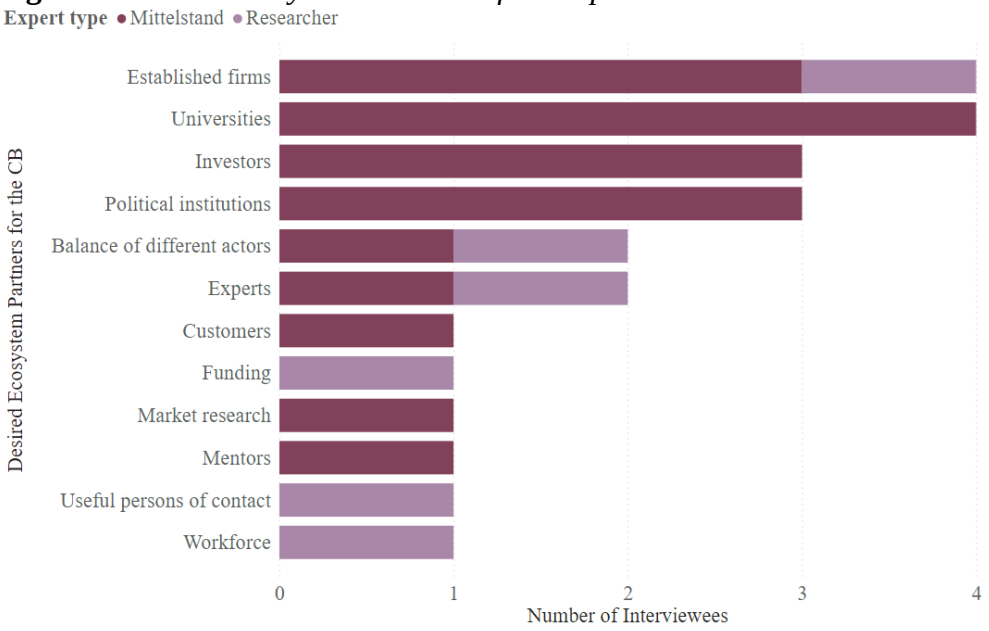
Figure 4. *Preferred Forms of Collaboration and Share Distribution of the Experts*



Regarding the collaboration duration with the CB platform and potential NVs, all experts prefer a long-term collaboration. It takes time and commitment to establish a network and to create a scalable business model (Interviewee 2, 2021; Researcher 2, 2021). Thus, the support should last until the NV can act independently, revealing collaborations are not time-dependent but depend on the goals of the project or business unit (Interviewee 1, 2021; Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021). As such, albeit regular exchange is welcomed, collaboration and participation on the CB might only last short-term over a specific project duration (Interviewee 1, 2021; Interviewee 3, 2021). In respect to support intensity, the level of support shifts over time. A NV likely requires less entrepreneurial and methodological support from academia once it established itself as a profitable business model, but increased support by the experienced Mittelstand firms to foster growth until it can manage operations independently (Interviewee 4, 2021; researcher 2, 2021; Interviewee 5, 2021). However, the support should be consistent or situational, which translate into regular meetings or panels taking place without impacting daily business or only when support is required (Interviewee 1, 2021; Interviewee 2, 2021; Researcher 1, 2021; Interviewee 4, 2021). Interestingly, it was mentioned the intensity of support may also depend on the benefits the parties receive.

Concerning the mechanisms of decision-making and processes, the experts prefer decentralized decision-making and a structured venture creation process, thereby maintaining the NV's autonomy, freedom, creativity, independence, and motivation (Interviewee 3, 2021; Interviewee 1, 2021; Interviewee 2, 2021). Thus, the CB should be a neutral party, mentor, moderator, and mediator between founders and established firms, and central network coordinator to generate value for the NV (Interviewee 2, 2021; researcher 2, 2021). Nonetheless, the Mittelstand firms want strategic influence as they are strategic investors who want a ROI; especially when the NV operates close to the core business (Interviewee 4, 2021).

Figure 5. *Desired Ecosystem Partners of the Experts*



The venture creation process should be adapted to the unique needs of each NV, should involve good project management, and phases to bundle decisions (Interviewee 4, 2021; Interviewee 5, 2021).

Looking at Figure 5 depicting the desired ecosystems partners of the experts, it is shown that a variety of actors are deemed valuable. Access to a broad network of actors is welcomed as every ecosystem partner is indispensable as their value depend on the unique requirements of a business idea (researcher 1, 2021; Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 5, 2021). One researcher stresses that the ecosystem should include a broad set of experts, such as lawyers for legal questions (Researcher 1, 2021). Furthermore, a diverse set of established firms with respect to their size, industries, and regions, who contribute with their experience and by offering technological support (Interviewee 2, 2021; Researcher 2, 2021). The Mittelstand emphasized universities played an important role in the ecosystems since they provide knowledge, know-how, student ideas, their research, and projects (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021). Political organizations and institutions predominantly contribute as a quality criterion (Interviewee 2, 2021). Regarding external investor involvement, three Mittelstand firms regard additional independent investors and venture capitalists as useful ecosystem partners (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 5, 2021), while refuted it due to their own role as strategic investor (Interviewee 4, 2021).

Table 1 reveals the CB platforms services and offerings highly desired by the experts categorized by general, resources, ecosystem, processes, and services. The Mittelstand experts are represented in each category while researchers main interest lies in the processes and services. The experts want to benefit by a good matching, the access to different resources on the CB platform, and the facilitated exchange with the different participants and the CB's ecosystem. The CB platform

should provide the methodological knowledge, such as lean start-up, design thinking, business model creation and entrepreneurial skills and tailor it to the needs of the emerging NV (researcher 1, 2021; Interviewee 2, 2021; Interviewee 4, 2021; Interviewee 5, 2021). The service of venture building is regarded as the core offering of the CB platform, which the previous data analyzed provided details on.

Table 1. *Desired Services of the Experts for the Company Builder Platform*

General	Resources	Ecosystem	Processes	Services
A good solution in as little time and effort as possible (interviewee 3, 2021)	Database of ideas (interviewee 2, 2021)	Access to alumni network (interviewee 1, 2021)	Interaction and communication to establish a relationship (interviewee 1, 2021)	Innovation coaching (researcher 1, 2021)
Access to platform (interviewee 4, 2021)	Access to ideas, founders, and researchers (interviewee 2, 2021; interviewee 4, 2021; interviewee 5, 2021)	Access to network and ecosystem (researcher 1, 2021; interviewee 4, 2021; interviewee 5, 2021).	Continuous support in new venture creation process (researcher 1, 2021; interviewee 4, 2021)	Mediation between the different partners (researcher 2, 2021)
matching idea & potential on different levels (interviewee 5, 2021)	Access to existing solutions (interviewee 4, 2021)	Funding (interviewee 5, 2021)	Digital exchange platform to facilitate collaboration (interviewee 2, 2021)	Events (interviewee 4, 2021)
			Regular structured exchange in panels (interviewee 3, 2021)	Problem space (interviewee 4, 2021)
			Controlling of activities and success (interviewee 2, 2021)	Informational newsletter on future initiatives and opportunities (interviewee 4, 2021)
			Systematic transfer of research into practice (researcher 2, 2021)	Option to build joint ventures (with other established firms) (interviewee 4, 2021; interviewee 5, 2021)
				Basic services for new ventures (interviewee 4, 2021)

Table 2. *Opinions of the Mittelstand Experts on Selected Company Building Offerings*

Interview Partner	Existing ideas/teams vs joint ideation	Innovation workshops	consulting	Expert network & mentors	Additional funding	Co-working space	Access to research	Access to technology	CB resource pool	Innovation hubs
Interview 1	Existing ideas & teams	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Interview 2	Both	Yes	Yes	Yes	New venture's decision	Yes	Yes	Yes	Yes	Yes
Interview 3	Existing ideas & teams	Yes, only for firms	Yes	Yes	Investors instead CB fund	Irrelevant	Yes	NA	Yes	NA
Interview 4	Existing ideas & teams	Maybe	Maybe	NA	NA	Irrelevant	Yes	Yes	No	Yes
Interview 5	Both	Yes	Maybe	NA	Depends on contract	Irrelevant	Yes	Yes	Yes	Maybe

Based on the analysis of the existing CBs, Table 2 was constructed. It depicts eleven offerings, which were shown to the interviewees to assess their relevance. As shown, most Mittelstand firms prefer collaboration with existing founding teams due to the strength of start-ups in ideation (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 4, 2021; Interviewee 5, 2021), the rigid structures of established firms (Interviewee 2, 2021), and the better identification of marketable innovation potential by intrinsically motivated founders (Interviewee 3, 2021; Interviewee 5, 2021). The two firms that can generally imagine both, the collaboration with existing founding teams and a joint ideation, emphasized the

collaboration with existing teams to be more valuable for similar reasons (Interviewee 2, 2021; Interviewee 5, 2021).

Regarding providing innovation workshops three of the experts see value in this offering while one expert argued innovation workshops as a natural part of company building and should not be listed as a formal offer (Interviewee 2, 2021). Interviewee 5 (2021) highlighted the chance to enhance their creativity and inspiration through their participation in workshops and other training formats. Only interviewee 1 (2021) does not see value in innovation workshops since their firm prefers to perform these internally and source support from more established providers. Interviewee 4 (2021) sees danger in innovation workshops as they distract the founding teams from their core product and recommends this service only for established firms. Two experts favor consulting services as they are essential in respect to the methodology and are goal-oriented due to the innovative student mind (Interviewee 2, 2021; Interviewee 3, 2021; Interviewee 5, 2021). Three experts are hesitant regarding consulting and hold the CB should only consults on specific topics of expertise, like new digital trends (Interviewee 5, 2021). The CB should prove success with their venture building before competing with established consulting firms (Interviewee 4, 2021), underlying that established professional services firms might be more favored (Interviewee 1, 2021). However, the access to an expert network and mentors is favored as it is key for establishing NVs and receiving support as a founder (Interviewee 3, 2021). The CB should ensure that access and interaction with the most fitting experts is established or to offer a sounding board, symposium, or forum, which can act as an environment for communication and knowledge exchange (Interviewee 1, 2021). The opinions on the CB providing additional funding vary. Interviewee 1 (2021) showed no interest in it as they apply acquisition strategies. Furthermore, it is believed financial investors may contribute to the selection of marketable ideas, signaling what ideas are more likely self-sustaining as investors may bear more risk for the NVs than CB funds (Interviewee 2, 2021; Interviewee 3, 2021). Interviewee 5 (2021) takes on a neutral stand, pointing out the dependence on additional conditions. Thus, it is recommended to offer the NVs both options via the CB (Interviewee 2, 2021). Offering of a co-working space is irrelevant for the Mittelstand firms and depends on the NVs choice to locate (Interviewee 3, 2021; Interviewee 4, 2021). While interviewee 1 (2021) positively voted on the access to a temporary space as it is dedicated to creativity and innovation, interviewee 5 (2021) viewed it critically since innovation cannot be forced into a room.

All Mittelstand experts value the access to research under certain aspects. Research should be easily accessible either via a database, which holds relevant ideas, theses, results, and contact details (Interviewee 2, 2021; Interviewee 3, 2021). However, customized reports or pro-active matching with relevant specialists by the CB is preferrable as database research might be too time-consuming (Interviewee 3, 2021; Interviewee 4, 2021). Importantly, the NVs should not spend time writing papers that may distract them from their business (Interviewee 3, 2021).

Regarding access to recent technologies via the CB, it is considered valuable when easily accessible (Interviewee 1, 2021). It is considered a way to accelerate

the NV and should be customized to the respective business model (Interviewee 4, 2021; Interviewee 2, 2021). Most experts are positive about access to a resource pool provided by the CB. Particularly, if it consists of experts with a niche focus or students adding value to the NV or the firm (Interviewee 1, 2021; Interviewee 2, 2021). In contrast, interviewee 4 (2021) prefers to employ people when required, for instance, by offering positions for trainees or interns via the CB (Interviewee 4, 2021). Furthermore, innovation hubs can be a valuable offering for Mittelstand firms since they inspire the exchange with experts on specific issues and solution, and are goal-oriented (Interviewee 1, 2021; Interviewee 3, 2021; Interviewee 4, 2021). Interviewee 7 (2021) appeared critical and pointed out that innovation requires a certain level of interaction beyond industry interfaces.

Discussion

This study aimed to conceptualize a company builder that systematically transfers university research and innovation into the German Mittelstand. Analyzing existing company builders extracted, among others, insights into organizational structures, services, offerings, and ecosystem partners deemed essential for company builder. In a consecutive step, expert interviews were conducted to assess a customized company builder's relevance for firms and derive essential elements attracting Mittelstand firms to become ecosystem partners. It was confirmed that the entrepreneurial ecosystem consisting of university and industrial and governmental actors creates interaction and spill-over effects beneficial to the participating parties. The interviewees confirmed that the firms are long-term oriented and customer-centric to strive for continuous improvement and remain competitive. Collaborating with start-ups, universities and participating in innovation programs to create collaborative innovation is crucial for the Mittelstand to overcome resource constraints and access more external explorative activities. In this context, it was shown that choosing the most suitable partner for a collaboration is challenging for the firms and at times considered merely beneficial as a short-term PR measure. Thus, as part of a company builder's ecosystem, German Mittelstand firms can evolve their ambidextrous activities by leveraging their limited resources in well-matched innovative joint ventures and collaborations with universities and other actors. In turn, they gain access to new ideas, talent pools, and individuals with an entrepreneurial mindset backed by university research and knowledge while liberated from bureaucratic restrictions or time-consuming processes. Similarly, researchers can make use of the opportunity to transfer their insights into practice and gain a more holistic view with the practical input while disengaged from bureaucracy.

The conceptualized CB stands out by putting the systematic transfer of university research, innovation, and potential founders, derived from innovation projects at its center. Therefore, the CB's core activity lies in the venture creation process, with its success depending on connecting the right actors, accumulating relevant resources, and providing ongoing entrepreneurial and organizational

support. The CB's role as a mediator between the Mittelstand firms and the NV's founders is critical for the collaboration's success because it ensures the NVs autonomy to foster creativity and innovation and navigate the Mittelstand's influential power towards the NV. Next to the core activity, additional services and offerings aim at turning a NV into a scalable and marketable business. As such, connecting founders, experts, mentors, researchers, and alumni in (networking) events and forums, providing innovations hubs or problem spaces, and ensuring regular exchange, interaction, and good communication throughout the venture creation process in an easy and accessible manner should be provided and managed by the CB.

This exploratory study has encountered some limitations that give rise to future research. To the authors' knowledge, previous studies have not focused on the design of company builders, aimed at fostering collaboration between the German Mittelstand and universities to transfer their unique knowledge and experience in a venture-creating environment. The requirements for a company builder targeting the identified entrepreneurial ecosystem partners are based on a thorough analysis of ten existing company builders and seven expert interviews. The existing CBs were selected based on specific criteria, which might have led to the exclusion of CBs that might have added more valuable insights. These two sources revealed primary insight into a company builder customized for the German Mittelstand and universities. However, due to the small sample size of interview partners, this study should be considered a preliminary study that revealed a company builder prototype that requires further verification and validation. Based on this study's findings, future research should be quantitative and present current findings in a survey to a higher sample of the German Mittelstand and researchers. It could be analyzed to what extent the extracted organizational structure, services, offerings, and resources hold and are statistically significant to improve the CB's design. Furthermore, this study focused on the conceptualization of the CB regarding its core activity, services, and offerings. Essential aspects, such as monetization, participation requirements for potential ecosystem partners, or in what form the CB should be conceptualized (digital or physical), were not the subject of this study. Future research should identify the CBs revenue streams, entry requirements, and whether it is more relevant to be accessible digitally via a digital platform or should occupy a physical space. Finally, although the chosen researcher signaled a willingness to share their research findings, the firm representatives shared their experience about researchers being reluctant to share their research findings. Future research should put a higher focus on the researchers to assess to what extent sharing research-based knowledge and participating in a knowledge-sharing environment, such as a CB, is attractive for other researchers.

Conclusion

This exploratory study revealed that the company builder should be designed with the venture creation process as the core activity to transfer university research

and innovation into the new venture (NV) and enrich it with practical expertise and knowledge from the German Mittelstand experts. Serving all participants' needs as a mediator, the company builder must manage and represent the partners' interests in a nurturing manner towards the NV. Additional services and offerings such as networking events, innovation hubs, and expanding the entrepreneurial ecosystem with relevant partners will determine the company builder's success and attract and retain more partners. In future research, this study's findings need to be validated with a higher sample of university and Mittelstand representatives to confirm the conceptualized company builder.

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FDI Flows and the Effects of the Shadow Economy: Evidence from Gravity Modelling

By Tobias Zander[*]

This paper analyzes the question of if the size of the shadow economy affects foreign direct investment (FDI) flows and what effects, if any, there are. Since about 1990, FDI has become the second crucial pillar of economic globalization in OECD countries and worldwide; such FDI inward and outward flows contribute to higher per capita income and international technology transfer. To analyze this question, both fixed effects, as well as dyadic fixed effects gravity models, are used on an OECD-only dataset that allows for data on bilateral, bidirectional FDI flows for the years from 1992-2018. The empirical results suggest a positive effect of the shadow economy for FDI target countries and a negative effect for FDI origin countries. Additional findings via an interaction term show that the shadow economy can counteract the negative effects of an increase in government size on FDI inflows. From a policy perspective, changes in the size of the shadow economy – typically taking place in periods of recession, in a high taxation environment, or in the context of a pandemic shock – should be carefully monitored by economic policymakers as well as by policy monitoring international organizations such as the IMF and the EBRD. If a group of (OECD) countries decides to adopt anti-shadow economy economic policies, there will be pressure on other (OECD) countries to also adopt similar policies since the difference between the size of the shadow economy in the source country and the host country has a negative impact on FDI inflows. Thus, FDI could indirectly be a catalyst for reforms.

Keywords: *international economics, foreign direct investment, gravity model, shadow economy, OECD countries*

JEL classification: *C23, E26, F21, F23*

Introduction

Total foreign direct investment (FDI) flows in 2021 amounted to 1.65 trillion US dollars (USD), thus showing a recovery from their exceptionally low level in 2020 due to the COVID-19 pandemic with an increase of 718 billion USD, with developed economies accounting for more than 500 billion USD, or more than three-quarters of total FDI flows (UNCTAD 2022a, 2022b). Compared to total FDI flows in 1990 of around 220 billion USD and it becomes obvious that FDI has grown very rapidly into a sizeable and important part of the world economy, particularly important in member countries of the Organisation for Economic Co-operation and Development (OECD), some Newly Industrialized Countries, and

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China. It is noteworthy that FDI is also associated with many benefits for the target economy (the recipient of the FDI flow so to say):

- FDI inflows contribute to capital accumulation (greenfield investment) and international technology transfer (via both greenfield FDI and international mergers & acquisitions (M&A)). Thus, FDI inflows can result in job creation and access to new technologies, thus promoting labor productivity and possibly also economic growth in the respective host country.
- The introduction of new technologies also encourages the enhancement of human capital and skill upgrading where both effects also in turn raise domestic real income.
- FDI can also bring advantageous spillover effects resulting from horizontal and vertical linkages in the host economy (OECD 2002).

Therefore, unsurprisingly, FDI has been and still is a popular and relevant topic in the research community (see, e.g., Zander (2021), Baier (2020), van Cuong et al. (2021), Huynh et al. (2020), Roeger and Welfens (2021)). A lot of research is done concerning the locational factors of countries that affect FDI flows using gravity models, and this paper follows this established approach.

The topic of the shadow - or underground - economy has also been a topic for quite some time in the economic literature. In the late 1970s, this topic started to first appear within a broader economic debate. Another thing observed at that time was the growth in the size of government and rising levels of taxation and higher tax rates; higher unemployment rates also increased the incentive for certain workers to seek additional income in the shadow economy in many OECD countries in the 1970s. This, combined with more regulation, led to growing incentives for individuals and corporations to enter the shadow economic sector in order to avoid taxes and regulations. Thus, at that time, a good case could be made for the shadow economy to be a growing concern (Tanzi 1999).

The corona (COVID-19) pandemic which induced a recession in many countries in 2020 and the following years and considering the concerns related to the Russian invasion of Ukraine in early 2022, coupled with inflationary pressure due to a global temporary shipping crisis – partly related to the Corona lockdowns in Shanghai and other Chinese ports in 2022 – and general distortions in sectoral global value chains, as well as the increasingly evident effects of climate change on the economy, has resulted in higher pressure on governments to step in and actively fight these crises. This, of course, usually means increased government spending which could, in turn, lead to an increase in taxes (Nikopour et al. 2009). Therefore, the case can be made that the incentive to avoid taxes and regulations is growing once again. This also means that it is important to research the effects of tax evasion opportunities, such as the extent of the shadow economy, empirically since the shadow economy is an important part of the overall economic system and can affect every aspect of the economy (van Cuong et al. 2021). The costs associated with the shadow economy can include labor market distortions, the suboptimal provision of public goods, revenue losses due to the under-reporting of wages and production, and the reduced provision of and access to finance

(Kelmanson et al. 2019). The Corona shocks in OECD countries have been found to contribute to the growth of the shadow economy (Schneider 2022).

Therefore, it is important to explore the linkages between FDI and the shadow economy as well as other drivers of FDI. Conducting such research can provide policymakers with the necessary empirical evidence and knowledge as both FDI and the shadow economy are important aspects of a country. If the goal is to attract FDI, does the shadow economy work against achieving that goal? It may be that the size of the shadow economy is considered by foreign investors as a signal of a rather poor institutional framework or inconsistent economic policy strategies. Is it important to reduce the shadow economy to be more attractive for multinational companies (MNCs)? Or is it the case that maybe the shadow economy – with its size signaling excess labor supply – offers opportunities for MNCs and therefore acts as a factor that may indeed attract FDI? This paper provides evidence to answer these questions by researching the effects of the shadow economy on FDI inflows through the use of a gravity model. There are relatively few empirical studies when it comes to the nexus of FDI flows and the shadow economy. Thus, this paper adds to the literature by making several contributions to the existing empirical frontier, namely by creating a new dataset for the gravity model analysis of shadow economy effects on FDI flows for OECD countries for the years 1992-2018, by giving new insights from state-of-the-art gravity modeling into the nexus of FDI and the shadow economy; and by including three interaction terms, which attempt to capture potential interactions between independent variables and the shadow economy.

The remainder of the paper is structured as follows: next section provides a brief review of the theoretical literature regarding the shadow economy, and FDI as well as empirical studies regarding the nexus of the shadow economy and FDI. Then the following section reviews the literature regarding the gravity model as well as the data, FDI determinants, and the specification of the model. Afterwards, in the coming section presents the results and additional considerations while last section concludes with economic policy implications.

Literature Review

In this section, the relevant theoretical and empirical literature will be reviewed. The goal is to build a theoretical basis and use empirical evidence in conjunction with the theoretical literature to build hypotheses concerning the links between the shadow economy and FDI flows which can be tested in the present analysis.

Theoretical Literature

One of the early theories in International Economics stems from the neoclassical trade theory's Heckscher-Ohlin model. The idea behind the theory is that countries differ in relative factor endowment which leads to international factor price differences and thus a clear specialization pattern in production and exports as well as imports. Following this logic, a capital-abundant country would

specialize in capital-intensive goods production if it is highly endowed with capital (relative to labor) so that economic opening up leads to more production of the capital-intensive good and indeed also to exports of the capital-intensive goods produced; and if the capital intensity is rather low, a country will specialize in labor-intensive production and exports after economic opening up; moreover, there could also be international capital movements to a country where returns on capital are higher until factor price equalization is achieved (Faeth 2009).

The traditional theory though made little distinction between FDI and international portfolio flows. Hymer (1960) was the first to find inconsistency between this approach and FDI data. In short, "Hymer envisioned a world in which real (not financial) factors shape the location of multinational activity and financial flows are a mere consequence of the financial structure decisions of multinational firms." (Antràs and Yeaple 2014). After refinement by multiple authors (see Antràs and Yeaple (2014) for more), the result was Dunning´s eclectic paradigm (Dunning 1977). Dunning looked more at the idea of what factors influence a firm's decision to invest abroad. He identified three broad advantages in his eclectic paradigm: Ownership (e.g., a firm's production processes), Location (e.g., market access), and Internationalization (e.g., lowering transaction costs) advantages. This became known as the OLI framework. These advantages can vary and depend on the characteristics of the country, industry, market, and the MNC itself (Faeth 2009).

Other models try to explain FDI dynamics using the concepts of horizontal FDI, vertical FDI, and the Knowledge-Capital (KC) Model. "Vertical MNEs [Multinational Enterprises] engage in trade and seek to exploit international factor price differentials whereas horizontal MNEs seek to save trade costs by serving markets locally" (Baltagi et al. 2007). Based on earlier work (see Markusen et al. (1996) and Markusen (1997)). Carr et al. (2001) develop the so-called "Knowledge-Capital model" which combines vertical and horizontal modes of MNC entry. The authors create a 2x2x2 model with three basic assumptions: firstly, knowledge-generating activities can be separated from production; secondly, these activities are skilled-labor-intensive, and - thirdly - knowledge-based activities have a joint-input character. The first and second assumptions lead to the motivation for vertical FDI (access low wages), whereas the third assumption delivers a motivation for horizontal FDI (access markets). This results in the horizontal firm being active in countries of a similar size and with similar relative factor endowments whereas vertical firms have an incentive to headquarter in countries with an abundance of skilled labor and have production in a country where skilled labor is relatively scarce.

Bergstrand and Egger (2007) extend the KC model into a three-factor, three-country, two-good model allowing now for physical capital as a third factor of production in addition to knowledge capital (skilled and unskilled labor). The assumption that physical capital is mobile leads to MNCs endogenously choosing "the optimal allocation of domestic physical capital between home and foreign locations to maximize profits" (Bergstrand and Egger 2010). This means that their "Knowledge-and-Physical-Capital model" actually has FDI. In their 2010 paper, Bergstrand and Egger create a more general version of their 2007 model, by

constructing a three-factor, three-country, three-good model thereby providing a theoretical rationale for estimating gravity equations for bilateral FDI flows (as well as bilateral final goods trade flows and bilateral intermediate goods trade flows) (Bergstrand and Egger 2010).

Regarding the definition of the shadow economy, this paper follows the definition of Medina and Schneider (2018, p. 4): "Shadow economic activities may be defined as those economic activities and income earned that circumvent government regulation, taxation or observation. More narrowly, the shadow economy includes monetary and non-monetary transactions of a legal nature; hence all productive economic activities that would generally be taxable were they reported to the state (tax) authorities." Generally, the literature on the shadow economy identifies four overarching reasons when it comes to why one would be active in the shadow economy. The first is to avoid paying taxes (e.g., income or value-added taxes), the second is to avoid paying social security contributions, the third is to avoid compliance with certain labor market standards (e.g., minimum wages, maximum working hours, workplace safety regulation), and the fourth and last is to avoid certain administrative procedures. This also means that while these activities could be part of the national accounts, they do not show up due to their illicitness (Medina and Schneider 2018, Schneider and Buehn 2018, Schneider and Williams 2013).

Based on the reasons why one would be active in the shadow economy, Schneider (2008) identifies the main causes for an increase in the shadow economy as follows:

- Increase of the Tax and Social Security Contribution Burdens
- Intensity of Regulations
- Social Transfers
- Labor Market Standards
- Public Sector Services

Another relevant topic when talking about the shadow economy is the links with corruption. Regarding corruption, there are two strands in the literature the "grease the wheels" view and the "sand the wheels" view. Proponents of the former argue that corruption can lead to second-best solutions (Bardhan 1997) and can, for example, help circumvent business-hindering government policies or a badly working government in general (see, e.g., Leff (1964), Bayley (1966), Lui (1985), Beck and Maher (1986), Lien (1986)). Supporters of the "sand the wheels" view, on the other hand, argue that no matter the situation, corruption is always the worst choice. For example, while bribes might at times be used to circumvent bad policies, they might also be used to do so for sound policies and a government that accepts bribes also has a considerable incentive to create legislation in order to maximize the amounts of bribes they can receive (see, e.g., Kaufmann (1997), Rose-Ackerman (1997), Kaufmann and Wei (1999), Lambsdorff (2002)).

As one can see, the effect of corruption on the official economy is in theory still somewhat unsettled, therefore the relationship between corruption and the shadow economy is not clear either. Should corruption help economic growth and

wealth, this in turn should ultimately lead to a decline in corruption and also a decline in shadow economy activity. Should corruption on the other hand harm the economy, this then would ultimately lead to more corruption and more incentive to do business in the shadow economy (Schneider 2008, Schneider and Williams 2013). Although important, the main focus of this paper will be on the linkage between the shadow economy and FDI.

Empirical Literature

The empirical literature examining the relationship between FDI and the shadow economy is relatively limited. The following papers represent, to the best of the author's knowledge, all empirical studies examining FDI and the shadow economy.

Nikopour et al. (2009) examine the relationship between the shadow economy and FDI using Granger causality analysis. For this, they first estimate a panel and then look for causality. The authors use data for 145 countries and 5 data points (1999/2000, 2001/2002, 2002/2003, 2003/2004, 2004/2005). Using a system generalized methods of moment (GMM) estimation, they find in all specifications in their panel data model, a positive and significant effect of the shadow economy on FDI inflows. They then use Granger causality tests and find that the shadow economy Granger causes FDI inflows in all models finding support for one of their hypothesis that a higher shadow economy causes higher FDI inflows (Nikopour et al. 2009). Davidescu and Strat (2015) examine the relationship between the shadow economy and FDI for Romania using two different causality analysis methods (Granger and Toda-Yamamoto) over the period 2000-2010. Their findings reveal a short-run causality from FDI to the shadow economy. The authors argue that, due to FDI stimulating economic activity, tax reforms may be possible and lower taxes would lead to less incentive for individuals to engage in the shadow economy.

Ali and Bohara (2017) use a gravity model to explore the effects of the shadow economy on FDI inflows for 34 OECD countries from 1999 to 2007. Their results show a positive relationship between the shadow economy and FDI inflows indicating that MNCs are motivated to take advantage of the shadow economy. Huynh et al. (2020) investigate the relationship between FDI, shadow economy, and institutional quality for 19 developing Asian countries between 2002 and 2015. Focusing on their findings regarding the FDI-shadow economy nexus, the authors find that FDI has a negative impact on the size of the shadow economy. Additionally, an improvement in institutional quality from FDI increases the negative impact of FDI on the shadow economy. In the most recent study, van Cuong et al. (2021) investigate the effect of the shadow economy on FDI for 158 countries for the period from 2003-2018. Therefore, they investigate total FDI as well as greenfield investments and cross-border M&As. Their findings show no clear effect on total FDI inflows, but a positive effect on greenfield investments and a negative effect on cross-border M&As.

Hypotheses

Based on the theoretical and empirical literature presented in this chapter, the following hypotheses are stated here:

1) The shadow economy is expected to attract FDI, therefore a positive sign for FDI inflows can be expected.
2) The difference in the size of the shadow economy between two countries is expected to have a negative sign, as countries with similar levels of the shadow economy are expected to engage in more FDI with each other; MNCs from, for example, country 1 – with a large shadow economy – will find investing abroad in other countries with a relatively high level of shadow economic activity as representing economic conditions in a crucial field which are not very different from the conditions in the source country so that established business models can be transplanted to subsidiaries abroad in a rather easy way; moreover, international transaction costs for intra-company trade should be relatively small which would make vertical FDI particularly attractive in some sectors.
3) Inflation typically leads to government intervention, including anti-inflation measures which, following the logic of the Phillips curve, will temporarily raise unemployment rates (e.g., in the case of reduced government spending); hence inflation interacts with the shadow economy in a way that the effective labor supply from unemployed workers will increase. As inflation reduces real income in many countries with no wage indexation or weak trade unions, there is also an incentive for workers from the official economy to seek additional hours of work in the shadow economy in order to restore the previous real income growth.
4) The size of the government, proxied by government consumption as a percentage of GDP, is expected to interact with the shadow economy as a larger government can lead to a larger shadow economy (Zhanabekov 2022). Therefore, a positive sign is expected.
5) Finally, a crisis dummy for the transatlantic banking crisis (as a proxy for the Global Financial Crisis of 2007/08) is interacted with the shadow economy in that a significant international crisis affects both FDI and the shadow economy. Therefore, a positive sign is expected.

Gravity Model of FDI and Specification

The broader theoretical foundation has been discussed in the previous section. Here we will focus more on the specification of the gravity model and best practices.

Gravity Model and Model Specification

The gravity model has a long history in science apart from the field of physics[1]. Ravenstein (1885) and Zipf (1946) were the earliest adopters of a gravity model followed by Tinbergen's (1962) adoption with regard to trade between countries[2]. The next big innovation concerning the gravity model of trade came in 2003 with the famous "gravity with gravitas" paper by Anderson and van Wincoop (2003). Building on the early intuition of the gravity model that the size of the country correlates positively with trade while the distance between countries correlates negatively with trade, Anderson and Van Wincoop (2003) introduced two new additional variables: outward and inward multilateral resistance (Benedictis and Taglioni 2011). The former captures the fact that exports from country i to country j depend on trade costs across all possible export markets while the latter captures the dependence of imports into country i from country j on trade costs across all possible suppliers.

Based on the aforementioned "gravity with gravitas" paper, Anderson et al. (2019) derive a structural gravity system for FDI, in particular for FDI stocks. Their model includes an equation for FDI and two multilateral resistance terms (one for the origin country and one for the target country). The main properties of the system are that FDI is related to the size of the host and origin countries' respective GDPs, is inversely related to FDI barriers, it links FDI to trade via a multilateral resistance term, and lastly, there is a relationship between the FDI stock and technology capital.[3]

The resulting gravity equation looks like this:

$$FDIflows_{odt} = \alpha_0 + \alpha_1 X_{ot-1} + \alpha_2 X_{dt-1} + \alpha_3 X_{dt-1} Z_{dt} + \gamma Z_{odt} + \delta_{od} + \delta_d + \delta_d + \tau_t + \varepsilon_{odt}$$

Where

- α_0 = regression constant
- $X_{o(t-1)}$ = lagged origin country shadow economy
- $X_{d(t-1)}$ = lagged destination/target country shadow economy
- $X_{d(t-1)}Z_{dt}$ = interaction terms for the target country
- Z_{odt} = set of control variables for both origin/destination countries (set includes time-invariant characteristics of country-pairs from the CEPII database for the country fixed effects regressions)
- δ_{od}, δ_{od}, δ_{od} = time-invariant country and country-pair fixed effects[4]
- τ_t = time-fixed effects
- ε_{odt} = error term

[1]The gravity model is based on Newton's Law of Gravity.
[2]A detailed history of the gravity model can be found in Benedictis and Taglioni (2011).
[3]For a more detailed explanation see Anderson et al. (2019).
[4]Of course, if country-pair fixed effects are used, country fixed effects are not included and vice versa. Also, the equation for the model with shadow economic distance is not presented. For the model without interaction terms simply drop $X_{d(t-1)}Z_{dt}$

Estimator and Best Practices

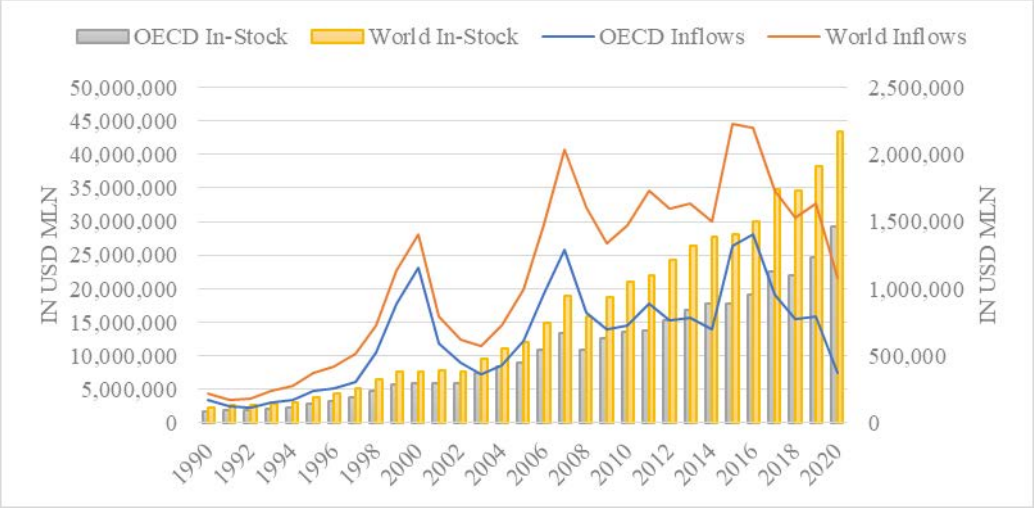
There have been additional advances regarding FDI gravity, namely dyadic fixed-effects, and the Poisson-Pseudo-Maximum-Likelihood (PPML) estimation methods. Baldwin and Taglioni (2006) argue for the use of time-invariant pair dummies (dyadic fixed effects) when it comes to estimating gravity equations. They caution though that this means that the coefficients of interest will only be identified on their time variation, meaning that there needs to be a significant enough time variation in the policy variable one is trying to estimate (one also cannot include time-invariant parameters, e.g., distance). Egger and Pfaffermayr (2003) also advocate for using bilateral fixed effects (dyadic fixed effects) and time fixed effects (two-way model) rather than country (importer and exporter) fixed effects and time fixed effects (three-way model). Head and Ries (2008) also use dyadic fixed effects in their gravity equation for FDI.

PPML is an estimator developed by Santos Silva and Tenreyro (2006) to deal with heteroskedasticity in gravity equations. It does so by estimating the equation in levels and not, as with Ordinary Least Squares (OLS) estimation, in log-linearized form, which, according to the authors, is inconsistent in the presence of heteroscedasticity. Additionally, it allows for the inclusion of zero FDI (or trade) flows and it takes account of observed heterogeneity (Santos Silva and Tenreyro 2006, Head and Mayer 2014, Kareem et al. 2016). Based on the original paper of Correia et al. (2019) the STATA command "ppmlhdfe" allows for a fast estimation of Poisson models with multiple high-dimensional fixed effects (HDFE). As Santos Silva and Tenreyro (2022) put it in their "The Log of Gravity at 15" paper*:* "PPML is efficient in the class of pseudo maximum likelihood estimators that are valid in models with fixed effects and are compatible with structural gravity models." As Breusch-Pagan/Cook-Weisberg testing for heteroskedasticity confirms heteroskedasticity in the sample, PPML is chosen as the estimator for all models. Additionally, there are no serious correlation issues, see the correlation matrix in Table 6 in the Appendix. Potential endogeneity between the independent variable and the variable of interest, the shadow economy, is avoided by lagging the shadow economy variable by one year.

The Determinants of FDI and a Description of the Data

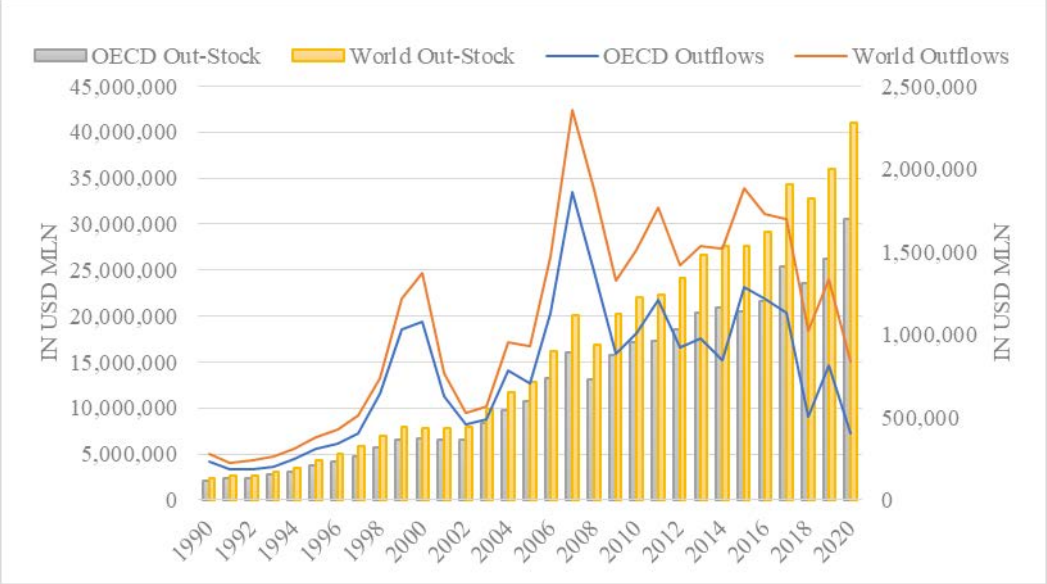
Figures 1 and 2 show the development of inward and outward flows and stocks, respectively, for OECD countries in comparison with the world total. The overall trend is that FDI stocks are growing for both the OECD group of countries and the world economy. FDI flows in comparison are more volatile and in the late 2010s are exhibiting more of a decline compared to the early and mid-2000s. Also, OECD countries stand for the majority of FDI flows and FDI stock in the world, albeit the proportion of OECD-related FDI is declining as other non-OECD countries increase investment.

Figure 1. *FDI Inflows and Inward Stock for OECD Countries and the World from 1990-2020*



Source: Own representation based on data available from UNCTAD (https://unctadstat.unctad.org/EN/Index.html).

Figure 2. *FDI Outflows and Outward Stock for OECD Countries and the World from 1990-2020*



Source: Own representation based on data available from UNCTAD (https://unctadstat.unctad.org/EN/Index.html).

In the following empirical analysis, bilateral FDI flow data from the OECD is used due to it being compiled more uniformly and it being less aggregated as compared to UNCTAD data, resulting in more data points. Moreover, looking at Figures 1 and 2 and especially the world inflows and outflows, one can see that in these graphs, which are made with UNCTAD data, there is a difference but there should not be a difference in terms of world inflows and outflows and this is most

likely a problem with data quality. Therefore, data from the OECD is preferred (Baier 2020).

The selection of the data and variables for the gravity model is based on empirical and theoretical literature. As Faeth (2009) puts it: "FDI should not be explained by single theories but more broadly by a combination of ownership advantages or agglomeration economics, market size and characteristics, cost factors, transport costs and protection and risk factors and policy variables." Therefore, following research from Faeth (2009), Blonigen (2005), Blonigen and Piger (2014), and Eicher et al. (2012) regarding FDI determinants as well as previous empirical literature, real GDP, distance, cultural variables, agglomeration effects, inflation, a transatlantic banking crisis dummy, and openness are included, furthermore government consumption as a proxy for government size, following Zhanabekov (2022), is also included.

Data for real GDP, inflation, and openness comes from the World Bank, time-invariant country-pair characteristics come were taken from CEPII, and data on the shadow economy comes from Medina and Schneider (2019) and is estimated using the MIMIC approach (see their paper for more details on this), agglomeration effects data is from the OECD database, government consumption data was taken from the Penn World Tables 10, and data on the financial crisis dummy comes from Laeven (2018). Details regarding the definition and source of the variables can be found in the following Table 1.

Table 1. *List of Variables*

Variable	Definition	Source
inflow	FDI inflow, from origin to target in current USD; Negative values to zero, excluding missing values	OECD FDI database; BMD3 data 1992-2012, BMD4 data 2013-2018
ln_target_gdp	Real GDP of FDI target country in mln. USD	World Bank
ln_origin_gdp	Real GDP of FDI origin country in mln. USD	World Bank
ln_dist	Simple geodesic distance between two countries	CEPII GeoDist Database by Mayer and Zignago (2011)
contig	dummy variable indicating whether the two countries are contiguous	CEPII GeoDist Database by Mayer and Zignago (2011)
comlang_off	dummy variable indicating whether the two countries share a common language	CEPII GeoDist Database by Mayer and Zignago (2011)
colony	dummy variable indicating whether the two countries have ever had a colonial link	CEPII GeoDist Database by Mayer and Zignago (2011)
openness	Total import plus total export of FDI target country, divided by its GDP	World Bank
ln_agglo_target	Agglomeration effects (inward FDI stock) in the target country lagged by 1 year	OECD
target_gov_100	Share of government consumption at current PPPs multiplied by 100[5]	PWT 10.0 by Feenstra et al. (2015)
target_inflation	Annual inflation based on Consumer Price Indices	OECD
target_fin_cri	Dummy describing whether a country was experiencing a systemic banking crisis as an effect of the transatlantic banking crisis	Laeven (2018)

[5]The original values are between 0 and 1. Multiplying by 100 makes the interpretation of the estimates easier.

shadow_target	Size of the shadow economy of the target country, in % of GDP	Medina and Schneider (2019)
shadow_origin	Size of the shadow economy of the origin country, in % of GDP	Medina and Schneider (2019)
shadow_diff	Absolute difference between size of the shadow economy of the target and origin country	Medina and Schneider (2019)
S_inf	Interaction term for the target country between inflation and shadow economy	Medina and Schneider (2019) and OECD
S_gov_100	Interaction term for the target country between government consumption and shadow economy	Medina and Schneider (2019) and Feenstra et al. (2015)
s_cri	Interaction term for the target country between financial crisis dummy and shadow economy	Medina and Schneider (2019) and Laeven (2018)
Eurozone	Dummy variable for when the target and origin country are both part of the eurozone	European Union

Source: Own representation.

In total, the resulting dataset has 19,921 observations for the years 1992-2018 for 35 OECD countries excluding Luxembourg[6]. Missing values get treated by deletion and negative values are set to zero following the methodology in Welfens and Baier (2018). Summary statistics can be found in Table 2.

Table 2. *Summary Statistics*

VARIABLE	OBS	MEAN	STD. DEV.	MIN	MAX
INFLOW	19,921	870.851	4160.598	0.0	116455.9
LN_TARGET_GDP	19,921	12.916	1.550	8.735	16.841
LN_ORIGIN_GDP	19,921	12.949	1.546	8.412	16.841
LN_DIST	19,921	7.946	1.171	4.088	9.883
CONTIG	19,921	0.077	0.266	0	1
COMLANG_OFF	19,921	0.071	0.257	0	1
COLONY	19,921	0.043	0.202	0	1
OPENNESS	19,921	0.828	0.410	0.158	2.274
LN_AGGLO_TARGET	19,921	11.561	1.567	4.761	15.875
T_GOV_100	19,921	18.326	4.850	6.701	33.758
TARGET_FIN_CRI	19,921	0.097	0.297	0.0	1.0
TARGET_INFLATION	19,921	3.391	7.335	-4.478	105.215
SHADOW_TARGET	19,921	16.359	6.597	5.1	35.8
SHADOW_ORIGIN	19,921	15.661	6.431	5.1	35.8
S_INF	19,921	75.935	241.228	-52.842	3661.482
S_CRI	19,921	1.428	4.623	0	23.1
S_GOV_100	19,921	304.123	146.887	36.634	757.133
EUROZONE	19,921	0.137	0.344	0	1

Source: Own representation.

[6]Luxembourg is excluded due to it being a major outlier in the dataset.

Results

In this section, the results from the gravity model regressions are presented. The regressions are done using the PPML estimator (Stata command: ppmlhdfe) with country- and time-fixed effects as well as another regression with country-pair and time-fixed effects. The reason for estimating both types of fixed effects is that dyadic-fixed effects do not allow for time-invariant dyadic variables such as distance. It also helps to show the differences in estimation results between the three-way and the two-way model.

Table 3 shows the results for the country and time-fixed effects PPML regressions. Model 1 is simply a baseline model. It confirms the gravity intuition that market size (GDP) is positively correlated with FDI and distance is negatively correlated with FDI, with ln_target_gdp being significant at the 1% level in all models and ln_origin_gdp being significant at 1% level in Model 1 and 3 and the 5% level in model 2 and 4. This can also be seen as confirmation that the model behaves as expected. Other variables of interest are trade openness which shows a positive effect and is significant at the 1% level, government size (proxied by government consumption) which expresses a negative sign and also significance at the 1% level and agglomeration effects which are positive and significant at the 5% level in Model 1 to 4. The eurozone dummy is also positive and significant at the 1% level in Model 1 to 4. In Model 2, the variables for the shadow economy are introduced and both are statistically significant, with shadow_target being significant at the 1% level and shadow_origin being significant at the 5% level. For the target countries, a positive effect is found and for the origin countries, a negative effect is found. The other control variables remain roughly unchanged. In Model 3, the variable for the difference between the target and origin shadow economy is introduced, which shows a negative sign and is statistically significant at the 1% level. Interpreting the results for the shadow economy variables in Models 2 and 3, we get a 17.3% increase in FDI inflows for target countries when the shadow economy in the target country increases by 1% and a -11.75% decrease in FDI outflows from host countries when their shadow economy increases by 1%. For Model 3 and the shadow economy difference variable, we get a -3.9% decrease in FDI flows between countries when the difference in their respective shadow economies increases by 1%.

Model 4 introduces interaction terms for the three variables that potentially interact with the shadow economy variable. These are inflation, the banking crisis dummy, and the government size variable all for the target country. Two interaction terms show statistical significance, with the shadow*gov term being significant at 10% and the shadow*crisis term at 5%. Both show a positive sign for their effect. This would mean that the effect of the shadow economy on FDI increases by **0.338%** for every 1% increase in gov consumption. In other words, the greater government consumption, the larger the effect of the shadow economy on FDI inflows. The shadow*crisis interaction term follows the same interpretation in that for target countries that are experiencing a financial crisis, the effect of the shadow economy on FDI increases by **3.7%.** The interaction term for shadow* inflation is negative but not statistically significant.

Table 3. *PPML Country- and Time-Fixed Effects Results*

	(1)	(2)	(3)	(4)
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ln_target_gdp	0.842***	1.313***	0.805***	1.337***
	(0.304)	(0.324)	(0.305)	(0.326)
ln_origin_gdp	1.135***	0.840**	1.109***	0.840**
	(0.369)	(0.415)	(0.375)	(0.413)
ln_dist	-0.427***	-0.426***	-0.441***	-0.427***
	(0.0810)	(0.0812)	(0.0808)	(0.0812)
contig	-0.127	-0.128	-0.110	-0.126
	(0.187)	(0.187)	(0.188)	(0.187)
comlang_off	0.267**	0.264**	0.268**	0.263**
	(0.132)	(0.133)	(0.127)	(0.132)
colony	0.263*	0.263*	0.272*	0.265*
	(0.144)	(0.144)	(0.141)	(0.144)
openness	1.540***	1.775***	1.496***	1.920***
	(0.407)	(0.419)	(0.410)	(0.431)
ln_agglo_target	0.257**	0.296**	0.257**	0.248**
	(0.129)	(0.126)	(0.129)	(0.126)
t_gov_100	-0.0583**	-0.068***	-0.0564**	-0.128***
	(0.0258)	(0.026)	(0.0258)	(0.0399)
target_fin_cri	0.125	0.127	0.115	-0.237
	(0.0903)	(0.0904)	(0.0907)	(0.193)
target_inflation	0.0005	-0.0044	0.0028	0.0635
	(0.0054)	(0.0054)	(0.0054)	(0.0489)
eurozone	0.366***	0.378***	0.335***	0.375***
	(0.127)	(0.126)	(0.121)	(0.126)
shadow_target		0.171***		0.161***
		(0.0391)		(0.0544)
shadow_origin		-0.115**		-0.117**
		(0.0574)		(0.057)
S_inf				-0.0022
				(0.0015)
S_gov				0.331*
				(0.184)
S_cri				0.0348**
				(0.0162)
shadow_diff			-0.0379***	
			(0.0086)	
Constant	-20.67***	-24.51***	-19.44**	-23.98***
	(7.735)	(9.074)	(7.870)	(9.162)
Observations	19,921	19,921	19,921	19,921

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. *PPML Country-Pair- and Time-Fixed Effects Results*

	(5)	(6)	(7)	(8)
VARIABLES	**Model 5**	**Model 6**	**Model 7**	**Model 8**
ln_target_gdp	0.812***	1.312***	0.791**	1.337***
	(0.307)	(0.327)	(0.315)	(0.329)
ln_origin_gdp	0.926***	0.634	0.911**	0.630
	(0.355)	(0.402)	(0.354)	(0.398)
openness	1.452***	1.685***	1.425***	1.825***
	(0.399)	(0.410)	(0.405)	(0.421)
ln_agglo_target	0.248*	0.292**	0.250*	0.247*
	(0.129)	(0.127)	(0.130)	(0.127)
t_gov_100	-0.0589**	-0.0698***	-0.0582**	-0.129***
	(0.0257)	(0.0259)	(0.0259)	(0.0392)
target_fin_cri	0.136	0.139	0.130	-0.179
	(0.0889)	(0.0887)	(0.0881)	(0.194)
target_inflation	9.37e-05	-0.0049	0.0008	0.0663
	(0.0053)	(0.0053)	(0.0053)	(0.0489)
eurozone	0.407***	0.502***	0.401***	0.482***
	(0.139)	(0.153)	(0.138)	(0.155)
shadow_target		0.183***		0.170***
		(0.0400)		(0.0554)
shadow_origin		-0.114**		-0.115**
		(0.0582)		(0.0579)
S_inf				-0.0023
				(0.0015)
S_gov				0.333*
				(0.178)
S_cri				0.0306*
				(0.0164)
shadow_diff			-0.0184	
			(0.0347)	
Constant	-20.02***	-24.54***	-19.44***	-24.00***
	(7.299)	(8.730)	(7.326)	(8.824)
Observations	19,214	19,214	19,214	19,214

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 shows the results for the country-pair and time-fixed effect PPML regressions. Models 5 to 8 repeat models 1 to 4 but with dyadic fixed effects instead of country fixed effects. As is the norm when using dyadic fixed effects, time-invariant variables get dropped (such as distance, etc.). Moreover, the number of observations falls because ppmlhdfe drops 841 observations due to them being singletons. This is done to guarantee that the PPML estimator converges. Generally, most control variables remain the same when it comes to significance and sign and only vary slightly in their point estimate (usually slightly lower) except for origin_GDP which loses statistical significance in models 6 and 8, when the shadow economy variables get introduced. Also, the variable shadow_diff in model 7 is no longer statistically significant (while the sign stays the same), which means that the time-variant part of the variable (since it is dyadic) is not statistically significant. The variables shadow_target and shadow_origin exhibit the same signs

and significance levels as in the previous estimations, findings for the two interaction terms, s_cri, and s_gov are also basically the same, except that s_cri drops from significance at the 5% level to the 10% level. Overall, the results point to robust and good findings coming from the gravity model which is corroborated by the constant, e.g. in model 2 the constant is slightly lower than in model 1 but model 2 exhibits higher GDP effects meaning that model 1 and 2 are of similar fit. Similar behavior can be observed in the other models as well.

Discussion

Regarding the hypotheses from the second section:

1) The shadow economy is expected to attract FDI, therefore a positive sign for FDI inflows is expected.
   - This hypothesis is accepted, as the shadow economy target country variable in both models is positive and significant and confirms the results of Ali and Bohara (2017). This also means that economies with a larger shadow economy receive more FDI.
   - Regarding the results for the origin country, here the sign of shadow_origin is negative which means that countries with a larger shadow economy send less FDI abroad. This might reflect the negative impact of the shadow economy on the profits of MNCs in the respective country – a lack of equity capital then becomes a problem for leveraged potential international M&A projects (assuming imperfect international capital markets so that the relative size of equity capital is relevant).
2) The difference in the size of the shadow economies between two countries is expected to have a negative sign, as countries with similar levels of shadow economy are expected to engage in more FDI with each other.
   - In the three-way model, this hypothesis is accepted as the variable is significant and the sign is negative but in the dyadic fixed-effects model this finding cannot be replicated. Therefore, the hypothesis can neither be accepted nor rejected.[7]
3) Inflation interacts with the shadow economy as inflation can be seen as a decline in real income and therefore increases the incentive to engage in shadow economy activities.
   - This hypothesis can neither be accepted nor rejected as both estimations have failed to produce statistically significant results that allow for a conclusive statement.
4) The size of the government, proxied by government consumption as a percentage of GDP, is expected to interact with the shadow economy as a

[7]One could argue for a tentative accept, but we will not do so here on the basis of the empirical evidence at hand.

larger government can lead to a larger shadow economy (Zhanabekov 2022). Therefore, a positive sign is expected.

- The hypothesis is accepted. In both models 4 and 8, the interaction term between the shadow economy and government consumption is positive, indicating that a larger government strengthens the effect of the shadow economy on FDI inflows. This could mean that the shadow economy allows for opportunities for MNCs in countries with big governments (and presumably high taxes or distorting policies). Vice-versa, the shadow economy lessens the effect (negative sign of t_gov_100) of an increase in government consumption on FDI inflows

5) Lastly, a crisis dummy for the transatlantic banking crisis (as a proxy for the Global Financial Crisis) is interacted with the shadow economy in that a crisis affects both FDI and the shadow economy.
   - The hypothesis is accepted. Indeed, for countries that are experiencing a banking crisis, the effect of the shadow economy on FDI inflows is increased, indicating that the shadow economy might offer opportunities even in a crisis struck country.

The findings here are in line with the previous empirical literature on the topics of FDI and the shadow economy in that there seems to be a positive correlation between FDI inflows and the size of the shadow economy. The motif of low labor costs comes to mind, in the sense that MNCs might interpret a bigger shadow economy as a locational advantage because it allows for the possibility of low labor costs. The findings of the negative sign of the shadow distance variable support this because MNCs invest in countries with a similar shadow economy size as their home country relying on the experience from doing business at home. The interaction terms support the findings from the theoretical literature in that government size as well as a banking crisis affect the size of the shadow economy positively. Of course, it is hard to say if the positives of attracting foreign investment outweigh the negatives of having people be part of the shadow economy and not paying taxes and social security contributions.

Additional Considerations

In this paragraph, the paper discusses certain additional considerations that are not part of the main analysis, namely institutional distance and corruption.

For institutional distance, the absolute difference between the origin and target countries' economic freedom index scores from the Heritage Foundation is used (Kostova et al. 2020). For the corruption measure, the control of corruption index from the World Bank's World Governance Indicator series is used[8]. See the results of models with these variables in the Appendix. Both variables are tested only with dyadic-fixed effects and, in the case of corruption, for target countries. Institutional distance is not significant in the models, corruption is significant and negative, and the shadow_target variable loses significance once the shadow_

[8]It is transformed so as to have an index that goes from 0 (high corruption) to 5 (no corruption). Missing years are interpolated.

corruption interaction term gets introduced. The interaction term is not significant aside from model 4A and only at the 10% significance level. Shadow_origin stays significant (albeit at 10%). Signs are the same for both shadow economy variables. What is notable is that in models 1 to 3, the inflation_shadow interaction term becomes significant and negative, meaning that more inflation leads to a lower shadow economy effect on FDI but again this is only significant at the 10% level. One can see a positive sign at the 10% level for the corruption_shadow interaction term. This means that an increase in the corruption variable (which indicates lower levels of corruption) increases the shadow economy effect on FDI inflows and vice versa. This can be seen as an indicator that the shadow economy and corruption are substitutes, as suggested by Schneider (2008) for rich countries since lower corruption levels increase the shadow economy effect and higher levels of corruption decrease it. Overall, the inclusion of the corruption variable and institutional distance variable did not result in robust findings and certainly more in-depth research is required here.

Conclusion and Economic Policy Implications

This paper explores the subject of the effect of the shadow economy on FDI flows. For this analysis, a dataset for 35 OECD countries from the years 1992-2018 was compiled and used in a state-of-the-art gravity model setting. For policymakers aiming to attract FDI, a sizeable shadow economy might not be a serious hindrance as the existence of the shadow economy does not deter FDI as the results of the gravity models have shown. The shadow economy seems to be recognized as an opportunity by MNCs rather than a risk. However, as the difference between the size of the shadow economy in the origin country i and destination country j has a negative impact on FDI, it is also clear that once a large group of (OECD) countries decides in favor of fighting the shadow economy – and the respective countries are successful in this policy – there will be a growing pressure on the other (OECD) countries to follow suit with a similar anti-shadow economy policy since those other countries will be afraid of losing out on potential FDI flows. From this perspective, FDI can be a transmission channel for similar policy strategies in a broad group of countries. To the extent that such anti-shadow economy policies, in the end, raise total factor productivity and bring significant efficiency gains, the broader picture and the relevant implications suggest that FDI and anti-shadow economic policies in some countries could contribute to major international welfare gains.

Moreover, an increase in government size seems to increase the shadow economy effect on FDI even further, the same is true in the case of a country experiencing a systemic banking crisis. A possible interpretation here is that a larger government is associated with a higher need for government financing which could mean higher taxes. As higher taxes lead to lower FDI inflows (see, e.g., Baier 2020) the shadow economy and its potential for tax evasion might present an opportunity for MNCs to avoid these higher taxes. Regarding the systemic banking crisis effect, one could say that in uncertain markets and a

struggling economy, the shadow economy presents MNCs with some kind of opportunity, possibly due to being able to employ people without having to pay labor taxes. This might even allow people to earn an income and two-thirds of income made in the shadow economy is immediately spent in the real economy (Schneider 2008).

As mentioned in the introduction, FDI comes with several benefits but, on the other hand, the shadow economy also comes with certain drawbacks. Thus, for policymakers aiming to combat the shadow economy efficiently, a fair and equitable tax regime seems necessary[9]. Moreover, the government needs to be able to collect taxes to maximize its tax revenue. Additionally, to reduce incentives for corporations to engage in the shadow economy and tax evasion, a country could impose heavy sentences for accountants engaged in facilitating tax evasion. Over time though, the shadow economy in OECD countries has reduced while FDI has grown. So, countries can reap the benefits of FDI while slowly working on improving the welfare situation for people thereby reducing the incentive to be active in the shadow economy. It is beyond the scope of this paper to assess if the FDI positives outweigh the shadow economy negatives or vice versa.

Overall, there are both positive and negative effects and it is up to policymakers to decide, which effects outweigh the other. The shadow economy is not necessarily a bad thing for a country, so focusing on policies that reduce regulation, make doing business easier, and a social security and tax burden that leaves people with more than just a livable income, as well as robust and trustworthy institutions, seems to be the best way to move forward, which ultimately will result in fewer incentives to engage in the shadow economy and a better

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[9]For example, in Greece, the unique geography of the country makes it very costly to administer and collect all taxes (see Papanikos 2015).

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Appendix

Table 5. *Regressions for the Additional Considerations Section, PPML Dyadic Time Fixed Effects*

	(1A)	(2A)	(3A)	(4A)
VARIABLES	**Model 1**	**Model 2**	**Model 3**	**Model 4**
ln_target_gdp	1.353***	1.466***	1.537***	1.506***
	(0.354)	(0.352)	(0.354)	(0.349)
ln_origin_gdp	0.673	0.708	0.708*	0.679
	(0.442)	(0.436)	(0.428)	(0.427)
openness	1.864***	1.948***	2.021***	2.008***
	(0.435)	(0.433)	(0.434)	(0.435)
ln_agglo_target	0.234*	0.209	0.219	0.224*
	(0.136)	(0.134)	(0.133)	(0.133)
t_gov_100	-0.131***	-0.122***	-0.122***	-0.120***
	(0.0407)	(0.0417)	(0.0422)	(0.0421)
target_fin_cri	-0.216	-0.288	-0.284	-0.293
	(0.199)	(0.206)	(0.205)	(0.208)
target_inflation	0.0784	0.0836	0.0804	0.0790
	(0.0517)	(0.0514)	(0.0514)	(0.0515)
shadow_target	0.167***	0.165***	0.0411	0.0311
	(0.0618)	(0.0616)	(0.0854)	(0.0880)
shadow_origin	-0.123**	-0.117*	-0.116*	-0.118*
	(0.0613)	(0.0607)	(0.0610)	(0.0610)
S_inf	-0.00290*	-0.00310*	-0.00273*	-0.00267
	(0.00163)	(0.00162)	(0.00163)	(0.00163)
S_cri	0.0332**	0.0363**	0.0348**	0.0353**
	(0.0168)	(0.0171)	(0.0168)	(0.0170)
s_gov_100	0.00340*	0.00282	0.00349*	0.00335*
	(0.00184)	(0.00194)	(0.00199)	(0.00195)
inst_distance	0.0122			0.0128
	(0.0110)			(0.0112)
target_coc		-0.409**	-0.839**	-0.863***
		(0.202)	(0.330)	(0.335)
s_corr			0.0326	0.0355*
			(0.0207)	(0.0213)
Constant	-24.53***	-24.74***	-24.38***	-23.55**
	(9.467)	(9.468)	(9.385)	(9.307)
Observations	17,412	17,412	17,412	17,412

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. *Correlation Matrix*

	inflow	gdp_t	Gdo_o	ln_dist	contig	comlan~f	colony	openness	Agglo_t	t_go~100	Fin_cri	Inflation	Shadow_t	Shadow_	S_inf	S_cri	s_go~100
inflow	1																
ln_target_gdp	0.2024	1															
ln_origin_gdp	0.1912	-0.0174	1														
ln_dist	-0.0708	0.1128	0.1349	1													
Contig	0.1096	0.0605	0.0308	-0.4402	1												
comlang_off	0.1774	0.1168	0.1017	-0.0026	0.2858	1											
colony	0.1175	0.0682	0.0526	-0.0525	0.2131	0.3462	1										
openness	-0.0372	-0.5222	0.069	-0.2803	0.026	-0.0446	-0.0689	1									
ln_agglo_targ	0.2418	0.8209	0.0333	0.0249	0.0662	0.1693	0.0581	-0.127	1								
t_gov_100	-0.1213	-0.5046	0.0282	-0.1968	-0.0275	-0.1896	-0.0274	0.4201	-0.3499	1							
target_fin	0.0444	0.0225	0.0581	-0.0268	-0.0074	0.0251	0.0069	0.0957	0.1201	0.0744	1						
target_inf	-0.0362	-0.1029	-0.0184	0.0204	-0.0209	-0.048	0.0015	-0.1304	-0.2057	-0.0258	-0.0237	1					
shadow_targ	-0.1452	-0.2315	-0.0598	0.0618	-0.0704	-0.1712	-0.0478	-0.0769	-0.3761	0.135	-0.0851	0.4229	1				
shadow_orig	-0.1527	0.0063	-0.298	0.0229	-0.0464	-0.1268	-0.0224	-0.0469	-0.0305	-0.041	-0.0588	0.0179	0.0345	1			
S_inf	-0.0395	-0.0797	-0.02	0.0239	-0.0215	-0.0498	-0.0019	-0.1355	-0.1922	-0.0407	-0.0447	0.9902	0.4525	0.0168	1		
S_cri	0.0141	-0.0367	0.0536	-0.038	-0.0088	-0.0031	-0.0033	0.118	0.0478	0.1285	0.9401	-0.0188	0.0014	-0.053	-0.0345	1	
s_gov_100	-0.1587	-0.4587	-0.0213	-0.0823	-0.0558	-0.2115	-0.0512	0.1944	-0.4695	0.6451	-0.0136	0.2903	0.8147	0.0001	0.3022	0.0854	1

Source: own representation.

Table 7. *List of Countries*

Australia	**Korea, Republic of**
Austria	Latvia
Belgium	Lithuania
Canada	Mexico
Chile	Netherlands
Czech Republic	New Zealand
Denmark	Norway
Estonia	Poland
Finland	Portugal
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Iceland	Switzerland
Ireland	Turkey
Israel	United Kingdom
Italy	United States
Japan	

Source: own representation.

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Water Consumption in Brazilian Economic Sectors – An Application from a General Equilibrium Model

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The manufacture of all products requires water, either directly or indirectly. Due to its peculiar nature, water is a unique input. Global economic growth and international trade put pressure on the demand for water in industrial and primary sectors. This paper seeks to analyze the total water consumption in Brazil by economic sector in scenarios of greater external demand for domestic products, considering especially the shift in the current national export profile. A typical computable general equilibrium model (CGE) based on the 2015 Brazilian Input-Output Table and the 2013-2015 System of Environmental-Economic Accounts for Water in Brazil are used for this analysis. The changes in total water consumption in the proposed scenarios are elastic in relation to the variations in demand for the other primary factors of the model (capital and land) and activity level. The extractive industry was the one with the highest increase in water consumption. The agricultural sector, which represents a large share of Brazilian exports and is the largest water consumer in the world, surprisingly had a variation in water consumption when compared to other sectors.

Keywords: *water consumption, CGE models, Brazilian economy, international trade, basic inputs*

Introduction

Fresh water is a natural resource with a unique economic characteristic due to its presence in almost all manufactured products, in addition to its importance to the biological aspects of the human, animal and, plant life. These resources and their availability are under intense pressure in terms of quantity and demand, given the economic growth, population growth, and human intervention in several areas (Ponce et al. 2012). The result of such practices is the position of water as a major concern among the environmental issues of the 21st century. Brazil in particular has a vast water reservoir both in absolute and per capita terms, when compared to the reservoir of other countries, even larger or less populated countries. Hence, the country's geographic features have a significant comparative and competitive advantage in the economic context, especially in the production of basic and industrial commodities. Such advantages, however, should not mask the possibility of social and economic problems involving the resource.

The relationship between economic growth and water availability is complex and gradually becomes more apparent (Hertel and Liu 2016). International trade is

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currently a determining factor to measure economic growth and it increases the demand for basic inputs such as fresh water, energy and land. In particular, there has been a growing interest in the literature on the relationship between water availability and international trade in recent years (Hoekstra 2010). This paper proposes to analyze the total consumption of fresh water in the Brazilian economic sectors, simulating some changes in international trade for the country, an important player in the global market of basic commodities, a sector which consumes a lot of water.

Brazilian economy benefits from an extensive fresh water reservoir, a large comparative advantage for its economic sectors. Total consumption is higher than in any other major country, in absolute and relative terms. In 2017, 18.9 million cubic hectometers were removed from the territory, with the average annual replacement for the same year being 13.3 million cubic hectometers (ANA and IBGE 2020). In this sense, the balance between supply and demand is a permanent object of study.

In order to contribute to this growing literature, this work aims to analyze the changes in total water consumption by the Brazilian economic sector from a hypothetical rise in the world demand for Brazilian products at different levels and different compositions. This increase would aim to generically reflect, for simulation purposes, the constant global economic growth observed in the last decades, since only in 2009 the overall real GDP growth was negative (IMF 2018). Methodologically, a typical Computable General Equilibrium (CGE) model was used, the ORANI-G, modified to adapt to the water input as primary input and its implications. The data were collected from the 2015 Input-Output Table from Brazil and the 2013-2015 System of Environmental-Economic Accounts for Water in Brazil. After the literature review, the methodology is presented and the results are discussed in connection with the scenarios created. A final considerations section ends the paper.

Literature Review

There are several estimates regarding the amount of fresh water available. One of these estimates was made by Shiklomanov (1999), and it shows that the total volume of water on Earth is approximately 1.4 billion km³, of which 35 million km³ (2.5%) correspond to fresh water and, of this total, 200 thousand km³ correspond to the part available for abstraction (Tomasoni et al. 2009). The total annual precipitation on the soil is about 119,000 km³, of which 72,000 km³ evaporate, leaving about 47,000 km³ of flow (4,000 km³ are collected annually). Brazil has a large fresh water reservoir, representing about 12% of the total amount of fresh water on the planet (Bicudo et al. 2010). The permanent growth of global and national demand for goods and services, however, puts pressure on this large reserve, and the risk of negative economic and social impacts are imperceptible due to water abundance. In addition, despite having made advances in the management of its water resources, the country's current structure is flawed. Furthermore, the distribution of water in the country is quite irregular. According

to Silva et al. (2016), the Brazilian Water Scarcity Index is 5%, which masks the high scarcity in several regions. The Northeastern states, for example, have an average of 76.7% water scarcity. Finally, in Brazil, there is a false notion of water abundance, secondly, in crises such as power outages are frequent. In 2001, for instance, there was a drought in dams in the Center-South region of Brazil; a drought in water reservoirs in the largest metropolitan area of South America, Sao Paulo, in the 2014/15 season; and great economic losses in the Northeast region in 2012-17, among others cases (ANA et al., p. 9).

In addition, according to Buriti and Barbosa (2014), quoting Granziera (2001), in the twentieth century, water came to be treated as "a scarce resource that could generate conflict of interest not only between human beings, citizens of the same country, but also between states and nationalities" (Buriti and Barbosa 2014, p. 239). This reality made it necessary to establish rules for the use and consumption of this unique and vital natural resource. Although it has existed in Brazil since 1930, Brazilian rules for national waters have undergone important changes since the end of the 20th century. Before the Federal Constitution of 1988, the existence of public and private waters was recognized. With the new Constitution, however, all the water resources of Brazil were recognized as public. In 1997, the Water Law (or “Lei das Águas”) was established and, most importantly, created the National Water Resources Policy. It has established tools to manage federal resources (i.e., across more than one state or border) and created the National Water Resources Management System.

According to the National Water Agency - ANA (2018), the National Water Resources Policy has two fundamental aspects: decentralization, by creating a national system that integrates the Federal Government and the federal states; and participatory, by setting up water resources management committees that unite the public authorities in three instances (federal, states and municipalities), resource users and civil society. According to ANA (2018), the evolution of water resources management at the national level is assessed by means of the Report on Water Resources, published every 4 years.

Amaral (2008) states that the Water Law represents an important initiative in favor of the rational use of water and the depollution of rivers and seas. In legal terms, as detailed by Buriti and Barbosa (2014), the National Water Resources Policy was enacted based on the following grounds, according to first article of the Water Law:

> "Water is a public property (Item I); water is a limited natural resource endowed with economic value (Section II); in situations of scarcity, the priority use of water resources is human consumption and animal nutrition (Section III); the management of water resources must be decentralized and have the participation of the Government, users and communities (Section VI)."

According to Buriti and Barbosa (2014), the Water Law created, as mentioned above, the National Water Resources Management System, a set of legal and administrative instruments, formed by "laws and institutions that have a set of instruments or management tools whose function is to enable the implementation

of the National Policy and State Policies for Water Resources." (Buriti and Barbosa 2014, p. 245).

This model of water management, according to Portela and Braga (2006), was inspired by a model developed in France. The cultural and territorial differences between countries present enormous challenges to the Brazilian management system, such as challenges of federal coordination, as well as the "permanent tension between centralization and decentralization that has been characterizing the country in the last 20 years" (Portela and Braga 2006, p. 75). These include vertical conflicts between the three levels of government (Country, States and Municipalities) and horizontal conflicts between governments of the same level of power, civil society organizations and business organizations (Portela and Braga 2006).

With the economic value attributed to water (item II, article 1), it is only natural to charge for its use, as can be observed in Article 5 of the Water Law. According to Amaral (2008), this charge can be considered one of the main instruments for the implementation of the National Water Resources Policy (of which the Water Resources Management System is part).

The economic activity most influenced by the establishment of the Water Law, given the charging bias, is the industry sector. A price is put on the use of water to establish it as an economic good. Attributing this role to the water radically changes its role in society, since the rationalization of water use and the obtaining of financial resources for the financing of water programs and policies become more feasible. Thus, its environmental aspect is expanded thanks to the "new" economic character, and vice versa.

The System of Environmental Economic Accounts (SCEA) of Water in Brazil was developed by the National Water Agency (ANA), the Brazilian Institute of Geography and Statistics (IBGE) and the Department of Water Resources and Environmental Quality (SRHQA). The system has information on the balance between the availability of water resources and water demands of the economic sectors on a national scale. The SCEA complements the System of National Accounts (SNA) using the same accounting principles as the latter for environmental resources. The SCEA thus allows a joint analysis between environmental data and economic information (in physical and monetary terms). They are considered "the relations between the economic, social and environmental dimensions of the countries in order to guarantee a truly sustainable economic growth. In this way, political decisions about economic growth, investment in social level and environmental management are increasingly sensitive to the value of natural resources" (ANA et al. 2018, p. 10).

In order to collect data on the water resources in Brazil, Tables of Uses and Resources (TRU) of the System of Environmental Economic Accounts of water were compiled. The composition of the Environmental Economic Accounts for Water in Brazil addresses the years 2013, 2014 and 2015 of the Water TRU and considers "the interrelations of water in quantitative terms and with physical representation (units of volume in time-flow) in the economy and between the environment and the economy." (ANA et al. 2018, p. 15). It is possible, therefore, to evaluate the flows of water use by the Brazilian economic sectors in a certain temporal cut. In sum, total water withdrawal, total water uses from other economic

activities, total supply to other economic activities, total resurfacing water, and total water consumption are quantified. For simplification purposes, only the 2015 values will be shown here.

The study, by separating the information by economic activities, grouped these sectors in a similar way to the hierarchical level of the National Classification of Economic Activities (CNAE). The activities of the CNAE, "agriculture, silviculture, forestry, fishing and aquaculture", "extraction industry", "electricity and gas" and "water and sewage" kept the same title and concept in the Environmental Economic Accounts of Water in Brazil. On the other hand, the sectors of the CNAE "processing industry" and "construction" were aggregated in the Environmental Economic Accounts of Water in Brazil, being named "processing and construction industries", a large and, unfortunately, generic sector. The rest of the sectors present in the CNAE were grouped in only one sector in the Environmental Economic Accounts of Water in Brazil, receiving the name of "other activities".

Table 1 shows the different water flows in Brazil in the 2015 economy. The total water withdrawal encompasses the volumes collected by the economic sectors directly from the environment, either for their own consumption or for the transfer to other sectors. Extremely high values for the electricity and gas sector are observed, since these values "(...) contemplate the turbine flows used for power generation in hydroelectric plants, considered a non-consumptive use, and the flows used in thermoelectric plants" (ANA et al. 2018, p. 32). It is necessary to clarify the difference between use and consumption. Water use refers to the use of the resource that does not waste it and may be returned or redistributed, otherwise, consumption refers to the use that waste the product.

The use and supply of water reflects the interaction between sectors and volumes of water, including wastewater to the sewage system and the supply of treated water to or from other economic activity. In both cases, the values of the "water and sewage" activity are highlighted, mainly due to the volumes of sanitary sewage and stormwater drainage of the CNAE 37 (Sewage and related activities) and the flows destined to the distribution to other economic activities by the CNAE division 36 (Water collection, treatment, and supply) (ANA et al. 2018).

The total return includes the releases to internal water resources. The expressive numbers of "electricity and gas" are given because "turbine flows for power generation" are fully returned to the environment by hydroelectric plants and thermoelectric plants have a significantly small consumption" (ANA et al. 2018, p. 43). The "water and sewage" sector returns water through the flows of collected sewage and rainwater. The sector "agriculture, silviculture, forestry, fishing and aquaculture" returns water to irrigation activities.

Table 1. *Water Flows by Economic Activity – Brazil 2015 – in Cubic Hectometers*

Sector /Water	Retirements	Use from other sectors	Supply for others	Total Return	Water Consumption
Agriculture	32.05	1.14	0	9.94	23.70
Extractive Industry	1.04	0.01	0	0.76	0.28
Industry and Construction	6.11	0.28	0.18	2.77	3.45
Eletricity and gas	3114.29	0.01	0	3114.20	0.10
Sewage and Water	47.09	7.16	10.86	41.11	2.27
Other Activities	0.70	2.05	1.30	0	0.75

Source: Research in ANA et al. (2018).

Total consumption and total use, as mentioned, have different values. Total usage is the sum of the Total Withdrawal and Usage columns coming from other sectors. Total consumption is Total use subtracted from Supply for other sectors and Total Return. Brazil's largest water consumers are irrigation and animal feed activities in the "agriculture, silviculture, forestry, fishing and aquaculture" sector with 77.6% of total consumption, followed by the "manufacturing and construction industry" (11.3%) and "water and sewage" (7.4%) (ANA et al. 2018). Table 2 summarizes these results.

Table 2. *Total Consumption by Economic Activity – Brazil 2015 – in Cubic Hectometers*

Sector /Water	Total Consumption	Share of Total (%)
Agriculture	23.70	77.6
Extractive Industry	0.28	0.9
Industry and Construction	3.45	11.3
Eletricity and gas	0.10	0.3
Sewage and Water	2.27	7.4
Other Activities	0.75	2.4

Source: Research in ANA, IBGE e SRHQA (2018).

Macroeconomic dynamics relates to the availability of natural resources in different ways. As a consequence of continued economic and population growth, demand for water is increasing worldwide:

> "Potential for greater political instability, population growth of underdeveloped countries and the growing need for natural resources caused by the increasing destruction of the natural environment, lead the world in the period that could be characterize by the conflicts for the natural resources." (Kurecic et al. 2014, p. 2)

According to Hoekstra (2010), there is a growing interest of trade and water experts in the relationship between international trade and water scarcity. This relation has two characteristics: first, the water commodity itself is hardly sold. It is different from other physical commodities in this respect. The types of water trade as a product are the bottled water trade and the beverage industry, and even these are not very relevant in the international scenario. Second, the relevant water transfers are those in the form of "processed" products, either exported or imported.

When a country consumes its water to produce an export good, water is virtually transferred to the importing country. (Hoekstra 2010).

The concept of virtual water is defined as "(...) the amount of water necessary for its (good) production." (Tamea et al. 2013, p. 1,205). According to Silva et al. (2016), most of studies on virtual water trade are concerned with the pressure on domestic water resources in importing/exporting countries and also on the issue of virtual dependence on water imports and food/ environmental security. Proposed by Allan (1998), the concept of virtual water has been a key feature for the scientific comparison of the water consumption of different goods (Tamea et al. 2013).

The most "direct" positive effect of international water trade, as discussed by Chapagain et al. (2006), is the national saving of the resource in question resulting from the importation of water-intensive goods. Water trade, however, also generates water losses for exporting countries, since water cannot be used for other purposes in the countries that export the products.

Also as analyzed by Chapagain et al. (2006), at the beginning of the 21st century, the total volume of water used in agricultural production was 6.4 billion m^3/year. Without international trade, i.e. assuming that all countries produce their own commodities, the use of water for agricultural production would be 6.75 billion m^3/year. International trade, consequently, reduces the overall use of water in agriculture by 5%.

The efficiency of water use can be increased if nations use their theoretical advantage or comparative disadvantage in relation to the availability of water in the country to stimulate or discourage consumption or "acquisition" of water resources in their exports or imports. According to Chapagain et al. (2006), little effort was made to analyze the use of water efficiency at the global level. Hoekstra (2010) extensively analyzes the effects of the relationship between international trade and water consumption. Based on the author's system, three points can be highlighted: first, imports of water-intensive commodities reduce national demand for water. Second, exports of water-intensive commodities increase national demand for water. Lastly, there is evidence that the trade balance of countries with very low per capita water availability is partially determined by the fact that these countries have a comparative disadvantage in the production of water-intensive goods.

Some studies, however, disagree with these arguments. Yang et al. (2003) quantitatively demonstrated that cereal imports played an important role in compensating for the scarcity of water. The authors demonstrate that below a certain limit on water availability, an inverse relationship can be identified between the importation of cereal from a country and its water resources per capita. In the early 1980s, according to the study, the limit was about 2,000 m^3 per capita per year. By the end of the 1990s, it had decreased to about 1,500 m^3 per capita per year.

According to Debaere (2014), water systematically affects countries' trade patterns in a manner consistent with trade theories. The international distribution of water resources is quite uneven and the differences in the sectoral intensities of

water are important enough to affect the international division of production and global labor trade.

Few studies deal with international trade relations and water availability in Brazil, even though Brazil is one of the countries with the largest availability of water in the world and one of the largest exporters of virtual water on the planet. However, the study by Silva et al. (2016) give an overview of exports and imports of virtual water in Brazilian agricultural products from 1997 to 2012. The strong participation of the agricultural sector in water consumption can be explained mainly by the use of water for irrigation (Carmo et al. 2008). According to Silva et al. (2016), in the period 1997-2012, a gross export of virtual (agricultural) water of 67.1 billion m³/year and a net virtual export of water of 54.8 billion m³/year. Europe is the largest importer of virtual (agricultural) water from Brazil, with a gross export of 27.7 billion m³/year (41% of the total). The Asian continent is the second, importing a total of 21.6 billion m³/year, (32% of the total). The Americas represent the third largest destination for Brazilian products, with a virtual water volume of 9.3 billion m³/year. Africa has imported 8.2 billion cubic meters per year of virtual water from Brazil. According to Carmo et al. (2008), the export of Brazilian general commodities has increased significantly in recent years, which is reflected in the volume of virtual water exported by the country. In less than ten years, this volume has more than tripled (Carmo et al. 2008).

Regarding the Brazilian imports (1997-2012), also according to Silva et al. (2016), that its values are quite reduced when compared to exports, confirming that Brazil is still a major exporter of water-intensive products. According to the authors, the average volume of water resources transferred to Brazil from other countries was 12.3 billion m³/year, 91% of South America. Finally, in relation to the Brazilian regions, the authors show that the Northeast region, the one with the most limited availability of water in the country, is the main importer of virtual water. The region with the highest availability of water in the country, the Northern (Amazon) region, however, does not present a high rate of export of water embedded in agricultural products. The other regions, the Mid-West, which contains two large ecological biomes of Brazil, the Pantanal and the Cerrado, the South-Eastern region and its sugar production, and the South region, a large soybean and corn area, one of the most humid in the country, present large volumes of virtual water exports in agricultural products.

By comparing the data available in the Environmental Economic Accounts of Water in Brazil to the literature analyzed here, a study on water availability in Brazil is made possible and justified. A Brazilian sectoral analysis, together with the innovation of the computable general equilibrium models generated the methodology and results described below.

Methodology

Computable General Equilibrium Models are extremely rigorous mathematical models for economic valuation of different subjects, including those of an environmental nature. In recent years, the number of studies that analyze water issues through CGE models has increased. The range of research includes water

pricing policies, water resource allocations, water markets, etc. (Wang 2016). Water experts and economists have a long history of knowledge exchange in their models even if there is a certain tension between the two parties, given the "stylization" of water in economic models and the economic simplicity employed in many of the models of water experts. (Robinson and Gueneau 2013). Since the 1990s, however, CGE models have been widely used and evolved to better analyze water issues of different natures (Luckmann et al. 2013). This study, therefore, used the input matrix of 2015 and the data of water consumption by economic sector available in the Environmental Economic Accounts of Water in Brazil to analyze the consumption of this important natural resource in Brazil due to changes in international trade.

Our purpose is analyzing the total consumption of water by the Brazilian economic sector due to the increase of the global demand for domestic products. Thus, shocks to Brazilian exports have been made. These shocks are all positive, reflecting, for the sake of simulation, the constant global economic growth observed in the last decades, since only in 2009 the overall real GDP growth was negative (IMF 2018). Such growth, as mentioned earlier, puts pressure on the water input. Shock values were determined using data from the World Trade Statistic Review of 2018 (WTO 2018). Positive values were found that could represent a soft increase (F) in world exports and a strong increase (G) in world exports. In the historical series 1981-2017, the values of the years 2016 and 2017 were chosen, since they are recent, sequential, positive and with a significant difference between the two. In 2016, there was an increase of 1.8% in the volume of world exports, while in 2017 there was an increase of 4.7% (WTO 2018). In addition, two export standards of the Brazilian economy were established. The first is the current Brazilian standard, and the second is a Brazilian standard with a strong preference for the services sector. In the first pattern, shocks (increase) in exports are uniform (U), that is, the same shock is assigned to all economic sectors, which shows the same behavior as the exporting pattern. In the second pattern, shocks are non-uniform (NU), i.e. stronger shocks are assigned to service sectors (favoring them) and weaker shocks are assigned to the remaining sectors. In the second pattern, shocks of 0.9%, 1.8% and 3.6% (soft) and 2.3%, 4.7% and 9.4% (strong) were used. Table 3 illustrates shocks in exports.

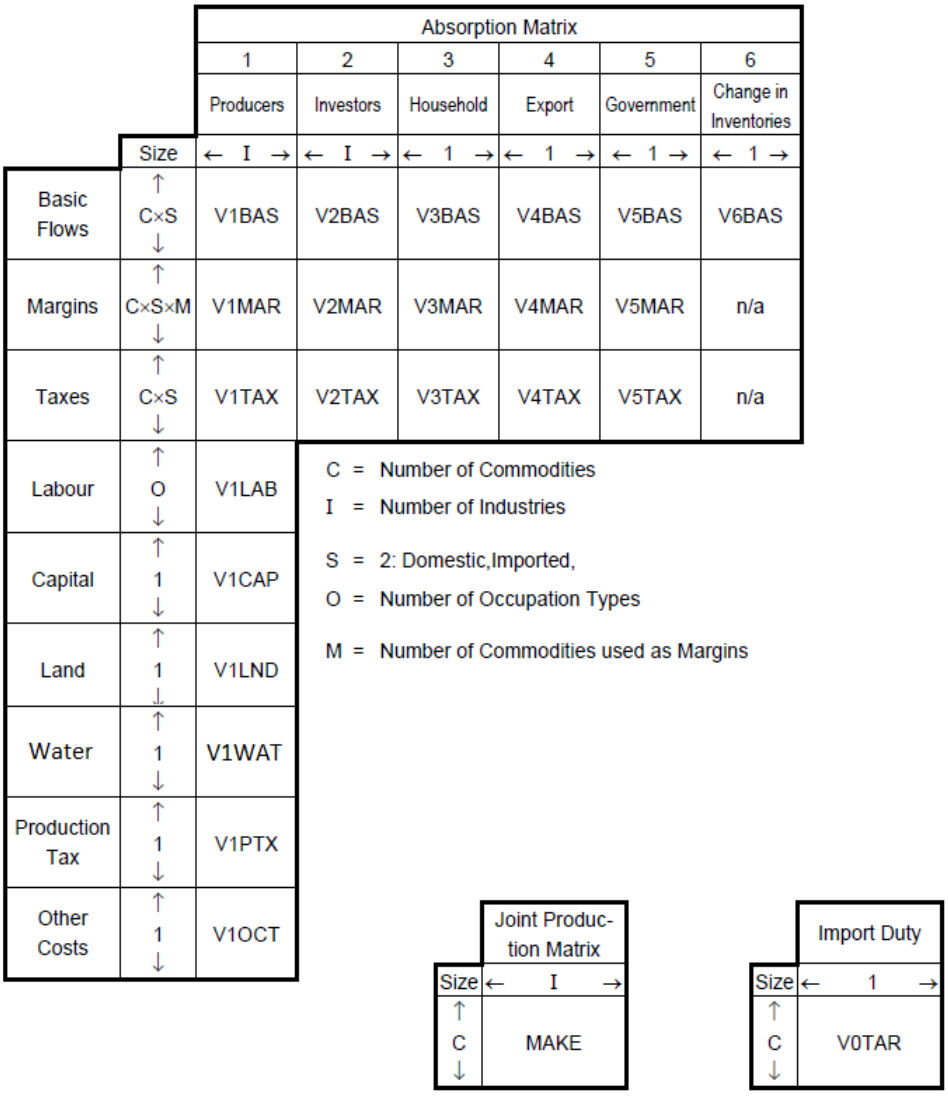
Table 3. *Simulation Values for Changes in Brazilian Exports*

Sector/Simulation (in % change)	**UF**	**NUF**	**UG**	**NUG**
Agriculture	1.8	0.9	4.7	2.3
Extractive	1.8	0.9	4.7	2.3
Industry and Construction	1.8	1.8	4.7	4.7
Eletricity, gas and water	1.8	3.6	4.7	9.4
Retail sector	1.8	3.6	4.7	9.4
Transportation	1.8	3.6	4.7	9.4
Information and Communication	1.8	3.6	4.7	9.4
Finance	1.8	3.6	4.7	9.4
Real Estate	1.8	3.6	4.7	9.4
Other Services	1.8	3.6	4.7	9.4
Public Adm, Health and Education	1.8	3.6	4.7	9.4

Source: Research from IMF and WTO.

The CGE model chosen for the simulations was ORANI-G. This model, however, underwent modifications for the effective inclusion of the water input in its structure. In the modified model, water is treated as one of the four primary factors alongside capital, labor, and land. This allows an efficient qualitative analysis of changes in its consumption, as also observed in the original model, in the primary factors of capital, land and labor. Thus, a "price x quantity" vector was created for the primary water factor. The established quantity is the total consumption present in Table 2, while the established price, according to Souza and Santos (2016), is 2.62 reais (Brazilian currency), since an Input Output table is published in reais, per cubic meter.

Figure 1. *Modified Flows of ORANI-G*



Source: Horridge (2005), modified.

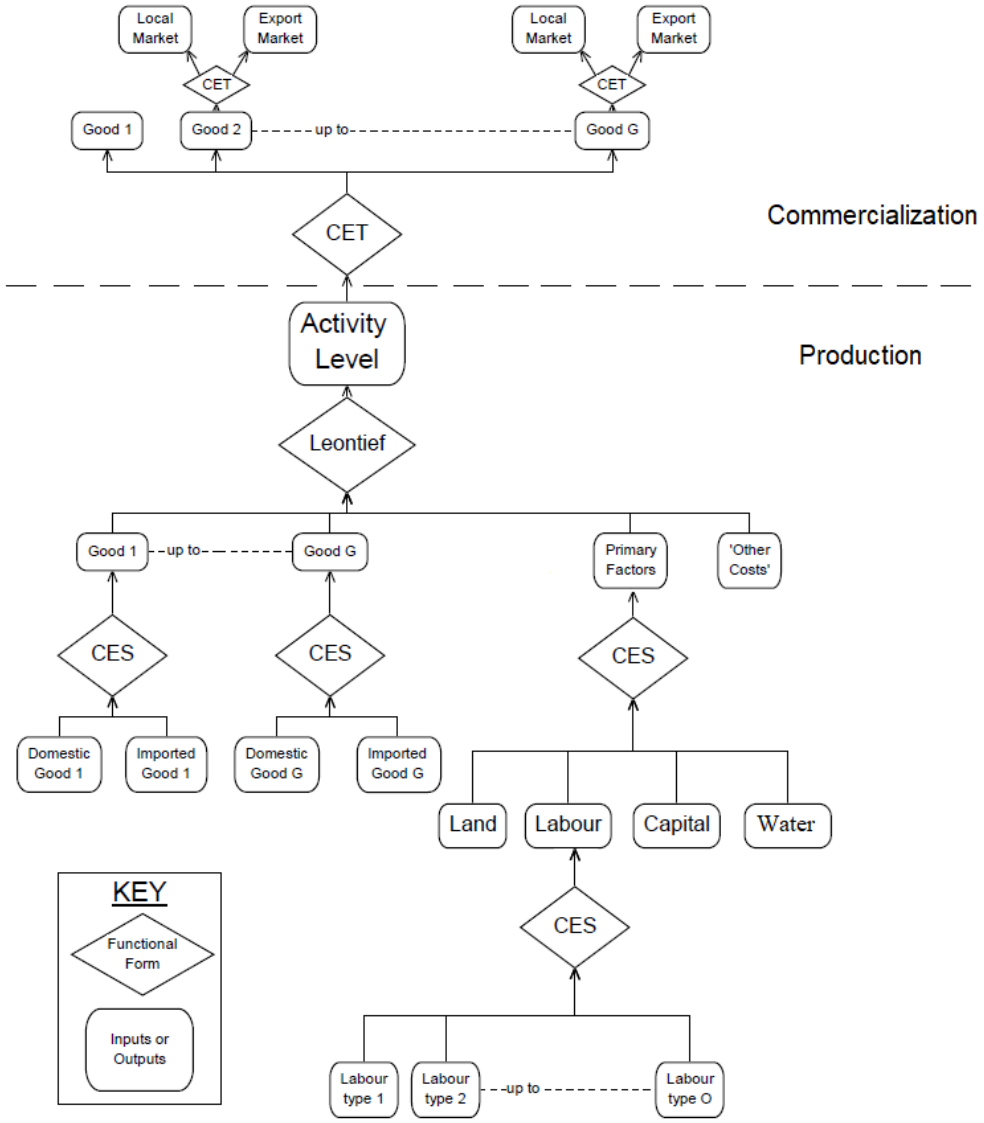
ORANI-G is a static model composed of several equations that explain flows. Each stream originates from a price x quantity multiplication. Supply and demand equations for private sector agents are derived from the solutions of optimization problems (minimization of costs, utility maximization and others) of a traditional new-classical agent. Agents in the model are price takers, with producers operating in competitive markets that prevent them from obtaining "pure profits." Figure 1, based on the work of Horridge (2005), shows the structuring of the modified ORANI-G model for water. The explanations that follow regarding ORANI-G in the remainder of this section are all based on those developed in Horridge (2005).

The model allows each industry to produce various commodities, using as input national and imported goods, labor of various types, land, capital, and water. Commodities destined for export are different from those used locally. The production specifications are illustrated by the nesting (Figure 2). This nesting can be divided into two parts. The lower part concerns production and is divided into a sequence of "nests". From bottom to top: the "work" compound is an aggregate of job types by occupation (O) combined by a CES function (constant substitution elasticity), representing in general the demand for different types of work; the compound "primary factor" is an aggregate CES of land, capital, water and the compound "work", generally representing the demand for primary factors; the commodity is a CES function of a domestic good and the imported equivalent, generally representing the demand for commodities from one source or another (as a "choice" of the source of the intermediate input). The "primary factor" and "well" compounds, combined with "other costs" are combined through a Leontief function, all of which are therefore demanded in direct proportion to the industrial activity index (X1TOT) (Horridge 2005).

The model allows each industry to produce a mixture of every commodity. For each industry, the mix varies according to relative prices. The upper part of Figure 2 determines the composition of the commodities of industrial production. This top part also deals with marketing. The nested CET functions (constant elasticity of transformation) determine whether the good is going to be sold overseas or to the domestic market (Horridge 2005).

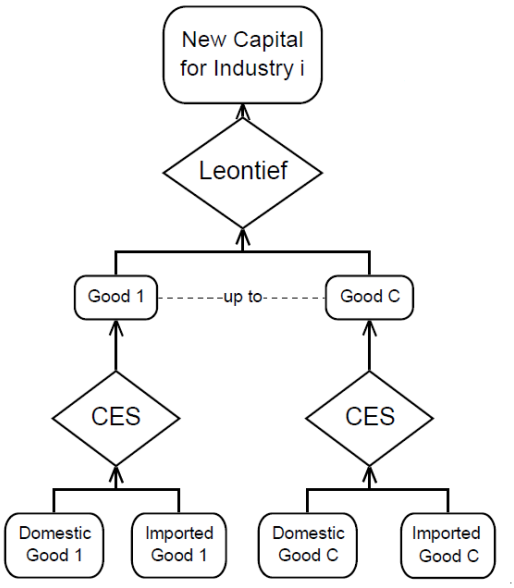
Figure 3 shows the structure of the demand for investment. Its structure is similar to that of intermediate goods. The figure shows, in other words, the nesting structure for the production of new units of fixed capital. Capital is produced with inputs from domestic and imported commodities. Commodity compounds are aggregated via a Leontief function. No primary factor is used directly as input for capital formation (Horridge 2005).

Figure 2. *Production Structure - Modified ORANI-G*



Source: Adapted from Horridge (2005).

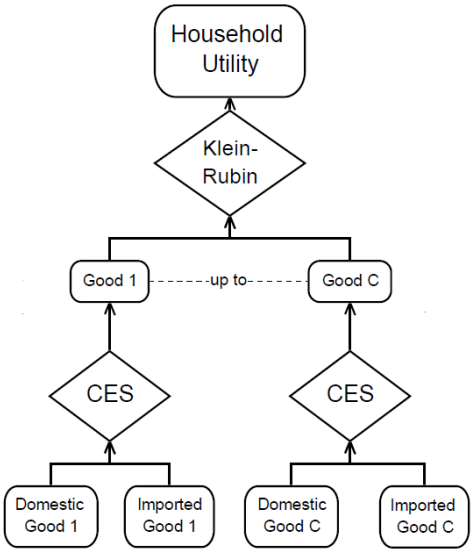
Figure 3. *Demand Structure in Investment*



Source: Horridge (2005), modified.

Finally, Figure 4 shows that the structure of consumer demand (households) is very similar to that of investment, different only by the Klein-Rubin aggregation function, which leads to a linear Horridge (2005) expenditure system.

Figure 4. *Consumer Demand Structure*



Source: Horridge (2005).

Results

The values presented in Table 4 clarify the percentage variation of the water consumption of the economic sectors in the four scenarios, in relations to exports growth.

Table 4. *Percent Change in Water Consumption – By Sector and Simulation*

Sector/Simulation	**UF**	**NUF**	**UG**	**NUG**
Agriculture	0.11	0.07	0.28	0.18
Extractive	0.93	0.57	2.43	1.48
Industry and Construction	0.41	0.41	1.07	1.08
Eletricity, gas and water	0.15	0.15	0.39	0.39
Retail sector	0.15	0.16	0.40	0.41
Transportation	0.33	0.42	0.87	1.09
Information and Communication	0.13	0.19	0.35	0.51
Finance	0.14	0.20	0.37	0.51
Real Estate	0.04	0.06	0.10	0.14
Other Services	0.17	0.25	0.44	0.66
Public Adm, Health and Education	0.03	0.02	0.08	0.06

Source: Results of the model/simulations.

The agricultural sector, the one that consumes the most water, was not the sector that presented the largest variations of total consumption, regardless of the shock under analysis. The extractive sector was the most affected in all scenarios, even in those with a higher demand for services, with values considerably higher than others, especially when compared to the agriculture and livestock sector. Other sectors that presented changes considerably superior to the agricultural sector were industry and construction and, in the same way, transportation.

The total water consumption in relation to the exporting profile was, in general, as expected. Uniform soft shocks generated greater variations in total water consumption in the primary sectors when compared to the non-uniform soft shocks and generated lower variations in the service sectors when compared to the non-uniform soft shocks. The same pattern was observed in the uniform and non-uniform shocks. Non-uniform soft shocks do not generate greater variations than strong uniform shocks in service sectors, even with the closest approximation of shocks. The exceptions for all these results were the electricity, water and gas and administration, public health and education sectors. The first showed no change in total water consumption with the change in the export pattern, maintaining 0.15% in soft shocks and 0.39% in strong shocks. The second, even with higher shock levels in non-uniform shocks, presented higher water consumption in uniform shocks (0.03% and 0.08% compared to 0.02% and 0.06%), contrary to the idea of improve of service sectors.

In the soft shocks, it was observed that the agricultural sector did not show great variations in the total water consumption in a possible change of pattern of the Brazilian exports. The extractive sector, however, presented considerable variation. On the other hand, the sectors of transport and other services have significantly changed their consumption with a change in the export profile.

Finally, the variations of the real estate and the retail sector, with a change in the export agenda, are little more than water consumption.

In strong shocks, there are generally stronger consumption variations among sectors, considering a change in the export profile. This is evidenced in the variation observed in the industry and construction sector. The shocks established for this sector were the same in the strong scenarios (4.7%) and even so, an increase of 1.07% to 1.08% in total water consumption was observed. The agricultural sector, contrary to its pattern in the mild shocks, shows considerable consumption variations considering a change in the export agenda and the extractive sector continues with high variations. The transportation, other services, information and communication and financial sectors show considerable variations, unlike real estate and retail.

The relationships between the shocks can be better observed in Table 5. Uniform shocks increase water consumption more than non-uniform shocks. Even though shock levels are considerably high in the service sectors in UN shocks, the intensive use of water in the primary sectors still causes their variations to be dominant.

Table 5. *Aggregate Shocks – Water Consumption*

Consumption/Simulation	**UF**	**NUF**	**UG**	**NUG**
Change in Total (%)	0.16	0.12	0.40	0.32
Change in Total Consumption (liters)	476 billion	371 billion	1,223 billion	963 billion

Source: Results of the model/simulations.

Table 6 shows the values in cubic hectometers of the percentage variations previously presented. Even though its percentage variations have been smaller, the agricultural sector remains the largest total consumer of water in Brazil by large differences.

Table 6. *Water Consumption – By Sector – Cubic Hectometer*

Sector/Simulation	**UF**	**NUF**	**UG**	**NUG**
Agriculture	23730	23720	23770	23746
Extractive	284	283	289	286
Industry and Construction	3464	3464	3487	3487
Eletricity, gas and water	2374	2374	2380	2380
Retail sector	689	689	690	690
Transportation	0.07	0.07	0.07	0.07
Information and Communication	0.07	0.07	0.07	0.07
Finance	0.07	0.07	0.07	0.07
Real Estate	0.07	0.07	0.07	0.07
Other Services	0.07	0.07	0.07	0.07
Public Adm, Health and Education	59	59	59	59

Source: Results of the model/simulations.

Finally, we can compare the water supply to two other factors, capital and labor, and the level of national activity. The variations of the Current Capital Stock and the Effective Labor Input show fairly similar values and are then presented

together. All variations of the water resource, as observed in Table 7, were superior to both capital and labor variations. As a result of the shock level of exports and the character of exports, the demand for water increases more than the demand for capital and labor. Resources in the economy, therefore, are more focused on water than on the other two primary factors.

Table 7. *Percent Changes in Current Capital Stock and Effective Labor Input*

Sector/Simulation	**UF**	**NUF**	**UG**	**NUG**
Agriculture	0.10	0.06	0.25	0.16
Extractive	0.92	0.56	2.41	1.47
Industry and Construction	0.36	0.38	0.94	0.99
Eletricity, gas and water	0.10	0.11	0.25	0.30
Retail sector	0.10	0.12	0.27	0.32
Transportation	0.27	0.38	0.70	0.98
Information and Communication	0.09	0.16	0.22	0.42
Finance	0.10	0.16	0.25	0.43
Real Estate	_0.02	0.02	_0.05	0.05
Other Services	0.12	0.22	0.31	0.57
Public Adm, Health and Education	_0.02	_0.01	_0.06	_0.04

Source: Results of the model/simulations.

Regarding the level of activity, Table 8 shows how much more was produced by the economic sectors given the proposed shocks. The variation in the level of activity did not overcome the greater demand for water in any of the economic sectors and in none of the proposed shocks. The extractive sector, however, presents variations of level of activity very close to the variations of total water consumption. This result is validated by the high variations of the Current Capital Stock and the Effective Labor Input of the sector. With simulated export increases (with or without profile change), the extractive sector increased its demand for water, capital and labor, which was reflected in the high variations in its level of activity and, consequently, importance to the national economy. The greatest alterations are observed in the agricultural sector, in which the level of activity presented considerably lower variations than those of the demand for water. Sectors such as public administration, health and education and real estate were affected by the increase in exports, given the negative variations in capital, labor and production level (resources flowing to other sectors), which contrasts with the positive variations in total water consumption.

Table 8. *Percent Changes on Activity Level*

Sector/Simulation	UF	NUF	UG	NUG
Agricultural	0.04	0.03	0.11	0.07
Extractive	0.92	0.56	2.41	1.47
Industry and Construction	0.36	0.38	0.93	0.99
Eletricity, gas and water	0.10	0.11	0.25	0.30
Retail sector	0.10	0.12	0.26	0.32
Transportation	0.26	0.37	0.69	0.97
Information and Communication	0.08	0.16	0.22	0.42
Finance	0.09	0.16	0.24	0.42
Real Estate	_0.02	0.02	_0.05	0.05
Other Services	0.12	0.22	0.30	0.57
Public Adm, Health and Education	_0.02	_0.02	_0.06	_0.04

Source: Results of the model/simulations.

Conclusions

This study analyses the impact of international trade in Brazilian economic sectors and it correspondent impact over water consumption across economic sectors. The Brazilian economy is characterized for its presence in international trade by use of natural resources and exports of goods with great natural properties, such as water, energy, and land.

The growth of international trade is one of the most important factors to increase the pressure on this water demand, both in industrial and primary sectors. Different Brazilian export growth scenarios proposed showed that the deviations in total water consumption exceeded the variations in demand for capital and labor in all sectors. In addition, the difference of the total water consumption exceeded the variation of the level of activity of each sector, presenting an elastic pattern for water consumption. The primary extractive activity, vegetable and mineral, observed the greatest increase in water consumption, and its variations in the demand for capital and labor and activity level were also significant in response to export growth. The pattern of the agricultural sector, however, was reversed. The largest water consumer in the world presented low variations in water consumption due to export shocks, with lower values than sectors such as commerce and transport, even in scenarios of preservation of the current exporting figures. The total consumption of the sector, however, is still vastly superior to any other activity developed in the country.

Given the Brazilian national data to 2015, through an input-output table, a typical computable general equilibrium model, given the sectoral distribution, made it possible to bring to the discussion concrete figures regarding the relationship between availability of water resources and exports. Stricter and better enforced charging/control policies are the main alternatives for a more rational use of water. However, it is necessary to recognize the need to unite two aspects: water as an indispensable resource for production and life, threatened by scarcity, and the continuity of this production, threatened by excessive and inefficient use of the national water resource.

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Structuring African Warehouse Receipt Systems to Succeed

By Anthony Aboagye[*]

Development economists have preached that functioning warehouse receipt systems (WRSs) will help smallholder African farmers access loans to help reduce poverty and enhance financial inclusion. Unfortunately, many reviews of African country WRSs have concluded that anticipated benefits are not accruing to smallholder farmers. Given the theoretical case and positive experience elsewhere, this paper meticulously reviewed reports that WRSs are not working in the interest of African farmers to identify the challenges. Then, several scenarios in respect of use of WRSs were formulated and analysed for Ghana and Uganda. Scenarios include paying/not paying collateral management fees, grading/not grading maize, using/not using warehouse receipts (WR) as collateral, using community warehouses, etc. Malawi and Zambia are also discussed. The paper concludes that the potential for positive impact of WRSs on the lives of smallholder African farmers exists. However, it is necessary to structure WRSs to suit the situation of smallholder African farmers. The key to profitably implementing WRSs in Africa is not to blindly replicate WRSs as implemented in other jurisdictions. Important African specific context ingredients include focusing on community warehouses rather than commercial warehouses, not focusing on grading of grains and not implementing full-scale collateral management arrangements.

Keywords: *warehouse receipts, smallholder farmers, Africa, Ghana, collateral management fees, community warehouses*

Introduction

Development economists are beginning to wonder why warehouse receipt systems (WRSs) in Africa appear not to be having anticipated positive results on smallholder African farmers, in spite of their success in other jurisdictions, given the promise that they hold in principle. It has been argued that paying attention to smallholder agriculture in Africa will play a major role in poverty reduction, help achieve food security and financial inclusion. Indeed, agriculture in Africa employs upwards of 50% of the labour force of most countries. Unfortunately, studies have shown that smallholder farmers, face major liquidity challenges which curtail their farm output and productivity growth. Liquidity challenges mean that many smallholder farmers are not able to access key farm inputs such as seed and fertilizer and so are not able to enhance their yields and farm sizes.

Many studies have shown that access to appropriate small loans to the poor positively impacts poverty reduction. Unfortunately, the majority of the poor in

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Africa do not possess collateral that is acceptable to financial institutions that grant loans, hence such persons are unable to access loans.

In response, a number of development practitioners have argued that farm produce that farmers harvest and own are assets which can be structured as collateral. WRSs have been proposed as a solution to this liquidity problem of smallholder African farmers.

Traditionally, to avoid the high losses associated with grain storage, farmers have adopted the practice of selling their grains soon after harvest, resulting in them realizing low market prices as many farmers try to sell at the same time. To hold on to the harvest for higher prices, farmers would dry some of the crop soon after harvest to reduce molds and insect infestation and store then in barns on their farms. But only the farmer knows the quantity and quality of the grain in his/her barn. Faced with this situation, the idea that an accredited warehouse would store agricultural produce safely and maintain its quality over a given period of time so that farmers are not tripping over each other to sell their limited produce at harvest would appear to be an enticing proposition to African farmers.

Accepting the theoretical advantages of WRSs, a number of African countries have adopted the modern concept of formal WRSs. They include Burkina Faso, Cameroon, Cote d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Niger, Senegal, Tanzania, Uganda, and Zambia. Some have even institutionalized commodity exchanges.[1]

However, Miranda et al. (2018), argued that warehouse receipt financing in Ghana and Africa has not yielded the theoretical promises to smallholder farmers. In fact, in Miranda et al. (2019), the authors posit that "Warehouse receipt financing involves significant transaction costs and complex risk transfers that undermine its value to the smallholders."

Before them, Sitko and Jayne (2012) had reported on six main factors that they said impeded volumes of agricultural produce traded on the Zambian Agricultural Commodity Exchange. Not long after, Chapoto and Aboagye (2017), looking back at 2014 data two years after Ghana Grains Council (GGC) started its WRS, documented that due to low output, no smallholder farmer targeted by the GGC WRS had been issued with tradable certified warehouse receipt to serve as collateral to potential lenders. However, Chapoto and Aboagye noted that grain aggregators (non-farmers) had aggregated enough grains from farmers to be issued warehouse receipts. They added that, small-scale grain farmers however report substantial reduction in post-harvest losses when they lodged farm proceeds with community warehouses.

This study probes deeper into the literature on performance of the WRSs in Africa and finds that all is not lost. Imposing how WRSs work elsewhere wholesale on smallholder African farmers is the problem. Requiring relatively high minimum quantities for commercial warehouse storage, commercial arrangements that require grading of grains and bearing the cost of traditional collateral management fees, bureaucratic dealings with warehouse operators, etc.

[1]South Africa is in a league of its own.

constitute challenges for the smallholder African farmer. High lending rates too are a problem.

Following this introduction is a brief review of the literature on WRSs and empirical studies on warehouse receipts in Africa. This is followed by the methodology adopted here. Findings are the presented, followed by discussion and conclusion.

Literature

Warehouse receipts (WR) are receipts issued to depositors as evidence that standardized specific assets (agricultural produce) of a certain quality and quantity have been deposited by a named depositor in a certified warehouse. Such receipts may then be presented to potential lenders as evidence that the depositors have collateral. Beyond facilitating access to finance, a functioning WRS has the potential of helping farmers earn more for their produce as farmers store their agricultural produce in well-equipped and secured warehouses and then sell at higher prices during lean seasons. Post-harvest losses too will be arrested. And farmers will be able to smoothen their consumption across seasons.

Standardisation of commodities allows trading by description, thereby reducing transaction costs, and also safeguarding against cheating on weights and quality. Also, trade using the WR shortens the marketing chain and can potentially increase producer margins. The WR can also help reduce the cost of procuring and managing public food reserves and create incentives for private players to invest in new business ventures. Further, commodities are better stored by professional warehouse operators, therefore reducing storage losses.

The concept of a warehouse receipt system for grains relies on the idea that during harvest season, because all farmers are harvesting and seeking to sell their surplus grains, the price of produce falls. A few months down the road, when much of the grains produced during the last harvest season have been consumed/ sold and others have been lost to post-harvest insects, etc. prices rise. Thus, the advice is that farmers should store some of the grains they produce at harvest at secured locations that are protected against post-harvest losses and then sell same later when prices would have risen. In the meantime, while waiting for more favourable prices, they may pledge the stored grain as collateral for a loan from a financial institution.

Warehouse Receipt Systems in Africa

In Africa, WRSs are operational in many countries. Some have even established commodity exchanges. Table 1 provides some evidence about establishment of WRSs and quantum of business undertaken in certain years. Clearly, these formal African WRSs are young. The last column is particularly interesting. It makes clear that for many countries, produce quantities for which WRSs were issued were miniscule percentages of country productions. Ethiopian and Tanzanian commodities are basically for exports.

Table 1. *Country WRS: Year of Establishment and Quantum of Commodities for which WRs were issued in 2015, 2016 and 2017 versus Crop Production in Metric Tonnes*

Country	Established	2015	2016	2017	% of Total National Production in 2015
Ethiopia	2009	590,000			66% Coffee; 100% Sesame
Ghana!	2008	29,000	18,000		1.2% Maize
Tanzania	2005	130,000	140,000		80% cashew
Kenya, Uganda & Tanzania*	2014	30,000	70,000		0.5% of maize
Malawi+	2011	150,000	110,322	16,373	5% of maize
Zambia	2014	11,440	12,760	10,560	4.4% of Maize
Nigeria	2014	48,000	48,000	29,000	0.5% maize
Rwanda	2014	15,000	10,000		2% maize

Source: Thunde and Baulch (2020), African Development Bank (2017), Safo (2017) and Miranda et al. (2019).
!A second WRS, Ghana Commodity Exchange, started in 2018. In 2019, quantity of maize for which its WRs were issued was 0.03% of the 2.9 million metric tonnes produced; in 2020, the proportion traded was 0.04% of 3.1 million metric tonnes; in 2021, it was 0.14% out of 1.8 million metric tonnes.
*One operator operates a common warehouse system in the three countries.
+Figures for Malawi's two operators.

Smallholder Farmers and WRS in Ghana

Miranda et al. (2018) analysed several scenarios that smallholder farmers face with their produce in the context of WRS. They concluded that for the smallholder farmer to benefit from warehouse receipt financing, one of two things must happen: i) either smallholder farmers realise substantially higher price for their graded grain which is stored in commercial warehouse, or, ii) the cost of warehouse receipt financing must come down for the undertaking to be worthwhile to farmers.

Much earlier, the United States Agency for International Development (USAID) (2012) worked out a Ghanaian scenario in which a bag of 100 kg of maize was harvested and stored for six months in an accredited warehouse for a WR which was then used as collateral for a loan on which the lender pays prorated interest at the rate of 20% p.a. Then, after 6 months the maize was sold and loan and interest paid off. The going cost of transportation and applicable handling and storage costs were also paid.

Their analysis showed that if the bag of maize would have sold for GHS 35 (USD 12) at harvest, a price increase of 50% would be required at sale time to break-even. If the cost of the bag of maize at harvest was GHS 45 (USD 15), a price increase of 41.1% would be needed to break-even. Note that break-even price calculated here has not included a profit margin for the farmer. The main point here is that such high price increases are not common.

Collateral Management and Warehousing Costs

Historically, commodity financing has depended on collateral management agreements. Under these agreements, a third party who specializes in inspection

and control assumes control of the warehouse in which commodities are stored and monitors safety and quality of all stocks as well as goods received, and goods taken out. Unfortunately, the cost of doing this is high, to reflect the risks. Thus, use of collateral management services has been limited to transactions/ commodities with high market values and has involved large and well-established counterparties.

For grains, warehousing costs include fees for sampling, grading, cleaning, drying, and bagging the grain on delivery, charges for pest and interest control, fumigation, use of electricity and use of warehouse space, charges for security, moisture monitoring and insurance. If the service is subsidized by government in a public warehouse, it does not take long for the quality of service to fall with time in many parts of Africa.

The International Finance Corporation (2013) discusses that the cost of collateral management services is relatively high in Sub-Saharan Africa. Unfortunately, financial institutions that finance warehouse receipts pay particular attention to collateral management arrangements.

This Study

This study identifies and documents details of WRSs in Ghana, Malawi, Zambia and Uganda. The rich evidence gathered in respect of Ghana, Malawi, Uganda and Zambia is analysed highlighting the challenges and positive evidence of WRSs in these African countries. The benefits of WRSs are realised when the traditional model of grading commodities that are received into storage, expensive collateral management and high the interest rates are not imposed.

Reference is made to maize much of the time for good reason. The International Institute for Tropical Agriculture reports that maize is "the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America." It is the main staple for over 300 million Africans, it adds. Over 30−50% of low-income household expenditures in Africa is spent on maize. Maize is rich in dietary fiber and other nutrients.

Methods

The approach adopted in this study was to review and analyse previous studies on the performance of WRSs and commodity exchanges to identify the basis for the findings in the literature and to recommend how to work on those challenges for WRSs to begin to unleash they promise they hold in Africa.

First, there was a search of the internet on the following key words and phrases and downloading same: *warehouse receipt systems in Africa; commodity exchanges in Africa; warehousing grains in Africa; warehousing maize in Africa; African warehouses for grains; trading grains in Africa; post-harvest losses in Africa; agricultural output in Africa; agricultural productivity in Africa; farm sizes in Africa, agricultural GDP in Africa*, etc.

Following this, downloaded articles, books and other publications were scrutinized for information and data relating to operation of WRSs in Africa. The following are noted: *types of grains deposited in warehouses for which warehouse receipts were issued*; *types of warehouse (commercial, government owned or community owned); how warehouses are managed; quantities (volumes) of grains for which warehouse receipts were issued and their market values; terms under which warehouse receipts were issued; whether depositors who were issued with warehouse receipts pledged them as collateral for loans; how depositors fared when deposited grains were finally sold and expenses incurred paid; whether storage was in accredited commercial warehouses for warehouse receipts; those who stored in non-commercial warehouses; those who sold all their grains at harvest (did not warehouse); proportion of depositors who pledged their warehouse receipts for loans; interest paid on loan; seasonal price fluctuations for various commodities over time, etc.*

Then, using pertinent data on the cost of maize, collateral management costs including grading cost and interest rates in Ghana and Uganda, several scenarios of outcomes realiseable by farmers in each country were contrasted against the base case of the farmer selling all produce at harvest rather than storing harvest in a commercial warehouse.

Findings

Ghana

In Ghana today, the Ghana Grains Council (GGC) is one of two entities involved in the certification and regulation of warehouse receipt systems. The other is the Ghana Commodity Exchange (GCX). Each has its own WRS. The GGC introduced an electronic commercial WRS in 2012. The warehouses are usually found in urban areas. Alongside the commercial warehouses, the GGC also put in place community warehouses. Community warehouses are located in farmer communities and are much smaller than the commercial warehouses and are less equipped. The GGC is a private sector-led initiative, led by players in the grain business in Ghana. GGC was formed with funds provided by the United States Agency for International Development (USAID). GGC started by receiving only maize into storage.

Operation of Commercial Warehouse Receipt System in Ghana

A farmer seeking to deposit maize in a GGC registered commercial warehouse brings the maize to the premises of warehouse, where it is tested for its moisture content. If the content is no more than 13%, the maize is accepted for further processing, which includes removing all chaff and stones. The cleaned maize is then weighed and re-bagged into 50kg bags. However, 51 kg of maize are put into each bag to allow for weight loss during storage. The warehouse also ensures that

the maize that is received into storage is free of agrochemical contamination and its aflatoxin content is tolerable (not more than 15 parts per billion).

Samples of the maize just received are sent to the Ghana Standards Authority (GSA) for grading. The depositor receives a legal WR that bears the name of the depositor, location of the warehouse, number of bags and specific grade of maize stored and expected duration of storage. Maize received into GGC commercial warehouses may remain in storage for up to 5 months. The minimum quantity to deposit in the commercial warehouse is 5 metric tonnes (5,000kg). GGC initially attached to each commercial warehouse, a collateral manager who monitored activities that took place in the warehouse on daily basis to ensure that grains stored are not compromised. By 2021, GGC was operating 12 commercial warehouses with total storage capacity of 54,000 metric tonnes. To access credit, a depositor with maize in the commercial warehouse pledges the warehouse receipt to an interested financial institution as collateral against the stored maize.

Unfortunately, loans based on GGC warehouse receipts have been issued mainly to corporate bodies or large traders. The financial institutions have hardly done any business with smallholder farmers. In fact, an overwhelming majority of warehouse receipts have been issued by the certified warehouse operators to themselves. The warehouse owners then present receipts issued to themselves as collateral for loans (Mulangu et al. 2017).

Community Warehouses

Alongside certified commercial warehouses, the GGC maintains warehouses in farming communities for smallholder farmers and farmer groups in farming communities which are far from urban areas to store their maize, possibly as a first stop ahead of transferring to a commercial warehouse. Quantities as low as 500kg of maize are accepted into the community warehouses, whose capacity does not exceed 100 MT. Besides, the criteria for accepting maize into the community warehouses were nowhere as stringent as what is required of maize to be accepted into certified warehouses. Stocks of grains in the community warehouses are managed with local expertise. Some technical support may be provided by non-governmental development organisations, government agencies and/or private consultants. Depositors may be asked to make some financial contributions.

To give smallholder farmers who deposit their produce in the community warehouses some chance at accessing finance, the GGC works to link the community warehouses to commercial warehouses. The GGC oversees 22 community warehouses with total storage capacity of 2,480 metric tonnes. Formers who store their maize in community warehouses are likely to leave their maize in the community warehouse until the beginning of the next farming season.

Often, formers storing their maize in community warehouses work with a nucleus farmer, who is likely to move the grains to a commercial warehouse in his/her name. The nucleus farmer may then contract a loan. Borrowed funds are used to procure farming inputs for his/her out-growers to purchase improved seeds, fertilizers and insecticides. The nucleus farmer also arranges ploughing of the farmland of the smallholder farmers for a fee. Farmers also receive advice on agronomic practices to enhance their productivity. At harvest, the nucleus farmer

arranges transportation to the community warehouse and from there to accredited warehouses in the urban areas if need be. When an out-grower is ready to sell, the nucleus farmer buys the produce at market prices.

Ghana Commodity Exchange WRS

The second WRS in Ghana is overseen by the Ghana Commodity Exchange (GCX). Commodities are deposited in GCX certified warehouses which issue warehouse receipts. These may be presented as collateral for loans at designated financial institutions. For now, commodities are held in storage for three months only. Cash settlement is effected within 24 hours of trade. Buyers have up to 10 days to pick-up their purchases from the warehouses.[2]

Operation of both GCX and GGC WRS is enshrined in Ghanaian law, the Securities Industry Act, 2016 (Act 929). The law recognizes the warehouse receipts as financial instruments. The receipts are backed by insurance, performance bonds and indemnities. The GCX emphasizes the quality of management of warehouses that are affiliated with it. Warehouse management services include regular fumigation, regular stock taking, around-the-clock security and camera surveillance and readiness to mitigate losses which may arise from unforeseen occurrences.

In July 2021, the Chief Executive Officer of the GCX held a press conference at which she disclosed that "More than 250 smallholder farmers who trade on the Ghana Commodity Exchange (GCX) have used their warehouse receipts to access loans to finance their activities." She did not give any indication about smallholder quantities or quantum of loans.

Commodity Prices and WRS

USAID (2012) reported on maize price fluctuations in Ghana (month-on-month) from 2003 through 2011. Further, the Ghana Ministry of Food and Agriculture (MOFA) (2020) indicated the price of maize in January and in July from 2015 through 2019. In addition, this author supplemented with 2020 and 2021 prices. MOFA works with the rule of thumb that prices for maize are lowest in January and highest in July reflecting demand and supply. The average of the annual price fluctuations between 2003 through 2011 was as high as 40.8%, while the average for the period 2015 through 2021 was only 10.7%, suggesting that price swings are narrowing.

Malawi

A study undertaken for IFPRI-Malawi in 2020 by Thunde and Baulch reported that the Agricultural Commodity Exchange for Africa (ACE) which currently operates only in Malawi is one of two warehouse receipt issuers in Malawi. The second is Auction Holding Commodity Exchange (AHCX). After some checkered history, ACE re-branded and re-started issuing WRs in 2011. AHCX started in 2013. Between 2011 and 2016, the number of warehouse receipts issued and

[2]https://gcx.com.gh/services/.

quantum of agricultural produce deposited by both certified warehouses, principally maize, grew.

Malawi passed their Warehouse Receipt Act in 2017 and subsequently issued a Commodity Exchange Directive in April 2019. Following the Directive, ACE and AHCX were licensed as commodity exchanges in 2020.

Thunde and Baulch lament the high cost of servicing loans received with WR pledged as collateral in Malawi. They add that this has adversely affected the development of Malawi's WRS. They point to domestic currency denominated commercial bank lending rates that were above 35% between early 2012 and end of 2016, which remained above 25% throughout 2018 and 2019.

Who Uses Warehouses in Malawi?

Another Malawian study for International Food Policy Research Institute (IFPRI) by Baulch (2019), documents that most reported trades involving Malawian grains were on behalf of processors of agricultural commodities and large national trading companies. The study points to a national survey conducted for IFPRI in July/August 2016 and repeated in August/September 2018, which found that no smallholder farmer had used the WRS. The study however found a small number of farmers associations/cooperatives and small traders who had been issued with WR.

Table 2. *Warehouse Receipts by Type of Depositor, 2011-2018*

Depositor Type	**Number of WRs issued**	**% of Total WR**	**Number of Maize WR**	**% of Maize WR**	**Total Volume (MT)**	**% of Total Volume**
Large Trader	194	27%	135	29%	8,048	67.2%
Medium Trader	128	18%	83	18%	1,435	12.0%
Medium/Large farmers	136	19%	90	19%	589	4.9%
Small Trader	189	27%	126	27%	1,315	11.0%
Farmer Group or Association	63	9%	30	6%	597	5.0%
TOTAL	**710**	**100%**	**464**	**100%**	**11,985**	**100.0%**

Source: Thunde and Baulch (2020). WR= warehouse receipt. MT= Metric tonne.

Further analysis of the Malawian WRS over the 2011-2018 period is provided by Thunde and Baulch (2020). Of the total of 710 WRs issued, Large traders and Medium traders, who typically supply grains to processors, as well as Medium/ Large farmers were issued with 64% of total warehouse receipts, (Table 2). The interesting thing is that these three categories of depositors owned 84% of total grains deposited, of which maize is the largest by far.

Analysis of the data by grain is provided in Table 3. It says 54% of WR were issued to maize depositors. This represents 70% of volume of grains deposited.

Table 3. *Number of Warehouse Receipts Issued by Grain Type (2011-2018)*

Commodity	Number of WRs issued	WR with financing	% WRs Financed	Total volume of commodity, MT	% of total volume	Annual Average Volume, MT
Maize	464	252	54.3%	8,429	70.3%	1,053.7
Soya beans	136	63	46.3%	2,246	18.7%	280.8
Pigeon peas	84	52	61.9%	1,139	9.5%	189.9
Groundnuts	7	0	0.0%	33	0.3%	16.5
Beans	8	5	62.5%	87	0.7%	29.1
Cow peas	6	3	50.0%	35	0.3%	17.5
Other	5	3	60.0%	15	0.1%	4.9
Total	**710**	**378**		**11,985**	**100%**	

Source: Thunde and Baulch (2020). WR= warehouse receipt. MT= Metric tonne.

Profitability of Use of WRS

Smallholder farmers are rational. Thunde and Baulch (2020) observed and analysed a trading rule used by some farmer groups in Malawi. The rule was designed to reduce the storage and financing costs associated with WR yet positioning the farmer group to benefit from price increases. The rule works this way. *Half the group's produce was sold at harvest to meet immediate cash needs. The other half is deposited for a WR but the WR was not used for a loan. This half was earmarked to be sold when prices were higher.*

This rule was applied to an experiment involving several farmer groups for different grains in one growing season (21 contracts). Authors found that the mean and median profits of this group, who did not borrow against their WRs, were +12% and +22% respectively. On the other hand, the mean and median returns for the same 21 contracts for a control group who sourced financing using WR as collateral were -4% and -7% respectively. One surmises that the potential for profits using WRS exists but that financing costs are high.

Zambia

The Platform for Agricultural Risk Management (2019) reported that after going through some teething stages, the Agricultural Credits Act of 2010 was eventually enacted into law in 2014. The law created the Zambian Commodities Exchange (ZAMACE) as the 'authorised agency' of the Agricultural Credits Act with powers to create, manage and enforce a warehouse receipt system.

By 2019, eight warehouse operators had been licensed to operate 300,800 metric tonnes of certified storage space. Other warehouse operators in Zambia include Zambia National Farmers Union, Food Reserve Agency, Grain Traders Association of Zambia, and Millers Association of Zambia.

In another document, CUTS International (2018) states that for the 2016/2017 agricultural marketing season, ZAMACE traded only 12,000 MT of grains (valued at USD 3 million). For that season, Zambia's maize production was estimated 3.6 million MT. Unfortunately, in 2017/2018, ZAMACE traded only 4,000 MT. CUTs conjectured that, for ZAMACE's operations to be sustainable, it should be trading about 250,000 metric tonnes of commodities annually.

Smallholder farmers dominate Zambian agriculture, like many other African countries. Table 4 shows annual production for 2013/2014, 2014/2015/, 2015/ 2016 and 2017/18 and the proportions produced by small-scale and commercial farmers. By a wide margin, the bulk is produced by smallholder farmers.

Table 4. *Zambian Annual Production and Proportions of Smallholder and Commercial Farmers ('000 MT)*

Crop	2013/14	2014/15	2015/16	2016/17	2017/18	Smallholder %	Commercial %
Maize	3,350.7	2,618.2	2,873.0		2,394.9	95.6	4.4
Soya beans	214.2	226.3	267.5		302.7	39.9	60.1
Cotton	120.3	103.9	111.9		88.2	98.8	1.2
Wheat	201,504	214,229	-		114,463	19.1	80.1

Source: Platform for Agricultural Risk Management (2019).

The Platform for Agricultural Risk Management stresses that because the collateral management system in place was based on the Agricultural Credit Act of 2010, receipts issued by licensed warehouses could not be traded. However, since February 2020, the law has been amended to now allow for trading of receipts. However, before the amendment, commercial farmers could access finance using their own receipts as collateral.

Costs to Warehouse Operators

ZAMACE derives its revenues from annual Warehouse Operator Certification fees (for operators) and annual Warehouse Certification fees (for warehouses). It also charges for issue of warehouse receipts, for changes in warehouse receipt ownership and for pledging of receipts for loans.

Interestingly, the structure of the fee system is such that large-scale and medium-scale warehouse operators benefit from economies of scale. To illustrate, a large-scale operator who has five warehouses that together have capacity for a total of 50,000 MT pays about USD 0.03 per MT as licensing fee. A medium-scale operator who has three warehouses that together have capacity for a total of 20,000 MT pays about USD 0.05 per MT. However, a small-scale operator with one warehouse that can store 200 MT pays as much as USD 2.92 per MT as licensing fee.

Another level of costs are charges that certified and non-certified warehouse operators charge depositors. Both charge for handling and storage, but in addition certified warehouse operators charge about USD 1 per MT for issuing warehouse receipts.

Uganda

The Ugandan Warehouse Receipt System was established in 2006. The law guiding its operations is the Warehouse Receipt System Act of 2006. The act provides for the body that will license warehouses, license warehouse keepers, license warehouse inspectors and for the issue warehouse receipts to depositors. Unfortunately, things did not take off satisfactorily. In 2017, the government

decided to re-launch the whole initiative under the 2006 law under the Uganda Warehouse Receipt System Authority established earlier in 2015 to drive the new WRS initiative. Katunze et al. (2017) stated that their findings suggest that in spite of challenges, actors within the revamped WRS were "optimistic that reinstating the WRS will lead to better access to markets and credit." The study noted however that, dealing with two grades of maize, Grade I and Grade II was causing some confusion in the marketplace.

Ethiopia

In 2008, several international donors including United Nations Development Programme, USAID, and the World Bank helped fund the establishment of Ethiopian Commodity Exchange (ECX). The ECX initially focused on grains, but coffee and sesame seeds were soon added and have become the major commodities traded. Available data indicate that ECX volume of commodities traded in 2008/ 2009 was 48,000 MT; 222,000 MT in 2009/2010; 509,000 MT in 2010/2011, 593,000 MT in 2011/2012 and 590,000 MT in 2014/2015. This exchange is cited as doing well, second only to South Africa, on the continent, but their performance data are not readily available.

Discussion

Having presented an overview of the state of WRSs in a number of African countries, the state of African agriculture and variables that have bearing on successful WRSs or otherwise are now analysed.

The State of Agriculture in Africa

To buttress the point on the state of agriculture in Africa, reference is made to the findings of Ghana's agricultural census conducted over 2017/2018 as a case study for Africa (Ghana Statistical Service 2021). Salient findings are: agricultural activities are mainly rural and rudimentary with little innovation and modernisation in the sector; little use of modern tools such as tractors, incubators, hatching and milking equipment; practically dependent on rain; most farmers do not use fertilizer; pesticides use is highly prevalent; the level of formal education among farmers low; most farmers produce for their own consumption; individuals cultivate less than two acres; and the youth are not attracted to agriculture.

Jayne et al. (2016) studied farm sizes in Africa and reported that, in Ghana in 2012, 84.5% of farms were less than 5 hectares in size; in the same year in Tanzania, 91.4% of farms were less than 5 hectares; in Zambia, in 2014, 78.7% of farms were less than 5 hectares and in Kenya, in 2006, 98.8% of farms were less than 5 hectares.

Also, within the typical African country, the connectedness of cities to towns to villages and to smaller communities is weak. Roads are the main modes by which to get from one place to the other. Unfortunately, in many countries, the

roads have been deteriorating. And this constitutes a barrier to trade and weakens the supply response to rising food demand.

Given this uninspiring state of affairs, African farmers' capacity to produce quantities that will promote other value-chain activities is low. The consequence of all this is that the surplus of the output of smallholder farmers is unlikely to meet the minimum quantities the commercial warehouses will accept into storage.

Use Versus Grading of Maize

A working rule of thumb about how the maize produced in Ghana is used was confirmed by USAID (2012). This rule of thumb was used by the Miranda et al. (2019). It says about 45% of maize produced in Ghana is used as subsistence consumption by households that produce it. Post-harvest losses are also included in this figure; 23% is used as animal feed, mostly poultry; 18% is informally traded and consumed by non-producing households. The remaining 14% is formally traded and bought by processors for industrial use and processed food producers.

The situation in Ghana and many African countries is that marketed maize for private household consumption is not graded to segregate quality. Households have found the quality of ungraded maize acceptable. It will be a huge challenge to convince households to pay premium for higher quality maize for household consumption. Next, the bulk of maize for animal feed is fed to poultry. This maize has also not been traditionally graded to segregate quality. Livestock farmers are unlikely to be willing to pay for high grade maize just to feed animals.

Then, about 25% of marketed maize is used by breweries, beverage producers and the packaged food industry. White maize grits used by breweries faces keen competition from local sorghum producers and imported barley. As such, breweries are also unlikely to pay more for higher grade maize. Beverage producers use maize in the form of corn syrup. This must compete with locally produced sugar or imported sugar. Thus, beverage producers too are unlikely to pay more for syrup extracted from higher grade maize.

However, the packaged food industry which targets the high-end consumers (subsidiaries of Nestlé S.A. of Switzerland, etc.) and the export market may benefit from grading maize. This category of users may be prepared to pay a premium for higher quality maize. In fact, they are likely to gain a marketing edge if they market their products as having been made from higher quality maize.

Some Scenarios that Ghanaian and Ugandan Smallholder Farmers Face

Table 5 presents realistic hypothetical scenarios of possible outcomes that maize farmers in Ghana and Uganda face when the store maize in commercial warehouses. These scenarios borrow from Miranda et al. (2019) for Ghana and International Finance Corporation (2013) and Katunze et al. (2017) for Uganda. The cost of handling and processing grain to meet regulatory standards for issue of warehouse receipts and storage costs are estimated at 30% of the value of the farmgate price in Ghana; 27% for Uganda. If a commercial loan is taken with the

WR, additional 10% is paid in Ghana as interest (5 months storage); 4% in Uganda (3 months storage). Historical price volatility in Ghana is 40%; 50% in Uganda. An unusual price rise of 50% may be realised in Ghana (Ministry of Food and Agriculture (2020); 70% in Uganda (Katunze et al. 2017). This is akin to earning a premium on graded maize – scenario (7). Scenarios involving no grading of maize and no interest on loans are informed by Safo (2017).

The base case is a smallholder farmer who harvests 100 kg of maize and sells it (no storage). Alternatives scenarios (2) to (7) are spelt out in Table 5.

The third and fourth columns of Table 5 rank the outcomes of the scenarios. In Ghana, the farmer fares best when he/she does not grade nor take a loan against maize stored in the commercial warehouse - scenario (6). Practically, for most applications, grading does not attract a premium in the marketplace. The farmer fares worst under scenario (1), when he\she sells proceeds at harvest and invests proceeds in treasury bills. In Uganda, the farmer fares best if he/she stores maize in the warehouse, for three months and pledges the WR for a loan but realizes an unusual price increase. The Ugandan farmer fares worst when he/she pays full collateral management fees and pledges the WR for a three-month loan.

Table 5. *Seven Scenarios Investigated for Ghana and Uganda. Usual Historical Price Increase: 27% for Ghana and 35% for Uganda Above Prevailing Price at Harvest Time, Except Scenario (7)*

Scenarios	**Details of scenario**	**Ranking of outcome**	
		Ghana	Uganda
(1)	Sell all produce at harvest and invest in treasury bills (16% p.a. in Ghana; 14% in Uganda)	7th	6th
(2)	Store the maize on the farm and lose 20% to shrinkage, pests, etc. Such does not qualify for a loan.	2nd	3rd
(3)	Farmer stores the maize in a commercial warehouse and bears transportation, handling including grading costs and takes a loan with the warehouse receipt.	6th	7th
(4)	Farmer stores the maize in a commercial warehouse and bears transportation, handling including grading costs but takes no loan	4th	5th
(5)	Farmer stores ungraded maize in a commercial warehouse. Bears only half the handling charges but takes a loan so pays interest	3rd	4th
(6)	Farmer stores ungraded maize in a commercial warehouse. Bears only half the handling charges and takes no loan, so pays no interest	1st	2nd
(7)	Maize is graded, a loan is taken, and the farmer realized a huge price increase of 50% in Ghana and 70% in Uganda above the price at harvest time.	4th	1st

Source: Author's construction.

The outcomes of the scenarios for the two countries are different. Analysts should bear this in mind. The crux of the matter is that grain storage in anticipation of high enough price to make a good profit is speculative business. If in addition, a smallholder depositor must borrow with WR as collateral, he/she would be up against seasoned lenders who would cover themselves either by charging high

interest or granting loan amounts that are well below the current face value of the receipts such that even if prices fall, the collateral represented by the warehouse receipts will likely remain valuable. Cost of grading and loan interest payment are a disincentive to a rational farmer.

Community Warehouses Come in Handy

As part of his PhD thesis, Safo (2017), administered structured questionnaires to 400 smallholder individual maize farmers in northern Ghana who had grown maize during the 2014/2015 cropping season. 141 of the farmers participated in the community WRS (overseen by GGC), 259 did not. Farmers who participated in the community warehouse receipt system reported that they stored an average of 17 bags maize (110 kg per bag) for an average of five months. They paid a storage fee of GHS 1 (USD 0.35) per bag. They were however allowed to withdraw part or all their produce from the warehouse anytime they wanted.

The community warehouse neither grades nor insures the maize. Only 2% of the participants in the WRS issued by the community warehouse reported that they experienced some post-harvest losses. The mean number of 110 kg bags realized by WRS participants was 29.6, while non-participants realized only 16.1 bags. The difference in these means was statistically significant at the 1% marginal level. The explanation is that WRS enhanced access to inputs.

Also, there were differences in the prices that the two groups realized when they sold their maize. WRS participants realized a mean of GHS 135.5 per bag (USD 35), while non-participants realized a price of GHS 103.6 (USD 29). The difference in the two means is once again statistically significant. Here, non-participants sold earlier after harvest than participants.

Thus, on both scores, quantity produced and price at which produce were sold, WRS participants fared better. But to speak of profitability, one must now consider the costs that were incurred, which data was not available.

Table 6. *Profitability when Warehouse Receipt is Pledged as Collateral for a Loan, 2011 to 2018*

Panel A: Warehouse storage with financing			
		Profit/Loss	
Commodity	**Number of WR**	**Mean**	**Median**
Maize	270	-7.4%	-6.2%
Pigeon peas	52	-81.5%	-115.8%
Soyabeans	63	6.5%	11.5%
Panel B: Warehouse storage without financing			
		Profit/Loss	
Commodity	**Number of WR**	**Mean**	**Median**
Maize	194	14.2%	5.6%
Pigeon peas	32	-7.8%	-0.8%
Soyabeans	73	0.1%	0.0%

Source: Thunde and Baulch (2020).

Malawi

For Malawi, indication of the profitability or otherwise of the country's WRS is obtained from two tables provided by Thunde and Baulch (2020). Table 6 speaks to the profitability or otherwise of using warehouse receipt for maize, pigeon beans and soya beans as collateral for loans for the 2011 to 2018 period.

Table 6 says, over the entire period, the average maize depositor who used his/her warehouse receipt to obtain a loan lost 7.4% of the harvest value of maize. Pigeon peas lost even more. There was however a positive profit to using soya bean warehouse receipt as collateral.

Of those who stored their grains in warehouses but did not pledge their warehouse receipts as collateral for loans, maize depositors realized a mean positive return of 14.2% of the price of maize at harvest. Pigeon peas receipts lost money but only about one-tenth the mean loss suffered by those who took loans. Soyabeans broke even.

Thunde and Baulch (2020) also reported that of the 710 warehouse receipts issued by ACE between 2011 and 2018 (Tables 2 and 3), depositors made profit on only 48% of them. For all warehouse receipts, they found that profits and fewer losses were associated with shorter periods in storage. Commodities for which warehouse receipts made profits were in store for 5.5 months on average, whereas, those that made losses were in storage for an average of 7.5 months.

Senegal

Senegalese evidence is interesting. Adjognona et al. (2020) report the results of an experiment involving 1,079 rice farmers, of whom 363 were offered access to WRS. Only 2% took-up the offer. Of those who did not take-up the offer, 48% cited high transaction costs as their reason, 43% said they did not have any rice leftover to put into warehouse storage, 2% said they were not convinced that they will realise a satisfactory price if they put their rice into storage and 7% cited other reasons. This finding emphasizes the fact that farmers are rational and have a sense of how the WRS works. It is also an admission that their outputs are low.

Community Warehouses Come in Handy

Evidence provided by Safo (2017) in respect of use of community warehouses is very instructive. 2% post-harvest losses reported by participants suggests that these warehouses maintain quality and quantity pretty well. That, patrons pay as little as USD 0.35 per 100kg bag stored makes this fee affordable to smallholder farmers. This fee is affordable because the community warehouses are not maned by expensive collateral managers. Handling charges too are low.

Concluding Remarks

This review has revealed that use of warehouse receipt systems involving commercial accredited warehouses in many African countries has not succeeded in serving the purpose of enhancing smallholder famer's liquidity during lean seasons. This is due principally to the fact that the price at which maize is sold during the lean season does not, on average, cover the relatively high cost of commercial warehouse handling, grading, storage and loan interest payments if loans are taken. However, the story has not been all doom and gloom. A number of bright spots have been revealed by all the Ghanaian, Malawian and Ugandan case studies.

The price at which warehoused maize is sold in the lean season is not high enough to ensure profitability of smallholder farmers principally because consumers do not, in general, pay premium for maize that is graded as high quality. In fact, for most applications/uses, premium quality maize is not demanded. Counting costs, convenience and required minimum quantities, certified warehouses should be targeted at large depositors and exporters, not smallholder farmers. For the smallholder farmer, the community warehouse provides an acceptable solution. They may not be "high class" storage facilities, but they serve the needs of smallholder farmer.

Direct dealings with financial institutions appear not to have benefited farmers much. But alternate arrangements that enable farmers to access seeds, fertilizer, insecticides, etc. exist. For example, as out-growers of nucleus farmers who are linked to accredited warehouses. These should be encouraged.

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