MASTERARBEIT / MASTER’S THESIS

Titel der Masterarbeit / Title of the Master‘s Thesis

„The sharing economy:

Labor in two-sided markets“

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2018 / Vienna, 2018

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	A 066 914
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Masterstudium Internationale Betriebswirtschaft
Betreut von / Supervisor:	Univ.-Prof. Dr. Franz Wirl

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Wien, Juli 2018

Yannic Diefenbach

Danksagung

Hiermit möchte ich mich bei allen bedanken, die mich durch mein Studium begleitet haben. An erster Stelle stehen in diesem Sinne meine Eltern, ohne die mein Studium nicht möglich gewesen wäre und die mich stets unterstützt haben. Dank gilt aber auch meinem Betreuer Herrn Univ.-Prof. Dr. Franz Wirl, der bei Fragen immer ein offenes Ohr hatte und mit guten Ideen und Einwänden mich bei dieser Arbeit unterstützte. Bedanken möchte ich mich zuletzt bei den Kommilitonen und Freunden, die mich durch das Studium begleitet haben. Sie haben dazu beigetragen, dass diese Zeit immer in meiner Erinnerung bleiben wird. Besonders hervorzuheben sind hierbei die Freunde und Kommilitonen, die sich die Mühe gemacht haben, die Arbeit Korrektur zu lesen. Vielen Dank!

Contents

List of Abbreviations

B2P	-	Business-to-peer
B2B	-	Business-to-business
DLM	-	Digital labor market
G2G	-	Government-to-government
P2P	-	Peer-to-peer
P2B	-	Peer-to-business
TSM	-	Two-sided market
U.K.	-	United Kingdom of Great Britain and Northern Ireland
U.S.	-	United States of America

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1. Introduction

In recent years a new approach to the establishment of workforce has emerged. Digital development and innovations in combination with the internet allow for a central coordination of loosely associated workers, potentially on a global basis. In this regard the car hailing service Uber may function as prime example, which digitally matches independent drivers with persons in need of a ride (Daidj 2018). Yet, the concept of digitally matching independent individuals in search of work opportunities with persons or organization in need of workforce is also observable in other fields. For instance, the procuration of classical handyman and freelancer jobs or the provision of simple cognitive tasks. This new approach to the provision of labor has been praised for various reasons. The benefit to access on-demand a large and accordingly scalable workforce has been positively noted. Noteworthy in this respect is also the high matching efficiency and the related low level of search and transaction costs these platforms provide through algorithms and review-based coordination, to name two major advantages. However, these firms also experience criticism. Amongst other issues, a particularly heavy discussion focuses on the situation of the workers. They trade securities and traditional employee benefits, for an increase in flexibility. This trade-off might not take place under fair conditions. Many issues and criticism related to DLMs condense in the central question whether the workers of this industry are treated fairly and can make a decent living. Litigations and other conversations center around the questions of whether workers are rightfully classified as independent contractors or if these firms are simply trying to avoid labor costs.

Nonetheless, a profound discussion and understanding of these firms requires a clear comprehension of their general practices. Respectively, the goal of the following thesis is to describe these digital labor markets (DLM or DLMs) under the perspective of two-sided markets (TSM or TSMs), while enabling a better understanding of their behavior and contributing to the ongoing discussion concerning workers. The TSM literature studies economic entities, which have to simultaneously satisfy two or more distinct groups of consumers, while showing specific characteristics, like unequal pricing between the different parties or network effects. In respect thereof, the industry of DLMs will be examined under the perspective of two-sidedness. Four specific research questions can be extracted from this stated goal:

1. Can DLMs be considered as two-sided?
2. Do DLMs impose new facets, which need to be considered in view of TSMs?

3. Which implications can a model-based analysis provide regarding the functioning of DLM-platforms, especially considering the different participating parties?
4. To what extent can the prior findings add to the ongoing discussion aimed at DLMs?

The first research question is needed for a purposeful research in view of two-sidedness. An analysis on the basis of TSMs is only viable if the covered firms can actually be considered as two-sided and show corresponding features. The second question is formulated in respect of the chosen methodology, a conceptual analysis based on a mathematical model. This approach demands to understand and display characteristics of DLMs, which need to be considered in a model suited to describe those markets. On the other hand, the two remaining questions are derived from the groundwork provided by the first two questions. The third research question covers the functioning and behavior of DLM-platforms while also considering the effect on the other involved parties, namely the workers and those who seek workforce. The fourth question was formulated under the premise to explore whether the derived findings can add new impulses to the ongoing discussion.

Different reasons speak for such an analysis, emphasizing the relevance of this thesis. As earlier mentioned, a clear understanding of the functioning and behavior of DLMs is crucial, especially concerning the ongoing discussion and potentially resulting regulations. Agrawal et al. (2013) and Codagnone et al. (2016a) recognize that DLM-platforms can possibly qualify as TSMs. This characterization of DLMs can be crucial since TSMs function in unique ways and show certain quirks. For instance, TSMs potentially face a chicken-and-egg problem concerning the two participating sides or show the tendency to concentrate (Evans and Schmalensee 2007; Nair et al. 2004). A very important characteristic, which is particularly addressed in the underlying thesis, is the potential for skewed pricing (Rochet and Tirole 2006). Only three sources could be identified, which discuss certain aspects of DLMs in view of TSMs (Codagnone et al. 2016a; Codagnone et al. 2016b; Codagnone and Martens 2016c). Codagnone and Martens (2016c) state that a connection of DLMs to TSMs might prove important as it can impose pivotal implications and consequences, especially in regulatory matters. Yet, their analysis is only a minor part of their essay and barely scratches the surface, affirming the need for an in-depth approach to this topic. This thesis can not only add to the DLM literature but also add to TSM-research. To the author’s knowledge, this thesis is the first piece of work, which examines the exchange of labor-related services on the basis of two-sidedness. However, this circumstance is not surprising, as DLMs only emerged in the past few years.

As briefly mentioned, the thesis adopts a purely conceptual approach in order to reach the described overall research goal, mainly following in the footsteps of Armstrong (2006) as well as Rochet and Tirole (2006). A basic model will be developed and analyzed under the premise of a monopolistic setting, later extended by considerations towards “timely matching” and competition. The model itself is designed in a stochastic fashion. Nonetheless, the first two subsequent chapters will cover DLMs in general as well as the first research question. Consequently, these two chapters are a review of previous literature.

The thesis is structured as follows: Chapter 2 introduces DLMs and provides fundamental knowledge in this regard. Chapter 3 will discuss whether DLMs can be considered as two-sided, based on different criteria derived from literature while at the same time contributing to a better understanding of TSMs and their characteristics. Chapter 4 will then introduce and discuss the basic model, which is extended by chapter 5 and 6. Chapter 5 will hereby focus on transportation services under the premise of timely matching and self-scheduling. Chapter 6, in contrast, introduces a competitive setting. The derived findings and related drawbacks will be summarized and presented in chapter 7. Lastly, the chapter 8 concludes the thesis.

2. Digital Labor Markets

This chapter provides necessary groundwork and information in regard to DLMs. Firstly, it covers the definition and conceptualization of DLMs to provide a clear-cut understanding of the analyzed industry. The second part presents a detailed display of the relevant industry branches, while applying selected examples. The subsequent section offers a short overview of the industry scope, allowing for a better comprehension of the topics' relevance and its general standing via statistics. Finally, this chapter concludes with an overview of the ongoing discussion related to this industry.

2.1 Definition and Conceptualization

The literature surrounding and covering DLMs and the related sharing economy is riddled by conceptual ambiguities and inaccuracies, which are caused by conceptual challenges. As presented in appendix A, three primary conceptual challenges can be identified while dealing with this industry:

I. Many different terms are in use to label DLMs or related business models.
II. Varying concepts and definitions exist to conceptualize the industry, many of them emphasizing different aspects.
III. Within and across pieces of literature semantical inaccuracies and errors can occur.

The discussion of these challenges does not directly add value to this thesis and is therefore moved to the appendix A. Yet, it is worthwhile to mention them, as they underline and justify the need for a detailed definition and conceptualization of the industry. The thesis can only add value to the literature and provide relevant findings if it is clear which industry and companies are affected by it. This problem related to the sharing economy and DLMs is also acknowledged by Codagnone et al. (2016b). They summarize this situation fittingly with following words, also mentioning other issues within this field:

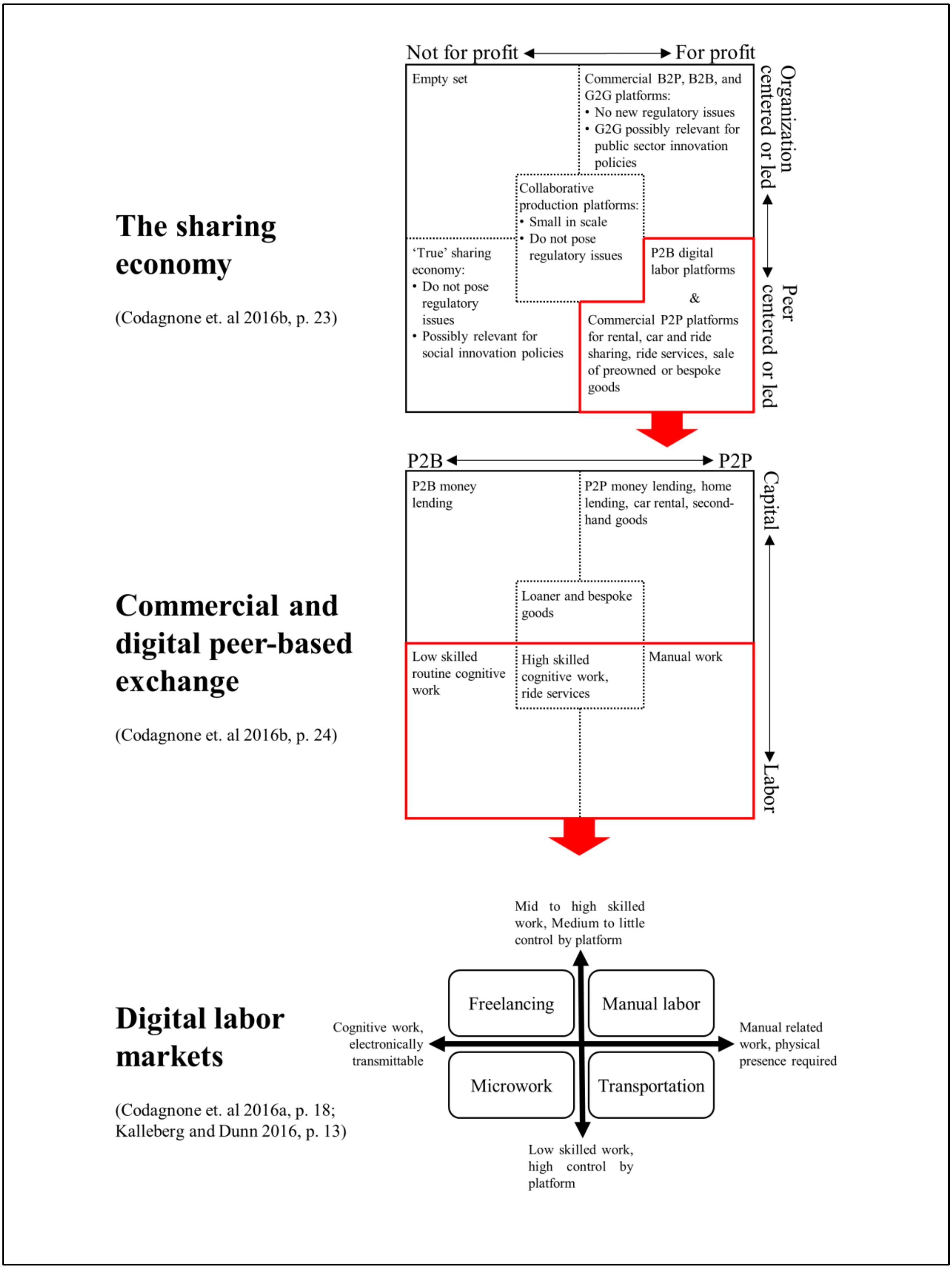
> *"Terms and concepts are used in such confused and confusing ways that it is at times difficult to ascertain whether advocates, opponents, regulators, and policy makers are discussing the same phenomenon. There is a closed self-reproducing loop between conceptual ambiguity, rhetorical controversies, and lack of sound measurements and empirical evidence. This loop, in turn, limits the space for a rational debate about alternative policy options and contributes*

> *to the fragmented regulatory approaches which currently address the 'sharing economy'" (Codagnone et al. 2016b, p. 6).*

This assessment is confirmed by other authors, as for example Garben (2017). In other words, a discussion and analysis of a specific phenomenon or type of industry requires a precise definition and conceptualization. Otherwise, a clear application and interpretation of findings become hindered, while restraining a rational debate. This is especially the case for DLMs due to the ambiguous use of concepts and the related conceptual challenges within this field of research, fostered by the great variance in business activities within the industry (Schor 2014). This circumstance, thus, requires this section to present DLMs and related conceptualizations in a detailed fashion. Furthermore, this approach allows for an initial assessment of the industry parts in terms of regulatory relevance and the ongoing discussion.

The basis for the applied and presented definition of DLMs is provided by Codagnone et al. (2016a), Codagnone et al. (2016b), and Kalleberg and Dunn (2016). The works by Codagnone et al. (2016a) and Codagnone et al. (2016b) analyze this type of industry in an excessive fashion by applying a systematic literature review, supplemented by a detailed technical annex. This circumstance and the excessive technical annex guarantees high transparency and comparability. Moreover, their comprehensive procedure allows them to be aware of the conceptual challenges and related problems, as the previous quote shows. By being cautious about these issues they are able to develop a concept, which has a general scope and includes the relevant aspects of the analyzed industry. Lastly, a crucial part in creating their typology is the regulatory relevance of each identified industry type, based on a systematic review of literature and empirical evidence. Since this thesis focuses on business models at the center of regulatory attention and discussion, Codagnone et al. (2016b) serves as ideal starting point. The work by Kalleberg and Dunn (2016) complements this groundwork in terms of DLMs, focusing on a more detailed level of description, solely describing business models related to labor and the features of the different industry types.

Figure 1: Conceptualization of digital labor markets with regard to the sharing economy



Note: Cumulated reprint of Codagnone et al. (2016a, p. 18), Codagnone et al. (2016b, pp. 23–24) and Kalleberg and Dunn (2016, 13).

Figure 1 represents a cumulated conceptualization of all three mentioned sources, showing a coherent picture of the industry. The figure depicts three major conceptual parts, accordingly named on the left-hand side of each graphic. The first one, at the top of the representation, shows the most general approach to the industry and is named “sharing economy”. This sharing economy is composed of different types of industry branches. One of these branches is the commercial and digital peer-based exchange of goods and services, accordingly marked in red. This branch is described in more detail in the second part of figure 1, below the depiction of the sharing economy. Yet, this industry section can also be split in different types. One of these sections is centered around the exchange of labor-based services, again marked in red. This commercial and digital peer-based exchange of labor services is defined as DLMs. Nonetheless, DLMs can further be divided into four branches, depicted by the last part of figure 1. The ensuing paragraphs will describe each section of figure 1 in more detail.

Codagnone et al. (2016b) define the sharing economy as follows:

> *“[T]he expression sharing economy is commonly used to indicate a wide range of digital commercial or non-profit platforms facilitating exchanges amongst a variety of players through a variety of interaction modalities (P2P, P2B, B2P, B2B, G2G) that all broadly enable consumption or productive activities leveraging capital assets (money, real estate property, equipment, cars, etc.) goods, skills, or just time” (p. 22).*

In other words, the term sharing economy refers to economic activities or exchange centering around online platforms which match clients and providers of assets, goods or services. The common characteristic is the exchange via digital means. A distinction in four main quadrants is achieved by differentiating between for-profit and non-profit business models and the form of interaction modality. The dimension of interaction modality distinguishes between business models, where organizations like firms or parts of the government issue or offer products/services to other organizations or peers. The opposing case describes the exchange of goods or services led or centered around peers, meaning that individuals and independent persons offer services or products. The dotted lines between the quadrants indicate a continuum between the dimensions and the quadrants themselves, as hybrid business forms also exist, further emphasized by the area in the center (Codagnone et al. 2016b). Collaborative production platforms hereby refer to a business model in which production occurs by a self-organized community (e.g., the community-based designing and production of T-shirts or other accessories on the website Teespring

(Teespring 2018)), either occurring in the form of a peer-to-peer (P2P), a peer-to-business (P2B), or a business-to-peer (B2P) approach and being either profit or non-profit oriented (Botsman 2013; Codagnone et al. 2016b). Codagnone et al. (2016b) describe this type of business as small in scale and attest them no regulatory relevance, solely in regard to industrial innovation policies.

They (Codagnone et al. 2016b) also place P2B digital labor platforms into the hybridization area, as they do not only provide P2P services but mainly a P2B-based exchange. However, figure 1 depicts them in the same quadrant as commercial P2P platforms and, thus, deviates from the original conceptualization provided by Codagnone et al. (2016b). This step was taken by the author of this thesis to increase comprehensibility but also provides a more coherent picture, as P2B platforms are equally peer-driven as P2P platforms in terms of service provision. Otherwise, it would be illogical and incoherent to place commercial B2P platforms into the upper right quadrant, as Codagnone et al. (2016b) did.

The commercial P2B and P2P business types of the sharing economy, marked in red within the first part of figure 1, can be identified as the entities in which labor is put in a new setting while being heavily discussed in terms of regulatory needs. This is discussed in chapter 2.4 in more detail. Codagnone et al. (2016b) also identify the commercial P2B and P2P platforms as the core type in terms of research interest. The other three remaining quadrants attract little to no attention in the ongoing discussion regarding regulations. Commercial B2P and business-to-business (B2B) approaches are already covered by existing laws. Government-to-government (G2G) business models, as the lending of underutilized assets like heavy machinery or medical equipment, for instance, are small in scale and do not impose issues as presented in chapter 2.4 (Codagnone et al. 2016b). The same is true for the non-commercial, peer-based exchange of services and products, like the gifting of reusable goods, which else end as refuse, for instance via the website Freecycle.

The commercial peer-based exchange of goods and services can further be differentiated, as the second part of figure 1 shows. Again, four quadrants and a hybrid area were identified by Codagnone et al. (2016b), this time differentiating between P2B and P2P business models as well as the type of exchanged goods or services. Platforms either center around the transaction of capital and asset, such as money lending, home or car rental; or the provision of labor. The considered dimensions represent a continuum, once again, rather than clear-cut opposing dimensions, represented by the dotted line between the quadrants. The extreme case of the labor dimension would be raw unskilled work. The hybridization area contains the exchange of bespoke and loaner goods, high skilled cognitive work and ride services. Bespoke and loaner goods are included, as for example the website Etsy allows designers to sell own products via the platform, thus, enabling the selling of bespoke products, but also offers designers means to work and distribute their products. Ride services are included as they allow drivers to work, however, are enabled by a car the driver owns. High skilled cognitive work is considered by Codagnone et al. (2016b) to rather be a tangible asset than raw unskilled labor.

All the presented types of commercial peer-based platforms impose potential regulatory concerns. The capital and asset related platforms mostly raise discussions in terms of consumer protection (Codagnone et al. 2016b; Evans 2008). The platforms, where the exchange of labor services dominate, are mainly at the center of attention regarding potential labor regulations and the need for worker protection. The thesis will focus on platforms, in which the exchange of labor services is paramount, marked in red in the second part of figure 1 accordingly, and referred to with the already familiar term digital labor markets, introduced by Codagnone et al. (2016a).

The sole focus on labor-based platforms is opportune since the nature of the related problems allows for a purposeful economic-based analysis. Asset-based exchange, on the other hand, faces problems, which center around legal questions and consumer protection. The last part of figure 1 already indicates that DLMs can be described by four main branches. These four types will be described in the subsequent chapter 2.2. In summary, the presented and analyzed DLMs are part of the sharing economy and can be defined as follows:

Digital labor markets are commercial and digital platforms, which center around the exchange of labor-based services provided on a peer basis (P2P as well as P2B).

2.2 Typology and Selected Examples

The last part of figure 1 already illustrates the four main branches of DLMs. The following chapter will present these in detail, as they all show unique features and, thus, have varying implications in terms of a two-sided market analysis. The typology is mainly based on the research by Codagnone et al. (2016a) and Kalleberg and Dunn (2016), both focusing on different dimensions. Codagnone et al. (2016a) apply two dimensions to develop a quadruplet of platform types. The first dimension is the skill level required by the conducted tasks. The second dimension is the differentiation between tasks, which can be transmitted purely online and are, thus, locally independent, and task, which require a physical and local presence. Kalleberg and Dunn (2016), on the other hand, differentiate between the dimension of the wage level and the extent of control workers have at their disposal. The derived four branches shown in figure 1 and table 1 represent a compound of both typologies, supplemented by further characteristics.

Table 1: Typology and features of the digital labor market

Features	Microwork	Freelancing	Manual labor	Transportation
Typical example	Amazon Mechanical Turk	Upwork	TaskRabbit	Uber
Work modality	Online	Mostly online	Local	Local
Work type	Cognitive	Cognitive	Manual	Manual
Skill level	Low	Medium to high	Low to medium	Low
Wage level	Low	Medium	Medium	Medium
Payment modality	By task	By task, hour, or contest	By hour	By task
Worker control	Medium	High	Little	Little to medium
Job duration	Extremely short	Project based, long in duration	Short	Short
Price/wage setting	By requesters	Negotiated	By workers, by platform	By platform

Source: Codagnone et al. (2016a, pp. 17–20) and Kalleberg and Dunn (2016, pp. 11-13, 74).

The following paragraphs explain these characteristics by exemplifying them on the basis of selected companies. This is required for two main reasons. Firstly, such an endeavor provides the reader with a detailed understanding of the industry. Consequentially enabling a better comprehension in respect to the points brought forward concerning the ongoing discussion, presented in chapter 2.4, and the analysis regarding two-sidedness, conducted in chapter 3. Secondly, many information provided in the following paragraphs will serve as groundwork for the analysis provided in the subsequent chapters.

The illustrated firms represent typical examples of their respective branch and are the biggest ones within the industry in terms of registered workers (Codagnone et al. 2016a, p. 23). A brief explanation about the applied terminology within this paper is needed to increase clarity and comprehensibility. The digital moderators and platforms who procure labor between different sides of users are simply denoted as platforms. The platform agents, who provide their labor are, henceforth, referred to as workers. The users who post tasks and require workforce are termed requesters, since they seek and request suited workers via the platform.

Microwork

The first identified branch is the so called “Microwork”. Typical examples include Amazon Mechanical Turk, CrowdSource and Figure Eight, formerly known as Crowdflower (Figure Eight Inc. 2018b). These platforms focus on cognitive, low skilled tasks (Berg 2016; Codagnone et al. 2016a; Kalleberg and Dunn 2016). Amazon Mechanical Turk allows individuals or companies to post tasks to a mostly anonymous mass of workers and usually comprise of jobs, which computers cannot fulfill or require human input. This includes, for example, the processing of photographs and podcasts or the completion of forms and questionnaires as well as an array of other types of tasks (Berg 2016). Crowdsource focuses on writing, moderating, data handling, and transcription services (CrowdSource 2018b). The tasks are digital in their nature or at least digitally transferable as well as the related results, therefore, tasks can be conducted on a worldwide basis and do not require a local presence. The websites will charge its users a fee per task, based on the payment for the worker (Amazon Mechanical Turk Inc. 2018a). The general wage level is low. A study analyzed by Berg (2016) shows that most workers earn on average between $1 and $5.5 USD per hour on Amazon Mechanical Turk as well as on Figure Eight. Workers are paid per task, while the requesters set the remuneration per task (Amazon Mechanical Turk Inc. 2018b). In general, a task pays only a few cents and requires only a few minutes for completion (Berg 2016). The workers are engaged on their own terms and are not directly employed by Amazon Mechanical Turk. They can choose which jobs they want to take and when to work (Amazon Mechanical Turk Inc. 2018b). The creators of the tasks, on the other hand, have two main sources of leverage. They can set certain requirements a worker has to meet in order to qualify for a posted task. Furthermore, they can reject the results submitted by a worker without further justifications, while the worker will not receive any payment (Amazon Mechanical Turk Inc. 2018b). The platform itself tracks workers via a rating system, which measures the rate of successfully completed tasks through customer feedback. Requesters can require workers to have a minimum completion rate. Thus, the control exerted by the platform over the workers is rather small, yet high control is transferred to the requesters, leaving workers with a medium level of control over the terms of labor conduct. CrowdSource functions mostly like Amazon Mechanical Turk, yet has a different system in terms of worker qualification based on work categories (CrowdSource 2018a). Figure Eight shows bigger differences in selected aspects after the rebranding. The posted tasks center around machine learning and data sorting (Figure Eight Inc. 2018a) and there is a higher emphasis on reviewing the workers by automatic control questions (Figure Eight Inc. 2018c).

Freelancing

The second industry section is coined "Freelancing", with Upwork and Freelancer as typical firm examples. In short, these platforms serve as marketplaces for cognitive freelance jobs, requiring a certain level of skill or professional background by the workers (Codagnone et al. 2016a; Kalleberg and Dunn 2016). This branch is named freelancing as it is close to classical freelancing with regard to the conducted tasks, the required skill level, and the worker independency (Codagnone et al. 2016a). The posted tasks can be related to software development, design, writing, translation, accounting, administration handling or engineering services as well as other fields (Freelancer Technology Pty Limited 2018a; Upwork Global Inc. 2018a). For the two given examples and most companies of this branch, the covered tasks are again either digital or digitally transferable, thus, a local attachment is not given and global competition possible.[1] Job duration varies with each task and is highly dependent on the conducted project (Codagnone et al. 2016a). The payment modes can vary on a platform itself but also across platforms. The firm Freelancer applies a project, milestone, or contest-based system, where workers receive a payment after the successful completion of a project or after reaching a milestone. The contest setting allows requesters to post a task where workers compete by submitting their contributions, while only the awarded results are remunerated. Upwork also allows a project- and milestone-based payment system or compensation by an hourly rate. In contrast to Microwork, workers on Upwork and Freelancer cannot simply select a job, as they must bid with other freelancers for the recruitment. The requester can choose the most suited worker in consideration of the bid, the worker rating, the

[1] Codagnone et al. (2016a) mention the concept of matching high skilled workers on a local basis. So far this can be considered as an empty set in terms of DLMs. An exception they mention is the platform Takelessons where teachers provide tutoring.

previous employment history, and other information. Direct negotiations between both parties are possible (Freelancer Technology Pty Limited 2018d; Upwork Global Inc. 2018c). On Upwork, the platform deducts a percentage-based fee from the payment the freelancer charges the customer, varying in the total sum of earnings the worker received (Upwork Global Inc. 2018d). On Freelancer, both sides are charged a percentage of the negotiated wage plus other optional fees, whereas the workers bear a significantly larger rate (Freelancer Technology Pty Limited 2018c).

In terms of the wage level, Codagnone et al. (2016a) report average hourly wages differentiated after job types. In the field of software development, workers can earn on average $16 USD per hour, $8 USD for writing and translation tasks, $4 USD for jobs related to administrative work and $5 for customer support as well as sales and marketing jobs. However, the source of Codagnone et al.'s (2016a) findings is not apparent. A worker review of 25 to 100 workers in 2016 and 2017, which was conducted by the website Fair Crowd Work, run by the German worker union IG Metall, reports an average wage of € 12.81 EUR per hour with a possible maximum of € 26.32 EUR (Fair Crowd Work 2016). Dunn (2016) analyzes anonymous wage data provided by the U.S. bureau of labor statistics, and data gathered of a DLMs-firm, matching the description of freelancing. He finds that workers earn on average roughly $34 USD per hour in the field of network and information systems as well as software development. Customer service and administrative support provides on average around $15 USD per hour. The differences between the three differences can be explained by geographical considerations or rather the lack of them. Dunn (2016) specifically analyzed the wage of U.S.-based workers. The other two sources do not further specify the geographic basis of their data, indicating a global mean of all workers on the platform or a not further specified regional mean. Data for the website Freelancer could not be found. For both platforms, a rating system is in place where both agent-sides can rate each other after the completion of a task (Freelancer Technology Pty Limited 2018e; Upwork Global Inc. 2018b). Overall, workers have a great deal of control. They can choose when to work, how many tasks they want to complete, which tasks to conduct, and further are able to negotiate their wage. A bilateral-rating system ensures integrity by both sides, while a simple rejection of completed work is hindered, supported by dispute resolving assistance (Freelancer Technology Pty Limited 2018b; Upwork Global Inc. 2018c).

Manual labor

The provision of generic services and house errands are summarized with the term “manual labor”. Typical firms in this regard are the U.S.-based companies TaskRabbit and Handy. Both moderate tasks associated, for instance, with furniture assembly, cleaning services, moving, mounting, and packing, or other handyman activities. The name of the branch itself and the nature of the stated tasks already indicate that the platforms center around tasks, which require physical presence by the workers. Consequentially, work is conducted on a local basis. Meaning, that the moderated exchange of labor on the platform is limited to specific areas and cities in contrast to the previous two branches. In general, the covered tasks demand a low to medium skill level and are usually short in duration (Codagnone et al. 2016a; Kalleberg and Dunn 2016); however, both platforms allow to schedule plans for repeating services, as for example cleaning or shopping errands. The wage is usually based on an hourly rate. Yet, the functioning of the two covered platforms is quite distinct. On TaskRabbit, workers set their own hourly rate for each type of task they cover. This rate is linked to the worker itself and not to a specific task. However, workers are not able to directly choose a posted task, as the requesters initiate a match by selecting a suited worker (TaskRabbit Inc. 2018b). The workers can than only choose to accept the offered task or decline. On Handy, the rates are set by the platform itself, varying from region to region (Handy Technologies 2018c). Here, workers can directly choose between posted tasks, but requests can also inquire a selected worker. The rejection and containment of a payment after a task was completed is in general not possible, but the platforms provide happiness guarantees as well as insurances (Sundararajan 2014; Handy Technologies 2018d; TaskRabbit Inc. 2018e). Both platforms apply a percentage-based fee on the worker’s hourly rate for the customer to bear (Kerr 2016; TaskRabbit Inc. 2018f), as well as a fixed fee upon registration (Handy Technologies 2018b; TaskRabbit Inc. 2018d). Handy further charges fees for disapproved behavior, like late arrivals (Handy Technologies 2018f). According to Codagnone et al. (2016a), the average job on TaskRabbit is worth $55 USD, yet again the source of this number is not apparent. Cullen and Farronato (2015) report an average price of $57 USD per task. Nonetheless, their data relates back when TaskRabbit was still functioning like eBay, where tasks could be actioned. As already stated, the rates on Handy are set by the platform and vary from region to region, while further being dependent on the type of work and the payment tiers. Payment tiers are related, amongst other things, to the work frequency of a worker and the received ratings. The lowest rate offered by Handy is $13 USD for tier one cleaning services in Las Vegas, Orlando, and Tampa. However, for most regions the basic rate is $15 USD, able to reach $25 USD depending on the region and applicable payment tier (Handy Technologies 2018c). Leverage over the workers is maintained by a rating system, where the customers rate the observed performance. However, workers can also rate the customers in return (Handy Technologies 2018g). The same is true for TaskRabbit (TaskRabbit Inc. 2018c). Kalleberg and Dunn (2016) attest that workers have little control in the setting of manual labor platforms. On TaskRabbit, workers can only set their own hourly remuneration rate and state timeframes in which they are available for potential tasks. Consequentially, work flexibility is heavily hindered, as matches are initiated by the requesters, whereas workers are only allowed to reject 25 percent of the offered tasks (Schmid-Drüner 2016). On Handy, workers cannot set their own wage but enjoy greater flexibility, as they can partially choose which tasks to conduct and are, to some extent, able to create an own schedule, with the exception of inquiries directly issued by requesters. Moreover, background checks and screening of the workers are common within the setting of manual labor (Handy Technologies 2018e; Schmid-Drüner 2016; TaskRabbit Inc. 2018a).

Transportation

The “transportation” services can be divided in two different segments: Taxi-like services, where requesters are moved from A to B, or services, where goods are delivered. A well-known company regarding taxi-services is Uber. Uber also provides a delivery service for food called Uber Eats. Naturally, these services are manual in nature, thus, function only on a local basis (Codagnone et al. 2016a). The required skill level is low, as optimal routes are indicated by the phone app provided by the platform (Codagnone et al. 2016a). The drivers work independently but are automatically matched with customers’ requests by Uber through an algorithm, which also calculates the fee charged per ride while automatically deducting a certain percentage for Uber to keep. Requesters can also not directly choose their driver. The workers provide their own car as means of transportation, able to choose by themselves when to work and for how long. Yet, the company has indirect ways to control and steer its drivers. Uber, for instance, applies dynamic pricing, drivers cannot freely select the jobs they accept, and must not fall below a certain rating and task acceptance rate level (Aloisi 2016). Uber’s wage provided to workers is controversially discussed. Its drivers earn in the U.S. on average $19 USD per hour before expenses, $6 USD more than traditional taxi drivers, according to a study conducted by Hall and Krueger (2015).[2]

[2] It must be noted that this study was issued by Uber itself, supported by data the company provided.

Campbell (2018) finds that Uber drivers earn on average $16.90 USD per hour before expenses. Drivers for ‘Lyft’, another car hailing firm like Uber, report an average pay of $17.37 USD per hour bevor expenses (Campbell 2018). Codagnone et al. (2016a) argue on the basis of a review of different investigative research articles that drivers rather earn around $7 USD when taking waiting time and running costs into consideration. Aloisi (2016) argues along the same line. A paper by Zoepf et al. (2018) analyzed a previous survey conducted by Campbell (2017), concluding that the median earning per worked hour is $3.37 USD, including costs and taxes. Workers’ control over the terms of labor are limited. They can neither set rates, nor choose a specific ride request and are not allowed to cancel too many incoming requests. On the other hand, workers can freely choose when to work and for how long (Kalleberg and Dunn 2016). Uber Eats mostly functions similar as the car hailing service, where independent workers deliver food orders via their own means of transportation, all being procured by the corresponding application (Uber Technologies Inc. 2018e). Uber Eats hereby partners with independent restaurants (Uber Technologies Inc. 2018d).

2.3 Scope

This section provides a quick overview of the sizes of the sharing economy and DLMs, this is to allow for a better understanding of its relevance. Similar to the conceptualization of DLMs, a coherent picture in terms of statistics is difficult to generate. This is, on the one hand, caused by the conceptual ambiguity related to the topic. Depending on the applied definition, the considered companies can vary (Donovan et al. 2016). Furthermore, it is hard to pinpoint a precise number in terms of labor force. Compounding this, it is easy to register with multiple platforms and certain platforms operate on a global basis.

One approach to understanding of the scope of DLMs is through the analysis of the worker numbers per platform, as done by Codagnone et al. (2016a) and by Smith and Leberstein (2015). Table 2 is a representation of their findings; however, it shows only selected companies, following mainly the mentioned examples of the previous section 2.2. The table is sorted in alphabetical order. The last column indicates where the platform offers its service. Overall, Codagnone et al. (2016a) cover 39 firms and Smith and Leberstein (2015) cover 11 companies. In total, Codagnone et al. (2016a) identify a labor force of around 52.6 million registered users. However, this figure is not accurate, as not all existing companies are covered and not all registered workers are conducting labor on the platforms.

Table 2: Workforce numbers of selected companies

Platform	**Type**	**Workforce reported by Codagnone et al. (2016a)**	**Workforce reported by Smith and Leberstein (2015)**	**Coverage**
Amazon Mechanical Turk	Microwork	500,000	500,000	International
Crowdsource	Microwork	8,000,000	8,000,000	International
Figure Eight	Microwork	5,000,000	5,000,000	International
Handy	Manual labor	5,000	5,000	U.S.
TaskRabbit	Manual labor	30,000	30,000	International
Freelancers	Freelancing	18,000,000	-	International
Upwork	Freelancing	10,000,000	-	International
Lyft	Transportation	50,000	50,000	U.S.
Postmates	Transportation	10,000	10,000	U.S.
Uber	Transportation	400,000	160,000	International

Source: Codagnone et al. (2016a, p. 23) and Smith and Leberstein (2015, p. 3). See publications for original references.

Other authors estimated an aggregated figure of the workforce within the industry, as shown by table 3, summarizing relevant studies identified by Codagnone et al. (2016a). The presented numbers are only referring to the U.S, sorted by rising numbers of workforce. The first column indicates the source of the figure. The second column states the year for which the illustrated figure is estimated. The last two columns give the estimated absolute numbers of workers within the industry and the relative size to the overall U.S. workforce. These numbers must be utilized carefully, due to the reasons already stated previously (conceptual ambiguity, registration with multiple platforms, and inactivity). The Time Magazine study reported by Steinmetz (2016) does not only consider labor related services but implements a conceptual approach related to the above identified 'sharing economy'. The same is true for Bracha and Burke (2014) as well as Bracha et al. (2015). Furthermore, a clear differentiation in work frequency and whether the industry is used by a worker as a full-time job or just as an income supplement remains unclear.

Table 3: Overview of the estimated workforce size of the sharing-economy in the U.S.

Source	Year	Workforce	Percentage of overall U.S. workforce
Harris and Krueger (2015)	2015	600,000	0.4%
Katz and Krueger (2016)	2015	-	0.5%
Manyika et al. (2015)	-	1,600,000	1%
MBO partners (2014)	2013	2,700,000	-
Codagnone et al. (2016a)	2016	6,000,000	4%
Businesswire (2015)	2020	7,600,000	5%
Steinmetz (2016)	2015	14,000,000	9%
Bracha and Burke (2014) & Bracha et al. (2015)	2015	39,500,000	25%

Source: The left column indicates the source of each study. The basis for this overview is the review by Codagnone et al. (2016a, p. 22).

Regarding Europe, Huws and Joyce (2016a, 2016b) find that around 3 percent of the labor force in the U.K. and Sweden work weekly via DLMs.

Donovan et al. (2016) analyze U.S. data regarding the numbers of self-employed workers and for unincorporated businesses. However, the applied data is contradicting and little telling in regard to the size of the industry related to DLMs. Codagnone et al. (2016a) also analyze figures regarding non-standard forms of work for the European Union as well as the U.S. Albeit delivering a general picture of the situation regarding non-standard work arrangements, to which DLMs count, direct implications considering DLMs cannot be derived.

Other noteworthy sources are a big data analysis issued by the JPMorgan Chase & Co Institute (Farrell and Greig 2016) and a study issued by PwC (PricewaterhouseCoopers LLP 2015). Farrell and Greig (2016) analyze income volatility in the U.S. in perspective to the online platform economy. They find that around 1 percent of Americans earn money from these platforms in a given month. However, the researched online platform economy closely resembles a conceptualization of the above mentioned commercial peer-based exchange and does not only cover DLMs but also the exchange of capital-based goods. The study by PricewaterhouseCoopers

LLP (2015) also does not only cover DLMs but the whole sharing economy, again focusing on the U.S. They report that 1 percent of the U.S. population have already provided transportation services and 1.4 percent have provided hospitality services, like room lending via Airbnb.

In summary, the presented sources indicate that DLMs are neither an overly big phenomenon nor too small to ignore, especially in the U.S. Particularly their growth rates justify their closer analysis, as most platforms show an exponential growth (Codagnone et al. 2016a). If the DLM-companies manage to maintain this pace of growth, they might be able to develop into major participants on the labor markets, not only having local impacts but also on a global scale.

2.4 Ongoing Discussion

DLMs experience an ongoing discussion within the academic literature. On one side, there are quite optimistic voices, such as Hall and Krueger (2015) or Evans (2008). On the other side, there are plenty of authors criticizing certain aspects of this industry, for instance Cherry (2016a) or De Stefano (2016b). Most argumentations can be concentrated to the question of whether and to which extent this industry needs to be regulated. The following paragraphs deal with this ongoing discussion, pursuing two main goals in doing so: Firstly, they underline the importance to analyze and research DLMs, especially in respect to the potentially growing significance of these platforms on various labor markets. Secondly, an awareness and a rudimentary understanding of the discussed advantages and problems of DLMs allows for a more directed analysis and interpretation regarding TSMs. Such an analysis might even add new aspects to the ongoing discussion. The ensuing table 4 presents an overview of the major advantages and concerns related to DLMs, which were brought forward by different authors, functioning as a summary of appendix B. The presented advantages and problems are sorted into main categories to increase clarity.

Table 4: Overview of the potential advantages and problems of DLMs discussed in literature

Potential advantages	Potential problems
I. Worker benefits: ▪ Flexibility ▪ Increased participation and inclusion ▪ Wage level	**I. Labor situation:** ▪ Worker classification ▪ Pseudo-flexibility ▪ Own equipment ▪ Insecure work ▪ Wage level ▪ Competition amongst workers
II. Requester benefits: ▪ Convenience ▪ Power and information asymmetry ▪ Consumer welfare	**II. Direct impact on workers:** ▪ Safety and health implications ▪ Discrimination ▪ Child and forced labor ▪ Privacy and data concerns
III. Platform functions: ▪ Efficiency ▪ Algorithms and ratings	**III. Platform functions:** ▪ Power and information asymmetry ▪ Rating, monitoring ▪ 'Invisible worker' ▪ Inefficiencies ▪ Professional development
IV. Economic effects: ▪ Growth and employment ▪ Production gains	**IV. Other issues:** ▪ Taxes ▪ Licensing and consumer protection

Source: Own representation. A closer examination and relevant sources are provided in appendix B.

A more detailed examination of each point was moved to appendix B for two main reasons: Firstly, such an endeavor would exceed by far the scope of this chapter. Secondly, a detailed presentation of each point would massively hinder the conceptual flow of this thesis, as a concentrated presentation of the central challenge is sufficient regarding an analysis in respect to TSMs. The ensuing summary is hereby based on appendix B.

Many issues related to DLMs condense in the central question whether the workers of this industry are treated fairly and can make a decent living, as appendix B and the ensuing paragraph exemplify. These voices argue for a regulation of the industry in this regard, especially concerning microwork and transportation services. On the one side, this argumentation makes sense, as wage levels can be low, paired with an infrequent supply of tasks and the need to provide own equipment, depending on the branch. This is further amplified by the circumstance that most workers are employed as independent contractors and, thus, have no access to employee benefits. Meaning that they must fully provide their own insurances and pension payments, have no claims to unemployment support, no paid vacation or sick leave, as well as other employee benefits. On the other hand, workers are granted certain freedoms, and only a fraction of workers provide their services on a full-time basis (Berg 2016; Hall and Krueger 2015). Where does one draw the line between workers who just provide their services for pocket money or an income supplement and those who work for their main living in DLMs? How does one proceed with the worker classification, especially if a worker provides services on multiple platforms? Should the waiting and task search times be considered by the level of remuneration or not? These questions allow a small glimpse at the complexity of this topic, making clear that a simple solution to the imposed issues is not possible. Through these questions, different authors argue for a regulation of DLMs and propose different solutions (Berg 2016; Rogers 2016; Todolí-Signes 2017b). Others acknowledge certain problems but promote a cautious approach to the industry in terms of regulations, to not dismantle a burgeoning industry, as, for example, a general reclassification of the workers would cause (Codagnone et al. 2016a; De Stefano 2016b; Koopman et al. 2015). Some even argue for a deregulation of the industry (Sundararajan 2014). As appendix B shows, DLMs are able to provide unique advantages, else the fast pace of growth would not be explainable (Codagnone et al. 2016a).

This thesis cannot provide a final answer to the question whether and in which form DLMs need to be regulated, since this is also a matter of legal and empirical research. However, it will provide insight into the functioning of these platforms. These insights, especially regarding the utilities provided to each side of agents and the behavior of the platforms might add to the ongoing debate. Findings and discussions during the course of this thesis will also be examined in view of the potential issues related to workers and the question about regulation.

3. Two-sided Markets and Digitally Moderated Labor

As stated in the introduction, the goal of this thesis is to explore DLMs within a two-sided setting. Such an analysis can only be useful and justified if an observed market shows two-sided characteristics. Thus, the first crucial question in need of an answer is whether DLMs can be considered two-sided. This chapter is dedicated to exploring and answering this question by applying four different approaches that previous literature has developed and utilized to identify TSMs. Each subchapter is dedicated to a specific approach, analyzing different criteria each view imposes. An intervening conclusion will summarize the findings and present further thoughts related to the first research question. Beforehand, some essentials regarding TSMs must be covered, including basic characteristics usually central within this field of research as well as related literature and notations.

Simplified, TSM literature studies economic entities, which simultaneously have to satisfy two or more distinct groups of consumers, while showing specific characteristics, such as unequal pricing between the different parties or network effects. In this regard, TSM-literature represents a subset of the network effects research field; yet, TSM-literature focuses on the behavior of the intermediary (Rochet and Tirole 2006; Rysman 2009). Having a two-sided business model is hereby not given by nature but is a strategic decision (Hagiu and Wright 2015). See for instance Amazon, which started as a pure reseller but then implemented the option for independent third parties to sell products. Another example would be Uber, as the company faced the decision to either apply a business model close to regular taxi services or to contract independent drivers and consequentially develop a new take on passenger transportation. Same as DLMs, the literature surrounding TSMs is riddled with semantic as well as denotational differences (Codagnone and Martens 2016c; Li 2015). On one hand, the relevant literature does not share a common understanding and approach to the definition of TSMs, hindering a simple answer to the question whether DLMs are also a form of TSMs, therefore requiring an analysis based on different criteria. On the other hand, literature has applied different denotations to name the phenomenon of TSMs. Caillaud and Jullien (2003), for example, applies the term ‘intermediary markets’. The name ‘two-sided markets’ was introduced by Rochet and Tirole (2003, 2006), and is also applyed by Armstrong (2006), while Evans (2003b) used ‘two-sided platforms’. Other authors (Parker and van Alstyne 2000) utilize the name ‘two-sidedness’, while others talk about ‘two-sided strategies’ (Eisenmann et al. 2006; Rysman 2009). Hagiu and Wright (2015) apply the notation ‘multi-sided platforms' to emphasize that more than two groups of customers can be involved. Regarding the terminology, this thesis follows in line with Armstrong (2006) as well as Rochet and Tirole (2006), as they inspired the subsequent analysis.

TSMs are usually associated with network effects and the related research (Li 2015; Rochet and Tirole 2006). Three crucial elements must be noted in this regard: Direct network effects, indirect network effects, and indirect network externalities. Their understanding will be necessary for the ensuing course of this thesis and will be explained in short.

Direct network effect: The benefits one can derived from a product are affected by the number of its members, as for example with social networks or messenger systems. If the derived benefits are increasing with the number of participants, these network effects are considered as positive. A reduction of benefits with an increasing number of members are denoted as direct negative network effects (King 2013; Shy 2011).

Indirect network effect: The benefits one can derive from a product are affected by the number of members of another group connected or affiliated with this product. Examples are heterosexual dating clubs (men and women derive an increasing benefit with the number of participants by the other gender), video game consoles (a console becomes more attractive for developers, the more gamers the platform can attract) or newspapers (the more readers, the more attractive the newspaper as platform for advertisers becomes) (Filistrucchi et al. 2012; Shy 2011).

Indirect network externalities: Literature covering two-sided markets often refer to the indirect network effects as externalities. This means that a group of agents does not consider and internalize indirect network effects it creates for the other side when joining or buying a product and is unable to demand a compensation in a practical fashion (Evans 2003b; Filistrucchi et al. 2012).

The anticipation of the derived findings will aid the reader by providing an understanding in which direction the following subchapters are heading. In general, all four branches show features of TSMs, depending on the applied criteria. Yet, two-sidedness is not a binary matter regarding on-sided business models. Often a fluidity is observable. The same is true for the four branches of DLMs. Consequentially, all branches but Freelancing are considered as two-sided by this thesis.

3.1 Criteria Based Assessment

The ensuing section will discuss whether DLMs can actually be considered as TSMs. As already mentioned, a common definition does not exist within this field of research. However, Li (2015) answered a more or less similar question but with respect to online-media. He identified four main approaches by literature to characterize TSMs. The following subchapters will cover these approaches and the related criteria based on different sources. These sources were selected as they either represent the founding literature for a certain approach (Codagnone and Martens 2016c; Li 2015) or as they show a certain aspect in a clear fashion.

3.1.1 Bilateral Network Externalities

Rochet and Tirole (2003) as well as Caillaud and Jullien (2003) were one of the first papers within the field of TSMs (Codagnone and Martens 2016c; Li 2015). They identified bilateral network externalities as a central feature of TSMs, meaning that both groups of agents generate indirect network effects for the other side. However, both groups of authors were probably aware that bilateral network externalities as sole main criteria might not be sufficient to distinct TSMs from classical business forms, as for instance resellers or retailers. They included other important criteria, which will later be covered. A straight forward definition of TSMs in regard to bilateral network externalities is provided by Evans (2003a, 2003b). He states three criteria which define a market as two-sided: Firstly, there must be two different group of customers. Secondly, the value a group derives increases in the number of agents of the other group and vice versa. Thirdly, an intermediary is required to internalize these network effects for both sides of agents. To anticipate the result: All four branches of DLMs can be interpreted as TSMs when applying the approach of Evans (2003a, 2003b).

All four branches of DLMs are fulfilling criterion one. On one side are workers who seek to sell their labor and time capacities; on the other side are the customer who are in need of a certain task to be completed.

The second criterion requires a more detailed elaboration, as its understanding will be central to the formulated model and the extension concerning transportation services. In general, the efficiency of DLMs should increases in the number of agents. The more workers there are, the more likely and faster a requester matches with a suited worker. The same holds true vice-versa. The more requesters there are, the more likely and consistent a worker finds a task to conduct, which suits her or him. Through this, a differentiation between transportation services and the other three branches seems to be appropriated, especially in regard to the indirect network effects worker generate. In the branches of microwork, freelancing, and manual labor, requesters should show increased interest with whom they match. As such, for an extra fee, Amazon Mechanical Turk allows requesters to set certain requirements and criteria for workers. Freelancing companies allow workers to display detailed information about their competencies and prior work history. Such information is required for requesters to find a qualified worker in a setting where mid- to high-skilled tasks are offered. It would be irrational to hire a random worker for a design or programming task. TaskRabbit also allows requesters to directly book a worker, enabling to choose on the basis of the charged rate, previous ratings and the work history of related tasks. Consequentially, market efficiency for these three branches of DLMs should not only increase in the number of workers due to faster matching but also due to an increased probability to find a suited worker.

In consideration of the transportation branch, it seems far-fetched that network effects are generated in regard to matching the right worker to the right task. These services are focused on getting a customer or product convenient, fast and safe from A to B without any incidents or scamming, such as the unnecessary deviation from the optimal route. Different surveys confirm this circumstance. Taverner Research (2014), an Australian research institute, report three main reasons to utilize taxi services: 1) these services are convenient, 2) they are quicker and direct, or 3) they represent a last resort. Rayle et al. (2016) specifically research the transportation services related to DLMs. According to their work, the three main reasons to rely on transportation services were 1) the ease of payment, 2) short waiting times, and 3) being the fastest way to get to a location. For the case of delivery service, Kedah et al. (2015) show that customers care directly about the delivery speed, the food quality and customer service provided by food delivery services. In both cases, requesters might prefer certain workers based on their trustworthiness and capability to find quick and direct routes; however, transportation platforms implemented two systems, which mitigate these potential considerations by customers. Platforms like Uber, Lyft, or Uber Eats have integrated navigation systems on their phone applications, which provide workers with an optimal route, allowing them to easily navigate to the desired designation, significantly lowering the required skill (Rogers 2016). Furthermore, rides are GPS tracked, thus, allowing requesters to check the route and see whether drivers deviate from the originally suggested directions. The rating system on top further ensures worker’s compliance. In fact, Feeney (2015) argues that transportation services are safer than classical taxi services, not only through the rating and route monitoring systems but also due to the cashless payment and the circumstance that the requesters are not anonymous. For food and other delivery forms, these concerns should be even less pressing, as similar systems are in place but without the involvement of passenger transportation and its related risks.

In summary, it can be assumed that requesters within the transportation branch do usually not care with whom they match, neither in a negative or positive way, unless they show certain inclinations like racist biases. The same should hold true for workers, as the above implemented systems are also supporting the workers (Feeney 2015). Indeed, neither workers nor requesters can directly choose in the setting of the transportation business with whom they match, they only have the option to decline a pending match.[3] Consequentially, for transportation services, indirect network effects only matter in a sense of matching speed and are not further affected by matching the right worker with the right task. Meaning that requesters only profit from increasing worker numbers through an increased matching speed, while workers enjoy a more consistent stream of tasks in increasing requester numbers. Rogers (2016) argues in a similar fashion in view of network effects drivers experience. This also has implications for the model-based analysis later on.

So in regard to the second criterion imposed by Evans (2003a, 2003b), it seems reasonable to assume bilateral network effects for all branches of DLM. However, the here presented argumentation solely moves in theoretical and indirectly proven spheres. No empirical research could be identified, which directly explores indirect network externalities in DLMs and quantifies the strength of these effects. Yet, many researches have empirically analyzed various other forms of markets, which could be considered as two-sided, where indirect network effects are apparent, thus underlining their relevance (Stremersch et al. 2007).

The last criterion requires the intermediaries to internalize the indirect network externalities for the two sides of agents. Evans (2003b) applies the example of heterosexual dating and dating clubs. Dating is affected by a coordination problem. Women profit the more men there are to choose from and vice versa, as the probability of a successful transaction grows with the number

[3] However, workers face consequences if they have a too low acceptance rate (Cherry 2016a; Codagnone et al. 2016a).

of agents from the other side. However, a women or man is not able to compensate all agents of the other side for showing up and the consequent network effects, as an agent only interacts with a limited number of opposing agents.[4] An intermediary and society profits, if an intermediary is able to solve this coordination problem by offering a platform, which internalizes these network effects and provides both sides of agents accordingly with value. Or in other words, as Evans and Schmalensee (2012) later formulate, the agents are not able to capture value from their bilateral interest and need a platform to facilitate value creating exchange, by mitigating coordination, search, and/or transaction cost.

The platforms within the DLMs meet this third criterion, as they overcome a coordination problem between workers and requesters, while internalizing externalities related to indirect network effects. The platform provides requesters with an array of potential workers to choose from and/or a convenient and efficient form of accessing labor force. Workers on the other hand, have an array of tasks to choose from and/or an easy way to access labor opportunities. The bundling of both sides on one platform allows to harness the above described indirect network externalities. This coordination problem related to the provision of labor is not new and experienced different approaches to finding a solution. One example is the classical issuing of job postings by a company. Workers can choose between different job postings by different companies while a firm can choose between the workers who responded to a specific job posting. Day labor markets are an example for labor coordination in which the efficient provision of tasks on-demand is paramount and less related to work with high skill requirements; much like within microwork, manual labor and transportation services (Valenzuela 2003). DLMs represent a new take on bringing together labor demand and supply, allowing the digitally moderated exchange of task- and project-based on-demand labor, potentially on a global basis. The relative short-term nature of the procured tasks and work relations, paired with access to a huge number of workers just-in-time, could possibly not be maintainable by a single company in the long-run.

In summary, applying the definition by Evans (2003a, 2003b), which mainly centers around bilateral indirect network externalities, all four branches of DLMs can be interpreted as TSMs.

[4] It would be difficult or expensive for a single man or women to attract a large number of agents from the other side to the same venue at the same time, if most would experience rejection.

3.1.2 Unilateral Network Externalities

The focus on bilateral network effects changed over time to unilateral network effects (Li 2015). For instance, Evans and Schmalensee (2007; 2012) revised their definition. They relaxed their criteria in regard to the indirect network effects, now stating that a platform is already two-sided if only one side of agents generates positive network effects for the other side. A direct reason for this subtle change is not given by Evans and Schmalensee (2007; 2012), yet Li (2015) states that this adjustment is pivotal when considering advertisement in hindsight to two-sided markets. Advertisement in different settings, like television, newspapers and other forms of media, is an often cited example for two-sided markets (Armstrong 2006; Evans and Schmalensee 2012; Filistrucchi et al. 2012; Rochet and Tirole 2006). In such a setting there are the advertisers, the platforms in the form of a newspapers; TV programs, or other forms of media; and the consumers. The advertisers show an increased valuation of a platform, the more consumers there are to reach with their advertisements. The consumers, on the other hand, could be exposed to negative indirect network externalities, as they might not enjoy advertisement or are indifferent to advertisement and the number of advertisers. The other imposed criterion by Evans and Schmalensee (2007; 2012) stayed basically the same, now appearing in a less formal style. A multi-sided platform has two or more sides of agents who need each other in some form but are incapable to derive value from their potentially mutual attraction in an effective way, thus, being in need of a facilitator. Even though not directly derivable from these criteria, they now consider unilateral network externalities as a sufficient condition: "In most cases, greater involvement by agents of at least one type increases the value of the platform to agents of other types" (Evans and Schmalensee 2012, p. 2). Naturally, all criteria are met as the previous chapter discussed. Especially, as unilateral network externalities represent a less rigid condition. However, a crucial specification was mentioned during the course of their paper from 2007, which will be covered later on (Evans and Schmalensee 2007).

Another important paper in regard to unilateral network externalities, according to Li (2015), is the paper by Filistrucchi et al. (2012). In which, they developed own criteria based on a review of previous literature:

> *"The identifying features are the existence of a firm selling more than one product or service, the presence of two distinct groups of buyers, each buying different products or services, the*

interdependency between their demands and the lack of a complete pass-through in case of transaction markets" (Filistrucchi et al. 2012, p. 9).

The DLM-firms provide two services to two distinct group of buyers. Requesters are either offered a platform where labor is provisioned under strict monitoring conditions or a mean to have certain tasks solved. Requesters are provided with a platform where they can find labor opportunities. The term "interdependency" refers to unilateral network effects, as Filistrucchi et al. (2012) elaborated previously. Especially noteworthy, however, is their differentiation of TSMs in transaction and non-transaction markets. They understand non-transaction markets as two-sided platforms where both sides of agents do not directly interact and transact with each other, for instance, within the setting of media and advertisement. Transaction markets are TSMs where both sides directly interact with each other and conduct a transaction; as is being the case for dating clubs, gaming systems and other examples. DLMs fall into the latter category, since the agents can only derive a gain in the case of a transaction. A differentiation between transaction and non-transaction markets is required, as direct interactions potentially allow both sides to negotiate away possible price differences. Yet, skewed pricing is of central interest in regard to two-sided markets (Filistrucchi et al. 2012; Rochet and Tirole 2006). Skewed pricing hereby refers to the circumstance that the involved sides can experience significant differences in the applied pricing. Thus, Filistrucchi et al. (2012) require two-sided transaction-based markets to disallow a complete pass-through of price differences between different agents. This consideration was introduced by Rochet and Tirole (2006) and heavily influenced succeeding definitions like the one by Filistrucchi et al. (2012). Thus, a final verdict whether DLMs meet the criteria imposed by Filistrucchi et al. (2012) will be postponed until the end of subchapter 3.1.3, where this requirements will be discussed in greater detail.

3.1.3 Non-neutral Pricing

Rochet and Tirole (2006) heavily influenced the definitional approach of literature towards TSMs (Evans and Schmalensee 2012; Filistrucchi et al. 2012). They were already aware in their earlier papers that a crucial feature of two-sided markets is the ability of the platforms to impose unequal pricing between the two sites (Rochet and Tirole 2003). See for example operating systems where developers have a subsidized access to developer kits while the end-users are charged (Rochet and Tirole 2006). A heterosexual dating club might subsidize one side of agents with free drinks while the other side has to pay an entrance fee. They (Rochet and Tirole 2006) later refined their first approach (Rochet and Tirole 2003) with regard to this important characteristic, formulating following definition:

> *"[A] market is two-sided if the platform can affect the volume of transactions by charging more to one side of the market and reducing the price paid by the other side by an equal amount; in other words, the price structure matters, and platforms must design it so as to bring both sides on board. The market is one-sided if the end-users negotiate away the actual allocation of the burden…" (Rochet and Tirole 2006, pp. 664–665).*

Notice that Rochet and Tirole (2006) do not consider gross-group externalities as a necessary condition for a platform to be two-sided, arguing that a sole focus on this characteristic might be to underinclusive (e.g., the example of advertisement in different media) or to overinclusive (every market shows indirect network externalities: increasing numbers of sellers (buyers) lower (rise) the price of a product).[5] The reason for this definitional approach is due to the importance of unequal pricing within the literature of TSMs and the related regulatory interest in such price structures. The central characteristic of their definition is price non-neutrality, meaning that a platform is able to charge the two sides differently while the agents have no mean to negotiate away these price differences. This means that not only the overall price level determines the volume of transactions, but also the distribution of the price between the parties. This circumstance requires a more detailed explanation, since price non-neutrality is a crucial assumption applied by the model-based analysis.

Imagine a marketplace where one firm sells widgets to one consumer, while the marketplace levies a charge per conducted transaction between the two. It would be of little interest how the fee is distributed between the firm and the customer under the assumption of perfect information and a lack of transaction costs (Coase 1960). The two parties will allocate the fee accordingly through negotiations. Only the overall level of the fee will affect the volume of transaction between them. Even if the Coase theorem fails, Rochet and Tirole (2006) expect that only the overall level of the levied fee can matter in terms of transaction volume. Under asymmetric information, a symmetric increase of the fee for the firm by Δ and reduction by Δ for the consumer would still leave them

[5] However, Evans and Schmalensee (2007) argue that indirect network externalities, which the involved parties cannot directly coordinate by themselves, are required for non-neutral pricing.

with the same bargaining strategies but now shifted by Δ, as both sides adjust their offer by Δ. The overall volume of transaction should not change, even though it is presumably suboptimal compared with the case where no asymmetric information occurred.

Yet, Rochet and Tirole (2006) postulate different conditions under which non-neutral pricing is given: if the parties can derive a gain by directly transacting with each other, including 1) transaction costs, which hinder the pass-through of prices differences to the other involved party, 2) constraints set by the platform, which do not allow the parties to set prices or hinders negotiations, and 3) fixed costs or fees, arising when joining the platform. With regard to transaction costs, Rochet and Tirole (2006) raise the example of a website, which faces increased charges by the internet provider for its outgoing data traffic. A billing system, which would charge every user according to the accessed content, might be uneconomical if the accessed content only justifies marginal charges. Regarding the third point, Rochet and Tirole (2006) argue that fixed fees and costs are sunk when transacting ex post and, thus, are not renegotiated, unlike a value-added tax or other transaction-sensitive costs. Moreover, they claim that a distinction between fixed costs and fixed fees is not necessary, as only the total sum of the transaction-insensitive costs should matter to an agent. Indeed, platforms have the ability to not only determine a fixed fee but also to influence the fixed costs incurred by an agent. Rochet and Tirole (2006) rise the example of a software platform trying to attract developers. The developers could be attracted by low fixed fees but also by a developing support, which would reduce the fixed technological development costs. An example related to DLMs can also be brought forward. Uber provides workers with tailored insurances and discounts on phone plans (Uber Technologies Inc. 2018b, 2018a). The company even started its own leasing branch with extremely flexible leasing conditions for its workers (Richter 2017).

Do the four DLM-branches still count as two-sided models with respect to this new perspective? Within the transportation branch, neither requesters nor drivers can set a price, allowing the platforms to charge each side differently. Uber, for instance, charges its customers with rates close to normal taxi rates; however, this is linked to surge pricing and, thus, potentially cheaper depending on the time of day and the type of trip (Salnikov et al. 2015). The platform then imposes a value added-tax on the charged fare before transferring it to the drivers (Rogers 2015). The drivers have no option to recoup the charges levied by the platform to the requesters.[6] Furthermore, drivers can face fixed costs on joining, especially if they do not own a car. Matters are a bit more complicated in regard to the manual labor branch. The company Handy sets the rates requesters have to pay and the rates workers receive. A change of rate imposed to one side cannot be passed-through to the other side. TaskRabbit, on the other hand, allows workers to set their own rate, while the company adds a 15 percent service fee as well as a 7.5 percent safety and trust fee to customers (TaskRabbit Inc. 2018f). This allows non-neutral pricing in only one direction. Charges imposed to the workers could be recouped by increased fares. Requesters, on the other hand, have no option to directly negotiate or pass-through price changes to workers. It might be possible that an increased price level for requesters reduces their demand, potentially causing workers to lower their rates in order to recover demand, consequentially leading to an indirect allocation of price differences between the parties in the long-run. It is not yet clear, whether such a process actually takes place, nor the potential extent or the required time frame. TaskRabbit and Handy also charge workers a fixed fee upon registration and require them to invest in their own tools at the beginning, if they do not already own the necessary tools. This circumstance indicates non-neutral pricing according to criterion 3).

Microwork represents the opposite case, as the requesters determine how much they pay the workers, thus allowing them to pass price differences imposed by the platform on to the workers. The workers have no direct option to negotiate away or pass through platform-imposed price differences. Here again, a potential adjustment might still be observable in the long-run, as requesters adjust the payment to workers in order to counter changes in work-supply caused by the platform altering worker prices. No other criteria for non-neutral pricing does apply for the case of microwork. Thus, it is debatable whether microwork can be understood as two-sided when applying Rochet and Tirole's (2006) definition.

The remaining branch, freelancing, allows and encourages open price negotiations. Other criteria, which would permit non-neutral pricing are also not met, indicating that skewed pricing would not hold in the setting of freelancing. In fact, the platform simply deducts a percentage-based fee from

[6] This has already caused some criticism expressed by drivers, when they faced increased charges by the platform while the customer fares were left the same (Huet 2015).

the payment the requester agreed to pay the worker, similar to a value-added tax. According to Rochet and Tirole's (2006) definition, freelancing must be considered a one-sided market.

Regarding fixed cost, all of the four branches requires worker to own requisite technical equipment, such as a computer and/or a smartphone, including access to the internet. It is highly questionable whether these costs can actually be seen as sunk costs specifically related to the joining of a DLM-platform, as many already own such an equipment, at least in developed countries (Broadband Commission for Digital Development 2015; Pew Research Center 2010). It would be far-fetched to include those fixed costs into the consideration of skewed and non-neutral pricing.

As mentioned in chapter 3.1.1, Caillaud and Jullien (2003) were already aware that skewed pricing is central to two-sided markets, also in definitional terms. They understand TSMs as intermediary markets with bilateral network externalities and the possibility for price discrimination with regard to users' identity. However, Caillaud and Jullien (2003) did not further provide an elaboration about their understanding of user-identity-based price discrimination, thus, preventing a final verdict in regard to DLMs. Chapter 3.1.2 showed that Filistrucchi et al. (2012) also considered the condition of no complete pass-through of price differences between the involved parties. However, they argue that the question of two-sidedness is not a binary matter, as the ability to pass-through price differences can vary in its strength, depending on the observed market and the platform setting. The applied criteria for the lack of pass-through are derived from Rochet and Tirole's (2006) work. This leads to the similar conclusion that the manual labor and the transportation branches can be considered as two-sided. The freelancing branch allows a high level of pass-through by enabling free negotiations between the parties while imposing no fixed fees to the parties. Microwork is the branch where the level of pass-through between the two sides is not clear, as only transaction related fees are imposed, and the requesters are endowed with the ability to set prices. However, a complete pass-through of price-differences can still not be expected in the short-run, as workers have no mean to directly influence the wage payed to them. Thus, the criteria set by Filistrucchi et al. (2012) would suggest the evaluation of microwork-platforms as two-sided. Evans and Schmalensee (2007) also specify during the course of their paper that the involved parties must not be able to arbitrage away the price structure set by the platform. Same as Caillaud and Jullien (2003), Evans and Schmalensee (2007) do not provide a further specification when this condition is met, also preventing a final evaluation of DLMs in view of their definition.

3.1.4 Direct Interaction and Affiliation

A completely different approach was taken by Hagiu and Wright (2015). They critically state that previous definitions of TSMs were either too vague, overinclusive, or underinclusive and that indirect network externalities in combination with non-neutral pricing are not enough to distinct TSMs from one-sided firms. This argument will be discussed shortly in more detail. Through this critique, they developed their own approach to defining TSMs. According to Hagiu and Wright (2015), TSMs show two main features[7]. Firstly, the involved platforms enable direct interactions between two or more sides of agents. Secondly, each involved side of agents is affiliated with the platform.

- "Direct interaction" means that the agents and not the platform have control over the key-terms associated with the interaction. Key-terms are, for instance, pricing, terms and conditions, bundling, marketing, the decision in which way to deliver goods, or the extent and quality of the delivered service.
- "Affiliation" is explained by Hagiu and Wright (2015) as the intentional spending of platform-specific investments by the agents, which enable the direct interaction with the other party. These platform-specific investments can occur in different forms such as fixed fees issued by the platform, the expenditure of resources or plain opportunity costs.

According to Hagiu and Wright (2015), this definition is suited to differentiate two-sided business models from firms positioned as resellers, like supermarkets, vertically integrated firms, or input suppliers, where agents either are not affiliated with the intermediary (input suppliers) or lack a direct interaction with each other (resellers or vertically integrated firms). Amongst other examples, they explain this consideration on the basis of supermarkets, which act as resellers. Here, customers potentially care about the number of suppliers, as they can cause a greater variety in assortment. The suppliers, on the other hand, value the number of customer, as a more frequent patronage leads to an increased need in inventory. Moreover, prices are presumably non-neutral. Increasing the payments of the supermarket to the suppliers while equally increasing the prices to

[7] Hagiu and Wright (2015) state that indirect network externalities can still occur within markets covered by their definition but they are not a necessary feature.

customers would most likely affect the volume of transactions.[8] By imposing direct interactions, Hagiu and Wright (2015) exclude resellers like supermarkets from the definitional scope of TSMs.

Hagiu and Wright (2015) were one of the few authors who directly mentioned companies associated with DLMs; namely, Uber, Lyft and Elance-oDesk, now known as Upwork. Surprisingly, they consider transportation services like Uber and Lyft as two-sided when applying their definition, as Uber and Lyft "enable independent drivers to offer rides to passengers in their own cars" (Hagiu and Wright 2015, p. 8). Yet, drivers within this branch have nearly no control over the key-terms of the transactions. Marketing decisions are a matter of the platform, drivers cannot set prices, nor directly choose whom to drive. A tight review and control system standardizes the required quality level, also accompanied by minimum standards regarding the drivers' car. The only control left is the choice of when to work, for how long to work and with which car to work, if a worker owns multiple cars that meet the standards set by Uber. The same is true for Lyft and also for food delivery services. However, food delivery services can be less rigid in regard to the means of transportation, usually allowing different forms, like bicycles, scooters, or cars and promote less rigid standards. The requesters also have no real control over the transaction. They can either accept or decline an offer that the platform has automatically proposed for them for a requested ride and have flexibility in the offered car types. So, whether these services can be considered as TSMs based on Hagiu and Wright's (2015) definition is open to discussion. Manual labor can also contain the same issue. Handy allows workers to directly choose when to work and which tasks to conduct, however, the platform imposes the pricing. TaskRabbit leaves workers no direct scheduling influence nor the capability to directly choose a task, but workers can set their own rates. However, platforms have rigid rating systems in place. The customers of both platforms can choose the time-frame for the task-conduction, while TaskRabbit also allows customers to choose a specific worker. Overall, this setting allows the agents more control over the transaction's key-terms opposed to the transportation branch, yet certain features are still in the hands of the platform, like marketing, the determination of quality standards and the related control over the review mechanism as well as the general terms and conditions of conduct. A classification as two-sided market in this regard can, thus, be also prone

[8] This is not a surprising circumstance when considering the previous chapter and the conditions set by Rochet and Tirole (2006), as the two sides cannot negotiate away the imposed price differences.

to discussion, especially in hindsight to the varying approaches by the companies within this sector. Microwork offers even more control over the key terms of the transaction. The platforms mainly ensure smooth operations by implemented review and monitoring systems and a digital platform for the easy and standardized exchange of tasks. The remaining terms of conduct are in the hand of the agents, a classification as TSM based on Hagiu and Wright's (2015) approach seems reasonable. As mentioned, Hagiu and Wright (2015) consider Upwork as a TSM. Indeed, the freelancing branch provides the biggest freedoms in terms of control over the transaction key-features, providing a digital environment to facilitate the exchange of freelance work. Here, even the review systems are less rigid in their functioning, as both the workers and requesters ultimately take the decision with whom to work, opposed to the other branches where only one or no side has this decision in its hand.

3.2 Interim Conclusion

Table 5 represents a summary of the previous discussion. The table is divided in four parts, representing the previously analyzed major approaches to TSMs in regard to their definition. The sources presented in the left column impose different criteria concerning TSMs. These sources are selected as they were either influential and unique or represent an exemplary take in their respective approach (Codagnone and Martens 2016c; Li 2015). A check mark indicates that the criteria imposed by the considered source are sufficient to categorize the respective DLM-branch as two-sided, while a cross expresses the opposite case. An exclamation mark shows that a clear statement is not possible for the respective branch and the applied criteria. A further discussion and new input are required where this is the case.

Table 5: Evaluation of DLMs as TSMs based on selected definitions.

Source	Microwork	Freelancing	Manual labor	Transportation
Subchapter 3.1.1: Bilateral network externalities				
Evans (2003b)	✓	✓	✓	✓
Subchapter 3.1.2: Unilateral network externalities and non-neutral pricing				
Filistrucchi et al. (2012)	✓	✗	✓	✓
Subchapter 3.1.3: Non-neutral pricing				
Rochet and Tirole (2006)	!	✗	✓	✓
Subchapter 3.1.4: Direct interaction and affiliation				
Hagiu and Wright (2015)	✓	✓	!	!

Note: Own representation.

Other authors, who have contributed to the question whether DLMs can be considered as TSMs, besides Hagiu and Wright (2015), were Codagnone and Martens (2016c). They specifically asked the question; however, not only in view of DLMs but with respect to the whole sharing economy. Furthermore, their analysis lacks depth and mainly centers around very general aspects as well as the argumentation presented by Hagiu and Wright (2015). Overall, their analysis could not provide a sufficient answer, only that Uber, Lyft and TaskRabbit are presumably TSMs. Loosely related literature was provided by Evans (2008), Li (2015) and Luchetta (2014). Evans (2008) covers what he called the "web economy", mainly considering web-based "matchmakers" like eBay, "audience builders" like Google, or "cost shares" like Windows or Linux, to just name a few but renown examples. Even though these platforms are also web-based like DLMs, a conclusion or other input concerning the risen research question cannot be derived. The same is the case for Li (2015), who analyzed whether online-media is two-sided and Luchetta (2014) who researched Google in this regard.

So, after such an excessive discussion, can DLMs actually be considered as TSMs? A final answer is difficult to give, as all branches can show two-sided features, depending on the applied criteria. Furthermore, two-sidedness is usually not a binary case but a fluent manifestation in regard to one-side firms (Filistrucchi et al. 2012). Especially Hagiu and Wright (2015) show and criticize this circumstance. Rysman (2009) proposes a rather pragmatic solution to this dilemma:

> *"The interesting question is often not whether a market can be defined as two-sided—virtually all markets might be two-sided to some extent—but how important two-sided issues are in determining outcomes of interest" (p. 127).*

To make this solution practicable one needs to know the main research interests of TSM-literature. According to Rysman (2009), the focus of this field of research is on platforms who procure between two or more sides of agents while demanding special considerations towards pricing paired with indirect network externalities. TSM-literature can be understood as an subset of the network-effects research field, mainly focusing on the actions of the intermediary, especially concerning the imposed pricing (Rochet and Tirole 2006; Rysman 2009). Network-effects-literature, on the other hand, mainly centers around user adaption and optimal network sizes (Rysman 2009). Especially the platform actions and the imposed pricing are of interest to analyze with respect to the ongoing discussion, presented in chapter 2.4, in the field of DLMs. All branches but freelancing show characteristics worthwhile to analyze in this regard. There can be observed an intermediary faced with unique pricing decisions paired with indirect network externalities in all other cases. Freelancing should not show noteworthy twists in form of non-neutral pricing, as free negotiations are possible, and since no fixed fees are in place. Filistrucchi et al. (2012) argues in a similar fashion. The higher the pass-through of prices between transacting parties is, the less important the two-sided nature of a market becomes. If non-neutral pricing is of little to no importance, a market is better analyzed as a standard market or in a general respect to network effects research (Weyl 2010).

In conclusion, all branches of DLMs but freelancing can be considered as TSMs. Thus, the subsequent analysis will ignore freelancing. This exclusion is reasonable as an analysis based on two-sided features would not fit freelancing. Additionally, freelancing is not the center of attention regarding the ongoing discussion, hence, does not represent a branch essential to research in this respect. The derived insights are valid for the industry branches, which face the most turmoil concerning regulations, namely microwork and transportation services but also the manual labor branch.

4. Basic Model

This chapter will introduce and analyze a basic model in scope of the three relevant branches of DLMs. The model is developed in the light of TSMs, basing its foundation on the work of Armstrong (2006) as well as Rochet and Tirole (2006). Corresponding extensions to the basic model will be conducted in the subsequent chapters 5 and 6. This section is organized as follows: The first subchapter will present the basic assumptions of the model. Secondly, the actual model will then be introduced and solved in the ensuing subchapter, which is followed by a discussion about the constraints and a rudimentary sensitivity analysis. The fourth subchapter represents a discussion and display of the interim findings the basic model already allows.

The following chapter as well as the two ensuing adjustments of the basic model presented in chapter 5 and 6 will therefore cover the second, third and fourth research questions. Each chapter will hereby not directly adhere to a specific research question like the previous chapter 3, since question three and four are relevant for all three ensuing chapters. This is also why each chapter refrains to directly present and discuss its findings in view of the posed questions, since each new chapter adds a new aspect. It is rather purposeful for the flow of the thesis to discuss all findings in respect to the research questions in one place, represented by chapter 7.

4.1 General Assumptions

Different assumptions must be clarified in advance to the presentation of the basic model. Many of the covered points will be presented in light of Armstrong’s (2006) as well as Rochet and Tirole’s (2006) papers, as they provide the groundwork for the ensuing model. This chapter and subchapter 4.2.1 will point out similarities and differences between the model presented here and those by Armstrong (2006) and Rochet and Tirole (2006) as well as other general assumptions.

The model is perceived in a **monopolistic setting**. This is not uncommon within this field of research (Armstrong 2006; Rochet and Tirole 2006; Weyl 2010). However, the acting of platforms in an competitive environment imposes also crucial insights and receives attention from different authors (Armstrong 2006; Caillaud and Jullien 2003). Hence, an extension regarding competition will be covered in chapter 6.

Even if there are direct interactions and transactions between the parties, bargaining is hindered by the business setting imposed by the platform, as discussed in chapter 3.1.3.[9] Thus, the ideal pricing policy by the platform for each side cannot be renegotiated by the agents and transformed into a less skewed form. **Non-neutral pricing** is expected to hold for all three considered industry branches.

A further standard assumption, for instance, found within the models by Armstrong (2006), Rochet and Tirole (2006) or Weyl (2010) is that each agent on one side values each agent on the other side equally. This assumption regarding **agent valuation** does not necessarily hold for a DLM-setting as this can be a reason for indirect network externalities.[10] However, this circumstance does not directly add complexity, as the model moves on a macro level and defines many crucial variables as average, also imposing the assumption of no failed tasks. Caillaud and Jullien (2003) is an example where agents from one side value the agents from the other side differently.

As earlier mentioned, many implemented variables must be considered on an **average** level, as, for instance, the wage a worker receives per task or the benefits a requester derives from a completed task. This is necessary since different factors can lead to a variation of certain values across a population of agents. For example, the wages can vary as workers set their own rates within the setting of manual labor (see for example TaskRabbit). Some micro workers apply algorithms to secure the best paying tasks (Berg 2016).

Different agent valuations do also not add unnecessary complexity, as the basic model rises the condition of **no failed tasks**. Every task that is conducted between a worker and a requester will yield a positive result and will not fail. This assumption does not represent reality; however, it is a fair assumption for DLMs. Trust and reputational systems are crucial mechanisms within the setting of DLMs (Jøsang et al. 2007). Requester must rely on independent contractors who are not directly employed by a company. Minor barriers of entry allow many people, potentially on a global basis, to join with ease. This circumstance requires requesters to show trust in advance not only towards the workers but also towards the platform and the imposed system itself while minor issues could cause major disturbances (Hawlitschek et al. 2016). Hence, the platforms

[9] Yet, it can be debated to which extent this is true for microwork and manual labor, ultimately requiring empirical input in this matter.
[10] See the discussion in chapter 3.1.1.

implemented different systems to tackle this challenge. Common for all three branches are rigid rating systems. Falling below a certain threshold with the average rating or with the job acceptance rate can lead to the exclusion of a worker. In most cases requesters are also facing ratings by the workers. An example where this is not the case is Amazon Mechanical Turk. Such a system should ensure that grains of sand in the algorithm-based running of the business are removed sooner or later. Furthermore, the platforms installed certain guarantees or insurances, which further mitigate potential issues. Amazon Mechanical Turk, for instance, allows the ability to reject the results of a conducted task without further explanations, while the requester can keep the task result and does not have to compensate the worker. TaskRabbit and Handy provide requesters with a happiness guarantee, where they get compensated if they are not satisfied with a conducted task. Both firms also automatically insure every transaction in the event of certain incidents. Uber offers the possibility for a refunding under certain circumstances (Uber Technologies Inc. 2018c). Of course, these measures are not suited to prevent a task from initially failing, but they help to mitigate the damage. This mitigation might reach so far in that an initially failed task is not further considered as failed but only as still uncompleted. The assumption of no failed tasks will be relaxed for the consideration of timely matching regarding the branch of transportation services, covered in chapter 5.

Both, Rochet and Tirole (2006) and Armstrong (2006), do not consider transaction-sensitive costs incurred by the participating agents, solely in regard to the platforms. However, Rochet and Tirole (2006) included fixed costs an agent suffers upon joining a platform. This can be a valid approach for the markets they considered when developing their model, for instance in regard of advertisement issued in certain media or payments conducted with a credit card associated to a certain card network like Mastercard. However, the following model does implement **transaction-sensitive and transaction-insensitive costs for both side of agents**, while assuming constant marginal costs. Furthermore, the costs are assumed to be homogenous within a side of agents. For one thing, the consideration of costs makes sense for the manual labor and transportation branches. Workers of the former branch must provide cleaning supplies and other tools. Workers of the latter branch incur running costs and fixed costs if they do not initially own a suited mean of transportation. Moreover, there is criticism that workers might not be able to make a decent living, if running costs are not accordingly covered by the remuneration, especially in the transportation branch. Even though not all branches show significant costs, notably in view of fixed costs incurred on joining, an implementation of these still allows for a more detailed analysis of the industry.

4.2 The Model

Hereafter, the actual model will be presented. The first portion will introduce the agent's utility functions and the platform profit function, while pointing out differences to Armstrong (2006) as well as Rochet and Tirole (2006). The model specifically emphasizes direct transactions as the driving force in generating utility and profit. Thus, the number of conducted tasks is crucial within the further analysis and will be covered in a separate subchapter. The third and last part presents the optimal pricing strategy under the given assumptions and functions.

4.2.1 Utility and Profit Functions

As mentioned, the basic model is set in a monopolistic framework in which a platform P moderates between two groups of agents, the workers and requesters. The average utility, $U_W \in \mathbb{R}$, a worker W receives is hereby dependent on different factors. The gains a worker obtains is foremost driven by the number $T_W \in \mathbb{R}_0^+$ of tasks a worker W conducts. For every conducted task a worker receives an average wage $w \in \mathbb{R}_0^+$, reduced by costs $c_W \in \mathbb{R}_0^+$ incurred per task and a fee $a_W \in \mathbb{R}$ charged by the platform per task. However, the model also includes indirect network externalities in a form that a worker receives an average benefit $\beta_W \in \mathbb{R}_0^+$ per conducted task for every requester, R, on the other side. For simplicity, β_W is deducted from the average monetary valuation a worker has for these extra benefits, a compatibility in terms of the applied units is consequentially given. $N_R \in \mathbb{R}_0^+$ hereby denotes the number or requesters. The gains generated through the conducted tasks are then reduced by the fixed costs $F_W \in \mathbb{R}_0^+$ a worker W has to muster on joining the platform and by a fixed fee, $A_W \in \mathbb{R}$, charged by the platform on joining. This is expressed by equation (1)[11].

$$U_W = (w + N_R\beta_W - c_W - a_W)T_W - F_W - A_W \tag{1}$$

The average utility $U_R \in \mathbb{R}$ a requester R receives is dependent on the number of tasks $T_R \in \mathbb{R}_0^+$ a requester gets completed. Every completed task generates an average base benefit $b_R \in \mathbb{R}_0^+$, which is reduced by transaction-sensitive costs $c_R \in \mathbb{R}_0^+$, the wage paid to the worker, and a fee $a_R \in \mathbb{R}$ levied by the platform per transaction. Again, indirect network effects are also represented by an

[11] The number of requesters and the conducted tasks are hereby defined as real numbers and not as positive integers since the model moves in a setting of averages. The same applies to the later introduced number of workers and number of tasks a requester gets conducted.

average benefit $\beta_R \in \mathbb{R}_0^+$ a requester receives per worker and completed task. Here, the parameters b_R and β_R are also derived from the average monetary valuation an agent musters for these benefits, granting compatibility regarding the applied units. $N_W \in \mathbb{R}_0^+$ describes the number of workers registered with the platform. The benefits are further reduced by fixed cost $F_R \in \mathbb{R}_0^+$ a requester R might incur by joining and a fixed fee $A_R \in \mathbb{R}$ imposed by the platform. Ultimately delivering equation (2) as follows:

$$U_R = (b_R + N_W\beta_R - w - c_R - a_R)T_R - F_R - A_R \qquad (2)$$

Compared to Armstrong (2006) as well as Rochet and Tirole (2006), both equations show distinct differences. In his basic model, Armstrong (2006, p. 672) describes the agent utility of both side with the same function. In this regard, *i* denotes one side of agents, whereas *j* the other side:[12]

$$U_i = N_j\alpha_i - A_i$$

The parameter α_i denotes the benefit an agent *i* receives from interacting with each agent *j*. Rochet and Tirole (2006, p. 653) describe agent utilities of both sides in ensuing form:[13]

$$U_i = (b_i - a_i)N_j + B_i - A_1$$

Here, an agent receives an average base benefit b_i per transaction and incurs a fixed benefit B_i for joining the platform. However, Rochet and Tirole (2006) clarify that fixed benefits are often a fixed cost and, thus, negative. Furthermore, this approach is only valid for TSMs where no direct payments take place between the two parties and, hence, does not allow to arbitrage away price differences imposed by the platform. They also developed an approach, which describes this circumstance (Rochet and Tirole 2006, p. 661): [14]

$$U_i = E[(b_i - a_i)x(b_1, b_2, a) + t_i(b_1, b_2, a_1, a_2)]T_i + B_i - A_i$$

[12] The hereby used parameters and variables are different in notation compared to the original in Armstrong's (2006) work. The here presented function applies a notation close to equation (1) and (2) to prevent confusions.
[13] Here again, the notations are accordingly adjusted to prevent confusions.
[14] $i \epsilon \{1,2\}$; $j \epsilon \{1,2\}$; $i \neq j$.

The first part of the equation, $E[(b_i - a_i)x(b_1, b_2, a)+t_i(b_1, b_2, a_1, a_2)]$, is the expected net-surplus an agent of side i receives per transaction. $x(b_1, b_2, a)$ is the probability of a trade, which depends on the benefits both sides gain per trade and the overall level of the transaction-sensitive price $a = a_1 + a_2$. The expectations are derived in regard to a production distribution $F_1 x F_2$. The part $t_i(b_1, b_2, a_1, a_2)$ describes a balance transfer between the two parties where skewed pricing $a_1 \neq a_2$ is completely or only partially arbitraged by negotiations dependent on the benefit levels and price levels. It must be noted that this is not the original formula by Rochet and Tirole (2006). They move on a per-transaction-level in regard to the agent utility, only giving $E[(b_i - a_i)x(b_1, b_2, a)+t_i(b_1, b_2, a_1, a_2)]$, even tough B_i and A_i are still in effect. However, this approach is reasonable, as the number of transactions T_i an agent of side *i* conducts cannot be directly stated under these circumstances. It is only possible to give the total number of performed transactions with $E[x(b_1, b_2, a)]N_1 N_2$. The product $N_1 N_2$ represents the number of all possible transactions. Yet, an adjustment of their function was necessary to increase the comparability with the other presented utility functions.

Already these few lines of equations indicate an important circumstance concerning TSMs and the generation of gain. Rochet and Tirole (2006) explain that two forms of externalities pertain to TSMs, namely usage and membership externalities and corresponding fees. Nearly all gains derived in the field of TSMs are related to usage. A reader studies a newspaper and stumbles upon an advertisement or convenience or potential bonus points are generated by paying with a specific credit card. An example, proposed by Rochet and Tirole (2006), where this might not be the case is the joining of an exclusive club, since membership already grants prestige. If an interaction is perfectly observable in its complete extent, transaction-sensitive fees are possible. This is not the case for transactions within dating clubs or in regard to newspapers and the act of reading an advertisement, to name two examples. Membership is associated with fixed fees and costs incurred when joining a platform. These can be levied in any case, especially if transactions are not perfectly observable. The latter case is covered by Armstrong (2006), by modelling this mostly in the light of advertisements in media, while focusing on a fixed fee, and while no direct payments occur between the two parties. Rochet and Tirole’s (2006) work was mostly perceived with regard to credit card networks. They consider transaction-sensitive and insensitive fees. Such an approach is also reasonable for DLMs, as all transactions are perfectly observable since they are all provisioned and paid via the applied platforms, even though not all branches are prone to fixed fees. A "transaction" in the light of DLMs denotes the conduction of a task by a worker for a wage *w*, which was issued by a requester.

The first and obvious difference to the models by Armstrong (2006) as well as Rochet and Tirole (2006) is the inclusion of transaction-sensitive costs incurred by both side of agents, as already mentioned in the previous chapter 1. Other unique characteristics are the direct exchange of a wage, the different approach to the number of transactions as well as to externalities.

The exchange of a benefit in the form of an acquired good or service for a payment is not a special occurrence in TSMs. However, Rochet and Tirole (2006) did not directly model the exchange of an payment for a certain good or service. They only display an average base benefit b_i an agent receives per transaction. On a very basic level, a seller's per-transaction benefit is generated by the payment received minus the costs. A buyer's average per-transaction benefit is generated by the valuation for a certain good or service minus the payment transferred to the seller. It is reasonable to only display the net-benefit generated through such a transaction, as Rochet and Tirole (2006) did. Such an approach reduces unnecessary complexity and is appropriated if the platform cannot directly influence the transaction. As equation (1) and (2) show, the model presented here will consider a more detailed approach, as a direct exchange of a wage is represented and not just a net-benefit. This adjustment is justified by the setting of labor. The overall level of utility, especially in monetary terms, is of particular interest in regard to workers and of central attention in the ongoing discussion. This is also one of the reasons why the wage a worker receives in (1) is not reduced by the average effort a worker has to put into the conduction of a task. Furthermore, it seems reasonable to assume that the required effort-level is constant within a specific trait. It seems very unlikely that an Uber driver has to input a significantly different amount of effort into the conduction of a ride in comparison to a classical taxi driver. Along with this, the amount of effort induced by self-organization should not differ in this regard. The expended effort might be even lower in the case of Uber, as everything is organized by the phone app. By committing to a trait where effort levels do not vary too much across the industry, a worker should be indifferent about the effort level, primarily caring about the sole monetary payoff a specific business offers in comparison to other firms.[15] It further is opportune to model

[15] However, if the overall ratio of effort to utility changes too unfavorably a worker might want to switch into a different industry.

the direct transaction of a wage, as it can be directly influenced or set by the different participating elements of DLMs. The requesters set the wage in microwork, while the workers or the platform set the wage in the setting of manual labor. In the transportation business, the platforms solely determine the wage.

Another difference to Armstrong (2006) as well as Rochet and Tirole (2006) is the approach to the numbers of transactions and the correlated network effects.[16] Armstrong's (2006) presented utility function and Rochet and Tirole's (2006) utility function in regard to a setting without direct transactions between the parties, depict the number of interactions to be equal to the number of agents N_j from the opposing side. Thus, they scale the generated benefits as a linear relationship to the number of the opposing agents, representing their approach to indirect network effects. The second equation with respect to direct payments by Rochet and Tirole (2006) presents a more refined concept. Yet, ultimately the number of transactions still depends on the overall number of participating agents. The amount of transactions in this model is also dependent on the number of agents on both sides albeit showing unique features, which will be covered in the following chapter. So, equal to Armstrong (2006) and Rochet and Tirole (2006), the here developed model perceives indirect network effects as relevant in respect to the transaction numbers, this circumstance, however, depends on the considered case, as chapter 4.2.2 will show.

Nevertheless, indirect network externalities also appear as another from within equation (1) and (2). The term $N_R\beta_W$ and, respectively $N_W\beta_R$ describe extra benefits generated through indirect network effects as described in chapter 3.1.1. Meaning, that these benefits are related to an increase of market efficiency with increasing agent numbers. This is necessary, since the network effects associated with the number of transactions are only related to the market volume, solely determining the number of tasks a worker can conduct and the number of tasks a requester gets completed. As mentioned, the parameters β_W and β_R are related to market efficiency, meaning that an increase in agent numbers leads to a potentially faster matching and a better allocation of tasks in terms of skill or worker characteristics. In respect to workers, more requesters lead to a faster matching, reduced search costs and an increased probability to find suited tasks. Conducting suited work could improve ratings and the acceptance rates, which would consequentially improve

[16] As mentioned, Armstrong (2006) rather focus on membership and settings where no direct transaction occur between the agents but sole interaction.

the further success on the platform (Horton 2014; Pallais 2014).[17] A requester also experiences faster matching with an increase in worker volume. Moreover, more workers should increase the probability to find a suited worker, which will deliver better results. As previously noted, these effects are still a question of empirical research in view of DLMs. Nonetheless, β_W and β_R can be adjusted and treated accordingly, depending on their actual impact in reality, further covered by the sensitivity analysis in chapter 4.3. Overall, this is a rather simplistic approach to this theme, owed to the initial assumption of no failed tasks. Yet, this rather simple take can illustrate some interesting facets in the later analysis. Another potential approach could be the relaxation of this assumption and the inclusion of a probability for a successful trade, which would increase in agent numbers. A related approach will be taken with regard to transportation services, as the here presented utility functions (*1*) and (*2*) do not necessarily hold for this branch. An extension dedicated to this kind of services will be presented in chapter 5.

Evans and Schmalensee (2007) explain the phenomenon of congestion, meaning that the crossing of a certain threshold in terms of agent numbers lead to a decline of received benefits. Imagine a dating club where there are so many man and women that dancing and passing through the crowd becomes impossible at a certain point. Direct physical constraints like the one in the example of dating clubs are not an issue within DLMs.[18] Thus, congestion does not need to be considered in regard to transaction numbers. In regard to the benefits related to efficiency, a congestion could be valid. A sufficient number of workers would leave a requester nearly indifferent if further workers register as the available choice is already broad enough and matching happens fast enough, equally true vice versa. The basic model will ignore this circumstance for the sake of simplicity and interpretability; however, the extension regarding transportation services will implement a form of congestion.

Not covered so far are the numbers of workers and requesters. Following the example by Armstrong (2006), the number of workers N_W is assumed to be directly related to the utility U_W a worker potentially receives and is described by

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[17] Caillaud and Jullien (2003) presented a model where one agent could only derive a benefit by matching with a specific agent from the other side. Naturally, the number of opposing agents increased the probability of a successful match.

[18] Of course, there exist natural borders subject to supply and demand.

$$N_W = \Phi_W(U_W). \tag{3}$$

The function Φ_W represents a not further specified increasing function. The same assumption is made for the number of requesters:

$$N_R = \Phi_R(U_R) \tag{4}$$

The profit $\pi \in \mathbb{R}$ a platform P gains, depends on the fees charged from the workers and requesters per task. $T \in \mathbb{N}_0$ denotes the overall number of completed tasks. Moreover, the platform receives fixed fees from both parties on joining, which are reduced by fixed costs $F_P \in \mathbb{R}_0^+$ incurred by the platform for each participating agent, leading to equation (5).

$$\pi = (a_W + a_R)T + (A_W - F_P)N_W + (A_R - F_P)N_R \tag{5}$$

For every agent joining the platform, it incurs a certain amount of fixed costs F_P. Transaction sensitive costs are assumed to not be relevant for the platform. These two assumptions make sense for a digital labor setting. A new agent should only lead to an extended need to provide certain server capacities, which must be provided at any given time. Only surges of transactions at times should affect the costs structure, as serves might experience an increased level of load. Of course, this is resembling a simplified approach, since platforms like TaskRabbit might need to arbitrage a failed task between a requester and a worker. Yet, most tasks should automatically be moderated via algorithms and not cause issues to the platform. Naturally, this profit function is close to the ones presented by Armstrong (2006) as well as Rochet and Tirole (2006). However, Armstrong (2006) does not include transaction-sensitive incomes through corresponding fees and Rochet and Tirole (2006) include transaction-sensitive costs incurred by the platform.

4.2.2 Number of Conducted Tasks

As the previous part illustrated, the here developed model puts more emphasis on the direct transactions between requesters and workers. This includes a unique approach to the number of transactions by introducing an average capacity $k \in \mathbb{N}$ of tasks a worker W can conduct and an average number $\gamma \in \mathbb{N}$ of tasks a requester R generates. It would be possible to simply model an approach where workers can only conduct one task and requesters only generate one task on average, as Rochet and Tirole (2006) did. However, the inclusion of these parameters allows for a more detailed description of circumstances. Moreover, a labor setting rises the issue of underemployment, especially in view of DLMs (Codagnone et al. 2016a). Workers, in the instance of microwork, often complain about an infrequent stream of tasks (Berg 2016). Aloisi (2016) as well as Cherry (2016a) also mention, that workers can face long hours in order to make a decent living, caused by potentially low wages and/or long waiting times. Campbell (2018) reports that many workers of transportation services are registered with multiple platforms, indicating an shortage of tasks at times. The introduction of these parameters allows for a more detailed analysis in this matter. Three general cases need to be considered under these circumstances:

<u>Case I: More capacity than demand</u>

This case is given, if following condition holds:

$$\frac{kN_W}{\gamma N_R} > 1$$

This causes the number of conducted task per agent to follow subsequent equations:

$$T_W = \frac{\gamma N_R}{N_W} \tag{6}$$

$$T_R = \gamma \tag{7}$$

The demand of a requester R gets completely fulfilled. The workers on the other hand must share the tasks between themselves. The presented condition assumes that the generated tasks are equally shared between the workers, and, thus, observe an indirect form of rivalry through direct negative network effects. The more workers there are, the less tasks a worker can conduct, if the demand generating side stays the same.

<u>Case II: Equal amount of capacity and demand</u>

This case is given, if following condition holds:

$$\frac{kN_W}{\gamma N_R} = 1$$

This causes the number of conducted task per agent to follow subsequent conditions:

$$T_W = k \tag{8}$$

$$T_R = \gamma \tag{9}$$

Every worker gets provided his full capacity for tasks, while every requester gets all his demand satisfied.

Case III: Less capacity than demand

This case is given, if following condition holds:

$$\frac{kN_W}{\gamma N_R} < 1$$

This causes the number of conducted task per agent to follow subsequent conditions:

$$T_W = k \tag{10}$$

$$T_R = \frac{kN_W}{N_R} \tag{11}$$

Every worker gets provided his full capacity for tasks, while the requesters must share the overall worker capacity between them. Subsequently, the overall level of demand is not satisfied. Case I already mentioned these direct negative network effects.

Each case has its unique implications on the number of transactions and the consequent indirect network effects related to the transaction volume. As already indicated in chapter 4.2.1, indirect network effects as perceived by Armstrong (2006) and Rochet and Tirole (2006) where transaction numbers are directly related to the number of agents by the opposing side, are not necessarily given for the here presented model. Case I, for instance, depicts only the worker's transaction numbers to be dependent on the number of requesters. The requesters, on the other hand, have all their demand satisfied. In fact, case II presents both variables T_W and T_R as independent from any agent numbers.

4.2.3 Profit Maximizing Pricing Strategy

The definition and conceptualization of chapter 2.1 explicitly classified DLMs as for-profit. It therefore is viable to solve the presented functions under the premise of profit maximization, hereby focusing on the pricing strategy imposed by the platform.

The ensuing profit formula and way of solving is derived from the model by Armstrong (2006). The profit of the platform can be rewritten as following function:

$$\pi = (p_W - F_P)N_W + (p_R - F_P)N_R. \tag{12}$$

In general, the price an agent pays is composed of the variable and fixed fees already appearing in (1):

$$p_W = a_W T_W + A_W \tag{13}$$

$$p_R = a_R T_R + A_R \tag{14}$$

Equation (1) can hence be rewritten as

$$U_W = (w + N_R \beta_W - c_W)T_W - F_W - p_W. \tag{15}$$

Equation (2) can be adopted in a similar fashion:

$$U_R = (b_R + N_W \beta_R - w - c_R)T_R - F_R - p_R \tag{16}$$

Rearranging (15) and (16) accordingly and including them as well as (3) and (4) into (12) delivers:

$$\begin{aligned}\pi = {} & [(w + \Phi_R(U_R)\beta_W - c_W)T_W - F_W - U_W - F_P]\Phi_W(U_W) \\ & + [(b_R + \Phi_W(U_W)\beta_R - w - c_R)T_R - F_R - U_R - F_P]\Phi_R(U_{R)}).\end{aligned} \tag{17}$$

Initially, **Case I** in terms of task numbers is considered, implying $\frac{kN_W}{\gamma N_R} > 1$, $T_W = \frac{\gamma N_R}{N_W}$, and $T_R = \gamma$. Deriving and rearranging after U_W delivers the utility the platform should provide each worker in order to maximize its profit:[19]

$$U_W \ = \gamma \Phi_R(U_R)\beta_R - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}. \tag{18}$$

Deriving and rearranging after U_R presents the profit maximizing requester utility U_R:

[19] Whether this is truly the case will be discussed in chapter 4.3, where the sufficient conditions will be covered.

$$U_R = \gamma[b_R + \Phi_W(U_W)\beta_R + 2\Phi_R(U_R)\beta_W - c_R - c_W] - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}. \qquad (19)$$

Under conditions where work capacity exceeds demand, the platform ideally only rewards the workers for their ability to generate network externalities for requesters, as (18) shows. These benefits are reduced by the workers' and platforms' fixed costs. Furthermore, transaction-sensitive costs are shifted to the requesters, while the wage is completely deducted in order to subsidize the requesters accordingly. The last part of (18), $\frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$, can be described and understood as a markup related to the groups elasticity of demand in terms of their participation (Armstrong 2006; Rochet and Tirole 2006). In simple words, high worker numbers do allow for a bigger markup. A high increase of worker numbers in utility reduces the markup, as a smaller markup grants bigger utility and, thus, more agent numbers. This becomes clearer, as (15) and (18) are applied to calculate the profit maximizing price workers are charged for by the platform:

$$p_W = \frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}[w + \Phi_R(U_R)\beta_W - c_W] + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} - \gamma\Phi_R(U_R)\beta_R$$

According rearranging yields:

$$\frac{p_W - [\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}(w + \Phi_R(U_R)\beta_W - c_W) + F_P - \gamma\Phi_R(U_R)\beta_R]}{p_W} = \frac{\Phi_W(U_W)}{p_W\Phi'_W(U_W)}$$

Next, following Armstrong (2006) as well as Rochet and Tirole (2006), $\mu_W = \frac{p_W\Phi'_W(U_W)}{\Phi_W(U_W)}$ is defined as the price elasticity of demand, thus, delivering:

$$\frac{p_W - [\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}(w + \Phi_R(U_R)\beta_W - c_W) + F_P - \gamma\Phi_R(U_R)\beta_R]}{p_W} = \frac{1}{\mu_W} \qquad (20)$$

This equation closely follows in line with the standard Lerner-condition (Rochet and Tirole 2006), potentially allowing for subsidizing if the elasticity is big enough and network externalities generated by workers $\beta_R \gamma N_R$ are substantial.[20] The same is true for requesters, with

$$\frac{p_R - [\gamma c_W - \gamma w + F_P - 2\gamma \Phi_R(U_R)\beta_W]}{p_R} = \frac{1}{\mu_R} \tag{21}$$

In general, requesters are treated more favorably by the platform, as (19) shows. Base benefits are not deducted as well as the network externalities generated by workers. They, furthermore, are subsidized for the wage they should pay per task and are remunerated for the network benefits they generate for workers, on top receiving the benefits generated through these network effects, which prior have been deducted from the workers' utility. Therefore, the multiplication of $\Phi_R(U_R)\beta_W$ with the factor 2. On the other hand, requesters must bear both task sensitive costs. Again, fixed costs and an elasticity markup are added on top. This favorable treatment of requesters is caused by their function as bottleneck, as shown in the ensuing discussion about the constraints and implications set by the Hessian matrix.

Case II requires $\frac{kN_W}{\gamma N_R} = 1$, $T_W = k$, and $T_R = \gamma$. Deriving and rearranging after U_W delivers:

$$U_W = k(w + \Phi_R(U_R)\beta_W - c_W) + \gamma \Phi_R(U_R)\beta_R - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \tag{22}$$

And deriving and rearranging after U_R delivers:

$$U_R = \gamma(b_R + \Phi_W(U_W)\beta_R - w - c_R) + k\Phi_W(U_W)\beta_W - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \tag{23}$$

This case presents balanced relations in terms of profit maximizing utilities and is related to the findings of Armstrong (2006) as well as Rochet and Tirole (2006). Utilities of both agent groups represent mostly (15) and (16) in their general setting. Again, both sides are rewarded for their

[20] However, certain conditions need to hold to not breach the initial setting of case I. Possibly making a scenario of subsidized workers for case I nearly impossible and irrelevant. This will become clear during the discussion of the constraints in chapter 4.3.

ability to generate network benefits for the other side of agents and both groups experience a markup related to their elasticity.

Case III, with $\frac{kN_W}{\gamma N_R} < 1$, $T_W = k$, and $T_R = \frac{kN_W}{N_R}$, delivers in the same approach as the previous cases U_W and U_R:

$$U_W \ = k[b_R + \Phi_R(U_R)\beta_W + 2\Phi_W(U_W)\beta_R - c_W - c_R] - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \quad (24)$$

$$U_R \ = k\Phi_W(U_W)\beta_W - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \quad (25)$$

The here presented profit maximizing utilities are the exact opposite of case I, again showing an initially skewed pricing. This time the requesters are at a disadvantage, while only being rewarded their capability to generate externalities. However, the transaction-sensitive costs and the wage are subsidized away. Workers, on the other hand, represent the bottleneck, thus, experience substantial subsidizing. In general, the form of the equations mirrors case I back-to-front with opposing factors and indices. Thus, the findings of case I are applicable in their general nature to case III. One needs consider the opposite factors and relations.

The obtained results are presented in a compressed form within summary 1. The prices are calculated via (15) and (16) by applying the profit maximizing utility level for each case and each type of agent while rearranging for p_W respectively p_R. The platform profit was then calculated by applying (12).

Summary 1: Profit maximizing strategy by the platform - basic model

Case 1: $\frac{kN_W}{\gamma N_R} > 1$, $T_W = \frac{\gamma N_R}{N_W}$, and $T_R = \gamma$

$$U_W = \gamma \Phi_R(U_R)\beta_R - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$$

$$p_W = \frac{\gamma \Phi_R(U_R)}{\Phi_W(U_W)}[w + \Phi_R(U_R)\beta_W - c_W] + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} - \gamma \Phi_R(U_R)\beta_R$$

$$U_R = \gamma[b_R + \Phi_W(U_W)\beta_R + 2\Phi_R(U_R)\beta_W - c_R - c_W] - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}$$

$$p_R = c_W\gamma + F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - w\gamma - 2\gamma\Phi_R(U_R)\beta_W$$

$$\pi_I = \Phi_W(U_W)\frac{\Phi_W(U_W)}{\Phi'_W(U_W)} + \Phi_R(U_R)\frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - \gamma\Phi_R^2(U_R)\beta_w - \gamma\Phi_R(U_R)\Phi_W(U_W)\,\beta_R$$

Case 2: $\frac{kN_W}{\gamma N_R} = 1$, $T_W = k$, and $T_R = \gamma$

$$U_W = k[w + \Phi_R(U_R)\beta_W - c_W] + \gamma\Phi_R(U_R)\beta_R - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$$

$$p_W = F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} - \gamma\Phi_R(U_R)\beta_R$$

$$U_R = \gamma[b_R + \Phi_W(U_W)\beta_R - w - c_R] + k\Phi_W(U_W)\beta_W - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}$$

$$p_R = F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - k\Phi_W(U_W)\beta_W$$

$$\pi = \Phi_W(U_W)\frac{\Phi_W(U_W)}{\Phi'_W(U_W)} + \Phi_R(U_R)\frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - k\Phi_W(U_W)\Phi_R(U_R)\beta_W - \gamma\Phi_W(U_W)\Phi_R(U_R)\beta_R$$

Case 3: $\frac{kN_W}{\gamma N_R} < 1$, $T_W = k$, and $T_R = \frac{kN_W}{N_R}$

$$U_W = k[b_R + \Phi_R(U_R)\beta_W + 2\Phi_W(U_W)\beta_R - c_W - c_R] - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$$

$$p_W = k(w + c_R - b_R - 2\Phi_W(U_W)\beta_R) + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$$

$$U_R = k\Phi_W(U_W)\beta_W - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}$$

$$p_R = \frac{k\Phi_W(U_W)}{\Phi_R(U_R)}[b_R + \Phi_W(U_W)\beta_R - w - c_R] + F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - k\Phi_W(U_W)\beta_W$$

$$\pi = \Phi_W(U_W)\frac{\Phi_W(U_W)}{\Phi'_W(U_W)} + \Phi_R(U_R)\frac{\Phi_R(U_R)}{\Phi'_R(U_R)} - k\Phi_W(U_W)\Phi_R(U_R)\beta_W - k\Phi_W^2(U_W)\beta_R$$

Note: Own representation.

4.3 Constraints and Sensitivities

This chapter is dedicated to shedding light on potential constraints imposed by the model and to provide a rudimentary sensitivity analysis. An analysis and discussion about these constraints will show that the derived pricing can represent a global profit maximum and the related limits parameter-wise. A sensitivity analysis will allow a better understanding of the applied parameters and their effect on the agent's utilities as well as on the platform's profit. In the ensuing paragraphs, the main focus will lay on case I and II. This limitation is for two reasons: Firstly, case I and III are closely related and, as mentioned, they mirror each other back-to-front with opposing factors and indices. Thus, the findings of case I mirror back-to-front the ones of case III, making an excessive discussion of both cases redundant. Secondly, the choice between case I and III is made in favor of case I, since underemployment can hinder a decent income and is therefore an issue discussed in DLM-literature (Aloisi 2016; Cherry 2016a; Codagnone et al. 2016a).

A discussion regarding constraints and sensitivities must first solve an initial challenge. The previously presented optimal pricing politic by the platform had a very general sense to it, since $\Phi_W(U_W)$ and $\Phi_R(U_R)$ are not directly specified. Yet, a more detailed analysis in view of constraints and sensitivities demands a specification of these two functions. A discussion in this regard without a further specification would just present excessive and hazy constraints, which would offer little to no value in terms of their interpretation. Moreover, a sensitivity analysis cannot be conducted without a clear formulation of $\Phi_W(U_W)$ and $\Phi_R(U_R)$. These two functions will be defined in following manner:

$$\Phi_W(U_W) = Y_W U_W \tag{26}$$

$$\Phi_R(U_R) = Y_R U_R \tag{27}$$

The parameters $Y_W \in \mathbb{R}^+$ and $Y_R \in \mathbb{R}^+$ represent a scaling factor, which transforms monetary-based utility into worker numbers, also determining the steepness of growth in regard to the agent utility. Of course, other functions can also be viable; for instance, any form of exponential function or a function related to natural growth. The here presented linear approach describes a middle ground between root functions and exponential functions with a natural exponent, while providing enough simplicity to enable easy and clear interpretations. In any case, some broadness is sacrificed by specifying the agent's number functions, but it also enables a more detailed analysis.

Already a general constraint for F_W , F_R, and F_P can be drawn under the assumption of equations (26) and (27). The fixed costs must not exceed the agent utilities of any side to the point where negative utility is experienced by the agents. A side, which experience negative utilities, would leave a platform or not even consider joining.[21] What basic economic logic dictates is not necessarily displayed in mathematical terms. The platform profits are depicted as positive under negative agent utilities, due to the recurring part $\Phi_W(U_W)\frac{\Phi_W(U_W)}{\Phi'_W(U_W)} + \Phi_R(U_R)\frac{\Phi_R(U_R)}{\Phi'_R(U_R)}$. With (26) and (27) this part turns to $Y_W U_W^2 + Y_R U_R^2$, which ignores negative agent utilities. Therefore, it becomes necessary to mention that the fixed costs must not cross a certain threshold in view of agent utilities. The same is true for the variable costs, yet, does not necessarily set as strict conditions since the subsidized side bears them within case I and III.

4.3.1 Case I and III

Case I: $\frac{kN_W}{\gamma N_R} > 1$, $T_W = \frac{\gamma N_R}{N_W}$, and $T_R = \gamma$

The first case imposes following Hessian matrix when applying (26) and (27)

$$H_\pi = \begin{bmatrix} -2Y_W & \gamma Y_W Y_R \beta_R \\ \gamma Y_W Y_R \beta_R & 2\gamma Y_R^2 \beta_W - 2Y_R \end{bmatrix}. \tag{28}$$

A crucial question is whether the prior found stationary points in regard to the platform's profit are determining a global maximum and under which circumstances this occurs. Luckily, all entities of H_π are free of the variables U_W and U_R, consequently simplifying the answer. Under these circumstance, a global maximum is given if H_π is negative definite and (17) is consequentially strictly concave (Bradtke 2003). For a 2x2-matrix this is the case if the first leading principal minor takes a value below zero and the second leading principal minor a value above zero. The first leading principal minor has a value of $-2Y_W$. This imposes the first constraint of $Y_W > 0$ for a global maximum. The second leading principal minor is the determinant of H_π:

$$\det(H_\pi) = -4\gamma Y_W Y_R^2 \beta_W + 4Y_W Y_R - (\gamma Y_W Y_R \beta_R)^2 \tag{29}$$

[21] In a dynamic approach, however, temporarily imposed negative utilities could be modeled to actively control the ratio of work capacity to demand, as the agent numbers could be depicted in regard to a growth rate, in contrast to the absolute terms here applied.

As already stated, the determinant must take a value above zero in order to fulfill the condition of negative definiteness, demanding the condition $4 > 4\gamma Y_R \beta_W + \gamma^2 Y_W Y_R \beta_R^2$ to hold. In sum, two conditions need to be fulfilled:

$$0 < Y_W \tag{30}$$

$$4 > 4\gamma Y_R \beta_W + \gamma^2 Y_W Y_R \beta_R^2 \tag{31}$$

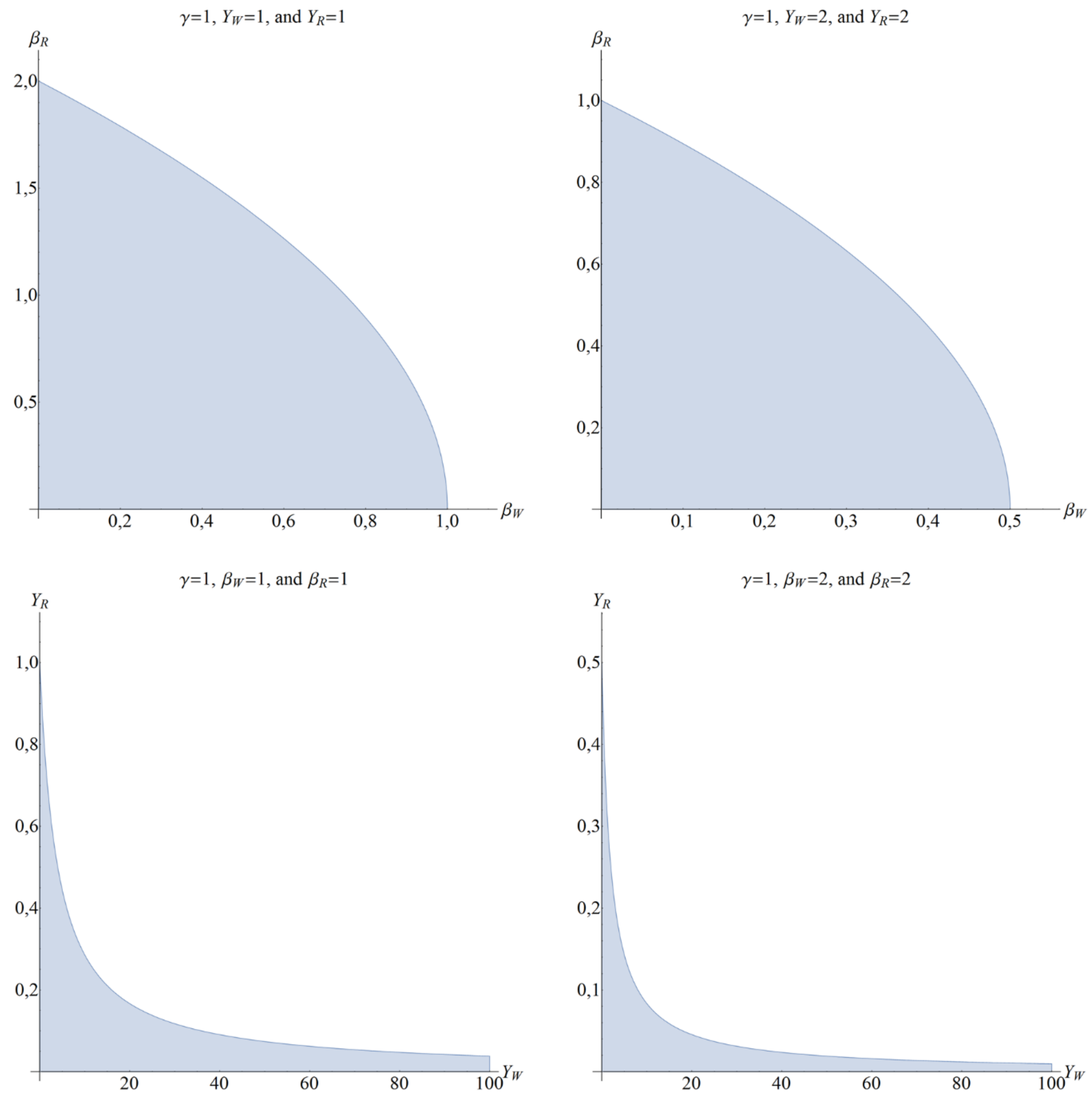
Condition (30) is obsolete. Y_W being negative or equaling zero is irrational in regard to agent numbers and the corresponding utility. Accordingly, the parameter's domain of definition was declared as strictly positive real number upon its introduction. Condition (31), however, holds only true under limited circumstances. In short, all occurring parameters need to be sufficiently low. Figure 2 shows four different graphs under which the underlying condition holds, in order to make (31) logical. The label above each graph shows the value for each other parameter not directly depicted in the graph. The network externalities, the increase of agent numbers with utility, and the task demand by requesters need to be below a certain threshold level.[22] Otherwise, (18) and (19) do not maximize the platform's profit and just represent a saddle point. If the parameters are too big, the system expands in a vicious circle of increasing utility, causing higher agent numbers, which lead to more indirect network externalities, ultimately closing the circle by further increasing utility. However, if k is too small and/or the constraints set by the Hessian matrix are violated, attracting more requesters through subsidizing leads to a breach of the initial condition $\frac{kN_W}{\gamma N_R} > 1$ under skewed pricing, consequentially leading to case II or III.

Moreover, constraint (31) indirectly indicates the requesters' role as bottleneck. The total amount of transactions is directly determined by γN_R. Thus, increasing the utility for requesters and consequentially the number of requesters does not only boost the indirect network externalities experienced by workers but does also increases the amount of transactions, possibly even in a disproportional fashion if Y_R becomes large enough. This explains the heavy subsidizing of requesters by the platform and the dominant occurrence of parameters related to the requesters in

[22] A worker's task capacity k is here irrelevant, as it was no part of the initial setup of case I, yet, is crucial in regard to the initial constraint of $\frac{kN_W}{\gamma N_R} > 1$. This will shortly become clear.

(31). Requesters and their subsidizing are more likely to cause the above described circle of increasing utilities than workers could under these circumstances.

Figure 2: Constraints set by sufficient condition - Case I



Note: Own representation.

This is illustrated by figure 2. Y_R has a clear maximum in regard to the other parameters, set by the constraint. The maximum defined range of Y_W, on the other hand, does not show a numerical boundary, meaning that Y_W could take extreme values, if the other parameters are sufficiently small. Under certain conditions, massive increases in worker numbers are irrelevant as the task generation is still limited, while increasing worker numbers provide too little indirect network externalities.

The remaining question is under what circumstances the initial condition $\frac{kN_W}{\gamma N_R} > 1$ of case I holds. This is a valid and crucial question since transaction numbers on both side are determined by the ratio $\frac{kN_W}{\gamma N_R}$. However, the platform implements a heavily skewed pricing to attract requesters and increase transaction numbers. As mentioned, workers get deducted all benefits directly related to a conducted task. The platform only rewards the workers' ability to create network externalities for the requesters and transfers task variable costs to the workers. Additionally, they must bear their and the platforms' fixed costs as well as a markup related to price elasticity. The requesters, on the other hand, keep all task related benefits while being subsidized in terms of wage and network externalities, bearing all variable costs as well as fixed costs and the elasticity markup. Under these circumstances, only limited scenarios allow condition $\frac{kN_W}{\gamma N_R} > 1$ to hold, as high requester utility can lead to high requester numbers.

Only two complementing scenarios allow for a stable but distorted pricing under the initial condition and the constraints set by the Hessian matrix:

a) The benefits workers receive through their capability to generate network effects in the form of $\beta_R \gamma N_R$ are relatively large while worker and platform fixed costs are low. On the other hand, $\gamma[b_R + \beta_R N_W + 2\beta_W N_R - c_R - c_W]$ yields in sum only little benefits for the requester and F_R is high, so that the workers' utility exceeds the one of the requesters.
b) Worker capacity k is large, so that an excessive number of requesters and little numbers of workers still lead to an overall excessive supply of work capacity, while the factor scaling the increase of worker numbers Y_W is sufficiently large.

The two scenarios are complementing. The occurrence of one scenario can already be sufficient to meet the set goals but can also be accompanied by the other remaining scenario. As already mentioned, the general nature of these findings holds true for case III but are reversed in applying to the two sides of agents as well as using the opposite factors. Yet, how do these insights and scenarios stack up to the reality of digital labor markets? Scenario a) is unrealistic to assume for DLMs. None of the three branches show features, which would justify the application of this scenario in terms of network externalities.

Scenario b), on the other hand, seems to be feasible. Condition (31) did not set any constraints to k, meaning that the task capacity of workers is not directly related to a blow up of utilities and profits within the system. This makes sense, as k has no influence on the transaction numbers in contrast to γ, neither on the agent numbers growth like Y_W, or Y_R, nor on the network effects like β_W, or β_R. This circumstance makes k crucial in regard to the abidance of condition $\frac{kN_W}{\gamma N_R} > 1$. If approached as a full-time job, workers can be available for a certain number of tasks per day, depending on the industry branch.[23] The parameter k paired with a decent remuneration per task is actually the central point of the ongoing discussion. A worker who works in DLMs to simply supplement income from a classical job is of little interest to the discussion regarding the unevenness of labor. These workers are already insured, receive employee benefits, and have a secure income, thus, due not require a certain level of remuneration as well as high number of tasks provided by a DLM platform. Their k is presumably lower compared to workers who work full-time for a DLM platform. Full-time workers need a certain level of remuneration to pay for insurances and compensate for all the benefits they do not receive as independent contractor. This circumstance is highly correlated to their demand for tasks. Aloisi (2016) and Cherry (2016a) state that workers might have to conduct many tasks and work long hours to meet this level of remuneration, leaving them with a high k. In this regard, two possible considerations should be relevant for case I. If a platform is dominated by full-time workers, the average k can take a high value, allowing for a stable skewed pricing if condition (31) is met. Then again, if a platform is dominated by part-time and casual workers, the initial condition $\frac{kN_W}{\gamma N_R} > 1$ cannot hold if the average k is too low. This leads to a balancing of the ratio $\frac{kN_W}{\gamma N_R}$, ultimately demanding case II or III. However, a sufficiently large Y_W is required, else little worker utilities paired with a small scaling factor lead to a small capacity supply, even under high k, as figure 4 will depict later on.

A closer look at utility behavior and the platform profit by applying real numbers will help to foster a feeling for the presented equations but also exemplifies the above described circumstances. The first numerical concretization, depicted in figure 3, will consider a very simple case with all costs being equal to zero. As stated, the model is perceived under no clear time horizon. It is therefore

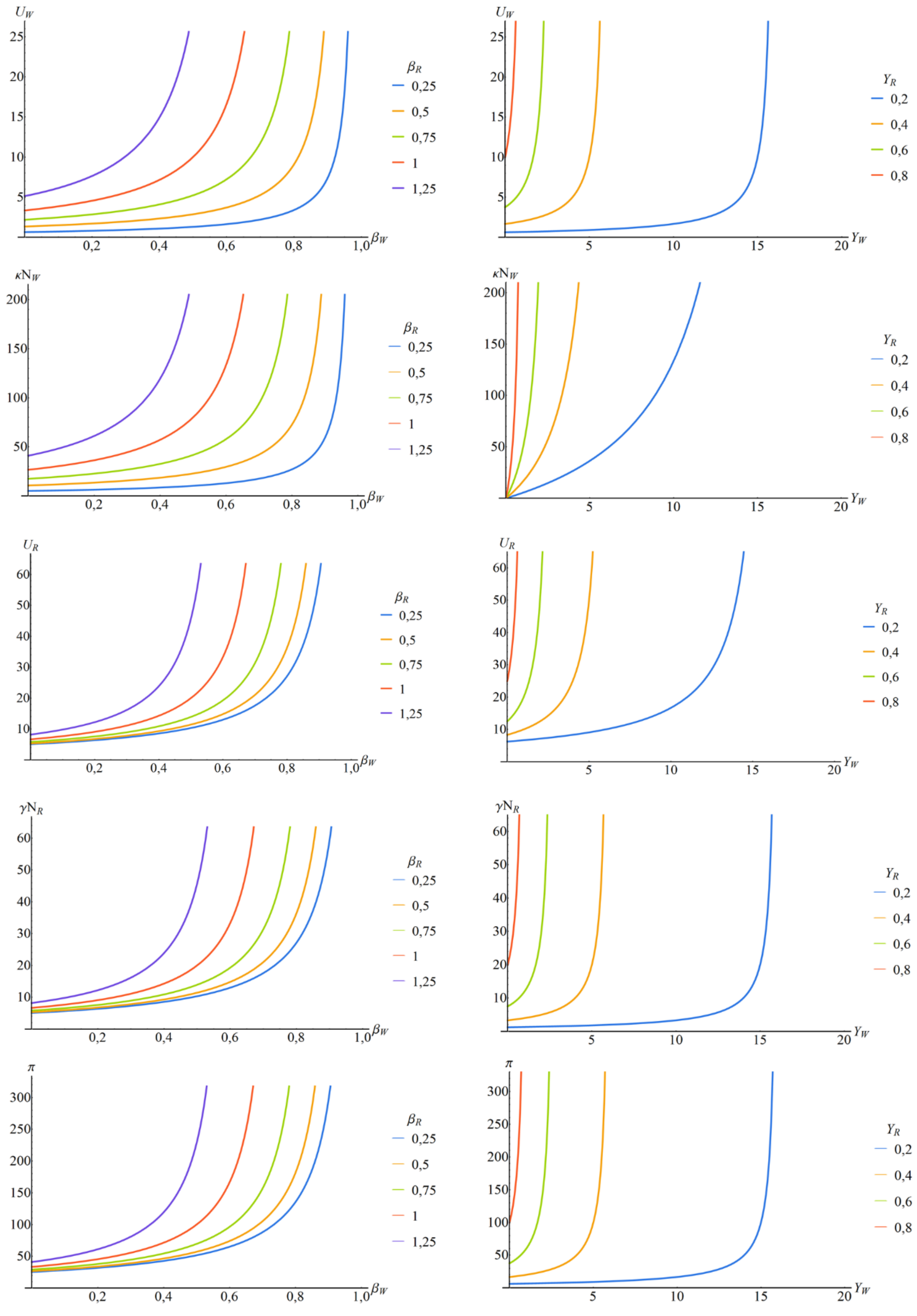
[23] In microwork, many tasks are just a matter of minutes, thus, allowing workers to conduct more tasks than within the manual labor or transportation branch.

possible to apply values in respect to different time intervals. The here presented values are perceived under the premise of a single working day: $k = 8$ tasks per day, $\gamma = 1$ tasks per day, and a requester values a completed task with an equivalent of $b_R = \$10$.[24] The parameters Y_W and Y_R take the value of 1 for the four graphs on the left-hand side. The parameters β_W and β_R take the value of 1 on the right-hand side. Both columns show the utility a worker and a requester receive, the corresponding overall demand kN_W and the provision γN_R of tasks, as well as the platform profit.

It is not possible to state whether the presented values are in accordance with reality. However, they seem feasible. For instance, within a setting of microwork, the left-hand column depicts, under the case of $\beta_W = 0.5$ and $\beta_R = 1$, a worker utility of \$10, a requester utility of \$20 and a profit of \$100. There is no source available to evaluate whether the values for the requesters and the platform are realistic; however, the research conducted by Berg (2016) indicates that at least the worker utility is reasonable under the setting of microwork. The applied values for β_W and β_R seem to suit microwork, as the tasks are menial and, thus, externalities related to matching the right worker with the right task seems far-fetched. In fact, the paper by Berg (2016) indicates that workers mainly pick the tasks according to the remuneration level. Thus, a low value for β_W seems appropriated, 0.5 may perhaps be too optimistic. A requester, on the other hand, enjoys efficiency in increasing worker numbers and faster throughput. As a general statement regarding Y_W and Y_R is not possible, a value of 1 must therefore suffice. Furthermore, Berg (2016) reports complaints regarding an insufficient supply of tasks, indicating that case I is suited to describe microwork. It must be noted that the here shown values for kN_W respective γN_R are relatively low in perspective to the numbers presented in table 2. This is a consequence of the static approach by the model, since no growth over time in regard to the provided utility level is model.

[24] Remember, the here applied values are the average oft the relevant population.

Figure 3: Behavior of utilities, capacities and profit - Case I

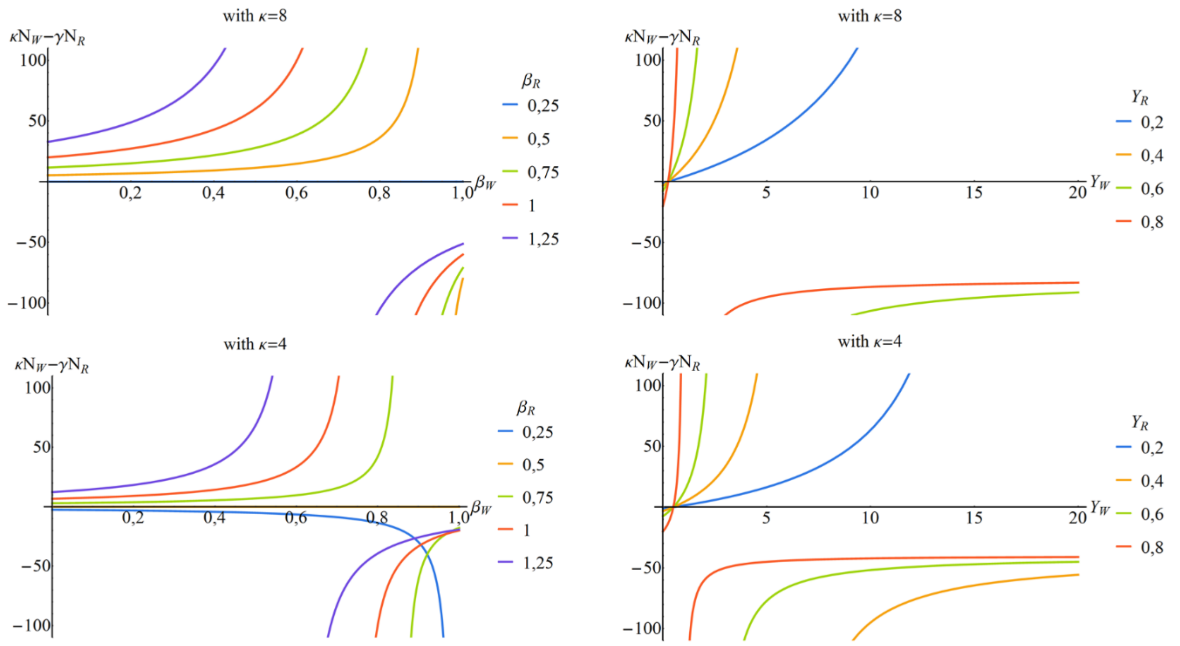


Note: Own representation. All graphs: $k = 8$, $\gamma = 1$, $b_R = 10$, and all costs being zero. Left-hand side: $Y_W = 1$ and $Y_R = 1$. Right-hand side: $\beta_W = 1$, $\beta_R = 1$.

The ratio of the depicted values for kN_W to γN_R further emphasizes the impact of indirect network externalities. For instance, under the above describe assumptions of microwork, kN_W takes the value of 80 while γN_R is 20. The platform is indifferent towards k, as long as enough work capacity is available, and it only cares about the sheer number of workers and the related ability to generate externalities. These circumstances foster overcapacities. Yet, a ratio of 1 to 4 seems extreme, especially in regard to the moderate level of β_W and β_R with 0.5 respectively 1 as values. Extreme ratios would mean that a worker receives high remunerations per task, while just being able to conduct a number of tasks below his capacity. In the above described numerical example are 10 workers and 20 available tasks, which would result in $5 per task on average in order to meet the $10 worker utility, which seems to not mimic reality (Berg 2016). Furthermore, requesters can experience massive subsidizing under relatively high network externalities, as figure 3 illustrates. Such an occurrence, however, is not observable in DLMs. For one thing, these circumstances emphasize the need of an empirical measurement of potential network externalities in DLMs. Then again, this circumstance also raises the question whether it is feasible to model network externalities as the basic model did.

Figure 3 further illustrates previously covered points in regard to the constraints. Each line of each graph approaches an asymptote, which is related to condition (31). The nature of power functions with an odd negative exponent prohibits values which would cause the right-hand side of (31) to take a value of 4, as this would mean a division by zero. Afterwards, the utility, capacity and profit values plunge into negativity, since the applied pricing of (18) and (19) becomes suboptimal. Yet this is not directly shown by figure 3 in order to prevent potential confusion. Moreover, figure 3 was generated by applying a relatively large k, with a value of 8. This state of k allows for $\frac{kN_W}{\gamma N_R} > 1$ under most circumstances. Figure 4 shows the difference of task demand and supply with k holding the value of 8 and again with 4. This hereby illustrates in figure 4 not only the impact of k in regard to $\frac{kN_W}{\gamma N_R} > 1$ but also in respect to β_W, β_R, Y_W, Y_R as well as the above mentioned nature of the function. Each figure's right-hand side to its respective asymptote section can be ignored due to the breach of condition (31). The two graphs on the left-hand side show that a small k paired with small β_R lead to $\frac{kN_W}{\gamma N_R} < 1$.[25] Y_W and Y_R, on the other hand, are of little importance in this regard, as the right-hand graphs depict. It is only required that Y_W is sufficiently large.

Figure 4: Difference between task demand and supply under two different k - Case I



Note: Own representation: All graphs: $k = 8$, $\gamma = 1$, $b_R = 10$, *and all costs are zero. Left-hand side:* $Y_W = 1$ *and* $Y_R = 1$. *Right-hand side:* $\beta_W = 1$, $\beta_R = 1$.

The last open matter are the costs, though no fundamental insights can be gained in this regard. All transaction sensitive and fixed costs simply reduce the utility of both agent sides and the profit of the platform. This is no surprise, as the agents are dependent in their utility on the other side through network externalities. The platform's profit is directly linked to the agent numbers. Any cost will result in reduced agent numbers and will consequentially reduce the utility/profit of all involved parties. Worth mentioning is also the strength of effect of the different types of costs. The costs with the most impact are the platform costs, as they are generated by both side of agents. The worker fixed costs mainly affect the workers while the requester fixed costs affect both side of agents, since the requesters function as bottleneck. Both variable costs equally affect workers and

[25] Remember, a small β_R causes a low remuneration of workers, as they are only paid for their ability to generate network externalities.

requesters, due to the imposed pricing scheme and the role of the requesters. Table 6 provides a small numerical outline based on the values of the previous microwork example to provide a better understanding. Naturally, the absolute extent of the effect of all costs varies in the applied parameters. Yet, a more in-depth discussion in regard to the other parameters would exceed the scope of this thesis while not providing any further important insights.

Table 6: Selected numerical example of cost effects on utility and profit - Case I

Cost	c_W				c_R				F_W				F_R				F_P			
Value in $	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
U_W in $	10	9	8	7	10	9	8	7	10	9	8	7	10	9	8	7	10	8	6	4
Reduction	-	10%	20%	30%	-	10%	20%	30%	-	10%	20%	30%	-	10%	20%	30%	-	20%	40%	60%
U_W in $	20	18	16	14	20	18	16	14	20	19	18	17	20	18	16	14	20	17	14	11
Reduction	-	10%	20%	30%	-	10%	20%	30%	-	5%	10%	15%	-	10%	20%	30%	-	15%	30%	45%
π in $	100	81	64	49	100	81	64	49	100	90.5	82	74.5	100	81	64	49	100	72.5	50	32.5
Reduction	-	19%	36%	51%	-	19%	36%	51%	-	9.5%	18%	25.5%	-	19%	36%	51%	-	27.5%	50%	67.5%

Note: Own representation. $k = 8, \gamma = 1, b_R = 10, Y_W = 1, Y_R = 1, \beta_W = 0.5, \beta_R = 1.$

<u>Case III:</u> $\frac{kN_W}{\gamma N_R} < 1$, $T_W = k$, and $T_R = \frac{kN_W}{N_R}$

Case III delivers following Hessian matrix and the corresponding determinant:

$$H_\pi = \begin{bmatrix} 2kY_W^2\beta_R - 2Y_W & kY_WY_R\beta_W \\ kY_WY_R\beta_W & -2Y_R \end{bmatrix} \tag{32}$$

$$\det(H_\pi) = -4kY_W^2Y_R\beta_R + 4Y_WY_R - (kY_WY_R\beta_W)^2 \tag{33}$$

This case imposes two conditions, which need to hold, in order to globally maximize profits with respect to the two derived utility equations.

$$1 > kY_W\beta_R \tag{34}$$

$$4 > 4kY_W\beta_R + k^2Y_WY_R\beta_W^2 \tag{35}$$

Condition (34) is set by the first leading principal minor while (35) is deduced from the second leading principal minor. Condition (35) is closely related to condition (31) of case I. New to this is (34), yet it does not lead to stricter constraints, since (35) already covers this condition with

$4kY_W\beta_R$, and can, thus, be ignored. Again, a certain threshold must not be crossed by the parameters in order to ensure a global maximum. Otherwise, profits can be further increased by providing both agents with added utility. This time, however, the workers are the bottleneck, justifying their subsidizing. Hence, if condition (35) does not hold and if γ is too small, the initial condition $\frac{\mathrm{kN_W}}{\mathrm{\gamma N_R}} < 1$ will eventually break, leading to case I or II.

4.3.2 Case II

The second case, with $\frac{kN_W}{\gamma N_R} = 1$, $T_W = k$, and $T_R = \gamma$, delivers following Hessian matrix:

$$H_\pi = \begin{bmatrix} -2Y_W & kY_WY_R\beta_W + \gamma Y_WY_R\beta_R \\ kY_WY_R\beta_W + \gamma Y_WY_R\beta_R & -2Y_R \end{bmatrix} \quad (36)$$

and the determinant

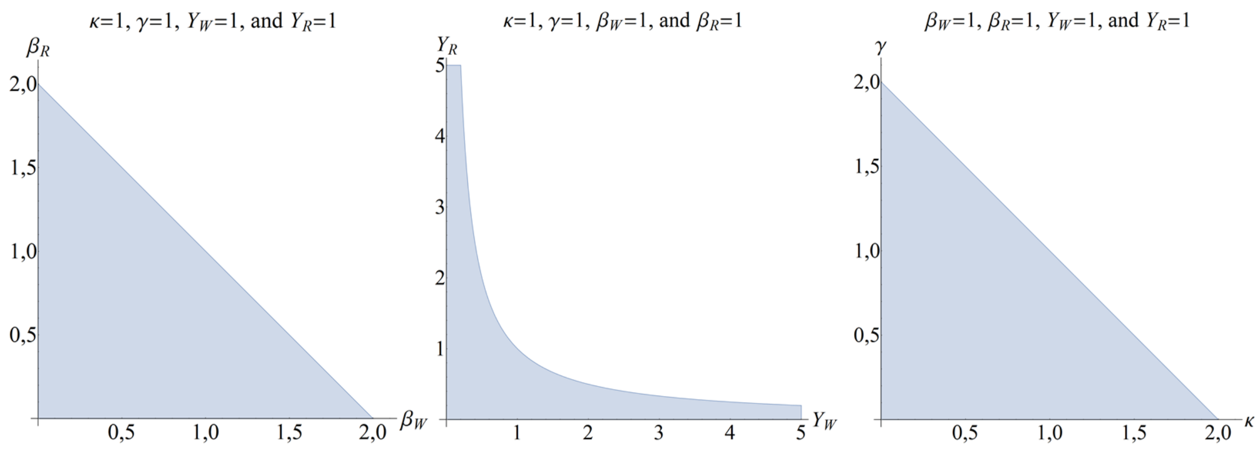
$$\det(H_\pi) = 4Y_WY_R - (kY_WY_R\beta_W + \gamma Y_WY_R\beta_R)^2. \quad (37)$$

Y_W and Y_R are required to be greater than zero and the second leading principal minor, derived from the determinant, imposes following constraint under which a global maximum is met:

$$4 > k^2Y_WY_R\beta_W^2 + 2k\gamma Y_WY_R\beta_W\beta_R + \gamma^2Y_WY_R\beta_R^2 \quad (38)$$

Condition (*38*) is stricter than (*31*), since it does not only impose constraints on the network externalities and the parameters scaling agent numbers but also on k and γ at the same time. This leads to a limitation of k in regard to the other parameters. In general, the applied parameters need to be reasonable in their extent and must not exceed the described threshold. Elsewise, the applied pricing scheme renders suboptimal. Figure 5 shows different possible values the parameters can take under varying circumstances, accordingly described by the corresponding label.

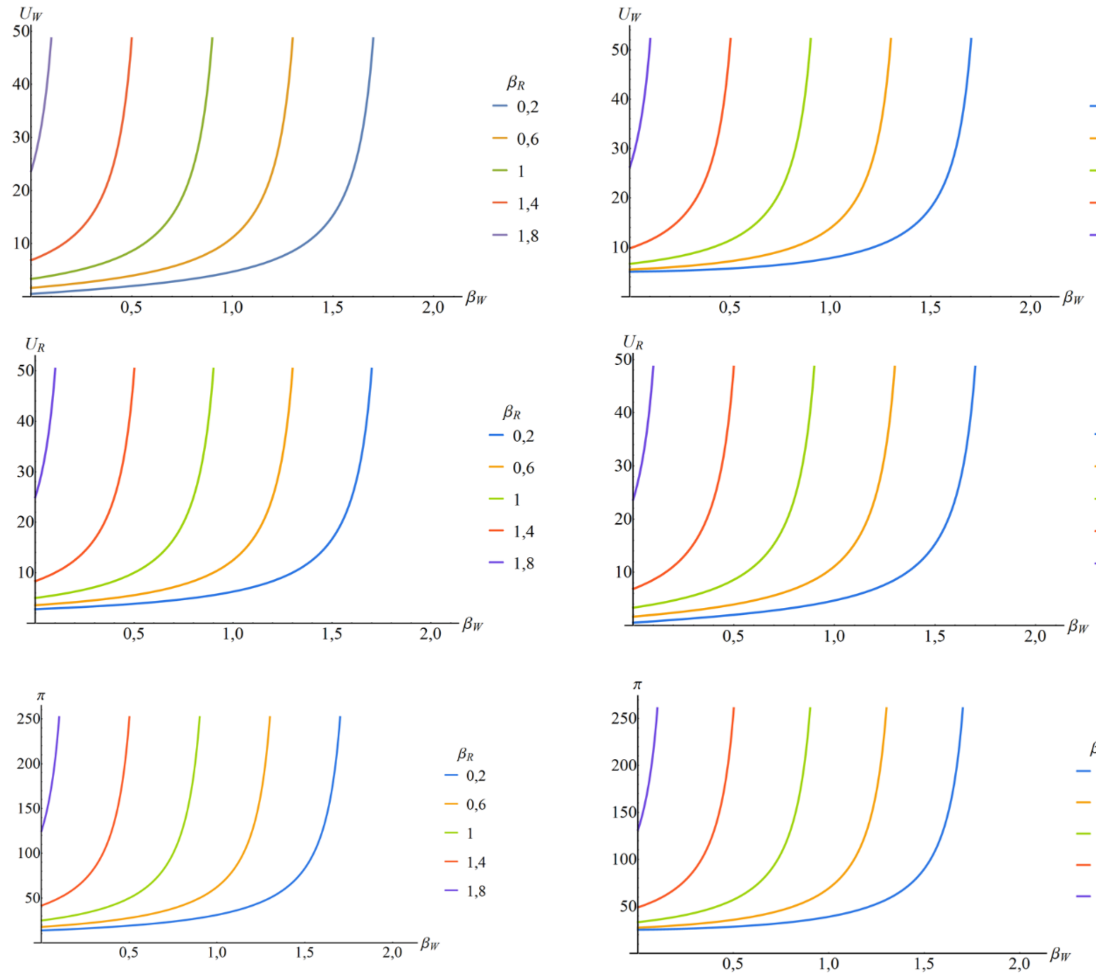
Figure 5: Constraints set by sufficient condition - Case II



Note: Own representation.

The first step regarding an analysis of case II is to look at the agents' utilities and the platforms' profit under relatively equal circumstances, meaning that k and γ take the value of 1, depicted by figure 6. The remaining parameters are related to the values applied during the analysis of case I, with $b_R = 10, Y_W = 1$, $Y_R = 1$ and no costs. Contrary to case I and II, however, the wage is now relevant. The left-hand graphs are based on a wage of 5 while the right-hand graphs are depicted while assuming a wage of 10.

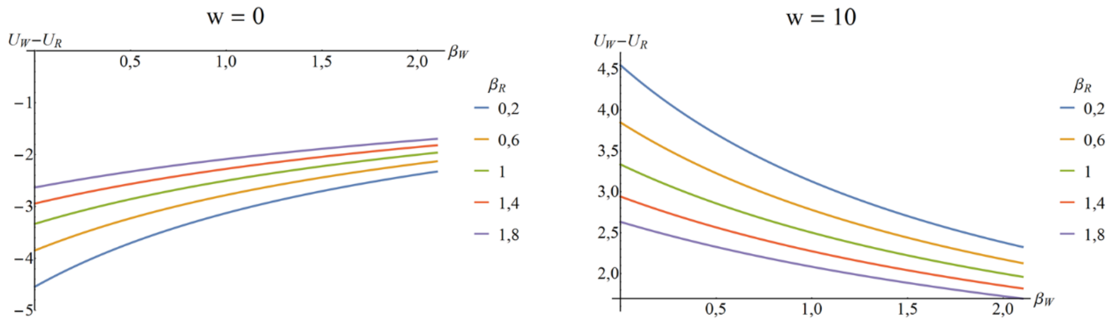
Figure 6: Behavior of utilities, utility difference, and profit - Case II



Note: Own representation. All graphs: $Y_W = 1$, $Y_R = 1$, $k = 1$, $\gamma = 1$,$b_R = 10$, *and all costs are zero. Left-hand side:* $w = 5$. *Right-hand side:* $w = 10$.

Overall, both agent sides experience relatively equal utility levels compared to case I and III. Noteworthy is the impact of the wage, or rather the relative lack thereof. Figure 6 already indicates that the wage deducted from requesters plays only a little role in regard to agent utilities or the platform profit in relation to varying β_W and β_R. This circumstance is clearly shown in figure 7.

Figure 7: Utility differences caused by two different wage levels - Case II



Note: Own representation. All graphs: $Y_W = 1$, $Y_R = 1$, $k = 1$, $\gamma = 1$,$b_R = 10$, *and all costs are zero. Left-hand side:* $w = 0$. *Right-hand side:* $w = 10$.

A high wage slightly improves the worker utility while equally decreasing requester utility. The differences in agent utility are hereby not determined by the absolute wage but how it splits the value b_R between the two parties. An equal splitting of b_R reduces the utility differences to zero, under the assumption of the presented parameter values. For instance, the case of b_R equaling 10 would require a wage level of 5. The same is true in regard to the other four parameters Y_W, Y_R, k, and γ. The impact of wage on the utility differences is further defined by the externalities and the absolute size of b_R. Figure 7 shows the dampening effect of the externalities. The higher they are, the greater an unequal splitting of b_R rebounds to the favored party. For instance, a high wage leads to a large transfer of b_R to the workers but at the same time reduces the requester utility and consequentially the requester number. This, on the other hand, reduces the utility workers gain from indirect network externalities. The greater they are, expressed in β_W and β_R, the more the utility is reduced. The impact of the wage is further influenced by the absolute size of b_R and the related potential extent of unequal splitting. The value of 10, as assumed in figure 6 and figure 7, is relatively small compared to benefits generated through network externalities and the related subsidizing through the platform. The higher b_R, the more effect a wage has. Utility differences potentially induced by an unequal splitting of b_R leads to a violation of $\frac{kN_W}{\gamma N_R} = 1$.[26] Yet these differences are marginal under moderate values for b_R, compared to differences encountered in

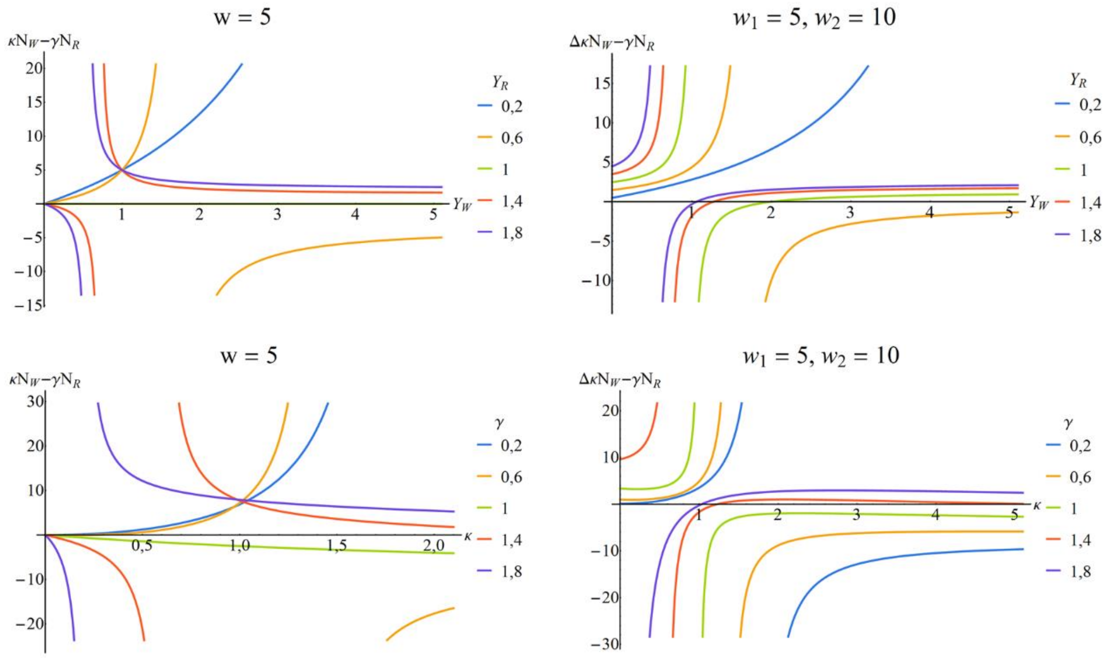
[26] Y_W, Y_R, k, and γ equal 1 in the above shown figure 6 and figure 7. The utility values therefor are the same as kN_W respectively γN_R.

case I and III. A complete transformation of case II into case I or III seems not to be justified under a moderate b_R with sufficiently large network externalities. The parameters β_W and β_R in isolation, on the other hand, have no influence on utility differences and the ratio of $\frac{kN_W}{\gamma N_R}$. This is owed to the circumstance that the platform subsidizes the other side equally for the externalities it generates for the other side.

However, wage differences in combination with adjusted parameters Y_W, Y_R, k, and γ can cause disturbances regarding the condition $\frac{kN_W}{\gamma N_R} = 1$, as illustrated by figure 8.[27] The disturbances are hereby mainly caused by the parameters Y_W, Y_R, k, and γ, as the left-hand graphs show, which were generated under the assumption of an equal splitting of b_R. The right-hand graphs depict the effect of an unequal splitting paired with variations in Y_W, Y_R, k, and γ, by illustrating the difference between $kN_W - \gamma N_R$ under a wage equaling 5 and then equaling a value of 10. This amplifies an unequal splitting and breaches $\frac{kN_W}{\gamma N_R} = 1$ but is not the main cause, unless b_R takes a large value, emphasizing the statement of the previous paragraph. The main cause in this regard represent distortions in Y_W, Y_R, k, and γ, since they directly influence the number of transactions.

[27] As previously mentioned, only the part left of a corresponding asymptote is within the boundaries of condition (38).

Figure 8: Differences in work supply and demand under different wage settings - Case II

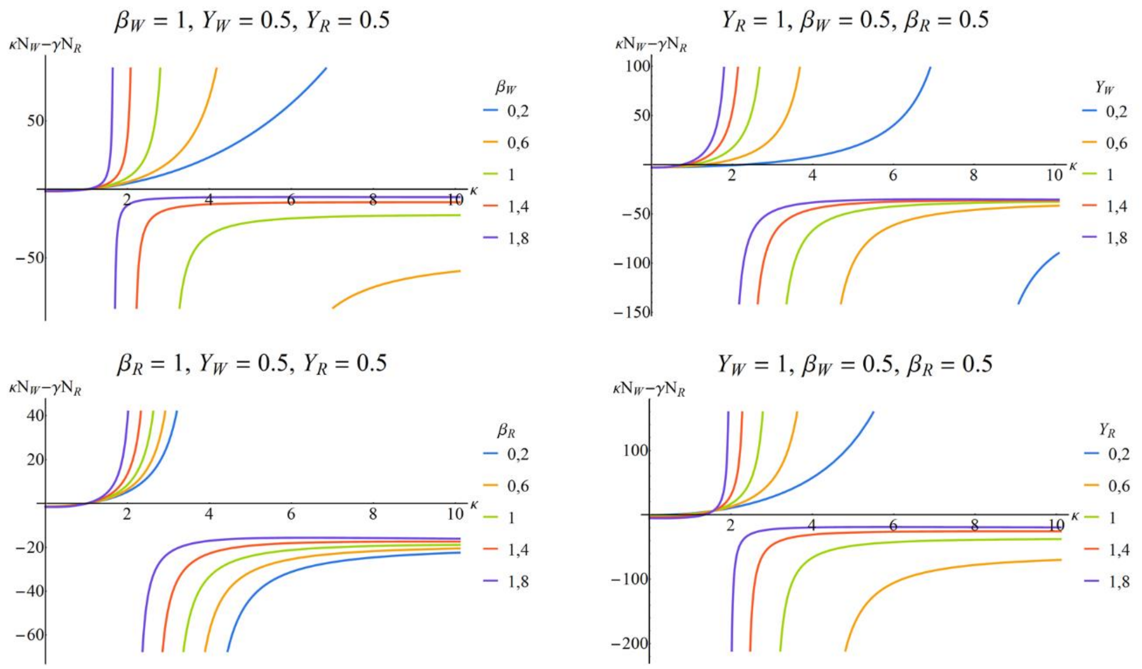


Note: Own representation. All graphs: $b_R = 1,\ \beta_W = 1, \beta_R = 1$, *and all costs being zero.*

Especially interesting in this regard is the parameter k, since workers are likely to have an increased demand in tasks to further boost their income. This is particularly relevant in view of the ongoing discussion, if a limited number of tasks is not sufficient to provide enough utility for a living. Figure 9 displays the effect of a varying k on the initial condition $\frac{kN_W}{\gamma N_R} = 1$ under different circumstances. The parameter γ hereby takes the value of 1. The other parameters need to take moderate values, or this causes an immediate breach of (*38*) under most circumstances. For all cases, figure 9 shows a rapid increase of worker overcapacities for a rising k, followed by a breach of condition (*38*). It must, therefore, be concluded that case II is only stable under very moderate levels regarding the applied parameters, as in, if k is significantly large than γ. Consequentially, the system moves towards case I in its setting, since a ratio of $\frac{kN_W}{\gamma N_R} > 1$ becomes apparent if strict requirements regarding the other parameters are not met.

Regarding costs, case II does not impose any new fundamental insights, compared to case I and III. All costs still have an impact on all parties. However, the agent costs have now an equal impact, as no side represents a bottleneck. The costs with the most effect are still the platform fixed costs incurred for every agent.

Figure 9: Effect of a varying k on the difference between task demand and supply



Note: Own representation. $\gamma = 1$, $w = 5$, *and* $b_R = 10$. *The values for the other parameters are stated above each graph.*

4.4 <u>Interim Summary of Findings</u>

The following chapter will quickly summarize the most important findings, which can be deducted from the basic model. Firstly, a comparison with shared results of Armstrong (2006) as well as Rochet and Tirole (2006) is appropriated as their papers served as the groundwork for this model. The common feature shared with Armstrong (2006) is the deduction of platform fixed costs and the elasticity markup $\frac{\Phi_W(U_W)}{\Phi'_W(U_W)}$ in regard to all agent utilities. Another shared feature is the circumstance that agents get rewarded for their ability to generate network externalities for the other side of agents. Rochet and Tirole (2006) also consider the demand elasticity as a crucial feature in determining optimal pricing by the platform. Both papers understand this elasticity as central in explaining skewed pricing occurring in two-sided markets and the subsidizing of one group of agents by pricing the other group accordingly. This also applies to the basic model regarding DLMs. Yet, this industry includes another factor that can cause skewed pricing, namely the ratio of work capacity to demand $\frac{kN_W}{\gamma N_R}$. In fact, worker capacities and requester demand are crucial factors in determining optimal utility levels and whether skewed pricing might be stable in the long run. None of the mentioned papers consider these factors, as they mostly focus on a setting, where benefits are not limited by the number of transactions.[28] The platforms profit function for case II, depicted in summary 1, is closely related to the findings of Armstrong (2006) as well as Rochet and Tirole (2006). The platform receives from every agent a corresponding elasticity markup while bearing the costs of subsidizing both sides of agents. Yet, case I and III showed deviations in the matter of subsidizing externalities, since the bottleneck side received the generated externalities plus a corresponding subsidy. More similarities are not shared with the other two papers in terms of derived findings.

As mentioned, skewed pricing is central to DLMs under the consideration of case I and II. This is not only caused by a markup related to elasticity of demand but is due to a shifting of costs and related benefits, and through a subsidizing of network externalities. Critical in this matter is the transaction number. The side, which functions as a bottleneck, will be treated favorably, while the other side will just be remunerated for its ability to generate network externalities. However, if the matters are balances in terms of transaction numbers, the pricing and the correlated agent utilities will assume a relatively balanced state. Only under the setting of case II, the wage does play a role, else it gets accordingly allocated by the platform's applied pricing scheme. Overall, wage has only a little effect on utilities and profit, if the valuation of a requester for a completed task is moderate and/or externalities effects are significantly large.

The initial utility equations for workers and requesters (1) and (2) presented a transaction sensitive fee and a fixed membership fee as the platforms' available pricing tools. Summary 1 specified the extent of prices but did not further elaborate on how to allocate it between variable and fixed charges. Armstrong (2006) argues that fixed and variable charges can make a differences, yet, not in a monopoly setting. A discussion on how to potentially allocate the derived pricing between fixed and variable costs will not be covered, as such a discussion would not add to the set research questions and would exceed the scope of this thesis. Readers interested in this matter are directed

[28] Rochet and Tirole (2006) did discuss direct interactions where direct payments between agents are occurring, but do not consider a limitation of interaction directly by agent numbers and their capacity respective demand.

to the papers by Armstrong (2006), Rochet and Tirole (2006) as well as Weyl (2010) as initial starting point of research.

Relatively unspectacular is the matter of costs. In general, all costs affect all involved parties through indirect network externalities. The strength of this effect can vary amongst the involved parties depending on the type of cost. For instance, in a scenario of unequal pricing, the agent party, which is not the bottleneck, will be affected the most by its fixed costs. The platform fixed costs have the most impact on all parties in all scenarios.

One rather subtle finding is related to the stability of the observed cases and the resulting consequences. With a high demand for tasks by the workers, the system usually leans towards case I, where the requesters act as bottleneck. A skewed state of the system and pricing is, thus, inherent to platforms under the assumption of full-time labor, if requesters only show a humble capacity to generate tasks and if network externalities play an important enough role. Here lies the main different between normal firms and DLMs; the latter can strive to attract many workers to the platform. This is allowed by the cost structure these DLM-companies exhibit through the classification of workers as independent contractors. The platforms can have a large number of workers on standby without facing labor-costs. This circumstance permits them to pursuit a large labor force, even if an undersupply of tasks is apparent. Yet, manual labor and transportation services offer their workers a relatively normal level of remuneration, so other factors, besides the transaction numbers and the markup related to elasticity, should also be considered for this industry. For transportation services, the circumstance of "timely matching" is relevant and a different approach to network externalities, which will be covered in the following chapter. Moreover, just because a platform might yield positive utility for workers does not automatically mean that workers group to this work option, especially considering the setting of labor. Platforms must compete with other job opportunities and selected parts of the labor market for workers. A setting in view of competition will be presented and analyzed in chapter 6.

5. Transportation Services

As previous chapters mentioned, transportation services require an adjusted approach. Two related factors make the adaption of the basic model necessary: Firstly, network effects possibly occur in a different form than previously. Secondly, timely matching imposes a new challenge on the transportation platforms. Timely matching describes the circumstance in which a free worker needs to be matched with a requester as soon as demand arises. The chapter will not provide an excessive approach as the previous chapter did, since this chapter's main motivation is to explain the relatively decent remuneration of workers in a transportation setting.

Chapter 3.1.1 explained that the consideration to skill and the idea of matching the right job with a suited worker to generate extra benefits seems far-fetched for transportation services. Customers and workers should not care with whom they match, only about the matching efficiency. Indeed, neither the customer nor the worker have a direct influence with whom they match, in contrast to the other industry branches. The part $\beta_W N_R$ respectively $\beta_R N_N$ to the prior worker and requester utility functions were dedicated to display increased benefits generated through matching the right worker with the right job but also the matching efficiency. The former consideration, benefits trough suited matches, becomes obsolete for transportation services. Matching efficiency will now be displayed in a different fashion, consequentially rendering $\beta_W N_R$ and $\beta_R N_N$ as redundant. However, indirect network externalities in regard to the transaction volume are still in effect.

Indirect network effects through matching efficiency will now be displayed by a matching probability. The model presented below will assume that a potential request by a customer will be forfeited if the customer must wait too long for his delivery or until a worker is there to pick him up. This implies the need of timely matching. In other words, work capacity must be available as soon as a customers' request arise, in contrast to microwork and manual labor.[29] This calls for an ideal ratio of provided work capacity to demand if the platform aims to serve all customers. This

[29] In the setting of microwork and manual labor, demand does not necessarily need to be satisfied immediately. However, the faster a match is generated and the sooner the task is completed the better for the requester. Still, the matching process should not take too long, or requester might search for a worker outside the platform.

ideal ratio will be denoted as v. Table 7 presents the three different numerical states $v \in \mathbb{R}^+$ can take and the related possible scenarios of the actually occurring ratio.

Table 7: Potential range of the ideal ratio of work capacity to demand and related scenarios

I: $v < 1$	**II: $v = 1$**	**III: $v > 1$**
I.1: $\frac{kN_W}{\gamma N_R} > 1$	**II.1:** $\frac{kN_W}{\gamma N_R} > v$	**III.1:** $\frac{kN_W}{\gamma N_R} \geq v$
I.2: $\frac{kN_W}{\gamma N_R} = 1$	**II.2:** $\frac{kN_W}{\gamma N_R} = v$	**III.2:** $1 < \frac{kN_W}{\gamma N_R} < v$
I.3: $v \leq \frac{kN_W}{\gamma N_R} < 1$	**II.3:** $\frac{kN_W}{\gamma N_R} < v$	**III.3:** $\frac{kN_W}{\gamma N_R} = 1$
I.4: $\frac{kN_W}{\gamma N_R} < v$	-	**III.4:** $\frac{kN_W}{\gamma N_R} < 1$

Note: Own representation.

The first possible state for v is to be less than 1, meaning an oversupply of demand is needed to satisfy timely matching. This case is generally irrelevant and economically irrational for every scenario where the requesters are driving demand and represent the initiating cause of a transaction and, respectively, the conduction of a task. It was added to the table for the sake of completeness. The second case depicts v equal to 1. This ratio is sufficient when a platform can estimate the extent, the timing, and the location of arising demand well enough and is able to schedule its' workers accordingly.[30] Thus, this case is idealized and difficult to realize or sufficient if timely matching in combination with self-scheduling are not an issue, as assumed by the basic model.

The third and last case is an ideal ratio above 1. This assumption is reasonable if the extent, the timing, and/or the location of demand cannot be predicted sufficiently precise. Another important factor, however, is the circumstance of self-scheduling, meaning that workers decide when to work. Gurvich et al. (2016) showed that self-scheduling requires employers or platforms to attract a greater pool of workers compared to the schedule being issued by the platform itself if a certain rate of served customers should persist. Self-scheduling is an important feature of DLMs. Most

[30] For instance, imagine an airport or train station where a taxi firm provides transportation in a monopolistic setting. Empirical values and experience gained with time will allow the taxi provider to schedule accordingly, permitting in the long-run a ratio of supply and demand near one.

workers are classified as independent contractors and decide on their own when and for how long to work. It is reasonable to assume that a transportation platform requires an ideal ratio above one, if aiming to satisfy all incoming requests under the constraints of timely matching.

With respect to the previous considerations, worker utility will be described as follows:

$$U_W = (w - c_W - a_W)T_W\lambda\left(v, \frac{kN_W}{\gamma N_R}\right) - F_W - A_W \tag{39}$$

Requester utility is expressed by

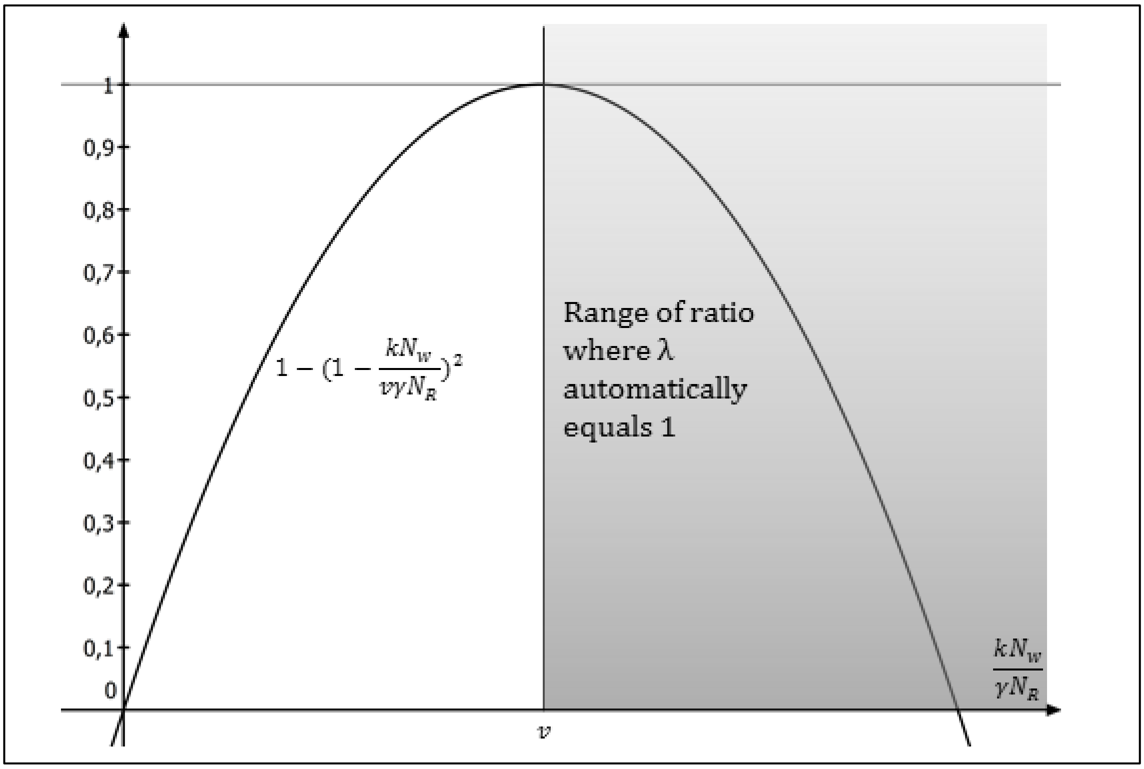
$$U_R = (b_R - w - c_R - a_R)T_R\lambda\left(v, \frac{kN_W}{\gamma N_R}\right) - F_R - A_R. \tag{40}$$

Both equations closely resemble the initial utility function (1) and (2), this time without benefits generated by $\beta_W N_R$ respectively $\beta_R N_N$, while being extended by $\lambda\left(v, \frac{kN_W}{\gamma N_R}\right)$. The function λ describes the average probability of a request to take place and depends on the ideal ratio of work capacity to demand and the actual existing rate, taking the ensuing form:

$$\lambda\left(v, \frac{kN_W}{\gamma N_R}\right) = min\left\{1 - (1 - \frac{kN_W}{v\gamma N_R})^2; 1\right\} \tag{41}$$

If the actual ratio $\frac{kN_W}{\gamma N_R}$ is below the ideal ratio v, the probability λ of a successful completion of a request is below 1 and is described by $1 - (1 - \frac{kN_W}{v\gamma N_R})^2$. As soon as $\frac{kN_W}{\gamma N_R}$ equals or is above v, all requests are fulfilled and, thus, λ takes the value of 1. The value of λ for the case of $\frac{kN_W}{\gamma N_R} < v$ is depicted in figure 10. The probability raises in $\frac{kN_W}{\gamma N_R}$, portrayed by a downward-opening parable, designed to take the value of 1 when $\frac{kN_W}{\gamma N_R}$ equals v.

Figure 10: Probability of a successful match



Note: Own representation.

In summary, the initial assumption implemented by the basic model of no failed task is not applicable anymore. A ratio of work capacity and demand below v will leave some customers waiting too long and consequentially forfeiting their request, while utilizing other means of transportations or transportation services. This accordingly reduces the overall number of conducted tasks on the platform, equally affecting the workers and requesters of the platform, as (39) and (40) depict. The indirect network externalities associated with $\beta_W N_R$ and $\beta_R N_N$ are irrelevant. They now appear in the form of waiting time and the subsequent probability of a successful request. Requesters indirectly experience, on average, greater utility the more work capacity is available on the platform, until the threshold v is met. Workers also experience this effect but as a positive direct network effect. They must now consider a trade-off between sharing the conducted tasks amongst themselves and the danger of reduced overall task numbers if not enough work capacity is provided.[31] Additionally, the inclusion of $\lambda\left(v, \frac{kN_W}{\gamma N_R}\right)$ automatically introduces a weak form of congestion to the model, since the matching probability immediately equals 1 as soon as the threshold v is met.

The profit function of the platform now takes the following form:

$$\pi = \Phi_W(U_W)\left((w - c_W)T_W\lambda\left(v, \frac{kN_W}{\gamma N_R}\right) - F_W - U_W - F_P\right) + \Phi_R(U_R)\left((b_R - w - c_R)T_R\lambda\left(v, \frac{kN_W}{\gamma N_R}\right) - F_R - U_R - F_P\right) \tag{42}$$

As already discussed, only the last column of table 3 should be of interest regarding digital labor markets. For $v > 1$, four relevant cases of the actual ratio $\frac{kN_W}{\gamma N_R}$ can be identified. The ensuing subchapters will analyze each case in regard to the profit maximizing pricing policy a transportation platform should implement, followed by a short discussion regarding the constraints and an interim presentation of the findings.

5.1 Profit Maximizing Pricing Strategy

The first **case III.1** requires $\frac{kN_W}{\gamma N_R} \geq v$ and therefore sets λ equal to 1, with $T_W = \frac{\gamma N_R}{N_W}$ and $T_R = \gamma$. Case III.1 resembles the case of the basic model in which $\frac{kN_W}{\gamma N_R}$ was bigger than 1, this time without the extra benefits generated by indirect network externalities. Thus, it seems obvious to expect a familiar result, yet, for the sake of completeness this case will be covered.

Deriving (26) after U_W delivers

$$U_W = -F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}. \tag{43}$$

Deriving after U_R provides

[31] Furthermore, in the long run, requester numbers might decrease if they have to forfeit a request too often, further negatively affecting drivers. Yet, such considerations cannot be displayed by the model, since the model is perceived in respect to an undefined time horizon and in a static fashion.

$$U_R = \gamma(b_R - c_R - c_W) - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}. \quad (44)$$

The pricing scheme is mostly the same as case I of chapter 4. The platform prices away the worker's wage while subsidizing the variable costs. Requesters, on the other hand, are subsidized for the wage charged while they have to bear both variable costs. Again, the platform imposes its fixed costs onto the agents while deducting an elasticity related markup. However, the agents are not subsidized for their ability to generate network externalities, which causes the workers to automatically incur a negative utility. As previously stated: Such an outcome is relatively irrelevant and irrational for a static model, yet it could be important in regard to dynamic considerations, while the platform might impose temporary negative utilities to adjust the rate of workers in order to move the ratio $\frac{kN_W}{\gamma N_R}$ in a more favorable direction.

Case III.2 demands $1 < \frac{kN_W}{\gamma N_R} < v$ with $T_W = \frac{\gamma N_R}{N_W}$, $T_R = \gamma$, and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$. Plugging these values into (26) and deriving after U_W delivers the profit maximizing worker utility:

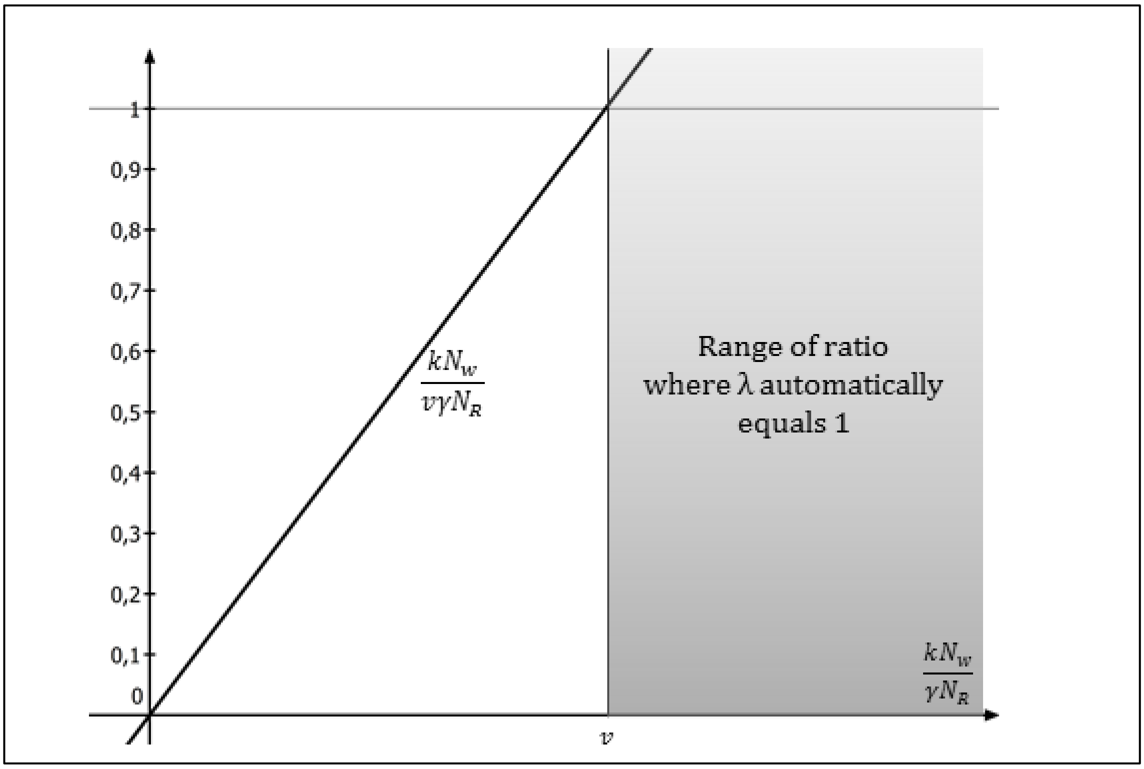
$$U_W = 2\frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}\Big(b_R - \frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}b_R - c_W + \frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}c_W - c_R + \frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}c_R\Big) - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \quad (45)$$

The repeating and crucial part $\frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}$ respectively $\frac{kN_W}{v\gamma N_R}$ of (45) already occurred in (41) and is depicted below in figure 11. To increase the clarity over the course of this thesis, $\frac{k\Phi_W(U_W)}{v\gamma\Phi_R(U_R)}$ respectively $\frac{kN_W}{v\gamma N_R}$ is referred to as $\bar{\lambda}$, delivering (*45*) as

$$U_W = 2\bar{\lambda}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}\big(b_R - \bar{\lambda}b_R - c_W + \bar{\lambda}c_W - c_R + \bar{\lambda}c_R\big) - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)}. \quad (46)$$

$\bar{\lambda}$ describes the linear relation of the actual occurring ratio of work capacity to demand in relation to the ideal ratio. A direct interpretation of $\bar{\lambda}$ is difficult, since it is not directly defined as a probability, like the function $\lambda\left(v, \frac{kN_W}{\gamma N_R}\right)$. It rather serves as a simple rate in relation to λ, which accordingly scales the number of transactions and the cross-subsidization between the two agent sides. $\bar{\lambda}$ takes smaller values than λ for ratios between 0 and *v*, since λ is a strictly concave function.

Figure 11: Linear relation of actual and ideal ratio to the probability of trade



Note: Own representation.

Deriving after U_R delivers the profit maximizing requester utility:

$$U_R \; = \bar{\lambda}\gamma(\bar{\lambda}b_R - \bar{\lambda}c_W - \bar{\lambda}c_R) - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \tag{47}$$

An interpretation of both functions is not directly intuitive. The first step in the direction of understanding these functions are the factors before the brackets, namely $\bar{\lambda}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}$ and $\bar{\lambda}\gamma$. $\bar{\lambda}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}$ can be interpreted as an adjusted number of tasks an average worker will conduct. On the other hand, $\bar{\lambda}\gamma$ is the adjusted number of fulfilled tasks a requester will experience. The part within the brackets requires to understand the initial utility functions of both agent sides as well as the pricing the platform applies. The initial utility functions under the application of λ and under the assumption of case III.2 delivers the following equation for workers

$$U_W \; = \frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}\left(2\bar{\lambda}w - \bar{\lambda}^2 w - 2\bar{\lambda}c_W + \bar{\lambda}^2 c_W\right) - F_W \tag{48}$$

and the subsequent equation for requesters

$$U_R = \gamma(2\bar{\lambda}b_R - \bar{\lambda}^2 b_R - 2\bar{\lambda}w + \bar{\lambda}^2 w - 2\bar{\lambda}c_R + \bar{\lambda}^2 c_R) - F_R. \quad (49)$$

Under the condition of timely matching, the actual effect of a parameter always follows the same pattern. See for example the base valuation b_R a requester has towards a completed task. A requester cannot expect that all requests are fulfilled under the initial assumptions, leaving only an expected value. Consequentially, b_R is adjusted to $2\bar{\lambda}b_R - \bar{\lambda}^2 b_R$ through the application of λ. This circumstance shows that the factors $\bar{\lambda}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}$ and $\bar{\lambda}\gamma$ are technically not an adjusted number of transaction. The $\bar{\lambda}$ is simply an artifact of the adjustment of the utility-determining parameters. Yet, the factoring out of $\bar{\lambda}$ provides an initially easier comprehension of the presented functions.

The last piece required for understanding the platform-imposed utility levels is the pricing the platform applies, with

$$p_W = \bar{\lambda}\frac{\gamma\Phi_R(U_R)}{\Phi_W(U_W)}\left(-2b_R + 2\bar{\lambda}b_R + 2w - \bar{\lambda}w - \bar{\lambda}c_W + 2c_R - 2\bar{\lambda}c_R\right) + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \quad (50)$$

and

$$p_R = \bar{\lambda}\gamma(2b_R - 2\bar{\lambda}b_R - 2w + \bar{\lambda}w + \bar{\lambda}c_W - 2c_R + 2\bar{\lambda}c_R) + F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)}. \quad (51)$$

With this groundwork, an understanding of the bracket's contents of (46) and (47) becomes apparent. The platform secures all worker utilities related to the wage by levying $2w - \bar{\lambda}w$ respectively $2\bar{\lambda}w - \bar{\lambda}^2 w$, while subsidizing requesters accordingly; yet, workers nearly receive all benefits generated through b_R. $2\bar{\lambda}b_R - \bar{\lambda}^2 b_R$ is only reduced by $\bar{\lambda}^2 b_R$, which the requesters can keep. The same happens in regard to the variable costs of both sides. The requester simply receives a ratio of $\bar{\lambda}^2$ in regard to the adjusted added value of $b_R - c_W - c_R$, while the workers can keep the rest. In any case, the platform does not subsidize any side of agents. Its profit function follows the ensuing from:

$$\pi = \Phi_W(U_W)\frac{\Phi_W(U_W)}{\Phi'_W(U_W)} + \Phi_R(U_R)\frac{\Phi_R(U_R)}{\Phi'_R(U_R)}. \quad (52)$$

The same is true for the other covered cases. The platform simply moves utilities between the parties by pricing accordingly.

But what does this mean precisely for the workers and requesters? They experience a splitting of the adjusted value generated by $b_R - c_W - c_R$. With this, workers experience positive and potentially bigger utilities than requesters under the assumption of $1 < \frac{kN_W}{\gamma N_R}$. The further away the actual ratio of $\frac{kN_W}{\gamma N_R}$ is from meeting v, the bigger the share the workers receive. However, striving towards v lets this share diminish until it is nearly zero. This means that workers can acutely experience a favored treatment or at least a decent remuneration, even under high k, contrary to the findings of chapter 4. This circumstance is partially expressed by surge pricing and special pricing actions on the weekend, for instance implemented by Uber (Cohen et al. 2016; Riquelme et al. 2015). This finding is not surprising, as it follows the universal logic of supply and demand.

The two remaining cases III.3 and III.4 are now quite predictive in their behavior. An increasingly favored treatment of workers can be expected, yet, these cases are presented for the sake of completeness.

The **case III.3** requires $\frac{kN_W}{\gamma N_R} = 1$ with $T_W = k,\ \ T_R = \gamma,$ and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$. Again, delivering the profit maximizing worker and requester utilities:

$$U_W = 2\bar{\lambda}k\big(b_R - \bar{\lambda}b_R - w + \bar{\lambda}w - c_R + \bar{\lambda}c_R\big) + \bar{\lambda}k\big(4w - 3\bar{\lambda}w - 4c_W + 3\bar{\lambda}c_W\big) - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \tag{53}$$

$$U_R = \bar{\lambda}\gamma\big(\bar{\lambda}b_R - \bar{\lambda}w - \bar{\lambda}c_R\big) + 2\bar{\lambda}\gamma\big(-w + \bar{\lambda}w + c_W - \bar{\lambda}c_W\big) - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \tag{54}$$

As previously seen in case II of chapter 4, the wage now has an effect on the parties' utilities and is not just allocated. Once again, presenting the pricing that the platform applies allows for an easier comprehension:

$$p_W = 2\bar{\lambda}k\big(-b_R + \bar{\lambda}b_R + c_R - \bar{\lambda}c_R + c_W - \bar{\lambda}c_W\big) + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \tag{55}$$

$$p_R = 2\bar{\lambda}\gamma\big(b_R - \bar{\lambda}b_R - c_R + \bar{\lambda}c_R - c_W + \bar{\lambda}c_W\big) + F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \tag{56}$$

Once more, the workers and requesters experience a splitting of the adjusted value of $b_R - c_W - c_R$. As stated, a wage is now also in effect, which increases worker utility the smaller $\bar{\lambda}$ is. Under the assumption of $\frac{kN_W}{\gamma N_R} = 1$, $\bar{\lambda}$ can only vary in size with respect to v, thereby causes a large ideal ratio a small $\bar{\lambda}$. This is generally true for case III.3. The higher v is the better remunerated the workers are. This circumstance is also observable for the other cases except for case III.1. The potential level of utility for workers in case III.3 is greater than in case III.2 since a wage is in effect. The smaller v is the less utility workers experience.

The last case III.4 expects $\frac{kN_W}{\gamma N_R}$ to be below 1 with $T_W = k,\ T_R = \frac{kN_W}{N_R}$, and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$, delivering:

$$U_W = \bar{\lambda}k\left(4b_R - 3\bar{\lambda}\, b_R - 4c_W + 3\bar{\lambda}\, c_w - 4c_R + 3\bar{\lambda}\, c_R\right) - F_W - F_P - \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \quad (57)$$

$$U_R = 2\bar{\lambda}\frac{k\Phi_W(U_W)}{\Phi_R(U_R)}\left(-b_R + \bar{\lambda}\, b_R + c_W - \bar{\lambda}\, c_w + c_R - \bar{\lambda}c_R\right) - F_R - F_P - \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \quad (58)$$

Case III.4 presents a distorted picture, since workers experience now a heavy advantage while the requesters are left with a potentially negative utility already before the deduction of fixed costs or a markup by the platform.

$$p_W = \bar{\lambda}k\left(-4b_R + 3\bar{\lambda}\, b_R + 2w - \bar{\lambda}w + 2c_W - 2\bar{\lambda}\, c_w + 4c_R - 3\bar{\lambda}\, c_R\right) + F_P + \frac{\Phi_W(U_W)}{\Phi'_W(U_W)} \quad (59)$$

$$p_R = \bar{\lambda}\frac{k\Phi_W(U_W)}{\Phi_R(U_R)}\left(4b_R - 3\bar{\lambda}\, b_R - 2w + \bar{\lambda}w - 2c_W + 2\bar{\lambda}\, c_w - 4c_R + 3\bar{\lambda}\, c_R\right) + F_P + \frac{\Phi_R(U_R)}{\Phi'_R(U_R)} \quad (60)$$

The requesters experience not only a deduction of an adjusted value of $b_R - c_W - c_R$ but have to pay an equal amount on top. Yet again, the wage is allocated.

5.2 Constraints

The subsequent paragraphs will quickly cover the sufficient conditions and the corresponding constraints required for the prior presented pricing schemes to globally maximize profits. The presented analysis will hereby only cover what is absolutely necessary, since a deeper discussion, as conducted in chapter 4.3, does not yield further insight regarding the set goals of the thesis and would go beyond its scope. The derived constraints are based on the familiar assumption of (26) and (27) in which the number of agents follow a liner relation while scaling in Y_W and Y_R.

Case III.1: $\frac{kN_W}{\gamma N_R} \geq v$, $T_W = \frac{\gamma N_R}{N_W}$, $T_R = \gamma$ and $\lambda = 1$

Case III.1 delivers a simple Hessian matrix

$$H_\pi = \begin{bmatrix} -2Y_W & 0 \\ 0 & -2Y_R \end{bmatrix}, \tag{61}$$

which only demands that the scaling of agent numbers in utility must be positive. As mentioned before, this dictates basic economic logic and therefore imposes no constraints. Positive scaling factors will also be taken as given for the following cases.

Case III.2: $1 < \frac{kN_W}{\gamma N_R} < v$, $T_W = \frac{\gamma N_R}{N_W}$, $T_R = \gamma$, and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$

The Hessian matrix and its determinant deliver two conditions, which need to apply, in order for the equations to represent a global maximum:

$$-1 < +\bar{\lambda}\frac{\gamma N_R}{N_W^2} Y_W\left(\bar{\lambda}b_R - \bar{\lambda}c_W - \bar{\lambda}c_R\right) + \bar{\lambda}\frac{\gamma}{N_R} Y_R\left(\bar{\lambda}b_R - \bar{\lambda}c_W - \bar{\lambda}c_R\right) \tag{62}$$

$$1 > \bar{\lambda}\frac{\gamma N_R}{N_W^2} Y_W\left(-\bar{\lambda}b_R + \bar{\lambda}c_W + \bar{\lambda}c_R\right) \tag{63}$$

Both constraints are complementing and are already met if a transaction between a requester and a worker is economically worthwhile, meaning that $b_R - c_W - c_R$ yields a positive value. A slightly negative value is also viable but would render a transaction between the two parties uneconomical.

Case III.3: $\frac{kN_W}{\gamma N_R} = 1$, $T_W = k$, $T_R = \gamma$, and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$

The Hessian matrix and its determinant demand the following conditions for a global maximum:

$$\begin{gathered} -1 < \bar{\lambda}\frac{k}{N_W} Y_W\left(\bar{\lambda}b_R - \bar{\lambda}w - \bar{\lambda}c_R\right) + \bar{\lambda}\frac{k}{N_W} Y_W\left(-2w + 3\bar{\lambda}w + 2c_W - 3\bar{\lambda}c_W\right) + \\ \bar{\lambda}\frac{\gamma}{N_R} Y_R\left(\bar{\lambda}b_R - \bar{\lambda}w - \bar{\lambda}c_R\right) + \bar{\lambda}\frac{\gamma}{N_R} Y_R(-2w + 3\bar{\lambda}w + 2c_W - 3\bar{\lambda}c_W) \end{gathered} \tag{64}$$

$$1 > \bar{\lambda}kY_W\left(-\bar{\lambda}b_R + \bar{\lambda}w + \bar{\lambda}c_R\right) + \bar{\lambda}kY_W\left(2w - 3\bar{\lambda}w - 2c_R + 3\bar{\lambda}c_R\right) \tag{65}$$

Again, a transaction must be economically rational, but also in regard to a wage. This requires $b_R - w - c_R$ to be positive. Moreover, the wage in respect to the worker's variable cost must be sufficiently large. Nonetheless, the wage is not allowed to be too excessive while $\bar{\lambda}$ mustn't be too small, otherwise the requesters' utility is completely consumed.

Case III.4: $\frac{kN_W}{\gamma N_R} < 1$, $T_W = k,\ T_R = \frac{kN_W}{N_R}$, and $\lambda = 1 - (1 - \frac{kN_W}{v\gamma N_R})^2$

Case III.4 demands following two conditions to hold for a global maximum:

$$\begin{aligned} -1 < +\bar{\lambda}\frac{k}{N_W}Y_W\big(-2b_R + 3\bar{\lambda}b_R + 2c_W - 3\bar{\lambda}c_W + 2c_R - 3\bar{\lambda}c_R\big) \\ + \bar{\lambda}\frac{kN_W}{N_R^2}Y_R\big(-2b_R + 3\bar{\lambda}b_R + 2c_W - 3\bar{\lambda}c_W + 2c_R - 3\bar{\lambda}c_R\big) \end{aligned} \tag{66}$$

$$1 > \bar{\lambda}\frac{k}{N_W}Y_W\big(2b_R - 3\bar{\lambda}b_R - 2c_W + 3\bar{\lambda}c_W - 2c_R + 3\bar{\lambda}c_R\big) \tag{67}$$

Overall, this case imposes two possible outcomes in regard to $b_R - c_W - c_R$, due to the heavily skewed pricing. The difference can either be positive while $\bar{\lambda}$ is sufficiently large or the difference is negative while $\bar{\lambda}$ is adequately small. The latter case, however, would not be economical. Furthermore, both cases would leave one agent side with a negative utility.

In summary, case III.1 and case III.2 can be expected to be stable regarding the sufficient condition. Case III.3 and III.4 impose more demanding constraints, especially the latter case III.4. Even if these sufficient conditions persist, it seems very unlikely that the initial condition of $\frac{kN_W}{\gamma N_R} = 1$ respectively $\frac{kN_W}{\gamma N_R} < 1$ are met under the imposed skewed pricing, as long as the factors, which scale the two sides in size, are not too different. The same is true for case III.1, since this case imposes a negative utility on workers under any condition. Only case III.2 is stable in its sufficient condition, while satisfying the initial condition of $1 < \frac{kN_W}{\gamma N_R} < v$, if the ideal ratio *v* is sufficiently large.

5.3 Interim Summary of Findings

This brief excursion into the branch of transportation services delivers complementing findings in respect to the basic model. It shows that certain circumstances, like timely matching in combination with self-scheduling, can yield a decent remuneration for workers, even under an oversupply of worker capacities. The driving factor in this respect is the ideal ratio *v* of work capacity to demand, needed to satisfy all incoming requests. The higher v is, the more favorable workers are treated in terms of remuneration. However, closing the gap between the actual occurring ratio of work capacity to demand and the ideal ratio will diminish the workers' utility. Same as the basic model, the presented system of cases is the most stable under an oversupply of work capacity, unless the threshold v is crossed. The parameter k, which determines the task demand from workers, is not crucial, in contrast to the basic model. It therefore seems reasonable to assume that such a system strives towards a setting of $1 < \frac{kN_W}{\gamma N_R} < v$ under most circumstances, if an economical reasonable exchange is applicable. Nonetheless, these findings are not particularly surprising, since the initial setup already indicates such a result and as they follow the basic logic of supply and demand. Further research in this regard represent the papers by Gurvich et al. (2016) as well as Riquelme et al. (2015). An elaborate approaches in respect to self-scheduling was conducted by Gurvich et al. (2016). Riquelme et al. (2015) offers an excellent analysis in view of dynamic pricing within transportation services like Uber, while specifically minding the setting of a TSM. Especially the paper by Gurvich et al. (2016) presents findings, which support the results discussed here.

6. Competition

As the previous parts showed, timely matching paired with self-scheduling can play a part in explaining certain phenomenon in DLM. For a complete picture, however, it is necessary to consider competition. Armstrong (2006) specifically covered the topic of competition related to TSMs. He named three major types of competition relevant within a setting of TSM:

I. Either-or choice by both sides
II. Multihoming by one side
III. Multihoming by both sides

Type I expects the agents of both sides to use or join only one type of platform. Armstrong (2006) does attribute little relevance to this type of competition in view of the types of TSM he analyzed and considered. Yet, an either-or choice is suited to describe DLMs, especially concerning the option between DLMs and classical job opportunities. Requesters can either choose to post their task on a platform related to DLMs or search for a suited worker via the classical way, utilizing means already in existence prior to DLMs. Workers on the other hand can either choose to work via a digital platform or look for classical job opportunities.

Type II describes multihoming by one side of agents, while the other side decides in an either-or fashion between different platforms or means of labor. Multihoming is a common term found within the TSM-literature and refers to a scenario in which an agent joins two or more platforms. This type of competition is suited to describe intra-platform competition where workers join and conduct tasks for multiple platforms.

The third and last type of competition is multihoming by both sides of agents. This form of agent behavior seems irrational. Armstrong 2006, p. 669) argues as follows: “If interacting with the other side is the primary reason for an agent to join a platform, then we might not expect case (iii) to be very common—if each member of group 2 joins all platforms, there is no need for any member of group 1 to join more than one platform […].” This type of competition will, thus, not be considered.

The subsequent subchapters, therefore, only cover the first and second type of competition, specifically, the first part will cover an either-or choice by agents and the second part expects one side to multihome. The analysis will thereby only cover a scenario in which the ratio $\frac{kN_W}{\gamma N_R}$ equals

1, with $T_W = k$ and $T_R = \gamma$. This step was taken in order to show the effect of competition in isolation without potentially distorting effects through an unbalanced relation of $\frac{kN_W}{\gamma N_R}$. A simplification in this regard allows for a clearer presentation of the implications and a more comprehensive interpretation. Furthermore, the inclusion of cases with an unbalanced ratio would further strain the tense extent of the thesis while delivering no new insights.

6.1 Either-or Choice

The first part of this section will cover competition of the first type. Agents can choose between a platform 1 and another option 2. Option 2 can either be presumed as another digital platform or as a classical way of labor execution. However, an either-or choice is particularly suited to describe the situation of labor and the decision of both agents between classical labor opportunities and DLM-platforms, under the assumption of full-time labor.

The ensuing equation describes the profit of platform 1, mainly following the logic of the previously presented approaches. The ensuing analysis expects a platform to have a unique impact on the costs incurred by the agents as well as on the wage level. The applied factors are subscripted accordingly.

$$\begin{aligned}\pi_1 = {} & [(w_1 + N_{1R}\beta_W - c_{1W})T_W - F_{1W} - U_{1W} - F_{1P}]N_{1W} \\ & + [(b_R + N_{1W}\beta_R - w_1 - c_{1R})T_R - F_{1R} - U_{1R} - F_{1P}]N_{1R}\end{aligned} \tag{68}$$

There are again modeled externalities in the form of $N_{1R}\beta_W$ and $N_{1W}\beta_R$, following the example of the basic model to foster comparability. The number of agents is now expressed by a Hotelling model basis, again following the approach by Armstrong (2006). He modeled the number of agents to follow $N_{1j} = \frac{1}{2} + \frac{U_{1j} - U_{2j}}{2t}$, with $j \in W, R$, while t describes the competitiveness of the market. The summand $\frac{1}{2}$ is hereby owed to the Hotelling's classical linear city model, where a differentiation can take place between 0 and 1, whereas an initially equal split between the two competing parties is assumed. The setting of DLMs makes an adjustment opportune in order to increase the generalizability but also to allow comparability between the findings of the here presented approach and the basic model. The number of agents on one side is expressed in the following form:

$$N_{1j} = z_{1j} + Y_j \frac{U_{1j} - U_{2j}}{2t_j} \tag{69}$$

As briefly mentioned, the parameter $t_j \in \mathbb{R}^+$ describes the overall competitiveness of the market, meaning that switching an agent from one to the other option becomes more difficult the higher t_j is. The part z_{1j} is closely related to the summand $\frac{1}{2}$ of the basic Hotelling model. It describes the initial standing of a platform or labor opportunity in regard to the participating agent numbers. This approach is chosen due to its generalizability and flexibility, since it allows the consideration of different scenarios. For instance, a newly founded DLM-platform would have no participating agents at the beginning and would be required to attract customers by offering bigger utility than its competitor. Later on, a platform might face a setting with equal matters in terms of agent numbers, where z_{1j} equals z_{2j} and the competitors share a market, if they offer the same utilities. Once more, a dynamic approach or the application of a differential equation in this respect are presumably more suited to display these circumstances, yet, the static approach allows for an easier handling and interpretation. The factor Y_j, which accordingly scales the agent number in regard to the provided utility difference, is already familiar. Both factors, Y_j and t_j, are assumed to be industry specific and not specific to the observed platform or labor opportunity. As previously stated, the number of transactions follows a setting where work capacity equals work demand, thus, T_W is k and T_W equals γ.

Deriving and rearranging the profit function accordingly presents us with the profit maximizing utility a platform should offer its workers:

$$U_{1W} = \frac{1}{2}[(w_1 + N_{1R}\beta_W - c_{1W})k + \gamma N_{1R}\beta_R + U_{2W} - F_{1W} - F_{1P}] - \frac{z_{1W}t_W}{Y_W} \tag{70}$$

The ideal pricing a platform should apply naturally shows similarities to the pricing scheme derived in case II of the basic model. Per transaction the workers receive a benefit generated through a wage plus a benefit the requesters provide through indirect network externalities, reduced by transaction-sensitive costs. Furthermore, workers are subsidized for their ability to generate externalities for requesters, while the worker and platform related fixed costs are deducted. New is the circumstance that the utility is reduced by the factor describing market competitiveness, accordingly scaled with the initial standing and the growth factor, expressed in $\frac{z_{1W}t_W}{Y_W}$. Naturally, a platform can price accordingly with respect to the market competitiveness for workers. The less competitive a market is, shown by a high t_W, the costlier or more demanding a switching becomes. This reduction in utility, on the other hand, has a negative effect on the number of agents and; therefore, is adjusted according to the growth scaling factor Y_W. This deduction is only relevant in respect to agents, which are initially on the platform. Another new aspect is the subsidization according to the utility the competitor offers his workers. This circumstance must be interpreted in perspective to the factor $\frac{1}{2}$ at the beginning of the right-hand side of equation (70). A worker receives the average of the utility he would receive in the basic model without competition and the utility the competitor provides. This means, the better off a worker is under competition, the more the competitor pays above the basic model utility level.

The same happens in regard to the ideal provision of utility to requesters, expressed by ensuing equation (71):

$$U_{1R} = \frac{1}{2}[(b_R + N_{1W}\beta_R - w_1 - c_{1R})\gamma + kN_{1W}\beta_W + U_{2R} - F_{1R} - F_{1P}] - \frac{z_{1R}t_R}{Y_R} \tag{71}$$

Accordingly, the platform's pricing equations are as follows:

$$p_{1W} = \frac{1}{2}[(w_1 + N_{1R}\beta_W - c_W)k - \gamma N_{1R}\beta_R - U_{2W} - F_{1W} + F_{1P}] + \frac{z_{1W}t_W}{Y_W} \tag{72}$$

$$p_{1R} = \frac{1}{2}[(b_R + N_{1W}\beta_R - w_1 - c_R)\gamma - kN_{1W}\beta_W - U_{2R} - F_{1R} + F_{1P} + t_R] + \frac{z_{1R}t_R}{Y_R} \tag{73}$$

These pricing functions ultimately deliver the platform's profit function:

$$\begin{aligned}\pi_1 = \frac{1}{2}N_{1W}[(w_1 + N_{1R}\beta_W - c_W)k - \gamma N_{1R}\beta_R - U_{2W} - F_{1W} + F_{1P}] + N_{1W}\frac{z_{1W}t_W}{Y_W} \\ - N_{1W}F_{1P} \\ + \frac{1}{2}N_{1R}[(b_R + N_{1W}\beta_R - w_1 - c_R)\gamma - kN_{1W}\beta_W - U_{2R} - F_{1R} + F_{1P}] \\ + N_{1R}\frac{z_{1R}t_R}{Y_R} - N_{1R}F_{1P}\end{aligned} \tag{74}$$

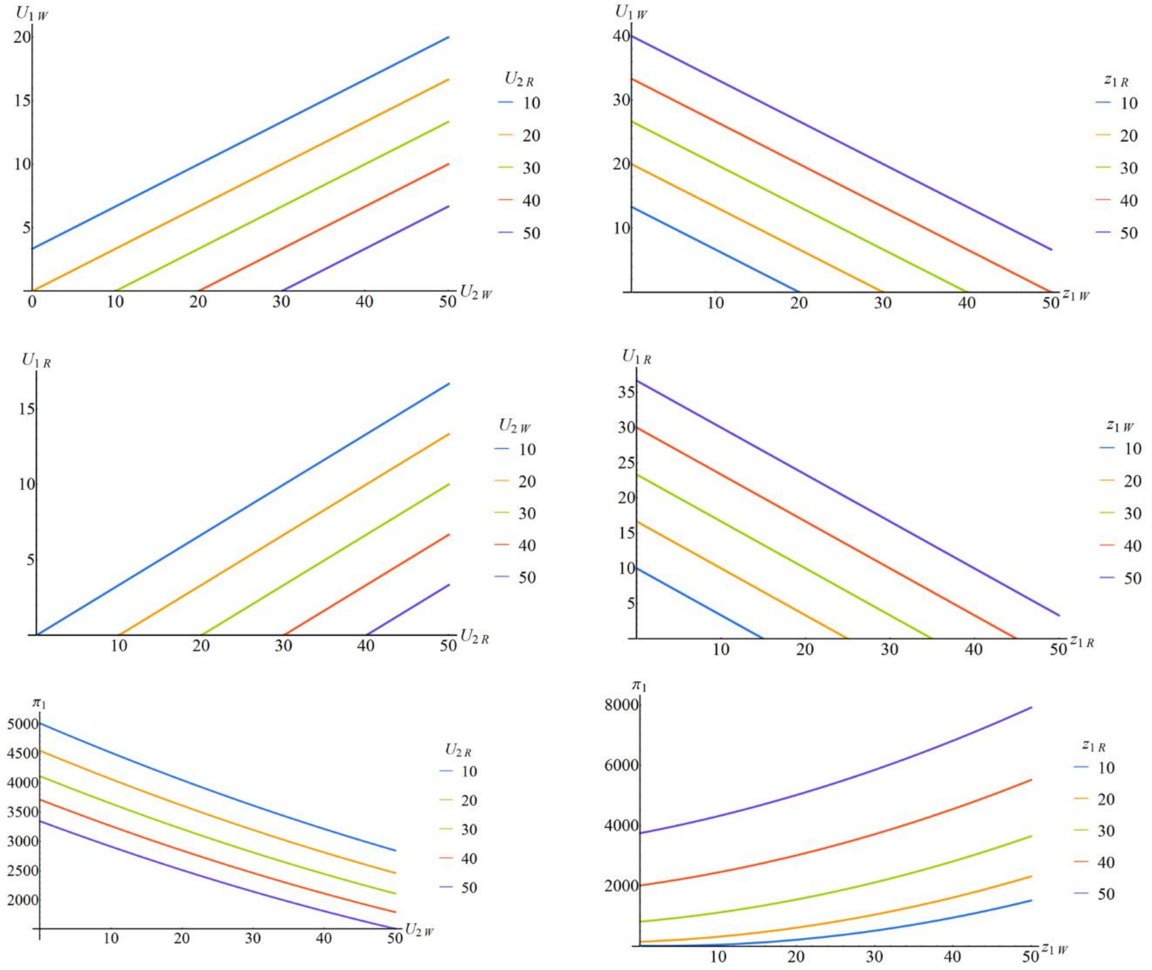
In order for the derived pricing scheme to represent a global maximum in regard to the platform's profit, two sufficient conditions must be fulfilled. Familiar is the requirement of the factors Y_W and Y_R to be positive. Furthermore, the ensuing condition (75) must be fulfilled:

$$1 > \frac{k^2 Y_W Y_R \beta_W^2 + 2k\gamma Y_W Y_R \beta_W \beta_R + \gamma^2 Y_W Y_R \beta_R^2}{16 t_W t_R} \tag{75}$$

Most of the parameters that have been covered must not cross a certain threshold in regard to the other parameters. In contrast, t_W and t_R must be sufficiently large.

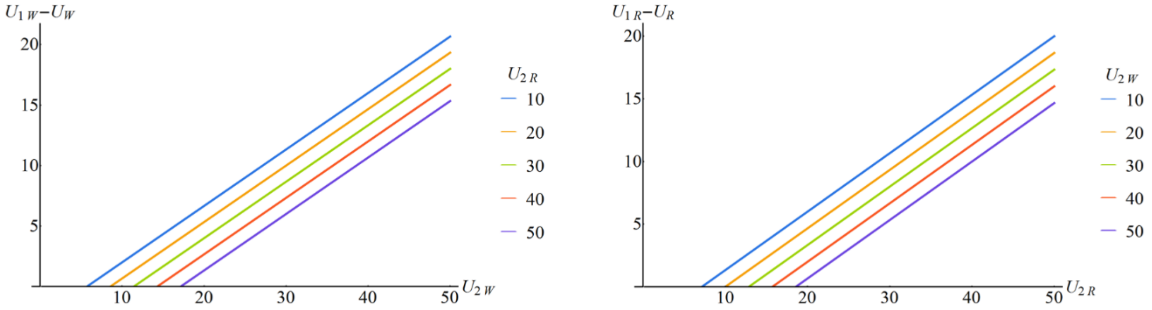
A basic application of actual values confirms the prior findings, as figure 12 illustrates. The left-hand graphs depict rising worker and requester utilities with increasing utilities the competitor provides its agents. The platform, on the other hand, suffers reduced profits through corresponding subsidizing. If the competitor offers its agents enough utility, the workers and requesters of platform 1 can be better off compared to a case without competition, shown by figure 13. These two graphs show the utility difference for workers and requesters under competition with varying competitor utilities compared to the utility level they would experience under a setting without competition, as presented in chapter 4.3.2. The upper-left graph shows a decrease of utility with rising values for U_{2R}. Naturally, this circumstance is given since high values for U_{2R} attract requesters from platform 1 to option 2, consequentially reducing the network externalities the workers enjoy. The same logic applies to requesters, as illustrated in the second left-hand graph.

Figure 12: Behavior of utilities and profit - Either-or choice



Note: Own representation. All graphs: $k = 1$, $\gamma = 1$, $Y_W = 1$, $Y_R = 1$, $\beta_W = 1$, $\beta_R = 1$, $t_W = 1$, $t_R = 1$, $b_R = 10$, $w_1 = 10$ *and all costs are zero. Left-hand side:* $z_{1W} = 50$, $z_{1R} = 50$. *Right-hand side:* $U_{2W} = 10$, $U_{2R} = 10$.

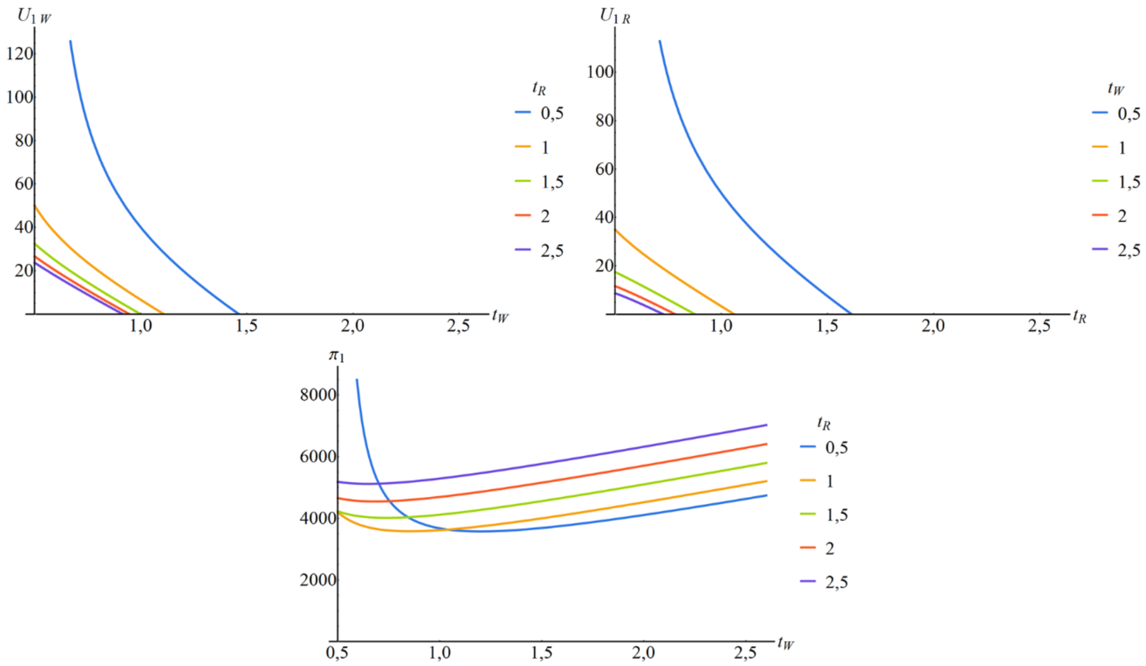
Figure 13: Utility differences through competition compared to Case II



Note: Own representation. $k = 1$, $\gamma = 1$, $Y_W = 1$, $Y_R = 1$, $\beta_W = 0.5$, $\beta_R = 0.5$, $t_W = 1$, $t_R = 1$, $b_R = 10$, $w_1 = 10$, $z_{1W} = 0$, $z_{1R} = 0$, *and all costs are zero.*

The degree of competition is further characterized by the factor t_i, which describes how easily agents can switch between different labor opportunities. As expected, the fact that it is easier to switch between the two options forces the platform to provide its agents with more utility, consequently reducing its profit, displayed by figure 14.

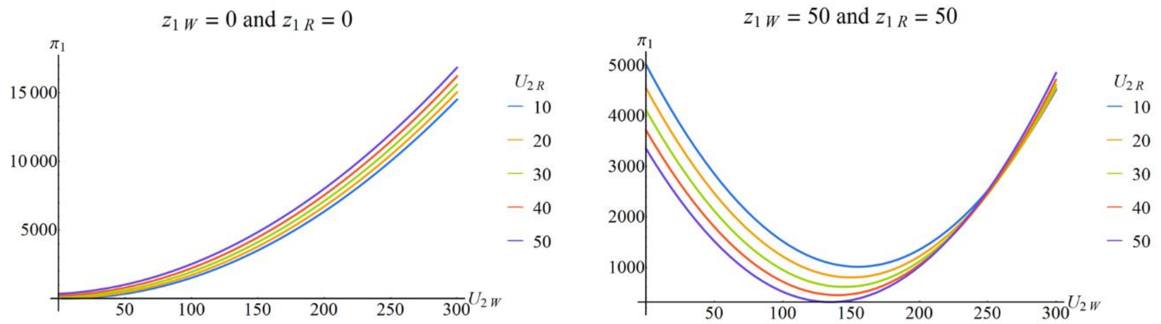
Figure 14: Effect of a hindered switching between two labor options



Note: Own representation. $U_{2W} = 20$, $U_{2R} = 20$, $k = 1$, $\gamma = 1$, $Y_W = 1$, $Y_R = 1$, $\beta_W = 1$, $\beta_R = 1$, $b_R = 10$, $w_1 = 10$, $z_{1W} = 50$, $z_{1R} = 50$, *and all costs are zero.*

The right-hand graphs of figure 12 and figure 15 portray the role of z_{1j}, the initial setting in terms of agent numbers. The higher the initial number of agents on a platform, the less utility agents receive since the platform deducts $\frac{z_{1W}t_W}{Y_W}$, potentially causing negative utilities. Concerning the platform, increases in profit are generally gained through rising initial agent numbers. However, the situation here is more complex, as figure 15 exemplifies. In combination with increasing competition, the initial agent numbers can have different implications regarding the platform's profit, the third left-hand graph of figure 12 does therefore not depict the complete situation. The left-hand graph of figure 15 shows that a platform automatically experiences increasing profits in regard to rising competitor utilities, since agents enjoy growing utilities, leading to increased worker numbers. The right-hand graph shows that an initial number of workers leads to primary reduced profits in rising competitor utilities. This circumstance occurs since the subsidizing will reduce the gains generated through $\frac{z_{1W}t_W}{Y_W}$. Crossing a certain threshold will again raise the profit prospect, as a sufficient number of agents is attracted through extremely high utility levels. Even though z_{1j} has such a distorting effect, an accordant pricing is inevitable, or else the subsidizing of the network effects would eat up all profits.

Figure 15: Profit differences with respect to the initial agent numbers



Note: Own representation. All graphs: $k = 1, \gamma = 1, Y_W = 1, Y_R = 1, \beta_W = 1, \beta_R = 1, t_W = 1, t_R = 1, b_R = 10, w_1 = 10$, *and all costs are zero. Left-hand side:* $z_{1W} = 0, z_{1R} = 0$. *Right-hand side:* $z_{1W} = 50, z_{1R} = 50$.

The role and effect of z_{1j} in this model might face heavy criticism due to the unintuitive outcomes it predicts. It seems unrealistic that workers experience negative utilities under such relatively moderate levels of z_{1j}, as assumed in figure 12. The effect on the platform's profit is also prone to debate. Again, these distorting effects are partially owed to the condition that the model is static. A dynamic approach would be more suit for the application of z_{1j}, while potentially describing the agent numbers and market situation of the previous period. Such a take would also be suited to describe the product life circle of a platform. In summary, a static application of z_{1j} is far from ideal to represent certain circumstances yet was applied to have a more generally applicable approach to the agent numbers in the setting of competition, compared to the classical Hotelling model approach applied by Armstrong (2006).

Indeed, two plausible findings can be derived from this section covering competition in a setting of an either-or choice by both agents: Firstly, both agent sides profit from competitive environments between the two rivaling labor options. Competition in this respect is characterized by a high utility level provided by the competitor to its agents and little restrains in switching the labor options. Secondly, the more mature a platform is in terms of agent numbers, the less utility its participating agents should expect. The last finding might face increased criticism as it is founded in regard to the parameter z_{1j}, yet can still be viable. Uber, for instance, shows tendencies to such an occurrence, as the company gradually increases the commission drivers face in cities where it has gained a foothold (Enemchukwu 2017). Lastly, it must be mentioned that the general findings and phenomenon of case II, presented in chapter 4, are also relevant to the model that has been adopted here.

6.2 Multihoming

The second part of chapter 6 will discuss multihoming by one agent-side, while the other side decides in an either-or fashion between two options. While the previous part was mainly suited to discuss competition between classical labor options and DLMs, this part is suited to analyze competition between two platforms or a situation where agents complement their income by working part-time on a platform. The transportation branch, in particular, experiences multihoming by its drivers and, thus, stresses the need of such an analysis (Campbell 2017, 2018). Once more, the number of requesters on a platform is based on (69). The number of requesters follows the already familiar function $\Phi_{1W}(U_{1W})$. This approach is highly stylized to describe the circumstance of multihoming by one side; yet, it still allows for certain findings and can add to the thesis and discussion and will suffice in this regard. A more detailed analysis of one-sided multihoming can be found within the work of Armstrong (2006) or Caillaud and Jullien (2003). Deriving (68) under these conditions deliver following profit maximizing agent utility the platform should offer its workers:

$$U_{1W} = (w_1 + N_{1R}\beta_W - c_{1W})k + \gamma N_{1R}\beta_R - F_{1W} - F_{1P} - \frac{\Phi_{1W}(U_{1W})}{\Phi'_{1W}(U_{1W})} \tag{76}$$

Naturally, this equation is identical to the one derived in the basic model for case II. The equation determining the ideal requester pricing is also familiar:

$$U_{1R} = \frac{1}{2}[(b_R + \Phi_{1W}(U_{1W})\beta_R - w_1 - c_{1R})\gamma + k\Phi_{1W}(U_{1W})\beta_W + U_{2R} - F_{1R} - F_{1P}] - \frac{z_{1R}t_R}{Y_R} \tag{77}$$

Overall, a favored treatment of the side, which fully commits by an either-or choice, is expected, if the competing platform offers enough utility to its agents.

The applied pricing falls in line with previous findings and simply delivers an accordingly compounded profit function.

$$\begin{aligned}\pi_1 = -\gamma\Phi_{1W}(U_{1W})N_{1R}\beta_R + \Phi_{1W}(U_{1W})\frac{\Phi_{1W}(U_{1W})}{\Phi'_{1W}(U_{1W})} \\ + \frac{1}{2}N_{1R}[(b_R + \Phi_{1W}(U_{1W})\beta_R - w - c_R)\gamma - k\Phi_{1W}(U_{1W})\beta_W - U_{2R} \\ - F_{1R} + F_{1P}] + N_{1R}\frac{z_{1R}t_R}{Y_R} - N_{1R}F_{1P}\end{aligned} \tag{78}$$

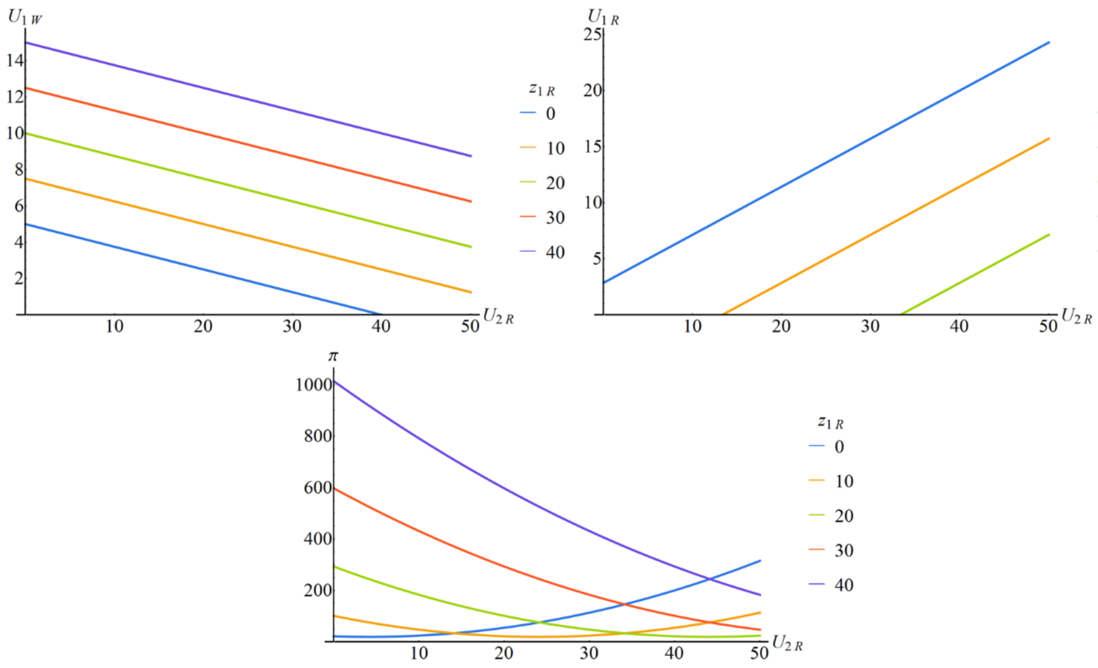
Once more, the sufficient condition requires the parameter Y_W and Y_R to be positive, in order for the presented pricing to maximize profits. Moreover, constraint (*79*) needs to be satisfied.

$$1 > \frac{k^2 Y_W Y_R \beta_W^2}{2t_R} + \frac{k\gamma Y_W Y_R \beta_W \beta_R}{2t_R} + \frac{\gamma^2 Y_W Y_R \beta_R^2}{2t_R} \tag{79}$$

Figure 16 illustrates the agent utilities and the platform profits under varying U_{2R} and z_{1R}.[32] Indeed, the requesters experience more utility than workers, if the competing platform offers enough utility and if z_{1R} is small enough, even under a wage which favors workers. The workers profit from a high initial requester number, while increases in U_{2R} reduce the participating number of requesters. A high value for z_{1R} will cause an according reduction of requester utility through the deduction of $\frac{z_{1R}t_R}{Y_R}$, whereas the platform profits through this. This behavior in respect of z_{1R} again emphasizes the need for a continued research under dynamic considerations.

[32] The parameters β_W and β_R have been adjusted to satisfy the constraint set by the sufficient condition. The overall findings are not affected by this adjustment yet are necessary since (79) is stricter than (75).

Figure 16: Behavior of utilities and profit - Multihoming



Note: Own representation. $k = 1$, $\gamma = 1$, $Y_W = 1$, $Y_R = 1$, $\beta_W = 0.5$, $\beta_R = 0.5$, $t_R = 1$, $b_R = 10$, $w_1 = 10$ *and all costs are zero.*

6.3 Interim Summary of Findings

In a broad sense, the findings presented here meet those of Armstrong (2006), even though he mostly focused on the platform perspective. High competition between two platforms lead to an intensified contest for agents. Armstrong (2006) does not mention the effect on the agents' utility level, but the model presented here predicts a potential increase. Multihoming by one agent side, on the other hand, can, under certain circumstances, lead to an unfavorable treatment through the platform of this side. Under Armstrong's (2006) model, the platform actually only cares about the side which commits to the platform, and just attracts enough multihoming-agents to maximize the joint surplus of the platform and the committing side. Such a skewed platform interest regarding the agent sides caused by multihoming cannot be observed in the model presented here through the dominating influence of the transaction numbers. Yet, a multihoming side might still face reduced utilities, if the platforms face a heavy competition for the committing agent side. The model further introduced an adjusted approach to the agent numbers concerning an either-or choice, compared to the approach presented by Armstrong (2006). This measure was introduced because Armstrong's (2006) approach was not suited to provide comparability to the basic model.

The adjustment is also more general in its setup; however, the parameter z_{1j}, describing the initial setup of the market and the platform, turned out to be crucial in affecting agent utilities and profit. Some of the findings in this respect turned out to be counterintuitive. This circumstance emphasizes the further need of research in regard to the life cycle of DLMs under a dynamic setting.

7. Findings

This chapter is dedicated for presenting and discussing the findings this thesis derived during its course. The findings will be mainly examined in regard to the four initially stated research questions, followed by a presentation of the drawbacks, the selected approach, and the imposed model, closed by a brief overview for potentially continued research in this respect.

7.1 The Research Questions

The initially presented research questions were formulated as follows:

1. Can DLMs be considered as two-sided?
2. Do DLMs impose new facets, which need to be considered in view of TSMs?
3. Which implications can a model-based analysis provide regarding the functioning of DLM-platforms, especially considering the different participating parties?
4. To what extent can the prior findings add to the ongoing discussion aimed at DLMs?

A separate chapter, namely chapter 3, was solely dedicated to covering the first question, already providing a conclusive answer in that respect. The three remaining questions, on the other hand are not directly covered by a specific chapter, due to their broad scope. Chapters 4, 5, and 6 all provided input and findings in view of these three questions. Therefore, a discussion of the derived findings should ideally take place in this chapter, to prevent redundancies. Hence, this chapter functions not only as a recapitulation but also as a mean to answer and discuss the initially posed questions. A corresponding structure is provided by discussing each question individually in the ensuing paragraphs.

Can DLMs be considered as two-sided?

The first research question was discussed and answered by chapter 3. Four main definitional approaches in terms of the applied criteria can be identified in respect to TSMs. One of the earliest criteria were bilateral network externalities between the two participating agent sides. All four branches are expected to show such externalities. However, a differentiation between transportation services and the other three branches seems appropriated, as only matching efficiency should matter under the aspect of transportation, while the other branches should also consider matching a suited worker with the right task. Nonetheless, empirical research covering

DLMs in this matter is lacking. It is open to debate to which extent these externalities actually play a role. The model-based analysis further emphasized the need in this regard. Unilateral network externalities represent an adjusted requirement in view of bilateral externalities. Naturally, they are in effect under the assumption of bilateral network externalities. A major feature, which was partially covered by definitional approaches centering around externalities, is the so called non-neutral pricing. This term implies that the involved parties cannot negotiate away price differences imposed by a platform. Price non-neutrality is especially met by transportation services. The freelancing branch, on the other hand, fosters free negotiations between its participating agents, consequentially rendering a non-neutral pricing unfeasible. The two remaining branches, microwork and manual labor, are open to debate and research in this regard, since one agent side can determine the transaction value. Yet, in the short run, an allocation of skewed pricing between the parties seems unrealizable. Further research in this matter is required. The last main approach to TSMs was the criterion of direct interaction, where the participating parties have control over the main means of the economic exchange. This criterion is especially fulfilled by freelancing but also by microwork. In summary, with the exception of freelancing all branches were considered as TSMs and investigated in the subsequent model-based analysis. All branches except for freelancing show features which are worthwhile to research under the aspect of TSMs, especially under the perspective of platform behavior and the imposed pricing.

Do DLMs impose new facets, which need to be considered in view of TSMs and a related analysis?

The second question was formulated under rather technical considerations, especially in view of the imposed assumptions and initial setting of the model. The answer to this question was mainly needed to adequately formulate a model to analyze DLMs under the perspective of TSMs. Thus, an answer was not specifically provided in a dedicated chapter but is spread across different sections of this thesis, only being provided where accordingly needed. This circumstance emphasizes the need to summarize the findings that were made.

To forestall the answer: The general functioning of DLMs does not impose new aspects or facets, which need to be considered by a model-based analysis. The general features distinctive to TSMs are in effect, namely non-neutral pricing and indirect network effects, even though a more in-depth empirical research into this matter is required. Yet, certain aspects were emphasized with the chosen assumption and approach. Most of these adjustments were formulated with respect to

Armstrong (2006) as well as Rochet and Tirole (2006), as they functioned as the inspirational and conceptual basis for this thesis. Three features in particular must be mentioned in this regard. Firstly, a direct payment between the two participating parties was implemented within the model. Secondly, network externalities were not only perceived in terms of the transaction volume but included under the assumption of increased matching efficiency and the idea of matching the right worker with the right task. The differentiation between the two later externalities leads to the adjustment of the basic model under the consideration of transportation services. Noteworthy in this respect is the role of timely matching under self-scheduling, which demands a high degree of matching efficiency. The third and most significant feature of the developed model was its unique approach to the transaction numbers. The model explicitly introduced a worker capacity for tasks and a parameter describing the requester capability to generate tasks. The relevant transaction number a specific side enjoys on average was not only related to the opposing agent numbers but also to these parameters. A case differentiation depending on task supply and demand was then applied accordingly. Especially the latter two described features, the introduction of a direct wage transfer and the unique approach to the transaction numbers, were implemented in consideration of the ongoing discussion regarding the worker situation. The thesis pursuits not only the aim to provide a better understanding of the functioning of DLM-platforms but also to potentially add new input in view of the ongoing regulatory discussion concerning the workers' situation. The mentioned features were considered in regard to this pursuit. Whether this thesis actually can provide input in this respect will be answered by the ensuing elaboration.

Which implications can a model-based analysis provide regarding the functioning of DLM-platforms, especially considering the different participating parties?

The basic model differentiated between three cases in terms of the transaction numbers an agent of the two participating sides experiences. Case I covered an oversupply of work capacity on the worker side, while case III described the opposing case with excessive task demand by the requesters. The remaining case II represented a balanced setting between supply and demand. The analysis focused on case I and II. Under case I, workers experience an unfavorable treatment while the requesters are heavily subsidized. This skewed pricing is not only due to potential differences in the elasticity of demand but is mainly a consequence of the transaction numbers, since the requesters function as a bottleneck. Case II provided rather balanced terms in view of the provided agent utility, as no agent side imposed a direct bottleneck on the transactions. Differences in utility were not inherent to the utility functions but a matter of parameter differences, demand elasticity and the transferred wage. Crucial in regard to the utility levels and the platform's profit were, amongst other factors, the indirect network externalities. If they were big enough, these externalities could cause distorted circumstances, emphasizing the need for further research in this regard.

A substantial part of the basic model analysis was the consideration of the case stability, especially under the consideration of the workers' situation, respective to the ongoing discussion. This forced the focus onto the parameter determining the task capacity that workers show on average. The higher their capacity, the more a tendency to case I can be expected, fostered by indirect network externalities, if the other parameters do not show balancing properties. Naturally, this is not a surprise since this behavior follows the logic of supply and demand. However, this behavior imposes attention towards the type of work being considered. Under the perspective of full-time labor on DLM-platforms, a skewed state of the system and pricing is, thus, inherent, if requesters only show a humble capacity to generate tasks.

Certain circumstances have the potential to mitigate skewed states of agent utilities. For one thing, the thesis considered timely matching under self-scheduling, particularly relevant for transportation services. An ideal ratio required to satisfy all incoming requests, which requires work overcapacities, will provide the workers with increased levels of utility while the requesters experience a less favorable treatment, even in a setting where they would normally expect a better utility prospect. Yet, the closer the available work capacity is to meeting the ideal ratio, the less utility workers will gain. Moreover, the thesis provided a brief extension of the basic model under the consideration of competition. In this respect, two approaches were considered. The first take described a setting in which both agents choose between two different alternatives, mostly suited to describe the competition between classical labor opportunities and the new DLM-platforms. The more competition between the two rivaling options exists, the better for both side of agents in terms of utility. More competition in this respect is characterized by a high utility level provided by the competitor to its agents and little restraints in switching between the two options. However, a mature and settled platform will lead to a reduction of the utilities. The second take in view of competition was the consideration of multihoming, meaning that one side participates on both competing labor options while the other agent side commits to one option. Such an approach is especially relevant when considering two competing platforms but also in the situation where agents complement their income by working part-time via a DLM-platform. The multihoming side can experience a less favorable treatment if the two rivals compete heavily for the committing side.

Other factors broached by the basic model were the transaction-sensitive and fixed costs as well as the wages transferred between the two agent sides. Both are relatively ordinary in their appearance and effect on the utilities and the profit. In summary, all costs have an effect on all three involved parties through the connection of indirect network externalities. Yet, the smaller the externalities, the less this effect is observable. This also applies under case I and III where the bottleneck ideally bears the transaction-sensitive costs. However, the strength of the effect on the utilities and the profit can vary with the observed party, the type of cost and the observed case. For instance, under case I, workers are affected the most by their own fixed costs, which explains why certain platforms try to mitigate these costs by certain offers or measures. The wage is only relevant for a case in which balance occurs in regard to work capacity and demand. Under case I and III the benefit a conducted task generates will be completely awarded to the bottleneck. Only under case II a wage is in effect to split the benefit between the two parties. Again, the network effects play a crucial role regarding the effect of the wage. For one thing, they lead to a connection of both sides, imposing a dampening effect on high or low wages. Furthermore, the higher the externalities are, the less noticeable a wage is in its effect. Overall, the wage strategy for the two agent sides is quite simple. Workers completely deduct a task benefit with a wage, while requesters aim to reduce the wage as much as possible. Such an approach could tilt the system in the direction of case I or III, if the externalities are too small. Nevertheless, the platform has the last word as to which value is actually transferred to the other side through its sovereignty in pricing, imposed by non-neutral pricing.

Can the prior findings add to the ongoing discussion aimed at DLMs?

In general, the model presented here and its derived findings are not able to provide an answer in regard to the ongoing discussion, which focuses on the workers’ situation and their ability to make a decent living, especially as independent contractors. However, certain impulses can be given.

One important finding in this respect is that workers encounter an inherently skewed situation under the assumption of full-time labor, if indirect network externalities are relevant and if requesters cannot generate a sufficient number of tasks. The assumption of full-time labor imposes the situation that the affiliated workers on average show a high capacity to conduct tasks, yet the requesters are the bottleneck in terms of transaction numbers, while the platform only cares about the absolute number of workers. Under such circumstances, the workers will experience a valuing, which will attract enough workers to provide the requesters with decent benefits, particularly in regard to the externalities. The workers' utility level, however, is deficient and can show low levels under certain settings of the involved parameters. Nonetheless, the provided utility level calculated in the model is only an average value. This implies that a task is potentially adequately remunerated while the workers simply experience underemployment, meaning that they are only provided a fraction of their actual task capacity in terms of task numbers. With this in mind, different scenarios can play out. One possible scenario is that a platform is predominately populated by workers who aim to work on the platform as full-time laborers. The planned average utility level a worker should receive according to the platform would presumably not suffice a full-time worker, since he faces many additional costs as an independent contractor. Such a worker will aim to increase his income by trying to conduct as many tasks as possible. The other workers will try to accomplish the same, consequentially leading to a high volatility in worker utility, ultimately fostering an unfavorable situation in terms of the related discussion. The second scenario is a platform with a healthy mix between full-time and casual workers. This would not only drop the average level of overall worker capacity but also mitigate the described tense situation. This can be the case if the main section of the casual workers is already in an employer relationship or if they are in another form not dependent on a constant stream of a sufficiently high remuneration, in contrast to the full-time workers. In such a situation, the full-time workers could compete for a remuneration above their means by conducting a number of tasks above the planned average, while some casual workers lag behind. In this case, however, the damage is not as grave if a casual worker occasionally makes less money than anticipated. In short, a DLM-platform should strive for a healthy mix between casual and full-time workers with a clear tendency to casual laborers, making it essential to be an attractive platform for part-timers and other people who only seek to supplement their income.[33] In any circumstance, workers must be aware that they are trading security for flexibility. Whether this trade-off occurs under fair circumstances will ultimately be decided by judiciary (Cherry 2016b) as well as empirical research.

Another important factor in regard to the ongoing discussion is competition. Naturally, the competitive state of the market influences the utilities of the participating agents. So far, DLM-

[33] Ideally, a platform with only casual workers would anyways not face the problems risen in the discussion regarding the worker situation, yet, such a scenario seems unrealistic, unless the relevant regulators prohibit full-time workers on DLM-platforms. Yet, such a measure seems extreme.

platforms developed and thrived in a relatively unregulated environment (Schmid-Drüner 2016). Regulators must be cautious to introduce measures, which might hinder the competitive environment of the industry. The according institutions must be aware of measures that hinder the switching between different platforms or different labor opportunities. Furthermore, network effects are often perceived under the tendency to concentrate a market (Nair et al. 2004). Regulators must be aware of this circumstance, since this could lead to a loss of competition. However, Evans and Schmalensee (2007) do not share this fear for TSMs. They showed that industries based on TSMs and two-sided platforms mostly show no monopolistic tendencies. Overall, it still seems reasonable to be cautious in this regard.

Lastly, the thesis emphasizes that the wage or rather the direct value transferred between the two agents is not an ideal tool to improve the workers' situation. The platforms' sovereignty over pricing and non-neutral pricing allow the firms to heavily influence and adjust the actual value transferred between the parties, with the transportation services as an extreme example in this matter. This is expressed by the situations where task capacity and demand are not balanced. The platform accordingly prices and distorts the transferred value to provide profit-maximizing utilities. Regulators might be prone to counter this with the application of a minimum wage or a minimum transaction value. However, this might be more challenging in reality than it initially sounds on paper, due to the flexible nature of the DLMs. For instance, should such a measure be valid for all workers or only apply to those who work full-time on a platform? If so, where should the line be drawn between workers who just provide their services for a pin money or an earning supplement and those who earn their main income in DLMs? Should waiting and task search times be considered by the level of remuneration or not? How can such a measure be implement in view of microwork, where tasks only last a few minutes and effective working times are hard to measure?

7.2 Drawbacks and Further Research

The ensuing part will cover drawbacks of the presented model and the applied assumptions, which might rightfully face criticism. Four potential directions of further research can be derived from this basis.

The model-based analysis was established under various assumptions. A very crucial assumption was the expectation of non-neutral pricing, meaning that the two agent sides cannot negotiate away imposed price differences. Especially for the branches of microwork and manual labor a possible pass-through of price differences might be possible, since most of the associated firms allow one side to set the price. Empirical research is required in this regard. Furthermore, the analysis ignored the effort workers have to put into a task, which might distort the presented results. Most parts of the presented model were perceived under the assumption that no task fails, which implies that every transaction will be conducted successfully. Such an assumption is obviously idealizing reality. Moreover, the modeled indirect network effects can have extreme effects on the outcomes and the applied pricing. Empirical research, which measures and researches the effect of indirect network externalities within the setting of DLMs, is required, as it was the case for other industries (Stremersch et al. 2007). The last point regarding the assumptions is the topic of multihoming. The chapter, which covered competition, ignored a setting where both parties multihome. Such an analysis, however, might be worthwhile, since such an occurrence can be relevant for transportation services where both sides, the workers and requesters, can easily rely on various platforms by simply installing the corresponding applications on their phone.

The presented model itself can also be viewed under critical aspects. A dynamic model would be able to emphasize other aspects. Most importantly in this respect would be findings regarding the life cycle of a DLM-platform and the resulting consequences for the participating parties. Clements and Ohashi (2005) showed, with respect to video games, that such an analysis can prove pivotal. Moreover, a dynamic approach would also be able to show the development of the agent numbers in the long run. This would allow for a more flexible modeling of the utilities, potentially allowing negative utilities in the short-run, for instance permitting the display of platforms' ability to actively adjust supply and demand. Furthermore, this would enable a more precise modeling of competition, since a mature platform presumably shows a different behavior than a new entrant. In general, the approach to transportation services and competition only moved on a very rudimentary level. For instance, in view of transportation services, the model indirectly assumes that the overall work capacity is the crucial part in satisfying demand. However, if a lot of requesters demand a ride or service at the same time, the overall provided capacity is irrelevant but instead is the sheer number of workers. Concerning the mitigating effect of timely matching and competition, other factors or circumstances might also be relevant, yet, the thesis was not aware of these situations. A corresponding extension and analysis is appropriate if this is the case. Moreover, the presented function to handle the matching probability was an overall inelegant take on the branch of transportation services, while a purely stochastic approach would have been more suited. In addition, the approach to varying agent valuations by the other side was also only tackled on a very basic level, while a more detailed take could provide further insights into this matter. Lastly, most parts of the analysis concerning the utility and profit behavior but also the discussion regarding the constraints assumed a linear increase of agent numbers in utility, even though this oversimplifies the matters.

On the basis of this criticism, four directly related opportunities for further research can be mentioned. Firstly, an empirical research of indirect network externalities is needed in order to better understand their effect and extent in DLMs. Secondly, further research in regard to price non-neutrality is required. Thirdly, timely matching and competition are possibly not the only mitigating factors concerning skewed pricing. Corresponding extensions and considerations can be appropriate and necessary. Finally, a more refined model might be able to add new findings and foster a better understanding of DLMs. In particular an extension under the light of dynamic and stochastic aspects could add value.

The presented findings and discussions also face two general limitations. Firstly, most literature directly aimed at DLMs mainly cover the situation in the U.S., since findings concerning European or other countries are sparse (Codagnone et al. 2016a; Codagnone et al. 2016b). Consequentially, the second chapter, which describes DLMs and provides related information, does not necessarily paint a generally valid picture of the industry. Secondly, the thesis was conceived under an economical conceptual perspective; therefore, it can only provide findings in this respect and cannot directly provide input concerning the worker classification discussion. Whether workers are rightfully classified as independent contractors is a matter of legal research.

8. Conclusion

The general goal of this thesis was to analyze digitally moderated labor under the perspective of TSMs, enabling a better understanding of how they function and potentially adding to the ongoing discussion regarding the workers. Such an approach to DLMs was so far lacking in the related literature.

The starting point was a relatively detailed conceptualization of the newly emerged industry, since the relevant literature is riddled by ambiguities in this matter. Chapter 2 identified DLMs as part of the sharing economy[34], defining DLMs as commercial and digital platforms, which center around the exchange of labor-based services provided on a peer basis. Overall, four relevant types of companies are part of DLMs - microwork, freelancing, manual labor, and transportation services. As of yet, DLMs are not an overly large phenomenon but are they neither small enough to ignore. A growing importance of DLMs can be expected, emphasizing the need to understand this industry and its functioning. This is required as DLMs are facing an ongoing discussion concerning a potential need for regulations.

The ensuing examination identified two-sided features for the branches of microwork, manual labor and transportation services. They show characteristics which indicate the existence of bilateral indirect network effects and non-neutral pricing. The latter aspect describes the circumstance that an unequal pricing imposed by the platform cannot be negotiated away by the participating agents. The subsequent model-based analysis was threefold. The first step represented the introduction and discussion of a basic model, providing the conceptual groundwork but also relevant findings. This foundation was extended under the consideration of transportation services and competition. Different findings were derived from this approach.

The basic model showed that price differences between the two agent sides are not only caused by dissimilar price elasticities but also by the transaction numbers. The side imposing a bottleneck on the number of conducted tasks will be heavily subsidized while the other side will just be considered in regard to its ability to generate network effects. Moreover, skewed pricing is inherent to these platforms under the assumption of full-time labor and if network externalities play a sufficiently large role. These characteristics can be mitigated by different circumstances, namely timely matching under the premise of self-scheduling and competition. However, the initially perceived value transferred between two interacting agents is of little importance in this respect, since the platforms reign supreme over the pricing through the incapability to renegotiate skewed pricing by the agents. These results also have implications concerning the ongoing discussion in view of the workers' situation. For one thing, DLMs in their current form might not be an ideal tool to procure tasks under the prospect of full-time labor. Moreover, competition can be crucial to alleviate concerns regarding worker utilities. Finally, a regulated wage could turn out to be difficult to realize and marginally effective. Nevertheless, the workers must be aware that they

[34] Referring to the definition formulated by Codagnone et al. (2016b).

face a trade-off between security and flexibility. Whether this trade-off happens under fair conditions is not for this thesis to evaluate but must be answered by empirical findings and legal assessments.

Further research concerning DLMs in view of two-sidedness could add crucial findings by empirically studying the potential indirect network effects and price non-neutrality within the industry. Moreover, valuable insights could further be gained by identifying other factors which are suited to mitigate skewed pricing. In addition, a more refined and elaborate approach to a model-based analysis of TSMs is also required, especially in regard of a dynamic and stochastic extension or adjustment.

In conclusion, this thesis represents a minor but first step in exploring the functioning of digital labor markets under the perspective of two-sidedness, capable to provide new insights regarding their operations.

Appendix A

Conceptual challenges related to DLMs

Three interrelated conceptual challenges can be identified regarding DLMs and the associated business models:

IV. Many different terms are in use to label DLMs or related business models.
V. Varying concepts and definitions exist to conceptualize the industry, many of them emphasizing different aspects.
VI. Within and across pieces of literature semantical inaccuracies and errors can occur.

As already mentioned, all three of these challenges are interrelated, especially the first and second one. A vast amount of different terms and names linked to digital labor markets and the related sharing economy can be found. Some of these labels basically describe the same concept or part of the industry, others emphasize selected aspects. The large number of different activities within this industry justifies to some extent the emergence of many labels. This variation and a significant quantity of distinct names are closely related to the second challenge. The different labels usually emerge with their own conception, some of them overlapping with other terms and definitions. It is not uncommon to encounter two or even more differing conceptions for a specific term. The third challenge is presumably a consequence of the first two points, which complicate a concise labeling and, thus, can foster semantically imprecise practice. In other words, the meaning of certain terms and the accompanying conception are blurry within or across some pieces of literature. The ensuing part will exemplify and present these issues in more detail.

Overall, the conceptual challenges can partially be displayed in table 8. The first column hereby lists different terms, which are related to the DLMs or can be encountered when dealing with this topic. It must be noted that the list of terms does not raise any claim to be exhaustive. Terms just loosely related or only appearing in a nonacademic setting are not listed. This includes terms and concepts which are too vague in their meaning or referring to other research fields. These are the matching economy, online labor platforms, the participation economy, the renting economy or talent marketplaces. Other left out terms can be found, for instance, within Codagnone et al.'s (2016b) work on page 20. The second column presents some illustrative pieces of literature for each term, where this specific term has an appearance. The chosen examples are limited to the academically suited material but otherwise do not follow a specific systematic. Some of these examples specifically resolve around this term and the related topic, using the term in a frequent and central manner.[35] Others mention the term just briefly and treat them mostly synonymous with others.[36] The third and last column gives a brief explanation of each row's term. The explanations are based on academic sources and intend to cover the concept behind the term in a rather broad and generally valid fashion, while including most of the relevant aspects. As already mentioned, this table has neither the claim to be in any form exhaustive nor is it based on a consistent systematic approach. Its main purpose is to allow for a better understanding of the conceptual challenges and the terminological complexity related to the DLMs via selected terms and examples. This goal does not require the table to be fully comprehensive or consistently systematic. In any case, such a thorough approach would not be purposeful in answering the thesis' research goal.

Table 8: Selected terms and definitions related to digital labor markets and the sharing economy

Term	Examples of appearance	Selected explanation
1099 economy	Aloisi (2016), Kalleberg and Dunn (2016), De Stefano (2016a)	The 1099 economy refers to businesses, which rely on self-employed independent contractors, rather than employees and in general the workforce who works as independent contractors (Aloisi 2016; Kotkin 2012). The income of independent contractors is reported via a 1099 form, as required by the U.S. Internal Revenue Service (Department of the Treasury - Internal Revenue Service 2018).
Access economy	Kalleberg and Dunn (2016), Sprague (2015), Valant (2016)	Goods as well as services are exchanged based on access instead of ownership. This term refers to business models and markets where renting temporarily is preferred and realized over permanent ownership (e.g., Airbnb). (Valant 2016)

[35] An example for such an case would be Garben's (2017) work, dealing with the online platform economy.
[36] As occurring, for instance, within the paper by Sprague (2015) with the term asset light lifestyle.

Asset light lifestyle	Aloisi (2016), Sprague (2015)	This term is closely related to the access economy, emphasizing the sharing or renting of assets rather than exerting direct ownership.
Collaborative economy/ consumption	Abele et al. (2015), Aloisi (2016), Botsman (2013, 2015), Donovan et al. (2016), (Ertz et al. 2016a, 2016b), Kalleberg and Dunn (2016), Schmid-Drüner (2016), Sprague (2015), Valant (2016)	Ertz et al. (2016a) define it as “the set of resource circulation systems, which enable consumers to both obtain and provide, temporarily or permanently, valuable resources or services through direct interaction with other consumers or through a mediator” (p. 6).
Commoning economy	Valant (2016)	“Initiatives that are collectively owned and managed (e.g., Wikipedia, Kickstarter)” (Valant 2016, p. 33)
Crowdsourcing / crowdwork	Berg (2016), (Kalleberg and Dunn 2016), Kalleberg and Dunn (2016), Todolí-Signes (2017a)	These terms refer to jobs conducted or moderated via digital platforms, outsourced to an undefined and large group of people, the so-called crowd (Berg 2016; Todolí-Signes 2017a).
Cyber labor markets	Cherry (2009)	Cherry (2009) uses this name to describe virtual labor markets for jobs, which are specifically conducted in “cyberspace” or “virtual worlds”, as for example within certain computer games.
Digital labor markets	Codagnone et al. (2016a)	Roughly speaking, Codagnone et al. (2016a) describes the exchange of labor-intensive jobs or services via a digital platform. These jobs and services can either be of digital nature or tangible nature, like cleaning services.
Freelance economy	Kalleberg and Dunn (2016)	This term refers to labor conducted by freelancers and freelancers themselves (Needleman 2009). Freelancers were defined by a study conducted by Edelman Berland (2014) as “individuals who have engaged in supplemental, temporary, project and/or contract based work” (p. 3).

Gig-Economy	Aloisi (2016), Berg (2016), Cherry (2016a), De Stefano (2016a, 2016b), Donovan et al. (2016), Farrell and Greig (2016), Friedman (2014), Kalleberg and Dunn (2016), Kuhn (2016), Rogers (2016), Schmid-Drüner (2016), Spreitzer et al. (2017), Todolí-Signes (2017b), Valant (2016)	The gig-economy describes a specific employment-situation, where workers are just employed from job to job. The term “gig” hereby is derived from the music industry, where musicians sometimes just work from gig to gig (Friedman 2014). The gig-economy, however, is not limited in its definition to a specific type of industry. (Friedman 2014; Kuhn 2016; Rogers 2016; Spreitzer et al. 2017)
On-demand economy	Aloisi (2016), Berg (2016), Cherry (2016a), De Stefano (2016a), Dokko et al. (2015), Donovan et al. (2016), Kalleberg and Dunn (2016), Smith and Leberstein (2015), Todolí-Signes (2017a, 2017b),	The on-demand economy is mostly understood by literature as an online app-based economy, where jobs are matched on an on-demand basis. This means that a job will just be matched with a worker as soon and as long as the demand for completion of this jobs exists by the customer. Consequently, the worker has no long-term employment relationship with the customer, and instead works from job to job. (De Stefano 2016b; Dokko et al. 2015; Smith and Leberstein 2015)
Online gig-economy	Dokko et al. (2015), Harris and Krueger (2015)	This concept is equal in terms of the employment-setting to the previously mentioned gig-economy. In this case, the online gig-economy solely focuses on business models, where labor is moderated and exchanged via digital platforms (Harris and Krueger 2015).
(Online) platform economy	Farrell and Greig (2016), Garben (2017), Kalleberg and Dunn (2016), Rogers (2016), Schmid-Drüner (2016)	In general, the online platform economy refers to economic activities centering around digital platforms who usually match, on a two-sided basis, clients and independent providers of goods or services (Farrell and Greig 2016).
Peer economy / peer to peer economy	Abele et al. (2015), Aloisi (2016), Botsman (2013, 2015), Donovan et al. (2016), Sprague (2015), Valant (2016)	Botsman (2013) defines the peer economy as “Person-to-person marketplaces that facilitate the sharing and direct trade of assets built on peer trust” (para. 26).

Reputation economy	Aloisi (2016)	The term reputation economy describes a broad concept, where social and business activities are closely linked to reputation. It is mostly related to online activities or “reputation” found on the internet; as for example reviews, ratings or certain internet activities. (Fertik and Thompson 2015)
Sharing economy	Abele et al. (2015), Aloisi (2016), Botsman (2013), Cherry (2016a)De Stefano (2016a), Donovan et al. (2016), Hall and Krueger (2015), Kalleberg and Dunn (2016), Schmid-Drüner (2016), Schor (2014), Sprague (2015), Todolí-Signes (2017a, 2017b), Valant (2016)	Codagnone et al. (2016b) defined the sharing economy as “wide range of digital commercial or non-profit platforms facilitating exchanges amongst a variety of players through a variety of interaction modalities … that all broadly enable consumption or productive activities leveraging capital assets … goods, skills, or just time” (p. 22).

Note: Own presentation. The examples of appearance and selected definitions are cited within the table according to the applied citation standard of this thesis.

The first column of table 8 is arranged to give an understanding of the first conceptual challenge and the use of many different terms to label DLMs or related parts of the industry. This table already displays 16 different terms and is far from being exhaustive. This circumstance can make it at times difficult at times to comprehend whether authors talk about the same industry and which part of the industry an author specifically covers. This issue gets leveraged by the second conceptual challenge. As the third column shows, many of these terms come with their own unique twist of conceptualization, emphasizing a certain aspect. Some conceptions and definitions are thereby quite blurry and overlap with other terms and definitions. For some terms matters are even worse, as different authors understand or apply various definitions and concepts. To prove this point and to make this situation more comprehensible, three selected terms and their conceptions are presented in more detail.[37]

[37] It shall be noted that these conceptual inconsistencies also exist for other terms of Table 8, besides the three shown examples.

The three selected terms are the collaborative consumption, the collaborative economy and the sharing economy.[38] Literature lists numerous understandings and definitions for each concept but usually applies only one of them as a general umbrella term (Codagnone and Martens 2016c). Some authors interpret the collaborative consumption as the overlaying concept (Ertz et al. 2016a, 2016b), others use the term collaborative economy (Botsman 2013; Schmid-Drüner 2016), then again there are authors which define the sharing economy as the all-encompassing umbrella term (Codagnone et al. 2016b; Codagnone and Martens 2016c; Valant 2016). To make matters worse, the notations collaborative consumption and collaborative economy are at times treated synonymously (Owyang et al. 2013; Valant 2016), sometimes as different concepts (Botsman 2013, 2015). The same is true for the sharing economy. Some literature considers it as a separate concept, other displays acknowledge or apply a synonymous use in regard to the other two conceptions (Codagnone et al. 2016b; Codagnone and Martens 2016c). While just having a look at the selected definitions of the collaborative consumption by Ertz et al. (2016a) and the sharing economy by Codagnone et al. (2016b), both presented in table 1, blurry tendencies are already noticeable. The definition by Ertz et al. (2016a) does also cover certain parts of Codagnone et al.'s (2016b) sharing economy. Other definitions show equal inclinations (Codagnone et al. 2016b; Ertz et al. 2016a, 2016b). Matters are also complicated and disjoint when trying to grasp a commonly shared understanding of just one of these concepts.

Ertz et al. (2016a, 2016b) portrayed and analyzed various definitions of the collaborative consumption. They found that many of these definitions tend to stress different aspects and rarely include all facets. For example, both Belk (2014) as well as Hamari et al. (2016) focus on web-based resource circulation systems. Yet, Belk (2014) excludes sharing-based activities, where no compensation is exchanged. Hamari et al. (2016), on the other hand, do consider such services and exchanges to be part of the collaborative consumption. Regarding the sharing economy, Schor (2014) states that it is nearly impossible to propose a precise definition, which meets the common usage, due to a huge variety of activities within it and self-set boundaries by its participants. Valant (2016, p. 33), for instance, characterizes the sharing economy as the sharing of physical and human resources, including the "creation, production, distribution, trade and consumption of goods and

[38] In table 5, the collaborative consumption and the collaborative economy are treated as a single concept to prevent confusions.

services", emphasizing access over ownership. Botsman (2015) defines it as an economic model centered around the concept of sharing underutilized assets or services with or without a fee, hereby only occurring within a peer-to-peer setting. Valant's (2016) definition is broader and states that the sharing economy could also be referred to as the "collaborative economy, peer-to-peer economy or collaborative consumption" (p. 33). Botsman (2015), on the other hand, limits her definition to a model based on the concept of sharing assets or services between individuals. This situation was also noted by Codagnone et al.; Codagnone and Martens (2016b; 2016c). They (Codagnone and Martens 2016c) found that there is "no 'shared' consensus on what activities comprise the 'sharing economy'" (p. 6), also leading to an overlapping use of different notations including the terms collaborative consumption and collaborative economy.

The third and last conceptual challenges are semantical inaccuracies and errors. These issues are closely related to the other two conceptual challenges and are presumably caused by them; as they emerged through a diverse understanding of the definition, scope and meaning of certain terms across the literature (Botsman 2015; Codagnone et al. 2016b; Ertz et al. 2016a). For one thing, this can lead to **the use of an identical term to describe different concepts**. A clear example of this case would be the term gig-economy. Some authors; for example Friedman (2014), Kuhn (2016), Rogers (2016) or Spreitzer et al. (2017) use this term to refer to a general style of working condition, where workers are just employed or work from job to job, not limited to a certain type of industry. Other authors like Aloisi (2016), Berg (2016), Donovan et al. (2016) or Todolí-Signes (2017b), just to name a few, use this term to refer to the above portrayed online gig-economy. T**he use of different terms by distinct authors to basically describe the same concept** can also be observed. Sprague (2015), for instance, uses the term sharing economy to refer to an online business model where a party with underutilized assets[39] is matched with another party who is in need of this asset. Rogers (2016) utilizes the name platform economy, which mostly covers Sprague's (2015) understanding of the sharing economy, underlined by many shared examples that both authors apply. The last issue is a **synonymous and interchangeable use of different terms by the same author**; although, some of these vary in their definition and stress other parts or characteristics of the industry. Examples for the second case are Aloisi (2016) or Donovan et

[39] This includes physical as well as non-physical goods, like spare time.

al. (2016). Both put the terms gig-economy, collaborative economy, sharing economy and on-demand economy in the same context and mostly use them synonymously.

Appendix B

Hereafter, the points of table 4 will be presented and explained in short, focusing mainly on issues which might not directly be self-explanatory. To increase comprehensibility, the structural approach of table 4 will be followed. It must be noted that the paragraphs below and the related table 4 show only the tip of the iceberg. The presented points are usually multi-faceted and would require an essay on their own to cover every aspect. Thus, for each point only a narrow view with a focus on the main arguments are presented. The hereby cited authors mostly present a general discussion of certain points, also relying on other sources, hence providing a suited first step for further research, if one chooses to go more in-depth into a certain aspect. Nonetheless, the applied scope of review is sufficient for this thesis to allow for a further discussion regarding TSMs.

The first section will cover the discussed **advantages** of DLMs:

I. Worker benefits: Benefits and advantages which directly affect workers.

Flexibility: As chapter 2.2 already showed, within most branches, workers are granted certain freedoms, like the ability to follow their own schedule and choose the tasks. (Eurofound 2015; Schmid-Drüner 2016)

Increased participation and inclusion: DLMs could lead to the inclusion of people who otherwise experience prejudice in a normal workspace due to automatic matching mechanisms (De Stefano 2016b). Algorithms and gathered data could also help to identify and overcome systematic discrimination (Sundararajan 2014). Furthermore, digital labor opportunities enable access to income to persons who are homebound, either through disabilities, children or other circumstances (Berg 2016; De Stefano 2016b; Eurofound 2015). Moreover, DLMs might grant easy access to labor in rural and war areas with little investment, as well as a first step into freelancing for young professionals (Eurofound 2015).

Wage level: The wage level provided by certain type of platforms can possibly be higher than classical means of labor in certain countries (Berg 2016). The research by Hall and Krueger (2015) concludes that workers of Uber earn more per hour than typical taxi drivers.

II. Requester benefits: Benefits requesters potentially experience.

Convenience: In general, these services are very convenient in their handling and are easily accessible, while providing rapid matching (De Stefano 2016b). Koopman et al. (2015) provide an overview and discussion of different sources, which underline the role and importance of convenience in regard to DLMs and the sharing economy.

Power and information asymmetry: The platforms provide rigid rating mechanisms and showcases, depending on the industry branch, relevant worker information. Amazon Mechanical Turk, for instance, allows for an uncommented and unpaid rejection of work while the requesters can retain the transferred results. This allows requesters to have better control over workers and access to worker-related information (Schmid-Drüner 2016). Koopman et al. (2015) argue that the established bilateral rating systems are suited to mitigate asymmetric information between workers and requesters, especially for the latter.

Consumer welfare: Koopman et al. (2015) state that these services and platforms offer more consumer choices, more service differentiation, better prices, and higher quality. The increased competition foster access to a bigger range of products and services. Cohen et al. (2016) calculated the consumer surplus Uber grants requesters based on a demand curve derived from the elasticity of demand. They found that Uber grants a higher consumer surplus than classical taxi services.

III. Platform functions: Advantages which are inherent in the platform functioning.

Efficiency: Many authors cover this feature (Agrawal et al. 2013; Codagnone et al. 2016a; De Stefano 2016b; Ipeirotis and Horton 2011; Koopman et al. 2015; Schmid-Drüner 2016). In general, this industry is enabled by digital technology and the internet, permitting matching with high speed, low transaction and search costs. It is possible to access a big pool of labor, potentially on a global scale, while being less expensive and scalable on-demand. The implemented rating and monitoring systems allow high levels of control with little costs, enabling outsourcing on relatively standardized terms and conditions while also remaining accessible by private persons and small enterprises.

Algorithms and ratings: The algorithms and rating systems permit a far-reaching outsourcing by low transaction costs (Drahokoupil and Fabo 2016). These systems grant the platforms the ability to create and meet certain levels of requester expectations with little effort (Rosenblat and Stark 2016). A relative homogenous behavior by the labor force can be achieved without explicit directives (De Stefano 2016b). Koopman et al. (2015) argue that these platforms are able to mitigate the classical lemons problem through effective monitoring and trust creating mechanisms.

IV. Economic effects: Potential positive economic effects on a country.

Growth and employment: DLMs could help previously unemployed to find a job and, thus, decrease unemployment (Codagnone et al. 2016a). Berg (2016) reports that one-third of the surveyed micro workers were previously unemployed. Codagnone et al. (2016a) further analyzed different sources, which researched temporary work arrangements, finding that this type of work can increase the likelihood of getting a standard job. Sundararajan (2014) expects an increase in consumption caused by new consumer experiences with higher quality and greater variety.

Production gains: Sundararajan (2014) states that the utilization of previously underused assets and human capital (under- or unemployment) generates production gains.

The ensuing paragraphs will cover the discussed **problems** associated with DLMs:

I. Labor situation: Factors affecting the labor situation of a worker and the ability to make a living.

Worker classification: A heavy discussed topic is the worker classification, especially in the U.S. Here, workers are classified as independent contractors and not as employees (Codagnone et al. 2016a). This has some major implications with respect to the employment law. The platforms do not have to provide employee benefits such as health and disability insurance (Abele et al. 2015), mustn't grant the workers paid sick or annual leave, (Aloisi 2016), a minimum wage (Todolí-Signes 2017b) or other employee-related benefits (De Stefano 2016b; Berg 2016). The classification is based on different tests, varying from state to state and the applicable law (Aloisi 2016; Cherry 2016a; Garben 2017; Todolí-Signes 2017b). Factors like the temporary nature, the worker autonomy, the informal nature of the workplace relations and the lack of a common and secure work environment hinder a clear classification (Garben 2017). Regardless, some authors claim that workers in certain branches of DLMs are wrongfully classified as independent contractors (Aloisi 2016; Todolí-Signes 2017b). Many ongoing litigations in this regard emphasize this issue (Cherry 2016a). Per se, a classification as an independent contractor mustn't impose a problem but could cause issues with respect to other points mentioned in the upcoming list, for instance a potentially low level of remuneration or the insecure characteristic of the provisioned work. Moreover, De Stefano (2016b) states that DLM-companies cause unfair competition by falsely classifying the workers as independent contractors in order to save labor costs. Other countries are also facing similar issues (Codagnone et al. 2016a; Garben 2017).

Pseudo-flexibility: Different authors (Aloisi 2016; Codagnone et al. 2016a; De Stefano 2016b; Smith and Leberstein 2015) argue that the praised flexibility of workers might just be an illusion. For a decent income, long hours have to be worked, global competition can reduce wages, peak hours and geographical time differences might limit flexible schedules as well as restricting guidelines and work frequency requirements (De Stefano 2016b). Working hours are heavily demand dependent and automatic matching can leave little control to workers (Codagnone et al. 2016a; Smith and Leberstein 2015).

Own equipment: The workers usually must provide their own equipment. For the above-mentioned examples of firms, only Handy allows workers to pass along certain costs to customers, but only if material outside the norm is required (Abele et al. 2015; Aloisi 2016; Handy Technologies 2018a; Todolí-Signes 2017b).

Insecure work: Workers income is highly volatile and directly linked to demand (Aloisi 2016). Furthermore, worker accounts can be easily and automatically disabled by a platform, if certain ratings or other criteria aren't met (Todolí-Signes 2017b; Huet 2014). According to De Stefano (2016b), workers experience a trade-off between (pseudo-)flexibility and added risks like the lack of employee-status related benefits. Codagnone et al. (2016a) reviewed different sources with respect to non-standard work arrangements, finding that such labor relations can be related to inequality and an increased risk of poverty.

Wage level: Chapter 2.2 showed that the remuneration level can be low for certain branches of the industry, especially if workers have to provide their own equipment and cover the running expenses (Aloisi 2016). Uber's minimum fare might not even be sufficient enough to cover the costs (Eurofound 2015). The previously cited study conducted by Dunn (2016) compared the freelancing wage levels in DLMs to classical freelancing earnings in the U.S., showing that freelancers usually earn significantly less in DLMs. Wages are especially low if no minimum wage regulation is applicable or implemented by the platform (Codagnone et al. 2016a). Wage levels are further impacted by the frequency of finding tasks (Berg 2016).

Competition amongst workers: There can be an increased competition between workers due to the low entries of barriers for workers and a potentially global scale of the labor force (Sundararajan 2014). Especially in microwork, an undersupply of tasks might be apparent (Berg 2016).

II. Direct impact on workers: Factors and issues directly affecting workers, which aren't related to the labor situation.

Safety and health implications: Garben (2017) argues that workers in DLMs are exposed to increased safety and health-related risks. On one hand, workers are exposed to classical risks related to the conduction of certain jobs. Other risks, are related to the precarious nature of the work, mainly having a mental effect. Furthermore, existing regulations are difficult to apply as the workers are just loosely related to the platforms, mainly responsible on their own to ensure the right safety and security measures. Constant monitoring could also lead to higher stress levels (Aloisi 2016). A comprehensive summary of relevant health and safety implications can be found within the work by Schmid-Drüner (2016) and Garben (2017).

Discrimination: Discrimination can possibly occur due to public profiles paired with racism, and geographical biases (De Stefano 2016b). Berg (2016) reports geographical restrictions and discriminating statements within the setting of microwork. Codagnone et al. (2016a) deliver a coherent overview of different aspects regarding this topic and related sources.

Child and forced labor: The global scale and easy registration progress paired with little screening in microwork might foster child and forced labor (Cherry 2009; De Stefano 2016b; Todolí-Signes 2017a).

Privacy and data concerns: Some authors (Codagnone et al. 2016a; De Stefano 2016b; Eurofound 2015) have brought forward concerns with respect to privacy and data security. These platforms gather sensitive personal data with little guarantee of confidentiality, as a recent data breach by Uber shows (Lee 2017). Smith and Leberstein (2015) share similar concerns, emphasizing the massive amount of data gathered by these platforms. Koopman et al. (2015) suggest the implementation of best practice solutions.

III. Platform functions: Problems which are inherent in the platform functioning.

Power and information asymmetry: In microwork, requesters are usually able to simply reject conducted work while retaining the results and the payment without further justification (Aloisi 2016; Benson et al. 2015; Berg 2016; De Stefano 2016b). Furthermore, workers cannot rate the requesters, which caused the emergence of third-party rating sites like Turkoption (Benson et al. 2015). Moreover, workers might face imprecisely explained tasks while it is hard to contact requesters for further specifications, possibly leaving the worker with the consequences of a bad rating (Eurofound 2015). In general, ratings have a heavy impact on the future ability of a worker to acquire tasks (Codagnone et al. 2016a). Furthermore, workers are dependent on the automatic algorithms of the platforms, with an opaque functioning in regard to pricing, task assignment and semi-automated evaluations (Codagnone et al. 2016a). Lastly, the platforms can automatically and freely adjust the rates without consulting the workers (Rosenblat and Stark 2016).

Rating, monitoring: The rating and monitoring systems implemented by the platforms can mitigate power and information asymmetries but also show own issues. Aloisi (2016) stresses the important role of ratings, as they put workers on a constant trial and highly affect the chance of a worker to receive jobs. Requesters take the function of a classical middle management function by evaluating the workers via ratings, whereas each requester could be affected by own biases (Rosenblat and Stark 2016). Codagnone et al. (2016a) review different papers, which analyzed such rating systems: Superstar effects can arise. The income is heavily affected by ratings but is potentially biased towards positive reviews.

Invisible worker: Moderated through IT-channels and with little direct interaction, workers might not be directly perceived as such but rather as a service. Working in the background, while being available on-demand could rise personal disconnection and the expectation that the workers run as smoothly as a software (Amazon Mechanical Turk enables requesters to automatically distribute tasks via algorithms). Such a setting possibly causes workers to receive bad ratings more quickly, even if they might not be the cause for certain problems, which consequentially affect their further prospect on the platform (De Stefano 2016b; Sundararajan 2014).

Inefficiencies: DLMs are perceived as efficient in terms of transaction and search costs, yet, there are factors which point in the direction of still existing inefficiencies. Berg (2016) criticize that microwork only shows limited possibilities for communication. Furthermore, it is not ensured that the same worker conducts all similar tasks of an issued task batch, there is no job-specific training, and there is still the need for work reviews conducted by other workers. Agrawal et al. (2013) and

Codagnone et al. (2016a) discuss more general factors, for instance superstar effects through ratings, country biases, earnings not correlating with skill, a bias towards positive ratings, and other points.

Professional development: Todolí-Signes (2017b) argues that the workers engage in no real entrepreneurial activities and have no prospect of a classical career or professional development, as opposed to workers employed outside of DLMs. This might be true for the microwork and transportation branches but could be open to discussion, especially for the freelancing branch. It is also not clear whether workers bring the necessary skills and if they are screened accordingly (European Agency for Safety and Health at Work 2015).

IV. Other issues: Issues which do not fit into the previous categories.

Taxes: The issued taxes are highly dependent on the willingness of the workers to report their earnings received via DLMs. Especially global acting platforms impose challenges to the fiscal institutions (European Comission 2016).

Licensing and consumer protection: Easy registration, the lack of licensing, and at times little screening might impose concerns in regard to consumer safety and quality (European Comission 2017).

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Abstract (English)

This thesis represents a first step in analyzing digitally moderated labor under the aspect of two-sided markets. New technological developments enable the central coordination of a potentially huge labor force, which is only loosely associated with a firm. This business is affiliated with certain benefits but faces also criticism regarding the laborers' potentially disparate trade-off between flexibility and security, ultimately fostering a discussion about a possible need for regulations. However, such a situation demands a clear understanding of the functioning and behavior of these labor platforms, especially in regard to the workers' remuneration. This is where this thesis steps in by pursuing to provide an according understanding, while applying a two-sided market approach. The analysis under the perspective of two-sided markets is opportune, since these labor platforms mostly classify as such. Two-sided markets hereby impose unique considerations, as they have to tend to two or more interrelated markets at the same time, consequentially showing special characteristics. Most parts of the analysis are based on a static mathematical model. The interpretation and evaluation of the model delivered different results. The foremost finding is the circumstance that workers will automatically face an unfavorable environment under the assumption of full-time labor. Yet, this can be mitigation under certain circumstance, like an increased demand in workers through "timely matching" or competition.

Abstract (German)

Die vorliegende Thesis repräsentiert einen ersten Schritt in Richtung einer Analyse von digital vermittelter Arbeit unter der Perspektive von zweiseitigen Märkten. Neue technologische Entwicklungen ermöglichen die zentrale Organisation einer potenziell großen Arbeiterschaft, die nur sehr lose an ein Unternehmen gebunden ist. Dieses Geschäftsmodell bietet gewisse Vorteile, erfährt aber auch Kritik hinsichtlich eines möglicherweise ungleichen Trade-offs zwischen Flexibilität und Sicherheit, den die Arbeiter erfahren. Jener Umstand fördert eine Diskussion in Bezug auf einen möglichen Bedarf nach Regulierungen. Dennoch verlangt dies ein klares Verständnis über die Funktionsweise und das Verhalten dieser Plattformen, insbesondere angesichts der Arbeitsvergütung. Dies ist der Punkt, an dem die Thesis ansetzt, indem diese das Ziel verfolgt ein entsprechendes Verständnis mittels einer Herangehensweise basierend auf zweiseitigen Märkten zu ermöglichen. Die Analyse unter der Annahme von zweiseitigen Märkten ist passend, da die Arbeitsplattformen meist als solche klassifiziert werden können. Zweiseitige

Märkte verlangen hierbei besondere Überlegungen, da diese zwei oder mehrere zusammenhängende Märkte gleichzeitig betreuen müssen und konsequenterweise spezielle Eigenschaften aufweisen. Weite Teile der Analyse basieren auf einem statisch-mathematischen Model. Die Interpretation und Auswertung des Models liefert verschiedene Erkenntnisse. Die wichtigste Entdeckung ist der Umstand, dass Arbeiter automatisch ein ungünstiges Umfeld unter der Annahme von Vollzeitbeschäftigung vorfinden. Wiederum kann dies durch besondere Umstände abgeschwächt werden, wie etwa ein gesteigerter Bedarf an Arbeitern durch „Timely Matching“ oder Wettbewerb.