Transaction Costs, Smart Contracts, and Independent Work

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Abstract: The rapid growth of technology not only is creating innovative goods and services, but it is also altering the workplace and the traditional understanding of relationships between employee and employer. This can be seen today with the rise of independent work or alternative work arrangements. This paper provides an understanding of how technology has reduced the transaction costs of contracting in the market. In particular, we identified the innovations that have led to reductions in triangulation, transfer, trust, and measurement costs. These costs are relevant for creating greater exchanges between consumers and labor suppliers, and greater use of contractors in firms. We then provide a preliminary extension of the transaction costs framework to understanding how innovations in blockchain technology and smart contracts could further reduce transaction costs. These technological innovations could continue to alter the employee-employer relationships, leading to more decentralized work that mirrors the fundamentals of "contract at-will" employment.

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Section 1: Introduction

Recent technological changes are impacting not only goods and services, but also labor markets in the United States. We find ourselves on the brink of structural changes in labor markets as the traditional relationship between employee and employer is being disrupted, and the applicability of labor regulations that govern these relationships appears to be dissipating. Most notably, this change can be seen in the rise of the gig or platform economy, which is comprised of labor market activities coordinated via digital platforms whereby individuals take on commissioned tasks without guarantee of further employment. The companies operating these digital platforms act as intermediaries between the consumers ('demanders') of the good or service and the workers ('suppliers') who provide the good or service.[1] These digital platforms have also given greater prominence to the rise of freelancers and other type of independent work. While there are distinctions, "platform-based work", "freelancing", and "contracting" are all terms that are often used interchangeably with "gig economy" because they are all forms of independent work referred to as "alternative or external labor arrangements" and are contrasted with the standard employer-employee relationship.[2]

Based on a 2017 survey, the U.S. Bureau of Labor Statistics found that 10.1 percent of workers engage in contractor, freelance, or gig work as their *primary* income source.[3] Another survey study found that there were 57 million freelancers, gig workers, or contractors in 2019, implying that close to 35 percent of the US labor force engaged in these types of self-employed work, either as a primary or secondary source of income.[4] In fact, between 2014-2017, these types of self-employed work have grown three times faster than the growth of the US workforce.[5] Other survey studies by MBO Partners and McKinsey Global Institute all point to a growth of gig, contract, and freelance work.[6]

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[1] See, Valerio de Stefano. (2016). "The rise of just-in-time worforce: On-demand work, crowdwork and labour protection in the gig economy." *International Labour Office – Geneva.*

[2] Following the literature on this, I also use gig, freelance, and independent contracting interchangeably to refer to work classified as alternative or external labor arrangements.

[3] Bureau of Labor Statistics, *News Release* (June 7, 2018): https://www.bls.gov/news.release/pdf/conemp.pdf

[4] Edelman Intelligence, "Freelancing in America: 2019." Study commissioned by Upwork and the Upwork and the Freelancers Union. https://www.slideshare.net/upwork/freelancing-in-america-2019/1

[5] Edelman Intelligence, "Freelancing in America: 2017." Study commissioned by Upwork and the Upwork and the Freelancers Union. https://www.slideshare.net/upwork/freelancing-in-america-2017/1.

[6] MBO Partners, *The State of Independence in America*, annual reports 2016–2019, https://www.mbopartners.com/state-of-independence/; James Manyika, Susan Lund, Jacques Bughin, Kelsey Robinson, Jan Mischke, and Deepa Mahajan, *Independent Work: Choice, Necessity, and the Gig Economy* (New York, NY: McKinsey Global Institute, October 2016).

Using micro administrative tax data from the IRS, a recent study found that the share of the workforce with income from alternative work arrangements has increased by 1.9 percentage points from 2000 to 2016, and it now accounts for 11.8 percent of the workforce.[7] The same study was also able to differentiate between gig and non-gig platforms, and concluded that more than half of this increase in alternative work arrangements occurred over 2013 to 2016 and "can be attributed almost entirely to dramatic growth among gigs mediated through online labor platforms."[8] In another study following tax forms, Eli Dourado and Christopher Koopman find there has been a 22 percent increase since 2000 in the use of 1099-MISC (independent contractor) forms accompanied by a decline of 3.5 percent in the use of W-2 (employee) tax forms.[9] Several other studies also document the rise of contractor and self-employed work in the United States through use of tax forms and other administrative data.[10]

Globally, one measure indicates that 1.5 percent of the global workforce is engaged in platform economy work.[11] In Europe, research suggests that individuals engaged in independent work comprise about 9 percent of the labor force in Germany and the United Kingdom, and about 22 percent in Italy.[12] Professional services company PwC estimates that the platform economy could generate revenues of $335 billion globally by 2025.[13] A recent study also found that among OECD countries, "solo self-employment" (self-employed individuals without workers—typically freelancers, contractors, and gig workers), account for between 4 and 22 percent of total employment, and that solo self-employment has been rising relative to self-employment with workers (i.e. owners of businesses who have employees), in almost all OECD countries.[14]

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[7] Collins, B., Garin A., Jackson, E., Koustas, D., and Payne, M. (2019). "Is Gig Work Replacing Traditional Employment? Evidence from Two Decades of Tax Returns." Working Paper.
[8] Collins et al (2019). "Is Gig Work Replacing Traditional Employment?
[9]Dourado, Eli and Christopher Koopman. 2015. "Evaluating the Growth of the 1099 Workforce." Mercatus Center Policy Report.
[10] Abraham, Kathrine G., John C. Haltiwanger, Kristin Sandusky, and James R. Spletzer. (2018). "Driving the Gig Economy": http://papers.nber.org/conf_papers/f110357/f110357.pdf; Jackson, Emilie, Adam Looney, and Shanthi Ramnath. (2017). "The Rise of Alternative Work Arrangements: Evidence and Implications for Tax Filing and Benefit Coverage," Office of Tax Analysis Working Paper No. 114, U.S. Department of the Treasury, Washington, D.C.; Mishel, Lawrence. (2018). "Social Security Data Confirm Same Old Patterns: Self-employment Headcount Has Risen but Economic Impact Remains Small," Economic Policy Institute Working Economics Blog.
[11]Hunt, A. and Samman, E. 2019. "Gender and the Gig Economy: Critical Steps for Evidence-Based Policy." Working Paper #546, ODI.
[12]Huws, U., Spencer, N., Huws, U. and Syrdal, D.S. 2017. "Work in the European gig economy: research results from the UK, Sweden, Germany, Austria, the Netherlands, Switzerland and Italy." Hat eld: Foundation for European Progressive Studies
[13]Hawksworth, J. and Vaughan, R. .2014. "The sharing economy: Sizing the revenue opportunity." PricewaterhouseCoopers
[14]Boeri et al. "Solo Self-Employment and Alternative Work Arrangements."

These studies indicate that the nature of work seems to be changing toward more independent work. Why might this be happening? Can we expect it to continue to happen?

To answer these questions, this paper draws on Oranburg and Palagashvili (2020) to understand how technological innovations have led to changes in transaction costs—in particular, reductions in triangulation, transfer, trust, and measurement costs. The fall in these transaction costs creates increased direct consumer-to-labor supplier exchanges, and hence more 'independent contractor' type of work. From the firm-level decision making, it reduces the costs of contracting relative to employing. These factors can help explain the rise of freelancing, contracting, and gig work today.

Furthermore, we apply this transaction costs framework to understanding the innovations in blockchain technology and smart contracts, and what it can mean for independent work. Smart contracts are computer programs that can automatically execute their own terms when a preconfigured condition occurs, which can solve many problems in contracting that currently need intermediation.[15] We argue that blockchain technology in general, and smart contracts in particular, will continue to incentivize greater use of contractor and freelance work. With countervailing factors held constant, this can lead to more disruption in traditional work arrangements. In other words, just as technological advancements up until this point have reduced transaction costs that have enabled more independent or "gig economy" work, smart contracts will continue to reduce these costs and push the decentralized notions of workspace that mirror "contract at-will" employment.

Our paper is not an empirical one that aims to quantify and isolate the primary reasons for why we see changes in the nature of work. We are merely providing an analysis of the way in which transaction costs can influence the changes in the nature of work. We acknowledge that the various reductions of transaction costs are not the only factors leading to the transformation of work today. Following the work of several labor economists and legal scholars, we agree that various labor regulations have made it more costly to use employees over contractors, and hence of contributed to more independent workers. Moreover, sociological factors also matter for the why the nature of work is changing. Richard Florida's work points to the "rise of the creative

[15] For a description of smart contracts, see Crosby, M.A., Pattanayak, P., Verma, S., Kalyanaraman, V. (2016), Blockchain Technology: Beyond Bitcoin, Applied Innovation, No. 2, at 8.

class," and how individuals are beginning to act as "creative," types, which in part means preferring greater flexibility and moving away from 9-5pm employment (Florida 2002).

Our paper will proceed as following: Section 2 will present the theoretical framework on firms, transaction costs, and the decisions to contract out labor. Section 3 will provide an overview of the Oranburg and Palagashvili (forthcoming) analysis of technological changes in transaction costs for independent workers. Section 4 will provide a preliminary analysis of how the transaction costs framework is applicable for understanding how innovations in smart contractors can further create opportunities for decentralized work. Section 5 will discuss the implications and conclude.

Section 2: The Transaction Costs Framework

Much of the literature on the study of alternative labor arrangements and firms' decisions to contract out labor has focused on identifying the characteristics of firms that will predict a preference for contracting out or staffing up (Davis-Blake & Uzzi 1993; Kalleberg & Schmidt 1996; Uzzi & Barsness 1998). Other scholars have focused on the characteristics of workers who prefer to be contractors instead of employees (Howe 1986; Williams 1989; Cohen & Haberfeld 1993). Yet others have explored market conditions that could predict more or less long-term employment (Abraham and Taylor 1996; Weil 2014).

One important theoretical framework on the contracting vs. employing decision has its underpinnings in the transaction costs economics literature, which has its beginnings in Ronald Coase's seminal paper on "The Nature of the Firm" (1937). Transaction costs refers to all costs associated with carrying out an exchange, which includes the costs of originating, negotiating, consummating, monitoring, and enforcing a contract for any given exchange. Coase explains how positive transaction costs are responsible for the creation and growth of firms. This is because it may be less costly for firms to set up and create one contract (an employment contract) when a job has to be done repeatedly rather than creating an infinite series of potentially costly contracts in the market.[16]

[16] Coase (1937, 391) explains that the owner "does not have to make a series of contracts with the factors with whom he is co-operating within the firm, as would be necessary of course, if this cooperation were a direct result of the working of the price mechanism."

In other words, transaction costs make the use of the market system somewhat costly for ongoing exchanges. From this, it follows that the higher the cost of transacting across markets, the greater the advantage of organizing within the firm. Or the corollary, as transaction costs decrease, there will be a tendency for greater use of the market system rather than use of the firm. Coase's foundational work was ambiguous about the specifics of transaction costs, but subsequent scholars investigated the particulars of these transaction costs—identifying concepts such as search, bargaining, and monitoring costs, among others (Alchian and Demsetz 1972; Williamson 1981; Cheung 1983; Grossman and Hart 1986; Holmström and Milgrom 1991). The relevance of transaction costs for the independent work is as follows: if technological advancements can reduce the costs of transacting outside of the firm (in the market) rather than inside of the firm, this cost reduction can help explain the rise of contractor work. Munger (2015; 2018) is one of the first to apply the transaction costs approach to one sector of the "new economy," the sharing economy (i.e. Uber, Airbnb), and specifically on the product and service side. We extend Munger's discussions into analyzing the labor market, and in doing so, we identify the mechanisms and specific types of transaction costs relevant for understanding the increase of contractor, freelance, and gig work. In the following sub-sections, we explain how changes in triangulation, transfer, and trust costs impact direct consumer-to-labor supplier transactions (referred to as a "peer-to-peer" relationship), and how changes in measurement costs impact the firm-to-labor supplier market, although these costs are generally applicable to both markets.[17]

2.1. Triangulation Costs

Triangulation costs are a category of transaction costs coined by Munger (2018) to encompass both search/information costs (Dahlam 1979) and bargaining costs (Alchian and Demsetz 1972; Dahlam 1979). Search/information refers to costs in determining what is available on the market, including information on ability and location of each counterparty. Bargaining costs are costs of coming to an agreement between the parties. For example, when buying a home, the search costs are the costs associated with finding and determining the home's condition. Bargaining costs are

[17] Changes in triangulation, transfer, and trust costs are most clearly illustrated by peer-to-peer transactions, because they can be quite high in the sort of one-off exchanges that are now facilitated by technology platforms, although they likewise impact a firm's decision to hire up or contract out for services.

the costs of negotiating a price and the conditions of the transaction with the seller. Munger groups these two categories of search/information costs and bargaining into one—calling it triangulation costs. We follow suit to simplify the discussion. Taken together, triangulation costs refer to the costs of finding the counterparty and agreeing to the terms of the transaction.[18]
We provide an illustration of how triangulation costs are relevant for peer-to-peer exchanges: Person A wants to have a painting hung in his/her apartment, but the costs of finding Person B, who is nearby and willing to hang the painting and has the ability to do so, and then negotiating on the terms of agreement, may be too high. If triangulation costs are too high, that exchange may not occur. In general, if the cost of discovering buyers and suppliers of a particular service and coming to an agreement for each transaction is high, then there will be fewer opportunities for exchange and thus fewer "peer-to-peer" transactions. Thus, the hypothesis with technological change is as follows: If technology can reduce the costs of discovering one another and reduce the costs of coming to an agreement, then there will be more peer-to-peer transactions, and thus more and contracting of labor, where a consumer will directly pay a labor supplier for providing a particular good or service.

2.2. Transfer Costs

Transfer costs are the costs of "transferring payments and goods that are immediate and as invisible as possible" (Munger 2018, 9). Where triangulation costs refer to the ability to get information about each party and to come to an agreement, transfer costs refer to the ability to process payments and to physically provide the good or service. This includes handling and storage costs, direct transport costs, costs of money transfer or verification processes, and the legal constraints that further impact the transfer of payments and goods and services. For example, Person A knows that Person B is willing and able to provide the service of hanging up the painting, but Person B does not have the ability to receive credit card payments. If Person A only has a credit card, they may not be able to transact, because transfer costs are too high. Similarly, if Person B needs to employ a costly transport to perform this service, that increases transfer costs, then again the parties will not transact if such costs are too high. Generally, transfer costs rise inversely to the ease of transfer of payments and goods or services, so, if the

[18] We follow Munger's decision to group search/information and bargaining costs together as "triangulation costs" to simplify the discussion, but the conclusion would be the same even if these costs were analyzed separately.

process of providing the goods or services and paying for the goods or services is less costly, then there will be more peer-to-peer contracting.

2.3. Trust Costs

Even if Person A and Person B are easily able to find each other and come to an agreement for hanging a painting, and they have few problems with transferring the service and the payment, there may still be significant concerns with having a stranger visit one's personal home, or concern about the quality of the service rendered. These are trust costs, and, if they are too high, then the peer-to-peer transaction may not occur. Trust refers to the ability to outsource "assurance of honesty and performance" (Munger 2018, 9). Person A could find out whether Person B is skilled in hanging a painting and to be trusted to enter his/her personal home, but it could involve a costly process of calling neighbors, finding someone who might know someone who might know Person B, and so forth. Person B might likewise be concerned that Person A will fail to make the payment once services are rendered. When assuring trust is costly, parties may decide not to exchange at all. But if trust becomes easier to assess with less costly information, then parties to a transaction will more likely come to exchange, thus expanding opportunities for buyers and sellers to contract with each other. In other words, if the costs of finding that each party can be trusted are lower, this further increases peer-to-peer transactions.

2.4. Measurement Costs

Important to the firm's decision to hire or contract is the ability of employers to measure the performance of the worker or the output he/she produces. This is referred to as measurement costs, and it can be higher where multiple workers are engaged in a single project. Alchian and Demsetz (1972) discuss the theory of team production and explain how firms solve the difficulty of ascertaining individual contributions. Cheung (1983) also explains that since some components of a particular good/service are assembled in a way that makes the separation of workers' contributions costly, firms hire employees.

In other words, if an individual worker's contributions are perfectly definable and measureable, then firms could directly "buy" their output in the marketplace. But many outputs require joint/team production, where it is difficult to ascertain individual contributions. In these cases, it is easier to employ workers and measure/monitor individual inputs (e.g., hours worked) as a proxy for outputs. For example, it is easier to commission a writer to produce a screenplay

or a manuscript than it is to contract separately with many lawyers to structure an acquisition. Screenwriting is an individual task, so a firm can simply pay a screenwriter for a finished product. Structuring an acquisition requires many workers' efforts because it may require several thousand person-hours of work to be completed in a few weeks' time, and it is hard to correlate an individual lawyer's effort with a successful result, so the acquirer will hire a law firm, and the firm will monitor the worker inputs (e.g., billable hours).

Thus, when measurement costs are lower, firms will tend to contract out rather than staff up (employ). If technology can lead to the performance of individual workers to be more definable and measureable, then firms are more likely to contract out the labor than to hire an employee. Williamson (1981, 564) similarly refers to this type of transaction cost but calls it "the ease with which the productivity of human assets can be evaluated."[19]

Section 3: Application to the Platform Economy

Before we begin to apply the mechanisms and specific transaction costs to understanding the labor market side and independent work, we provide a description of how the sale of goods and services and the type of transactions have changed with new technologies. Such changes have created new sets of economic activities, for example, the sharing economy and the on-demand economy.

3.1. Descriptions of New Economies

To contrast the new economies, consider how goods are created in a traditional manufacturing economy. For a car, first, coal and ore are mined and smelted, to make steel. This steel has more value than the coal and ore did in the ground. Second, that steel is transported to a car assembly-line factory, where it has more value as a car door panel. Third, that door panel is incorporated with other "inputs" from other "upstream producers" such as glass windshields and electronic components to create a functional car. A whole car that can drive is worth more than the sum of

[19] In the transaction costs literature, monitoring costs are a type of transaction cost that, if decreased, would lead to greater usage of contract labor. It's important to note, however, that if technology reduces specifically the *input* monitoring costs, this can lead to greater usage of employees rather than contractors, given other factors for why the firms are relying on the proxy measure of inputs rather than outputs. Cheung (1983) elaborates on this analysis, and Baker (2015) provides an empirical investigation of how the reduction in input monitoring costs lead to an increase in truckers as employees rather than contractors.

its static parts. Fourth, the finished product (our new car) is transported from a centralized manufacturing facility in, say, Indiana, to retail auto dealers all over America, where it is more convenient for prospective buyers to test and acquire that car. Fifth, salespeople at those dealerships inform buyers about the car's features, help buyers secure financing, and teach them to use the technical features on the vehicle. Sixth, independent aftermarket car maintenance and repair services providers help keep that car running. Each step in this process, which can be visualized as a river upon which inputs flow from upstream supply to downstream sales, adds value to the product.

In contrast, the sharing economy is based on resource re-allocation. The resources that were extracted and sold in the traditional economy may be under-utilized. For example, consider a vacant home. This home is built from materials extracted via the traditional economy. It was sold to someone who no longer has as much use for it, but it is not a good candidate for resale due to tax or other reasons. This vacant home is an under-utilized asset. The sharing economy provides technological solutions to make better use of this asset: the Airbnb platform connects individuals who have vacant homes with individuals who would pay to stay in those vacant homes.

Cars are also underutilized assets when they sit in driveways and parking garages. GetAround is a peer-to-peer car-sharing platform where individuals borrow an idle car, and car owners place a piece of technology on their car that tracks the location of the car and locks/unlocks the car. With the tap of an app, owners can indicate when they want to make their car available or when they are taking it off the market. A car borrower uses the app to find available cars and unlock them. When the borrower is finished, the app finds a new parking spot for the car, under a set of conditions for how far the owner would like it to be from the original location. The platform also processes payments and insurance information and provides user ratings.

These are examples of the 'on-demand' economy, a digital marketplace that matches consumer wants with providers to immediately deliver those goods and services.[20] It includes companies such as InstaCart, Handy, and Postmates; these platforms connect buyers and sellers

[20] The definition used by the coalition of on-demand companies is as follows: "The On-Demand Economy is defined as the economic activity created by digital marketplaces that fulfill consumer demand via immediate access to and convenient provisioning of goods and services." (theondemandeconomy.org)

for all types of goods and services to be rendered "on demand." Typically, on demand-economies will utilize contract work precisely because the on-demand business models necessitate a flexible labor supply (Palagashvili 2017). A decade ago, these types of exchanges would have been too costly to facilitate, and it would have been easier to buy or rent a car in the traditional manner. But with new technologies, especially web platform technology, peer-to-peer bike-riding, clothes sharing, and a host of other assets are now proliferating the market.

3.2. Transaction Costs and Independent Work

As technology is reducing transaction costs and allowing for the emergence of the sharing economy, peer-to-peer networks, and on-demand goods and services, it is also altering labor markets. This remarkable reduction in transaction costs has sweeping implications for labor and its regulation. With the reduction of transaction costs, it is becoming more common for firms to "rent" workers rather than create long-term contracts with them (i.e. "buy" them). Meanwhile, consumers are increasingly "buying" labor directly—via web platforms—thus leading to the emergence of the "gig" or "platform economy," or independent work. For example, Amazon Mechanical Turk (MTurk) is a web platform that "operates a marketplace for work that requires human intelligence." MTurk facilitates posting job ads and offering services, which makes it easier and cheaper for buyers and sellers of labor to find each other. Amazon supports MTurk with a highly advanced web payment system, and it incorporates a robust bilateral rating system that informs people about the trustworthiness of market participants. Generally, performance of work via MTurk is cheap to observe: for example, a mechanical turk might be paid $1 to watch a 1-minute video and write the first five words that come to mind. It is easy to determine whether the video was played and words were entered.

While the tasks currently performed on MTurk are generally mundane, they may become more complex as technology continues to reduce transaction costs of contracting in the market. Munger predicts this as well, as technology continues to reduce transaction costs, "the very notion of a firm may start to be eroded. A group of people, each of whom has developed a set of specialized skills and a reputation based on ratings on software such as LinkedIn, would be hired for a project" (Munger 2015, 206).

3.2.1. Triangulation Costs and Independent Work

Thanks to the Internet, and specific software platforms and agreements, the costs of discovering buyers and sellers have become so low that it has enabled opportunities for suppliers of labor to directly contract with consumers. This reduction in triangulation costs not only facilitates the peer-to-peer economy perspective; it also in some cases diminishes the necessity of firms. Platform technology has driven down triangulation costs, making a broader range of work suitable for contractor arrangements.

Software used on these platforms includes such things as advanced GPS techniques to easily locate consumers who want a particular service with suppliers who are willing to provide it. Software also allows for users to easily indicate preferences, including the willingness to buy/sell at particular price points—thus enabling the algorithm to instantly find a match between two parties. Quick and simple search functions, internal messaging systems, and dashboards to keep track of interested parties significantly increase the ability and reduce the cost to search and find a particular buyer or seller. In this way, the technology is reducing search costs and thus the ability for two parties to find and match with one another.

Furthermore, the platform itself is a formal channel for standard provision of services. Contracting costs are reduced as terms are essentially crowdsourced from the feedback of millions of platform users, so that users converge to a focal contract based on reasonable expectations. Furthermore, in some cases, the price is set by the platform (i.e. Uber), and that further reduces the bargaining costs, which could be significantly costly for every time a user took an Uber ride.

3.2.2. Transfer Costs and Independent Work

With the innovations in credit cards, online payment systems such as Paypal and Venmo, and payment verification technologies, the transfer costs of payment have fallen. This allows for companies to hold funds in escrow. In the case of Uber, the platform holds the rider's payment in escrow for the driver until the ride is completed, and these funds are automatically released when the destination is reached. Drivers no longer have to worry that a rider will have insufficient funds to pay when the destination is reached.

Furthermore, the transfer of physical goods or services is made easier with location tracking and GPS technologies that can reduce the costs of moving the particular good or service.

For example, the process of receiving and providing a ride on Uber are simple: riders do not need to give directions to drivers to pick them up nor to drop them off at their designated locations. The software provides everything and includes traffic or construction problems that may get in the way of delivering the service of a ride. These new technologies have reduced the transfer costs, thus allowing more exchanges between consumers and suppliers of the particular service—hence, the emergence of greater independent work.

3.2.3. Trust Costs and Independent Work

Platform economy companies employ rating and review systems that make it much easier to learn information about the honesty and probable performance of a potential counterparty via information on the Internet. Depending on the software, there are personal profiles of users, where one can observe relevant information that are proxies for 'trust.' Information on both buyers and suppliers are crowd-sourced and up-to-date, meaning that if a particular driver is rated poorly at any given moment, that automatically gets updated onto the driver's profile. Drivers can also rate riders, so if a rider harasses a driver, that information is added to the rider profile. This robust two-way rating system employed by most platform economy companies provides valuable trust information that would be unavailable or too costly in a traditional economy, where phone calls or personal knowledge is needed to ensure trust. Thus, with this technology, both parties to a transaction have better information on the counterparty before they agree to the transaction. In the example discussed above with Person A who would like a stranger to come into his or her home to hang a painting, TaskRabbit, the platform that enables this type of transaction, utilizes software to provide vetting and rating systems for both buyers and suppliers. Thus, new technology reduces the problem of trust, allowing for greater consumer-to-labor supplier transactions, and hence more 'gig' type of work.

3.3.4. Measurement Costs and Independent Work

Technology has enabled the creation of discrete outputs that can be separated into individual contributions, and hence reduce the problem of measurement costs faced by employers. Innovations in software that run automated surveys, aggregation of reviews, and big data, also provide low-cost methods of measuring, thus allowing workers to be compensated

directly for their performance. This can be best illustrated by innovations in software developing, which has been the largest role that firms have outsourced in the form of contractor labor. High-level decomposition of a software design technique called modular programming, where code is written in a set of discrete, independent, interchangeable modules, allowed for the separation of individual contributions. Each module contains everything necessary to perform just one aspect of the overall program's function. This is distinguishable from a monolithic application both in terms of code structure and industrial organization. With modular programming, no one person or team is responsible for creating the whole program. Instead, the program is broken down into discrete projects. Each project can be completed by a small team or even one person. The success or failure of each project can be easily evaluated by determining whether the module performs its discrete function. In other words, because of modular programming, software coding is much less of a "team production" exercise. Instead of the entire code either functioning or not (which would make it hard to determine which programmer broke the code), modules — the output — can easily be measured and attributed to individual efforts.

Section 4: Applying Transaction Costs Economics to Blockchain Technology

4.1 Overview of Blockchain and Smart Contracts

Blockchain technology (or simply "blockchain") allows transactions to be recorded without a centralized authority. Blockchain has the power to reduce transaction costs in many industrial applications. While blockchain is presently best known for propagating cryptocurrencies, blockchain actually has a much broader set of applications including identity verification, the internet of things, smart property, and smart contracts. It is not cryptocurrency but **smart contracts** that we believe will most significantly impact the nature of the firm for reasons discussed in the next section. But first, we explain basic concepts about blockchain itself, and it is probably easiest to understand blockchain through its original use case of cryptocurrency. The concept of blockchain originated in 2008 as a solution to a double-spending problem that would otherwise make decentralized cryptocurrencies unreliable, although it solves many other problems in industrial organization.

For illustration, consider going to Tali's Video Arcade. You put a five-dollar bill in the token dispensing machine, and out comes five plastic Tali Tokens. These tokens have no financial value per se. You cannot take them to the corner store and exchange them for a pack of

gum. But you can insert one into a ski ball machine and get the opportunity to play that game. And the end of the night, a Tali employee retrieves all the Tali tokens from all the video game machines and puts them back into the dispensing machine. In this simple example, the Tali token can only be spent once because it returns to a central authority before being re-issued. The dispensing machine acts like a mint. This is fine so long as the mint works, but it is not a robust solution, because the mint is a bottleneck. If the dispensing machine breaks down, the entire video arcade ceases to function until it is replaced. The dispensing machine is also vulnerable to attack because it is a centralized store of value. It could be literally "hacked" open with a hacksaw. Is there another way to track these tokens?

Instead of using physical tokens that are stored in a central location, we could use digital tokens. While we could still task a central mint to track the ownership of all those tokens, we have also unlocked a new solution by going digital. Digital token can be recorded in infinitely many places at once at virtually no additional cost. The record of who owns what tokens is called a ledger, and such a record that exists in many places at once is called a distributed ledger. For example, both the ski ball machine and the air hockey machine could have a copy of the distributed ledger. When you sign away your digital Tali Token by agreeing to play a game of ski ball, you should no longer own that token to play a game of air hockey. But the Internet does not transmit information instantaneously. Nothing can travel faster than the speed of light, so the message that you spent you token on a game of ski ball could take several seconds to reach an air hockey machine on the other side of the world. An enterprising American fraudster could partner with a comrade in China so they both hit "play" on their video game machines at the same time. The transaction at the air hockey table is not transmitted (or "published") to the ski ball table until the balls have been dispensed, and our fraudster will get to enjoy a free game. In other words, your Tali Token has been double spent.

Double spending seems like a trivial matter when it relates to video games, but what if that token represents one million dollars? Obviously, a solution to the double-spend problem is necessary if distributed ledgers are to be useful, and digital signature are not enough. Blockchain thus adds two features, a timestamp server and proof-of-work, that solve the double spending problem.

A timestamp server widely publishes all the transaction that occurred in a prior period of time. Each publication constitutes one block. For example, this Tali Block will show two

transactions: the spending of one Tali Token to play a ski ball game in America, and the spending of the same Tali Token to play an air hockey game in China. Blockchain technology is programed to invalidate double-spend transactions, so neither video game machine will accept the token, and our fraudster will be thwarted. However, our timestamp solution has created a new problem: we cannot validate a transaction until a block is published. That makes instantaneous transactions impossible. While our fraudster is thwarted, Tali's legitimate customers will be frustrated by waiting ten minutes or more to play a game of ski ball.

But our technologically savvy fraudster is not done yet. In a last-ditch effort to get one free play, the fraudster attempts to publish a false block that erroneously shows ownership of two tokens. Proof-of-work is a cryptographic solution to this problem. Digital information of any length can be converted into a fixed-length hexadecimal code by a process called "hashing."[21] It is very easy to create a hash value based on any given set of input data.[22] But it is very hard to determine the input data given only the hash value output.[23] Blockchain technology is programmed only to accept published blocks whose hash value begins with several zeros. This requires block publishers to add an arbitrary number (a "nonce") to each block until the block returns a hash value starting with the specified number of zeros. Scanning for a nonce that returns an acceptable hash value for the block takes a huge amount of computing power. It would be cheaper for our fraudster to simply buy a second Tali Token legitimately than to spend more money on computer hardware and electricity. However, this also creates a new problem: block publishers have to spend huge amounts of money on electricity to solve the blockchain hash problem, which is bad for the environment.

To summarize, blockchain technology uses proof-of-work to prevent double spending on a peer-to-peer network of digital signatures (Nakamoto 2008, 8). Blockchain has the advantage of a decentralized system that is inefficient to hack. But it has the disadvantage of being too slow for some applications and of being extremely energy intensive. Technologists are working on

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[21] For example, the input data "fox" results in the output hash value "776cb326ab0cd5f0a974c1b9606044d8485201f2db19cf8e3749bdee5f36e200" when put through the SHA256 has algorithm. The input data "The quick brown fox jumps over the lazy dog." Results in the hash value "ef537f25c895bfa782526529a9b63d97aa631564d5d789c2b765448c8635fb6c". Note that the hash values are exactly the same length even though the input data are very different lengths.

[22] http://www.unit-conversion.info/texttools/sha/#data

[23] This feature of "one-wayness" is more technically described as "preimage resistance." Peters, G.W., Panayi, E. (2015) Understanding Modern Business Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money, at 4.

solutions to these and other problems with blockchain, but even in our current state of affairs, the blockchain can be used for a new application that may transform the nature of the firm: smart contracts.

Smart contracts are computer programs that can automatically execute their own terms when a preconfigured condition occurs. This can solve many problems in contracting that currently need intermediation. For instance, consider problems that can occur in traditional requirements contracts. A requirements contract is an agreement to purchase as much as you need from a certain seller. Requirements contracts are commercially necessary, but they can be abused. Consider a case of purchasing heating oil for a factory.[24] In a traditional economy, Buyer agreed to buy all its heating oil from Seller for a fixed price of $2.14 per barrel. Buyer initially purchased about 1.5 million barrels per year. But when the market price for oil exceeded $4.30 per barrel, Buyer increased its "requirements" order by about 63%. Seller refused to deliver to oil, claiming that Buyer was "not acting in good faith." It took the court system seven (7) years to resolve this dispute in favor of Seller. Obviously, the uncertainty and potential legal costs significantly increases the transaction cost of requirements contracts. Are smart contracts better?

Perhaps smart contracts can be more efficient in this case. For example, instead of selling as much as the buyer claims to need and relying on courts to determine good-faith need in the event of a dispute, a smart contract can be programmed to sell as much oil as is truly needed. If a factory wants to maintain a temperature of 68 F from the hours of 9 am to 5 pm, the amount of heating oil required to do this can be calculated based on external weather conditions. If the winter is especially cold, the smart contract will automatically debit additional funds from the buyer and require the seller to supply additional oil. If the weather is mild, less oil will be sold. Other factors, such as decisions to operate the factory after hours, can also be factored into the smart contract. In this automated contracting system, parties do not have to rely on the good faith of the other, and courts do not need to get involved. Discrepancies are resolved as fast as the blockchain operates, which could be as little as ten minutes, as opposed to resolving disputes at the speed of the judicial system, which could take ten years.

[24] See Orange and Rockland Utilities, Inc. v. Amerada Hess Corp., 397 N.Y.S. 2d 814 (App. Div. 1977).

Section 4.2: Transaction Costs and Smart Contracts

While the illustration above contemplates the use of smart contracts between traditional firms, blockchain smart contracts could also be used to replace firms (or create entirely 'platform forms') in the sharing economy by reducing transaction costs to zero or near zero. For example, consider Uber, the ride-sharing platform. Someone who wants to make money by giving people rides (a "driver") downloads the Uber app and follows steps to be approved by the platform. Someone else who wants to get a ride (a "rider") does the same. The rider then uses the app to request a ride, and the app pings a driver to perform this service. The transactions are centralized in that Uber makes decisions about who can be a driver or rider and which driver should pick up which rider. But smart contracts make it possible for drivers and riders to match without a central firm doing the matching.

Smart contracts are the killer application of the cryptocurrency world (Crosby et al. 2016). They are already being used to match buyers and sellers of private equity securities.[25] They can verify ownership, authenticate documents, protect digital rights, make investments, store data, prevent counterfeiting, and tally votes. This could obviate firms' needs for recording services, notaries, copyright, stock brokers, and even some government functions (Atzori 2015). The potential reduction in transaction costs using smart contracts will likely encourage firms to go to the market for immediate needs instead of increasing the size of the firm. In other words, smart contracts may lead to labor mirroring "contract-at-will."

We do not opine on whether the contract at will is normatively better or worse than a set of regulations and statutes that are designed to redress perceived imbalances between firms or between individuals and firms.[26] Instead, we focus on whether smart contracts will tend to bring

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[25] See Orange and Rockland Utilities, Inc. v. Amerada Hess Corp., 397 N.Y.S. 2d 814 (App. Div. 1977). (NASDAQ Private Equity).

[26] For contemporary perspectives disfavoring the contract at will, see, e.g., Blackburn, Restricted Employer Discharge Rights: A Changing Concept of Employment at Will, 17 AM. Bus. L.J. 467, 491-92 (1980); Blades, Employment at Will v. Individual Freedom: On Limiting the Abusive Exercise of Employer Power, 67 COLUM. L. Rev. 1404, 1405-06, 1413-14, 1435 (1967); Blumrosen, Employer Discipline: United States Report, 18 Rutgers L. REV. 428, 428-34 (1964); Feinman, The Development of the Employment at Will Rule, 20 Am. J. LEGAL HIST. 118, 131-35 (1976); Murg, G.E. and Scharman, C., Employment at Will: Do the Exceptions Overwhelm the Rule?, 23 B.C.L. REV. 329, 338-40, 383-84 (1982); Peck, Unjust Discharges from Employment: A Necessary Change in the Law, 40 Omo ST. L.J. 1, 1-10 (1979); Summers, Individual Protection Against Unjust Dismissal: Time for a Statute, 62 VA. L. Rev. 481, 484 (1976); Weynard, Present Status of Individual Employee Rights, PROC. N.Y.U. 22D ANN. CON. ON LAB. 171, 214-16 (1970); Note, Guidelines for a Public Policy Exception to the Employment at Will Rule, 13 CONN. L. REV. 617, 641-42 (1980); Note, Protecting Employees at Will Against Wrongful Discharge: The Public Policy

about the contract at will by solving some of the perceived problem with it. For present purposes, we only consider smart contracts in labor arrangements, as this is probably the thorniest problem to solve. Future work may extend the discussion to the relatively efficiency of smart contracts in other arenas.

The transaction costs scholars recognized that people sometimes behave opportunistically: an employee may take advantage of an employer, given the opportunity. Opportunistic behavior can be blatant, like stealing from the money till, or less obvious, such shirking and dereliction of duties. These agency costs result from the mismatch in incentives of capital and labor. Put simply, capital wants to maximize return on capital, which means getting as much efforts from a worker for as little salary as possible. Labor wants to maximize on labor, which means getting as much salary as possible for as little work as possible. A firm will only exist to the extent that these internal agency costs can be minimized, "and the persistence of firms shows that this can be done" (Epstein 1984, 964).

The common law of agency imposes duties on employees that provide legal recourse when an employee shirks or usurps a corporate opportunity for himself. But leveraging the legal resources are costly for employers, who must engage in monitoring and discipline activities. Monitoring is costly because the firm has to hire someone to perform the monitoring – and then who will monitor the monitorer?[27] Moreover, if an employee commits an infraction, it may be costly for the employer to impose discipline. Firing a worker means spending efforts to hire and train another, and statutory rights to employment maintenance raise the risk that firing an employee will result in legal costs. As a result, statutory worker protection laws increase agency costs and thereby decrease the incentives of firms to hire employees in the first place. Empirically, we can see that the workforce is increasingly becoming more contractor-based.

Blockchains and the smart contracts that operate on them are trustless system. A computer program is different form a human agent because the computer will not shirk or self-deal. To be sure, the computer program has to be tested for bugs and errors, and secured from hacking and malware, but if it is set up properly and securely it does not have to be monitored as

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Exception, 96 Harv. L. Rev. 1931, 1931-35 (1983); Note, Protecting At Will Employees Against Wrongful Discharge: The Duty to Terminate Only in Good Faith, 93 HARV. L. Rev. 1816, 1824-28 (1980); Note, A Common Law Action for the Abusively Discharged Employee, 26 Hastings L.J. 1435, 1443-46 (1975); Note, Implied Contract Rights to Job Security, 26 Stan. L. Rev. 335, 337-40 (1974); Note, California's Controls on Employer Abuse of Employee Political Rights, 22 Stan. L. Rev. 1015, 1015-20 (1970).

[27] M. Todd Henderson refers to this as the "bee-watcher-watcher problem."

an agent does. Moreover, discipline can be coded into the program. For example, consider a smart contract to pick up a rider on Main Street and drive her to the airport. The smart contract could automatically verify that the driver took the most efficient route based on extrinsic evidence such as traffic data. It could also verify that the pickup and drop-off happened timely by using the GPS on the rider's smart phone. More systemically, the blockchain could keep a record of which drivers are the safest, most efficient, receive the best rider ratings, or whatever that system wants to maximize, and then can reward the drivers who meet those objectives with a higher rating that will encourage more riders to select that driver.

It seems quite likely that blockchain technology will be used to made ad-hoc work agreement like the ride-sharing illustration above. This raises serious questions about what is the firm. Under current law, it is already unclear as to whether a driver for Uber is an employee of that firm. What happens when Uber is not a corporate entity but instead of a decentralized network that can perform any ad-hoc function that can be coded into a smart contract?

Even for traditional firms, the use of blockchain technology to manage labor relations with employees has massive implications. On the one hand, blockchain makes it cheaper to monitor and discipline employees. This reduction in agency costs should incentivize firms to hire more employees. But that presumes that employment relationships could be governed by smart contracts. However, the present legal regime presents a number of legal and statutory barriers to doing so. Meanwhile, the cost of a firm contracting with the marketplace will also go down thanks to the relative efficiency of smart contracts – and these at-market transactions are not so strictly regulated by labor law. Firms therefore will be incentivized to contract with the market instead of growing the firm. It is for these reasons that smart contract may accelerate the shrinking of the firm and the move from employment to independent contract relationships unless and until the labor laws and liberalized to permit firms to engage with employees on a more at-will basis.

Section 5: Conclusion

In the Spring 1988 special edition of the *Journal of Law, Economics, and Organization* celebrating 50 years of Coase's "Nature of the Firm," Sherwin Rosen posits that if factors such as monitoring costs, joint production, or transport costs did not exist, then it would be "difficult to imagine why complete decentralization of labor markets would fail to achieve efficient

allocations. Most workers would be, in some sense, self-employed" (1988, 53). Thirty years after that publication, are we beginning to see the onset of just that type of decentralized world, created by the broader reduction in transactions costs?

We do not claim that technological change will cause traditional employment to dissipate completely, as there are a number of countervailing factors. We have argued in this paper that technology powering the platform economy, and perhaps to an even great extent, blockchain technology (smart contracts), have reduced and will continue to reduce specific transaction costs and create more contractor labor and self-employed work. We discussed the specific technologies that are leading to these changes, and thus creating more contract work and greater "decentralization of labor."

Of course, there are other reasons why firms are contracting out instead of staffing up. Scholars in particular has extensively elaborated on the regulatory costs of employment—the legal risks associated with terminating an employee, the mandatory benefits that must be provided to employees, and the statutory rights of employees to collectively bargain are all costs that firms must bear when then staff up instead of contracting out. The decision to contract out may thus be understood a type of regulatory arbitrage. Furthermore, there may be sociological factors why the nature of work is changing. Richard Florida's work points to the "rise of the creative class," and how individuals are beginning to act as "creative," types, which in part means preferring greater flexibility and moving away from 9-5pm employment (Florida 2002).

One important implication of the rise of independent work is what it means for changes to labor law. Current labor law is predicated on people working as employees. Most individuals working through this platform economy are considered "independent contractors" or "1099 workers" or "self-employed" individuals, whereas traditional employees are considered "W-2 workers."[28] Most labor regulations and most healthcare benefits, retirement plans, and other worker benefits apply to individuals who are legally defined as employees but not to those who are defined as independent contractors. This can be seen as problematic because if more work becomes contract-based, more workers may be faced with less health insurance coverage and fewer other worker benefits.

[28] These terms come from an Internal Revenue Service (IRS) distinction which requires employees to file a W-2 form and independent contractors to file a 1099 form.

For this reason, there has been interest in rethinking the role of labor regulations and employment benefits with attempts to move toward a solution that encompasses more flexible and portable benefits packages for workers, which are not tied to a particular employer. Future policy-relevant research should further explore the question of the changing nature of work and the implications on labor law and polices.

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