Dane Pflueger, Tommaso Palermo and Daniel Martinez

Thinking infrastructure and the organization of markets: the creation of a legal market for cannabis in Colorado

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Dane Pflueger

HEC Paris

Email: pflueger@hec.fr

Tommaso Palermo

London School of Economics and Political Science

Email: t.palermo@lse.ac.uk

Daniel Martinez

HEC Paris

Email: martinez@hec.fr

AUTHOR BIOGRAPHIES:

Dane Pflueger is an Assistant Professor in the Department of Accounting and Management Control at HEC Paris. His research, focusing on the intersection between accounting and organizations, platforms, and markets, is published in leading journals such as *Accounting, Organizations and Society*.

Tommaso Palermo is (post major review) Assistant Professor of Accounting at the London School of Economics. His main research interests include the design and use of enterprise risk management and performance management systems, risk culture in financial sector organisations, and risk regulation in new markets for contested commodities, such as recreational cannabis in Colorado.

Daniel Martinez is an Associate Professor in the Department of Accounting and Management Control at HEC Paris. His research examines how performance measurement is implicated in the management and regulation of NGOs, pension plans, and cannabis markets. He has been published in *Critical Perspectives on Accounting*; *European Accounting Review*; and *Accounting, Organizations and Society*.

ABSTRACT:

This chapter explores the ways in which a large-scale accounting system known as Marijuana Enforcement Tracking Reporting and Compliance (METRC) contributes to the construction and organization of a new market for recreational cannabis in the US state of Colorado. Mobilizing the theoretical lenses provided by the literature on market devices on the one hand, and infrastructure on the other, we identify and unpack a changing relationship between accounting and state control through which accounting and markets unfold. We describe this movement in terms of a distinction between *knowing devices* and *thinking infrastructures.* In the former, we show, regulators and other authorities perform the market by making it legible for the purpose of intervention, taxation and control. In the latter, thinking infrastructures, an ecology of interacting devices is made and remade by a variety of intermediaries, disclosing the boundaries and possibilities of the market, and constituting both opportunities for innovation and domination through "protocol".

KEYWORDS:

1. infrastructure
2. cannabis
3. markets
4. market devices
5. accounting
6. regulation

> "This isn't just about making marijuana use legal. It's about creating a legal industry. Very different proposition." (Mark Kleiman, U.C.L.A. professor and policy advisor for legal marijuana)

1. Introduction

On 6 November 2012 voters in the US state of Colorado passed the popular initiative ballot measure, Amendment 64, calling for the creation of a fully-legal and regulated market for cannabis available to anyone over the age of 21. Amendment 64 and similar initiatives in other states marked a radical shift in the governance of cannabis at the state level from criminalization and stigmatization as exemplified by the decades-long "war on drugs" to a regulated market-based model as seen in the alcohol industry (Hudak, 2016).

The amendment and subsequent legislation specified much about this new market and the process and timetable of construction. It stated that cannabis would be "regulated in a manner similar to alcohol" (p. 2, 1.25) and subject to licensing and a "secure, reliable and accountable system" for production (ibid). However, cannabis production, manufacturing, sale and consumption had for decades been concealed from view (Hudak, 2016). Its active ingredients, its production process, forms of consumption, psychotropic effects, and many of its other qualities were unclear.[1] Moreover, threat of intervention from the federal government (which maintains cannabis as a Schedule 1 "dangerous drug") then, as now, loomed large. So, while the alcohol market and the existing grey and illegal markets served as convenient images of the market, important for market construction (see Kjellberg & Olson, 2017), the kind of market that would emerge and the process by which it could actually be constructed were unclear (Dioun, 2018; Hsu, Koçak, & Kovács, 2018; Palermo, Martinez, & Pflueger, 2016).

This chapter is about the work required to construct a market and to achieve a market-based model of governance. The quantity and variability of this work should not be underestimated. It included the work of establishing new agencies, legal codes, inspection

[1] See for instance http://www.economist.com/topics/marijuana

regimes, licensing processes, etc., the innovation of alternatives to traditional means of banking, advertising, etc., the development of new products, the transformation of vast amounts of real estate and the neighbourhoods around them, and much else besides. The focus of this chapter, however, is on the development and use of a technology that came to "silently" (Kjellberg, Hagberg, & Cochoy, this volume) underpin all of these disparate actors and activities: the seed-to-sale inventory accounting system known as Marijuana Enforcement Tracking Reporting and Compliance (METRC).

In this chapter we seek to answer the research question: *how does METRC contribute to the organization of this new market?* In answering this question, we tell two different but crucially related stories of METRC and the market, reflecting different theoretical motivations and traditions, as well as the evolving empirical setting. In the first story, we conceptualize METRC as what Muniesa, Millo and Callon (2007) describe as a "market device": "a material and discursive assemblage that intervenes in the construction of markets" (p. 2). We show, consistent with a long line of research on accounting and statecraft, the way that in the hands of state authorities, accounting is extended so as to construct the market and its participants in a means amenable to inspection, auditing, intervention and taxation (Desrosières, 2002; Power, 1997; Scott, 1998; Williams, 2013). In the second story, we draw from an emerging literature on accounting as infrastructure (Arena, Arnaboldi, & Palermo, 2017; Kornberger, Pflueger, & Mouritsen, 2017; Power, 2015) to demonstrate the use of METRC as a loose and evolving ecology of devices constituted by the cumulative and distributed work practices of both regulators and those being regulated, which disclose new worlds by relating distinct uses and users, while at the same time also making visible and active recalcitrant objects and residual categories that do not fit seamlessly.

These two stories of how accounting organizes the market allow us to identify and unpack the changing relationship between accounting and state control. We develop our contribution by discussing a distinction between *knowing devices* and *thinking infrastructures*. We highlight that when accounting is mobilized by state and other authorities as a market device, control closely relates to knowledge and knowing, by which we mean the ambition to construct a relatively stable and singular relation between

the world and the representation of the world necessary for it to be acted upon. Accounting, state control, and the objects of control emerge together primarily through accounting's "territorializing" and "adjudicating' capacities (Miller & Power, 2013): constituting the boundaries of objects/entities (Hines, 1988), making them commensurable (Espeland & Stevens, 1998), and adjudicating between normal and deviant (Williams, 2013). This kind of control, however, sits uneasily alongside governance of and through markets which, alongside containment, requires innovation and change.

Alternatively, when accounting is mobilized by state and other authorities as an infrastructure, we suggest that control becomes more closely related to *thinking*. Thinking is a more tentative, situated, and incomplete form of knowing. Reflecting its etymology, it is about directing one's mind toward something, imagining possibilities, and forming opinions or beliefs. Thinking infrastructures, as shown in our study of METRC, emphasizes the capacity of accounting to produce questions as much as answers and to facilitate innovation and change as much as stability (Revellino & Mouritsen, 2015). We show that this kind of accounting constitutes a distinctive new means of state control (see Deleuze, 1992) through what Galloway (2004) calls "protocol," in which the distribution of control and centralization of power, and the opportunities for innovation and domination, go together hand-in-hand (Kornberger et al., 2017).

This chapter proceeds as follows. Section 2 illustrates the research context and sources of data. Section 3 provides an initial overview of METRC and its functionalities. Section 4 illustrates key features of METRC by drawing on the literature on market devices. Section 5 further explores its features and workings, borrowing from the budding accounting literature on infrastructure. Section 6 discusses the interrelations between these two stories about METRC, and how a notion of thinking infrastructure, derived inductively from our study of METRC, helps to enrich our understanding of the role of accounting in market-making. Section 7 provides concluding remarks, focusing on implications of a distinction between knowing devices and thinking infrastructures for state-governed market-making.

2. Research context and data collection

Colorado's effort to create a legal market for cannabis provides a valuable research setting for a number of reasons. Firstly, the speed of implementation has ensured that some of the market scaffolding has been hastily constructed, left exposed, and found insufficient and repaired. Indicatively, there have been hundreds of amendments to both legislation and regulations in response to challenges and risks revealed since implementation. Secondly, as the first state to legalize recreational cannabis, Colorado regulators have gone to extraordinary lengths to develop a system of regulation and control that minimizes the risk that federal regulators and prosecutors will intervene in the market to potentially shut it down (Hudak, 2014). Thirdly, Colorado has been a primary location for what is described as a cannabis "green rush;" "hemp-reneurs" have flocked to the state to develop new products and services and secure a first mover advantage in anticipation of legalization in other states in the coming years. The market for cannabis in Colorado therefore presents an opportunity to investigate markets in the making (Beckert & Wehinger, 2013) and the consequent challenges for those who seek to regulate and monitor entrepreneurial activity, balancing business opportunities and public safety concerns.

Between June 2015 and December 2016, we undertook 37 semi-structured interviews (35 are recorded and fully transcribed), participated in one industry conference (and transcribed audio files of selected conference sessions), and visited four marijuana manufacturing facilities as well as several dispensaries. In total, we spoke with a wide range of individuals, including entrepreneurs and business owners, dispensaries' managers and staff, academics and public health professionals, state and city regulators, prosecutors, members of prohibitionist associations, and consultants (i.e. providers of information systems, legal advice, training, and product "expertise").

In addition to interviews and field observations, we examined a set of publicly available user guides and participated in an online METRC tutorial demonstrating the process of inputting data about the plant from seed-to-sale as well as the options available to regulators for deriving synthetic charts and tables about the dynamics of the cannabis recreational market.

We examined this set of data with the aim of understanding the role of METRC in the organization of the market. In the first step of our analysis below, we descriptively map its functionalities drawing mainly on user guides and public documents. In the second step, we describe what METRC is for its users, and how it intervenes in the construction of the market, first from the basis provided by studies of market devices, and then with the help of the notion of infrastructure as recently developed in the accounting literature.

3. METRC

METRC is the seed-to-sale inventory accounting system commissioned by Colorado's primary regulators, the Marijuana Enforcement Division (MED) of the Department of Treasury to create a "closed-loop" medical and recreational cannabis market. The system, developed by Franwell (an agricultural supply chain solutions company), employs "chain of custody" principles in order to track all of the people and products in the legal markets throughout the entirety of the production process.

This tracking process involves data input and licensing, accounting for physical spaces, and tracking the movement of cannabis products. First, the MED authorizes a lead administrator in each licensed facility (a separate license is needed for cultivation, manufacture, retailing, and testing) to input data through the METRC web browser and mobile application.[2] This administrator then adds additional accredited users using their Occupational License or badge numbers and grants them different levels of permission to access and input data related to their duties. Second, the authorized users configure

[2] Licensing is a major piece of work for the MED, and requires among other things, that "key associated people" meet a variety of requirements in terms of age, criminal history, residency, etc.

METRC to account for all of the physical spaces or "rooms" implicated in the cannabis cultivation and manufacturing process. Third, all of the movements of cannabis plants and products are recorded in METRC as they are moved throughout the cultivation process (i.e. between the "immature," "vegetative," "flowering," "harvested," and "packaged" stated of the flower, between different licensed facilities, and between intermediate product states such as extracts, as illustrated in Figure 1).

Figure 2 HERE

In a cultivation facility, this involves ordering radio frequency identification (RFID) tags and affixing them to each individual plant as they reach a viable vegetative state. The tag documents the market they are grown for (i.e. medicinal or recreational), the facility name, the business license numbers, the tag order date, a barcode, and a unique 24-digit ID number for the batch which is then inputted into METRC, which then links to information in METRC regarding the plant count, date, and strain (see Figure 2 and Figure 3). The maturation of each plant is then updated in METRC as it is moved between rooms and/or between stages of the cultivation process.[3] At the point of harvest, the plant material is put into harvest batches, and a new batch tag is attached. At this stage, early processing is typically undertaken (trimming, drying, and curing) as well as separation into various kinds of products (e.g., flower, shake, and 'kief' or cannabis resin).

Figure 2 HERE

Figure 3 HERE
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[3] Along the way, destroyed plants, as well as waste and manicured plant products are recorded in the standardized waste log or through the creation of a manicure product batch.

These batches are then combined into various packages for onward shipping. METRC batch tags are affixed to each package, the harvest batch identifiers, total weight and the outcome of mandatory testing.[4] To ship a package to another licensed facility, licensees generate a travel manifest in METRC that includes the transporter's name, vehicle number, packages included, estimated departure and arrival times, and a confirmation of receipt from the receiving facility. In a manufacturing facility, the received packages are combined and recombined into various products such as chocolates and sodas, following additional rules for testing, serving size and potency outlined by the MED. Each intermediate step of manufacturing entails the ordering and affixing of a new METRC tag, and the association of that tag with the tag preceding it in order to keep the chain of custody intact. Once the products arrive at a retail facility, finally, each sale is recorded in METRC. Sales are linked to the packages in which they arrived, and the sales time, date, and price are recorded the purpose of taxation.

From this brief overview, it is clear that METRC is a large-scale accounting technology that extends throughout the market. But, consistent with our research question, we are interested in understanding how the development and use of accounting relates to the disparate market-construction activities. In the following sections, we interrogate our data to understand what METRC is to its users, and how it relates to and intervenes in the construction of the cannabis market in Colorado.

4. METRC as market device

One way to investigate how METRC organizes the market is to focus on its performative capacity in the hands of the principle state regulator, the MED. METRC is, after all, and according to all market participants first and foremost, the state's system, and according to one influential study, "the backbone for the regulatory regime's enforcement activities" (Hudak, 2014, p. 9). Consistent with a long line of studies that investigate accounting as a "market device" (Muniesa, Millo, & Callon, 2007), we explore and describe how regulator's aspirations are encoded in METRC's functionality and made

[4] Testing for contaminants and potency by production batch is required for all cannabis products.

real through its diffusion. This exploration tells a familiar and revealing story of the relationship between accounting and state control. Consistent with a variety of studies pertaining to accounting and the state (Desrosières, 2002; Power, 1997; Scott, 1998; Williams, 2013), we show how METRC is extended to envision and then remake the market and market participants in a format amenable to state dreams and schemes of inspection, control and taxation.

4.1 Making the market legible

METRC organizes the market by making it, to use Scott's (1998) words, "legible" to the state. Although plants, products, operators, grow operations, testing results, etc. in the illegal, medical, and recreational markets may look identical, it is the (non)correspondence with METRC that constitutes their difference. METRC, therefore, quite literally constitutes the boundaries of the market. These boundaries make it possible for the MED and others to know what is legal and illegal and to intervene. This is why it is described as the backbone of the MED enforcement work (Hudak, 2014): inspectors are able to download METRC data—the number and maturation of plants in a room for instance—and compare it to the physical sites as the basis of intervention. As a MED regulator explains:

> [METRC] gives you some basis to confirm that what they are doing is what they say they are doing. If they are not, then it also gives you a lot of the information that you need to take a case.

METRC also makes the market legible through the data that it generates (Williams, 2013). At the time of writing, over 11,000 users have been registered into the system and over 3,000,000 plans and 2,000,000 packages have been tracked. Regulators use this data to identify trends and, over time, constitute a definition of what is normal, and what is a red flag. This allows them to move from a "reactive" to a "risk-based proactive assessments" of diversion (Hudak, 2014, p. 25). As one MED regulator explained:

> Last year we collected thirty-seven million transactions in the system. We've got some tremendous data in there that's really going to help us to

> monitor the industry. We're developing a lot of risk matrixes right now. For example, we're starting to get a really good handle by strain of what the average yield is per plant. That's really critical to us. We can start seeing, if somebody's falling outside of the expected outcome, we can go out to the field and target our limited resources to say, there's something not right about this. Let's go out in the field and let's do some investigative work.

Finally, METRC allows regulators and other authorities to see the entire market and demonstrate control. In real-time METRC shows the aggregated number of flowers and other products at their various points of maturity. In doing so, it makes it possible to see the market, as well as the illegal one. Indeed, when authorities wanted to understand the size of that market they subtracted the number of sales registered in METRC for a year from the sales that would correspond to consumption as measured by a population survey (see Orens et al., 2018). This legibility is said to "keep at bay a federal government that is closely watching enforcement and compliance" (Hudak, 2014, p. 679).

4.2 Legibility and reactivity

METRC also organizes the market as market participants react to the legibility that it affords. In the same way that physical objects such as forests are transformed in response to new ways of accounting for them (Scott, 1998, p. 17) and social worlds are remade in relation to public measures (Espeland & Sauder, 2007), the market makes itself fit the functionality of METRC and the dreams and schemes of inspection, taxation, auditing, and control (Power, 1997).

Indeed, METRC encouraged operators to change various aspects of their production processes. For example, one cultivation expert highlighted the benefits of working with bigger batches of homogenous strains:

> You can generate basically one tag for a plant in the same amount of time that you can generate 100 tags for 100 plants. With the requirement that

> we had to tag every single plant, it became quite obvious that propagating plants in larger blocks of single homogenous strains was desirable in terms of keeping the labor hours down, keeping your own personal frustrations down.

We also found examples of how METRC affected the physical layout of operators' growing facilities. METRC encouraged operators to create rooms that mirror those in METRC, rather than maintaining virtual rooms that can be complicated to maintain. Similarly, METRC encouraged operators to place computer terminals with access to METRC directly outside of the entrance of rooms and to integrate RFID into its systems in order to decrease labor costs of compliance. Finally, METRC's manifesting requirements encouraged operators to locate vertically-integrated facilities close together.

The work to operate METRC also, and perhaps more significantly, encouraged market actors to invest in the necessary data entry, audit, and compliance staff and training, and the development of professional business practices necessary to keep METRC up to date. The operators we interviewed explained that METRC requires "you to be on-point by the gram in an agricultural environment." Doing this was said to be "extremely difficult" and to require "dedicated staff" and "tried and true business practice." Some suggested dedicating at least seven percent of FTEs entirely to compliance and tracking.

To summarize, in this section we have shown that METRC, as a market device, contributes to the construction and organization of the market for cannabis in two interrelated ways. Firstly, it contributes to make the market legible and amenable to state ambitions of inspection, taxation, and control. Secondly, it encourages and perhaps even requires market actors to react to such legibility. In the following section, we seek to expand our understanding of the relationship between METRC and the market, drawing on recent accounting research using the notion of infrastructure adapted from the literature on information systems, classifications, and standards (e.g. Bowker & Star, 1999; Lampland & Star, 2009; Star, 2010; Star & Ruhleder, 1996).

5. METRC as infrastructure

Our discussion of METRC so far reveals a technology that is used by regulators to monitor the flow of goods and people throughout and between organizations It also, however, suggests elements of an enterprise solution that is adopted by market actors in response to compliance requirements. This characterisation of METRC suggests a multiplicity of uses as well as the possibility of distributed, collective and cumulative actions that together contribute to sustain the legal market for recreational cannabis.

In this section, we expand the intuition that METRC is entangled with distributed, collective and cumulative actions. In order to do so, we attend to a different image of technology via the notion of infrastructure, as it has been developed in studies of information technology (Bowker & Star, 1999; Star, 2010), and more recently in the literature on accounting as a social and institutional practice (see Arena et al., 2017; Kornberger et al., 2017; Power, 2015). By iterating between our field study of METRC and the literature on infrastructure, we shed light on three features of METRC that help to characterize new ways in which it organizes the market.

5.1 Loose ecology of devices: Add-ons and patches

The first feature of infrastructure is to understand accounting technologies as constituted by an evolving "ecology of devices" (Kornberger et al., 2017) or "assembly" of work arrangements (Arena et al., 2017), rather than being a single device, such as an information system used by regulators or an enterprise solution adopted by market actors. Kornberger et al. (2017) focus on the innovative business models of platform organizations such as Uber, eBay, and Airbnb, to shed light on "overlapping and interacting devices forming a dynamic network of control technologies" (p. 84). Similarly, Arena et al. (2017) use the concept of infrastructure to reveal how "integrated" risk management is constituted by an assembly of devices such as risk sheets, risk maps, networks of internal change agents, risk models, and classification systems. Finally, Power (2015) stresses how the aspiration to make university research accountable for

impact in the UK becomes tractable across different organizational and institutional settings through the accretion of roles, rules, routines, and governance structures.

As discussed in the previous section, regulators aspire to use METRC to monitor the flow of goods and people throughout and between organizations. In line with the idea of an ecology of devices, rather than a distinct regulatory market device (Williams, 2013), we found that operators, consultants, and other third-party vendors were developing and extending METRC through various add-ons, patches and extensions. For instance, instead of maintaining a separate tag for grow management software some cultivation facilities were grafting their system onto METRC by either writing on the tags or actually integrating the METRC numbers into their software. Similarly, quality controls, point of sale, and other existing systems were being connected and attached to the tags and plant and package numbers that METRC provided. As one entrepreneur developing such software explained:

> Well if you have to gather this data anyway, let's add some value along the way. If we're already scanning these things, let's keep track of not only how many of these plants we have and where they are on a greenhouse. […] If I have one table in my greenhouse that has certain […] level of light, a certain wattage, just keeping track of power is very important, it's one of your business metrics. When we scan and modify and move plants from place to place I can know not only exactly how many watts went into growing this particular plant but which pesticides were used.

Perhaps more interestingly, some operators used parts of METRC even if they are no longer part the regulatory system. Asked why plant tags remained with a batch (something unnecessary from a regulatory perspective), a compliance officer at a cultivation facility explained:

> So we keep the plant tags with them strictly for our own tracking and compliance because sometimes the batches can get messed up. If we have the plant tags with them, we can trace it back and rectify any sort of issue that might arise, but it's not legally required to have these with it anymore.

> Those are now trash in the [METRC] system. They're inactive, and it's turned into a batch, which may or may not be labelled, which is another reason why we keep it. That way, at no time is it ever in an un-tracked situation, so it gives them time to actually come in and get the tags on there.

This development of patches and add-ons to METRC has been expanding since the addition of an Application Programming Interface (API) to METRC in 2016. The API facilitates communication between METRC and other systems. During our December 2016 field visit, there was a growing consensus among different market actors that the API would contribute to a blurring of the distinction between METRC and other systems such as point of sale, grow management, and inventory management in the coming years.

To summarize, as a result of these patches and add-ons, METRC came to exist in a different form in nearly every regulated facility. Control, as such, was achieved not only through the work of regulators to impose or construct an ideal, but also by the ever-more collective efforts of various users to do new things. We suggest that these collective and cumulative efforts are indicative of an infrastructure, rather than a single market device, through which (il)legality is revealed as various users test, try, and tease-out the boundaries of the market that are possible and viable. Iterating between our empirical material and studies of infrastructure, the section that follows further illustrates this second feature of METRC as *generative* infrastructure.

5.2 Generativity: Disclosing market boundaries

A second feature of infrastructure illustrated in the recent literature is that it generates and discloses as much as it constructs its objects. This notion of disclosure, defined as the capacity of coordinated practices "to create an openness wherein things and people can show up" (Spinosa, Flores, & Dreyfus, 1999, p. 190 cited in Kornberger et al., 2017, p. 85) differs from the notions of performativity and construction advanced within the literature on market devices. Regulatory objects are not constructed to be auditable or

amenable to intervention (Power, 1997), but rather they are generated endogenously to the infrastructure. As discussed by Power (2015), "impact" is not defined elsewhere and then imposed upon the education sector through accounting. Rather, its dimensions are generated from, and endogenous to, the "accretion" of an accounting infrastructure among and between various field and organizational levels, and overlapping and interacting communities of practice.

As we highlighted in section 4, there are important ways in which METRC operates as a market device to define and construct objects. Most notably, METRC constructs a definition of (il)legality as that which is (not) accurately recorded in METRC and remakes the markets in order to match this definition. For example, growers design physical rooms to match METRC's specifications. This construction, however, also creates a grey zone in which the boundaries of (il)legality are continually disclosed through an endogenous ordering in which various users test, try, and tease-out the boundaries of the market that are possible and viable. While METRC imposes a strong and sharp distinction of (il)legality in terms of the correspondence between what exists in METRC and what exists elsewhere, the work required to align physical operations with their digital representation in METRC is riddled with ambiguity and uncertainties. As one operator explained: "We might have a different opinion, a different take on the regulations. That's where it creates this circle of confusion of what is actually the regulation? What does it say? What's compliant, what's not compliant?"

As such, operators, in conjunction with consultants and lawyers, continually work with and around and test the limits of what is legally possible. Speaking of how a room-layout might be recorded in METRC, for instance, one operator, noted the sort of conversation they may have with the regulators if they were to test the boundaries of what is permitted:

> I don't know if they [regulators] would like it if we did one room as all flowers. They'd probably get fussy with us […] They'd probably be like, "What!" But we can do all of this as a physical room, but you really want to harvest the room together. Room is synonymous with harvest is how I would put it.

Other operators, more nefariously perhaps, would test the boundaries of the market by introducing new strains into METRC. Our conversations with MED's regulators suggested that they watched as the new strains of cannabis emerged in the system, referring to them as "magic beans," and their entry in METRC as the "original sin." To control the market, they seemed aware that they could not define possible strains and growing innovations a priori. Nor could they close it off entirely from the rest of the world because the black market would more likely flourish. But with METRC, they could at least know the boundaries of the market as they were disclosed and, with that knowledge, they had new capabilities to intervene.

Importantly, the continued building-out of METRC does not limit but enhances its regulatory capability. The MED gains regulatory power by distributing the underlying technology widely throughout the market, as suggested by a senior regulator:

> If licensees start to use that same technology to do their daily [operations]... they're going to start to see the same issues we see as we go into licensed businesses. They're going to be a lot more interested in moving the tag up to a branch and getting higher accountability on the product that they have. If they show that they've got 500 plants in there, and they go and run and get 450 and they have to go in and pull them up out of the dirt, the next thing they're going to do is say: "Hey, guys. Make sure you're pulling these up out of the dirt." They're actually helping us get a higher compliance rate.

On this basis, regulators used METRC not just to impose their vision of the market, but to also think about what the market was becoming. While they could detect outliers and variances, they knew little about the business practices and products, which were complex and constantly in flux. Therefore, regulators would use METRC to think about what they did not know, constructing categories of similarities and differences in order to count, measure and control products and business actors with many different qualities (Espeland & Stevens, 1998; Power, 2004). For example, in the following exchange

between senior regulators, we learn how a new growing modality, in this case outdoor growing facilities, helped construct a vision of the market that did not previously exist:

> We went down this summer, and we saw some [greenhouses] that are actually going to be underground.
>
> Researcher: Really?
>
> Yeah, because the temperature is consistent underground.
>
> What is fascinating about this industry is we have some really entrepreneurial folks in there that are looking for their competitive advantage and also interested in green practices. We really saw that this summer down in Pueblo county.

METRC, in summary, not only constructed a definition of (il)legality that regulated entities needed to confirm to; it also created a grey area where the meaning of (il)legality might be further disclosed. Through the actions and innovations of regulators and operators, to say nothing of the myriad consultants that would give opinions to justify different operational arrangements, the boundaries of the market were constantly in flux, their dimensions continually disclosed. The boundary between legal and illegal, as such, existed not through the performative power of a market device, but through the ongoing and distributed actions that that the infrastructure allowed. As illustrated in the section that follows, this generative, ongoing, and distributed infrastructure work also contributes to shaping the *terms of competition* and possibilities for domination in the market.

5.3 Master narratives: The changing terms of competition

The previous section's discussion of generativity and market boundaries leads us to another property of infrastructure, which is related to how these processes of disclosure constitute new distinctions and categories that may not fit in the emerging market. Arena et al. (2017), describe this property of infrastructure in terms of the "master narratives" (Star, 1999) that they uncover in relation to the practice of "integrated" risk management. They show that the knitting together of heterogeneous elements such as risk sheets, risk maps, risk managers, and front-line managers simultaneously makes visible elements that

do not seamlessly fit, such as particular types of risk categories or ad hoc risk management processes. Similarly, Kornberger et al. (2017) describe the way that the unfolding of evaluative infrastructure simultaneously creates new forms of "Ubercapital" (Fourcade & Healy, 2017) and new equivalents of living "on the wrong side of the tracks."

In line with this view that infrastructure serves as both an engine and a barrier to the generation of new relations among market actors, our analysis of METRC reveals how it contributed to "filtering out" (Martinez & Cooper, 2017) certain market actors and disclosed and stabilized distinctive terms of competition. As a filtering mechanism, alongside the licensing requirements, METRC was, as one experienced grower put it, "the push, I think, that a lot of the early movers needed to really make that jump in terms of refashioning their approach to operations." Making METRC work required "compliance culture," "tried and true professional business practices," and dedicated compliance staff, as described in Section 3. Although regulators were patient with regulated businesses, it became clear that some did not have the "aptitude," "culture" or mindset to become comprehensively regulated. As put by an experienced entrepreneur, who started a now successful edibles manufacturing company, looking back on these early movers: "[METRC] played a very very pivotal role in helping people who may have been less than transparent in their previous career in the cannabis industry, now are fully transparent."

For those organizations that cleared the compliance hurdle, however, METRC and the professional business practices that it required were made into strong symbols of legitimacy and sources of competitive advantage. Speaking with more "sophisticated" market actors about what set them apart from other competitors in the legal and black markets, they point to their business professionalism, their data driven approach, and to their ability to manufacture, market, package, etc. the cannabis in just the same way as the standardized widget. As the CEO of large manufacturing company noted:

> We're now a commercial manufacturing facility. We make widgets. One of the most powerful ingredients in that widget is THC or CBD[5], and we crank them out by the thousands an hour, and you'll see those on the shelves.

This kind sophistication, moreover, was used to pursue market power. For the interviewee quoted above, by "tapping into METRC" they could begin to understand the consumer and consumer trends "like Pepsi or Frito-Lay" and to access an expanded range of capital. During our December 2016 field visit, it was apparent that some of the more "sophisticated" actors were becoming more proactive in the way they addressed regulation and competition—for example, dedicating more resources to political lobbying in order to influence regulator decision-making.

METRC, in summary, helped to shape the terms of competition and the variables upon which market power and consolidation could occur. It contributed to the disclosure of what it meant to be compliant, legal, and a participant in the market. In doing so, it made visible those objects and people that did not or could not fit.

6. Discussion

The creation of the legal market for recreational cannabis in Colorado can be seen as a recent and visible form of "state-governed market making" (Aspers, 2011). In the analysis presented in this chapter, we focused on a particular accounting technology that plays a central but often silent role in Colorado's experiment with market creation: the seed-to-sale inventory accounting system known as METRC. Our analysis explored how METRC intervenes in the market through two overlapping theoretical lenses.

One, provided by a well-established stream of literature developing the notion of "market devices" (Muniesa et al., 2007), was mobilized to shed light on the programmatic and performative role of METRC. Through this lens, we illustrated how METRC enabled

[5] THC (tetrahydrocannabinol) and CBD (cannabidiol) are the two most well-known cannabinoids.

regulators to intervene in the market by constructing an image that both represents the market in a way that allows for intervention and discipline (Williams, 2013) and encourages and even requires that operators and products are transformed to make themselves visible, accountable, and auditable by the state (Power, 1997; Scott, 1998).

Another lens provided by a budding literature on infrastructure was also explored in order to make sense of empirical materials. With its help, we highlighted three elements: firstly, how METRC is an ecology of devices made up and remade not only by regulators but also via the work practices of those being regulated; secondly, how METRC helps to constitute relations through which the market boundaries and products could continually be disclosed; and thirdly, how METRC, as a large-scale governance technology that is used by different market actors, affects the structure of the market, the types of products on offer, and the terms of competition among market actors.

In the following sections, we discuss these two stories and their interactions, and how a notion of *thinking infrastructures*, derived inductively from our study of METRC, helps to enrich our understanding of the organizing relevance of accounting in market construction.

6.1 From knowing devices to thinking infrastructures

Figure 4 tentatively summarises our analysis of METRC, which builds on studies of market devices as well as the recent literature on infrastructure. In the rectangle at the centre of the figure, we schematically illustrate how METRC works as a market device. This tells a familiar, albeit important, story about accounting, organization, and state control. In this story, accounting is extended by state authorities (in this case the MED) in order to render amenable to control, taxation, and intervention an area of business activity that was formerly obscure and "in the shadows" (Palermo et al., 2016). In the process, the market is remade, directly and through the reactivity of market participants, in order to fit the dreams and schemes associated with state control.

Both means of organizing point to a relationship between accounting and state control in which *knowledge and knowing* feature prominently. As a device, accounting organizes the market and provides the state with control by constructing a relatively stable and singular relation between accounting and its object. It "territorializes" (Miller & Power, 2013) by performing the objects it seeks to know. It also "adjudicates" (Miller & Power, 2013) by making heterogeneous market actors, activities, and products commensurable (Espeland & Stevens, 1998) and understandable as normal or deviant (Williams, 2013).

Figure 4 HERE

In Figure 4, we enrich this view of METRC, and of accounting more generally, by showing how the market is also organized through the collective and cumulative patchwork activities of various users, and how such collective efforts disclose the boundaries of (il)legality and structure competitive relations among market participants—a set of working and conceptual relations we refer to as *thinking infrastructure*. The triangle in Figure 4 points to the three different dimensions of thinking infrastructure through which the market is organized: the day-to-day operations of those manufacturing and selling products; regulatory definitions of what are to be considered legal or illegal practices; and innovation and competition among market actors. What is important about these dimensions, and in line with the view of infrastructure as "relational" (Kornberger et al., 2017; Star, 1999, 2010; Star & Ruhleder, 1996), is that they recursively and continually interact. The analysis of these relations and interdependencies highlights how infrastructures think.

To illustrate such interdependencies, we can begin with the work of regulators to convey what is legal through the governance technology. This element is captured at point A (see section 5.2): what is *in METRC* is legal, while what is *outside METRC* is not. This distinction has implications for the terms of competition in the market for recreational cannabis (point B, see section 5.3). METRC acts as a filtering device (Martinez & Cooper, 2017), becoming a compliance hurdle that only market actors with a certain kind of compliance culture and resources can address successfully. But, as illustrated in

section 5.2, entrepreneurs and the regulators themselves are in the process of thinking about the market and its (il)legal practices. Through Figure 4, we suggest that both the terms of competition and the boundaries of (il)legal practices are mutually related to the way in which operators extend the functionality of METRC via add-ons and patchwork (point C, see Section 5.1). For example, the more sophisticated business actors are able to exploit METRC data, in combination with their own internal information systems, to get a better sense of where the market is going (e.g. increasing consumer demand for cannabis-infused drinks), shape their product offer accordingly, and possibly gain a competitive advantage (point B). Some operators are also encouraged to pay attention to mundane activities such as pulling up tags out of the dirt as part of their operations and production processes (point C), which would help operators to improve their compliance rate and regulators to reinforce the regulatory power of METRC in defining the boundaries of (il)legal practices (point A).

These interrelations among different uses and users of METRC show accounting to be a technology that works less by constituting knowledge and more by opening up spaces for questions and possibilities to unfold (Revellino & Mouritsen, 2015). Disassociated from a singular focal user, a strong programmatic ambition, and even a precise starting point or end (as we might infer by looking at the rectangle "METRC as market device" at the centre of Figure 4), accounting does not create the stable reality that knowledge requires. Instead, accounting is about *thinking*: constituting the possibilities to direct one's mind toward something, imagining possibilities, and forming opinions or beliefs.

The story of METRC as thinking infrastructure shows that the boundaries of the legal market are not pre-defined but endogenously discovered as various users test and tease out what is possible and viable. The market is organized, in other words, through the collective endeavors of widely dispersed groups that not only pursue their own pre-existing interests but also continually engage with accounting technologies to determine what is possible to want and to do. In the section that follows, we discuss the implications of a conceptualization of METRC as thinking infrastructure for our understanding of the role of the state in market-making and control.

6.2 Control as protocol

The movement from knowing devices to thinking infrastructures suggests a changing relationship between accounting, state control, and market-making. When accounting and other technologies are understood and investigated as *devices* for central authorities to *know* their subjects and for subjects to internalize their demands, then power is seen to be centralized in the hands of technology owners (see, for example, Espeland & Sauder, 2007; Pollock & D'Adderio, 2012; Williams, 2013). When accounting and other technologies are understood and investigated as *infrastructures* for dispersed market actors to *think* about what it is possible to do and become, however, the site and sources of power become less clear.

The notion of "protocol" (Galloway, 2004) helps to specify and differentiate this shift in the organization of power. Protocol has two significant features. First, it operates through the simultaneous distribution of control and centralization of power (Kornberger et al., 2017). State authorities distribute control widely, opening up METRC to add-ons, patches, etc. and relinquishing ownership of all but the most low-variability parts. This allows the transformation of the technology to various, overlapping, and rarely-predetermined ends. At the same time, however, and as a result of such opening-up, state authorities gain and maintain power and the capacity to maintain visibility on a market that is quickly moving, innovative, and competitive with its rivals. Like the powerful platform owners such as Uber (see Kornberger et al., 2017), the MED can see the market because it has handed over some control of accounting to other users and uses. As shown in one quote in Section 5.2, if operators start to use METRC for their daily operations, they will be encouraged to carry out mundane activities such as pulling tags out of the dirt that will increase compliance rates and enhance regulators' understanding about the plants' lifecycle and about the market.

Secondly, protocol operates through fractures and incompleteness (Galloway, 2004). Protocol structures not just by performing state ambitions, but also by allowing breakdowns and maintaining grey areas and blind spots. These fractures, which indicate a

lack of control from the perspective of knowing devices, are sites and sources for control from the perspective of thinking infrastructures. As we illustrated with the case of "magical beans," it was only by making METRC porous and incomplete that the MED could maintain its grip on a quickly evolving market. Compared to knowing, thinking infrastructures stress the emergent and unfinished nature of how accounting does not make distinctions with certainty, but makes possible questions about what distinctions matter and what they mean for market participants. Notably, this emergent and unfinished nature of thinking infrastructure also provides a point of contrast with previous accounting studies on infrastructure. For example, Power (2015) suggests that an infrastructure is made of systematic and integrated organisational processes, roles, and accounting technologies that cumulate over time and contribute to create and stabilise the "facticity" of new managerial objects such as research impact, thus enabling managerial intervention. Our study of METRC suggests that a more tentative, situated and distributed form of infrastructure is equally powerful in constituting objects amenable to regulatory and managerial intervention, be it cannabis-based products in their various forms or the variety of entrepreneurs, consultants and operators that seek to operate in, and profit from, the Colorado cannabis market.

To conclude, our inductively-derived theorization of METRC as thinking infrastructure is indicative of a form of control as protocol, which is both more far-reaching and less visible than other forms of disciplinary power. METRC allows innovation and multiple possibilities and dimensions for action and at the same time, and as a result of such activity, closes off some possibilities for the market and its participants. In the next and last section of the chapter, we summarize key themes of our study, focusing on the empirical and methodological implications of the distinction between knowing devices and thinking infrastructures.

7. Conclusion

Our analysis of METRC emphasises relationality and connectivity as key features of large-scale regulatory accounting technologies. We show how, by relating things, people,

and their work practices, METRC is generative and constitutive of identities and values such as "legality" in the emergent and uncertain context of the Colorado cannabis market. Moreover, our analysis extends understanding of the generative role of infrastructures showing how a loose and evolving ecology of devices discloses new worlds by relating distinct uses and users. But, at the same time, it also makes visible and active recalcitrant objects and residual categories that do not fit seamlessly. We show how such dynamics have important effects on the organization of the market.

All these elements, we suggest, are indicative of a distinctive configuration of accounting and the state that emerges when accounting and other technologies become and are investigated as thinking infrastructures rather than knowing devices. They point to an important movement at the heart of the kind of "state-governed market-making" (Aspers, 2011) of which Colorado's cannabis experiment is emblematic.

This movement is empirical/historical. We find that as the object and means of government become markets, accounting organizes space and exercises power in a distinctive and new way. Existing studies that explore the relationship between statecraft and accounting highlight its territorializing and adjudicating capacities (Miller & Power, 2013). Here, accounting organizes primarily through its relationship to knowledge and to knowing: the capacity to constitute relatively stable and singular relations between the world and the systems to account for it. In contrast, we show that, as accounting is extended as an infrastructure necessary to simultaneously accommodate the market and control it, accounting organizes more through its relationship to thought and thinking. Thinking infrastructures emphasize the capacity of accounting to produce tentative knowledge, questions, and possibilities for innovation and action. We show that this kind of accounting constitutes a distinctive new kind of state power and accountability: a power through protocol in which the distribution of control and centralization of power, and the possibilities for innovation and domination, all go together hand-in-hand.

This movement is also methodological. In order for us to understand the full breadth of ways in which large-scale accounting technologies intervene in the construction of markets, we must think of infrastructures rather than devices. This has at least two

notable implications for scholars interested in accounting technologies, control, and market-making. First, it means moving away from a view of technology from the perspective of a single or stable user and use, as has been the tendency in studies of market devices on regulators (Williams, 2013), consultants (Pollock & D'Adderio, 2012) or media organizations (Espeland & Sauder, 2007). In contrast, we need to look at technologies from the point of view of different users, and how their uses of the technology dynamically shape one another. Second, it also means finding out ways to explore that which by its very nature goes unnoticed until it breaks down (Star, 1999, 2010; Star & Ruhleder, 1996). To think infrastructure, we need continued attention to background and mundane activities (for example, in our study, data entry, manifesting requirements, the position of workstations) that, as part of the cumulative and distributed efforts of variety of actors, may contribute to sustain and shape markets as well as other organizational and institutional contexts. Our study suggests that, by focusing on such mundane activities, we can begin to understand how front-stage actors, such as regulators, entrepreneurs, and policy-makers engage in something visible such as the creation and maintenance of a new market.

To conclude, as Star (2010) notes, infrastructures are notoriously elusive objects of study. Not only are they difficult empirically to see, but they are equally difficult to describe because we lack a good relational language. This chapter has attempted to overcome these challenges, however imperfectly, through the articulation of the notion of thinking infrastructure and its implications for an understanding of control as protocol. While far from being a fully-developed concept, we hope that this research begins to illuminate how this notion opens up a new mode of investigating and knowing about the role of accounting and other technologies in the construction, ongoing transformation, and control of markets.

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Figures

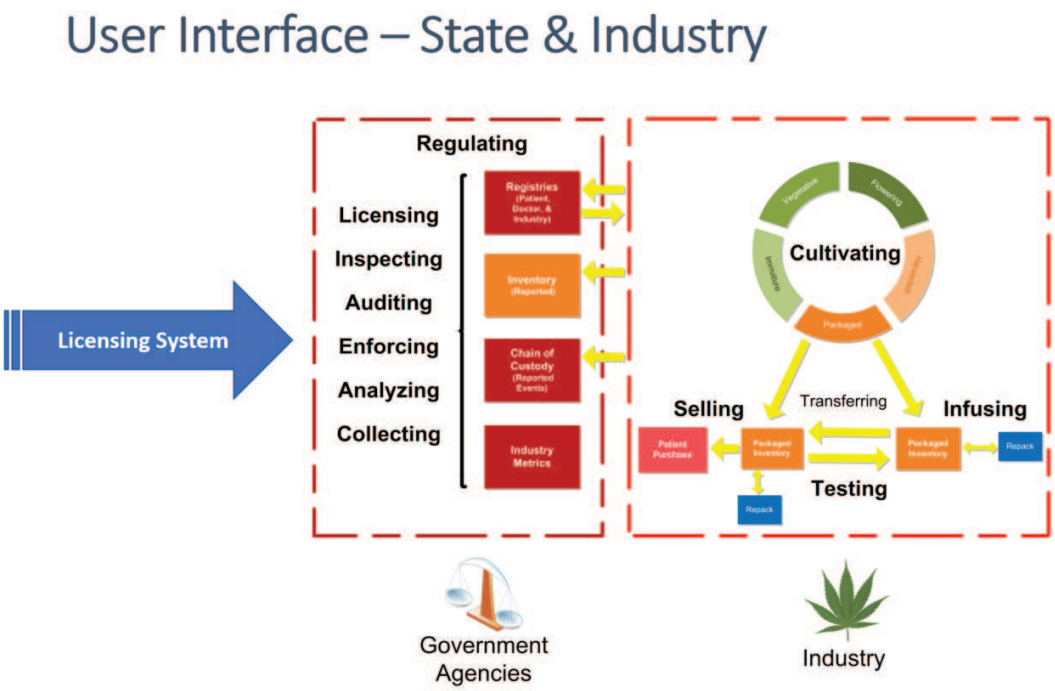

Figure 1: METRC (source: Franwell)

Figure 2: RFID plant tags (source: Franwell)

Figure 3: RFID attached to plant (source: authors' fieldwork)

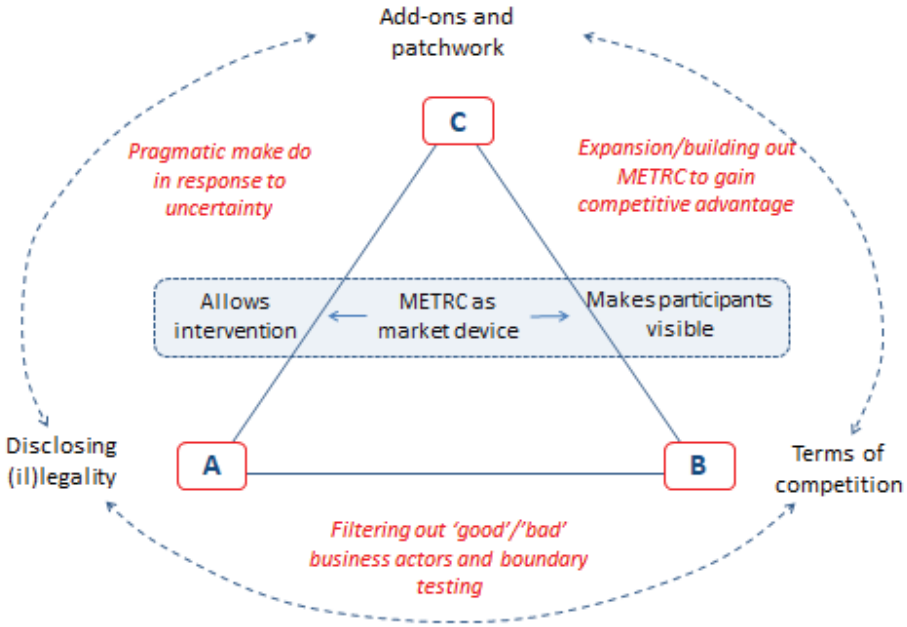

Figure 4: METRC as 'thinking infrastructure'