Storage Matters: Managing Grain, Securing Finance, and Building Markets

by

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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

This dissertation analyzes the nexus of agriculture and finance, specifically the mediating role of grain storage. How grain markets are organized and governed is foundational to food security. Hundreds of millions of metric tonnes of grain are traded and moved around the world, and hundreds of billions of dollars are invested in grain commodities via global commodity exchanges. During the late 20th century, agricultural commodity exchanges (ACEs) usurped other marketing models such as state marketing boards, and now play an increasingly influential role in global agricultural commodities. The development of ACEs and changes in grain storage over the twentieth century had implications for how financial actors could or could not access grain as a financial asset. To understand grain storage in relation to finance, I examine the governance of storage by developing a political history of storage through the three processes of stabilization – ideational, regulatory and physical. The thesis is guided by a question: How does the examination of twentieth century US grain storage stabilization – the ideas, regulations and physical infrastructures – help us to understand the financialization of agriculture?

To answer this question, I draw from international political economy (IPE) scholars and actor-network theory (ANT) to show how the stabilization of grain requires an assemblage of regulations, technologies and economic ideas that make up the politics of grain storage, and how a close examination of grain-storage governance helps to explain the financialization of agricultural commodities. Financialization of agricultural commodities is the work of assembling and turning a bushel of corn, or any other agricultural good – primarily grain – into a financial asset stream. This definition highlights the role that grain storage plays in commodity speculation, and encompasses the mundane practices of collecting and managing amassed grain in containers.

This dissertation shows how ideas, regulations, and industrial projects to stabilize and store grain for collateral contribute to the emergence of ACEs as a model of global grain marketing. By looking beyond corner offices, commodity exchanges and other institutions, the theoretical framework brings non-human storage actors into view by drawing attention to the assemblages of grain bins, fumigants, dryers, documents and regulations that attempt to stabilize unruly grains, and to leverage stored grain for credit and asset streams. The research shows a model of agricultural finance that is reliant on grain-storage governance, a constellation of mid-century economic ideas, agro-chemical technologies, and state regulation, and how they are applied to twenty-first century market "problems" in new frontier sites. The research has applications to contemporary global financial inclusion projects that aim to build new agricultural markets and connect small producers to global markets.

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Chapter 1- Building Markets: The Politics of Finance, Agriculture and US Grain Storage

1.1 Introduction

The events of the 2007–8 financial and food crises drew attention to a dramatic increase in financial activity in agricultural commodity markets. The crises sparked food riots and hoarding around the globe, and poor food-importing countries were particularly hard hit (Adam 2008; M. Schneider 2008). International organizations (IOs) and scholars were prompted by the crises to examine agricultural commodity markets – in particular, how changes in the regulation of agricultural commodity and commodity derivative markets affected global food security (Clapp 2009a, 2009b; De Schutter 2010; FAO et al. 2011; UNCTAD 2012; Staritz and Küblböck 2013). Many social movements and some scholars have argued that the increased financial activity, especially commodity speculation, was connected to negative outcomes, including increased food price volatility, food insecurity and repeated food crises (Ghosh 2010; Friends of the Earth Europe 2012; Clapp 2014). The "financialization" of food and agriculture described the increased influence of financial actors and activities in these areas (Clapp 2009a; Clapp 2012a; Burch and Lawrence 2013; Isakson 2014). Conversely, a number of scholars stated that financialization was a positive development (e.g. Irwin and Sanders 2011; Till 2011). Epstein (2001) defines financialization as the increasing importance of financial markets, financial motives, financial institutions, and financial elites in the operations of the economy and its governing institutions on various scales. Scholars use this definition to draw attention to the negative impacts of speculators and rentiers in agricultural commodity markets and also throughout agrifood supply chains, from land speculation to retail outlets (e.g. Clapp 2014; Burch and Lawrence 2009; Isakson 2014; Fairbairn 2014; Fuchs, Meyer-Eppler, and Hamenstädt 2013). Epstein's (2001) definition also draws attention to the development of speculative practices and innovations such as over-the-counter (OTC) contracts based on commodity prices, which account for much of the dramatic rise in speculative investment in agricultural commodities (see Clapp and

Helleiner 2012). These studies have brought a needed focus on the activities of elite financial actors and their effect on agriculture. But there is another set of financial actors – both human and non-human – that has received less attention, and it centers on the changing role of US grain storage over the twentieth century.

Contemporary global food security debates, especially in reaction to managing volatile global agricultural commodity markets and the growth of speculation by financial actors, have prompted a re-examination of grain storage and reserves (e.g. B. Wright 2009; Lilliston, Ranallo, and IATP 2012). Over the twentieth century there were significant changes in the regulation and management of grain storage and global grain reserves. Many mid-twentieth century economists supported public grain reserves and storage because they contributed to the stabilization of volatile commodity prices and provided vital supplies year-'round (e.g. Keynes 1938; Zaglits 1946; Bodde 1946). Support for public grain reserves, however, has declined over the last 40 years for a variety of reasons, including trade liberalization and structural adjustment policies (Murphy 2009; Lilliston, Ranallo, and IATP 2012).[1] Many contemporary economists associated with international organizations (IOs) argue that buffer stocks and reserves are ineffective and costly, in comparison to liberalized trade and market-driven grain storage provided by agricultural commodity exchanges (ACEs) (e.g. B. Wright 2009; FAO et al. 2011; Brenton and World Bank 2012). In turn, there was an opening in the 1990s for IOs to encourage new agricultural market projects such as ACEs and futures markets, which included oversight of privately managed grain storage. Agricultural commodity exchanges facilitate new asset streams premised on stored grains and also facilitate access to these asset streams for new kinds of financial actors, such as speculators. The US held a unique position in the mid to late-twentieth

[1] Notably, China and India continue to manage large grain reserves, although India is shifting to public-private partnerships (Reardon et al. 2012).

century because it shaped global financial (Strange 1994), and agricultural relations (Clapp 2012a) and as I will show, grain storage.

How does the examination of twentieth century US grain storage stabilization – the ideas, regulations and physical infrastructures – help us to understand the financialization of agriculture? To address this question, I start by focusing on how asset streams are built on agricultural goods such as grain in storage. In contrast to Epstein (2001), who highlights the increased activity of financial actors as a core characteristic of financialization, Thrift and Leyshon (2007) state that financialization is characterized by speculators who access asset streams built on a combination of aggregated resources or goods (see also Aitken 2013). Speculation in grain commodities without grain storage is difficult for two reasons. First, ACEs and futures rely on regulated, stable storage to write and secure derivative contracts. Second, speculators rely on reported levels of stored grain supplies, along with anticipated demand, to estimate prices and price movements. The determination of grain prices underpins basic derivatives from forward contracts to more complex OTCs derivatives that use commodity price indexes. Following Thrift and Leyshon (2007), I define financialization of agriculture as the work of assembling and turning a bushel of corn, or any other agricultural good – primarily grain – into a financial asset stream. This definition draws attention to the central role that grain storage plays in commodity speculation and ACEs, and encompasses the mundane practices of collecting and managing amassed grain in containers.

There are three key characteristics that make US grain-storage governance and its relationship to finance significant, both in the international political economy, and more specifically in terms of the relationship between ACEs and grain storage. First, in the international political economy, the US wields structural power in global financial markets and in agricultural markets (Strange 1994; Clapp and Helleiner 2012). Over the twentieth century, state support for domestic farms and the industrialization of agrifood production reshaped global agricultural markets (E. Sanders 1999;

Phillips 2007). US state institutions and their policies pushed US-modelled agriculture and commodities beyond the country's borders in various ways, from trade and the dumping of surplus stock to the export of Green Revolution technologies (Friedmann and McMichael 1989; Shiva 1991; Murphy, Lilliston, and Lake 2005).[2] In addition, US state regulation had a strong influence and reshaped global agricultural trade and financial markets (Friedmann 1982; E. Helleiner 1994; Clapp 2012a). Together, the dominance of the US in both global financial and agricultural markets illustrates its influence and how it reshaped global agricultural markets.

Second, modern ACEs and futures markets were developed and regulated in the US over the nineteenth and twentieth centuries, which influenced the development of innovative derivatives in the late twentieth century.[3] A commodity exchange is an organized market that provides a centralized platform for trading commodities usually with two kinds of markets: a cash market, in which there is no intermediary and a trade or purchase with cash is done on the spot, and a futures market, in which intermediary's trade contracts that are settled on a future date. The US agricultural commodity exchanges, especially the large Chicago exchanges, are credited with forming the first modern futures market with grain derivatives during the nineteenth century. The US state regulated ACEs to protect a large agrarian class in the early twentieth century, but moved to lighter regulatory controls towards the end of the century. In turn, new financial derivatives emerged, but they were still modelled on ACEs. For example, the development of exchange-traded funds in the 1990s were based on the commodity derivative system of storage and documentation (Moriarty 2009). US agricultural commodity exchanges remain the model for newly established futures markets, and for privately

[2] The model was influential on a global scale, but not hegemonic.

[3] Earlier "futures" had been developed, notably in Japan during the seventeenth century, but most scholars credit the Chicago markets as the start of modern futures markets. For example, Williams (1982) argues that there was no real evolution of futures markets – that is, from primitive markets to sophisticated futures markets – but that there were instead many different kinds of futures contracts already existing before the development of the "modern" futures market formalized in Chicago.

managed grain storage. While other agricultural commodities can form the basis for commodity derivatives, grain has specific physical qualities that make it storable, transportable, and exportable.

This leads to the third significant characteristic of US grain storage, its relationship with technology and credit. Famously, grain storage was revolutionized starting in 1842 when mechanical elevators were introduced along the Great Lakes, and their introduction contributed to the development of the modern ACE (Cronon 1992). ACEs leveraged stored grain to develop futures markets and other derivatives. The industrialization of agriculture in the twentieth century was not exclusively a mechanical revolution. The US state-led project to industrialize agriculture in the 1920s included new sources of credit to help capitalize farm investments. The state institution, the Commodity Credit Corporation (CCC), developed regulations and technologies to secure stored grain as collateral for loans for farmers from the 1930s to the 1990s. As I will show below, developing stored grain into a form of collateral was not an easy task. When the US public reserve was abandoned, leveraging stored grain for collateral and asset streams entered the realm of ACEs. The development of US ACEs and changes in grain storage had implications for how financial actors could or could not access grain as a financial asset.

This dissertation will provide a close examination of US grain storage during the twentieth century, which I argue helps us to understand the financialization of agriculture. I examine US grain-storage governance by analyzing three "stabilization" processes – ideational, physical, and regulatory – that underpin the creation of asset streams based on stored grain. I use the term *grain-storage governance* to encompass and describe these processes, in which governance includes governmental institutions and informal non-governmental mechanisms, drawing from Rosenau and Czempial (1992, 4). Where my definition differs from that of Rosenau and Czempial is that I also include non-human actors under the governance umbrella. Non-human actors includes the grain itself, and the physical infrastructure that supports its storage. Grain is one actor in a relational field, or assemblage that is dependent on a network of alliances. Global financial actors have difficulty developing asset streams based on agricultural commodities if certain assemblages are not in place. Without asset streams, ACEs and specifically futures markets are unsuccessful. This difficulty will be illustrated when I trace the three stabilization processes associated with a number of UNCTAD and World Bank attempts to establish ACE markets in new sites.

This thesis fills a gap in agrifood studies and in IPE scholarship. Agrifood scholars often consider the material qualities of food and agriculture, but are less focused on the material qualities of finance. IPE scholarship often focuses on global and elite forces of finance and is less focused on the material. To help explain the governance of storage, I draw from IPE scholars to examine the regulatory and ideational realms of food and finance, and from actor-network theory (ANT) to examine physical and technological shifts in grain storage. ANT allows me to ask what assemblages are needed to sustain a particular storage governance structure. Assemblages are presumed to be unstable. This means that stabilization is precarious and an on-going process. When applied to grain-storage governance and to ideas, regulations, and physical realms, assemblages can illuminate the connections between finance and agriculture. The study of how and when asset streams are assembled, illuminates networks, connections, and relationships that might otherwise be overlooked. This framing can help define the contours and edges of the financialization of agricultural commodities. In turn, IPE is critical to understanding the political history of the regulatory and ideational changes to storage governance.

The remainder of this chapter is structured as follows. First I discuss grain-storage governance in more detail, and describe the role of storage in the context of recent contemporary crises. I then provide more background and describe the context of US grain storage and its relation to ACEs during the twentieth century. The US state managed grain storage and facilitated collateral based on stored commodities, which had implications for agricultural markets and commodities. The background helps introduce the unique position of the US in the international political economy, and its role in establishing a physical and financial infrastructure based on state-managed grain reserves. The next section, ACEs for Export, provides a brief overview of, and context for, ACEs within the international political economy, and outlines recent projects to establish ACEs. The methodology section discusses my research and data collection. In the section following that, I review the international political economy context of changes to financial and agricultural commodity regulation, and begin to examine the alternative explanations of the financialization of agricultural commodities. Finally, I summarize the dissertation's argument and introduce the remaining chapters.

1.2 Grain-Storage Governance

My argument is built on the concept of grain-storage governance. Grain-storage governance is made up of the complex ties and connections between humans and non-humans that stabilize stored grain for asset streams. Grain-storage governance is underpinned with what Barry (2013) has called the "philosophy" of actor-network theory. The actor-network theory assemblage is an entity whose existence relies on a network of alliances and relations between human and non-humans (Barry 2013:2).

Grain-storage governance draws attention to how asset streams are established. Before asset streams can be established, and loans given on the basis of stored-grain, collateral must be established. Collateral is a form of security usually established on assets that are difficult to sell quickly, or illiquid assets. Securing collateral is an on-going process, or what I call stabilization. Assemblages are always presumed to be "becoming" and unstable. This means that stabilization is on-going and changeable. When applied to grain-storage governance and to ideas, regulations, and physical realms, assemblages can illuminate the connections between finance and agriculture.

The quality and quantity of collateral needs to be verified regularly to assure lenders and to build asset streams. In addition, grain-storage governance can draw attention to the varied purposes of grain storage, and the varied levers of control that are brought to bear on it. I will show how grain storage stabilization processes developed over the twentieth century, and their connection – sometimes direct, sometimes indirect – to finance. The lens of grain-storage governance helps to analyze the changes in regulations, ideas and physical technologies over time, and the implications for the financialization of grain commodities and agriculture. Grain-storage governance provides an entryway to examine how asset streams are established, leveraged, and controlled through the three stabilization processes.

How can we examine, and make sense of the assemblages required to establish stored grain as collateral? I develop the analysis of grain-storage governance by categorizing three stabilization processes – ideational, regulatory and physical. Ideational stabilization depicts how new ideas about grain-storage governance, in particular who should govern and value grain storage emerge. It is not enough to identify the importance of epistemic communities; it is also crucial to examine how specific claims to scientific knowledge, in this case economic claims about how its value is measured, are adopted by governments and policy-makers as fact (Barry 2013; Porter 2013; McKeen-Edwards and Porter 2013). The ideational stabilization of grain storage is part of the assemblage of grain management practices and infrastructure that facilitate the storage of grain. Ideas, in Cox's (1996) term, become common sense, and taken for granted.[4]

I use ideological stabilization to describe the work of what I call the Chicago Futures School of Agricultural Economists. This school has produced over 70 years of scholarly material that contrasts the "efficient" management of grain storage and commodity markets by ACEs with the "inefficient" management by the state. In particular, I trace how new econometric tools were used to develop a scientific explanation of the value of grain storage, and the function of these ideas in relation to ACEs and the US state-managed grain reserve. Since the 1940s, the theory of storage has been the

[4] Cox draws from Gramsci (1991) to show how ideas are institutionalized and contribute to historical structures.

theoretical foundation of private grain-storage governance and it has been strengthened and built upon. The theory of storage showed through economic calculations the advantages of the free market over other governance mechanisms (e.g. Hieronymus 1977; Irwin 2012). A close examination of the ideas about grain storage and how they were adopted illuminates how scientific facts, and economic tools are stabilized and became common sense. The effect of the change in value and ideas about storage led to changes in who had the authority, and in which economic tools were used to control grain storage.

The second stabilization process, regulatory stabilization, is the assemblage of rules, laws and institutions that help guarantee the ownership and value of stored grains. I use this term to describe the US state and its regulation of agriculture, and in particular its provision of credit based on stored commodities. The laws, legislation and state institutions stabilized the value of grain with documents of title, inspectors, legislated standards and regulations. Warehouse receipts were legal documents that represented the value and condition of grain and secured its ownership. The Commodity Credit Corporation managed a national grain reserve from 1933 to 1977, and supported a farmer-owned reserve from 1977 to 1996 by extending loans, using commodities for collateral. Regulatory stabilization also describes futures regulations and draws attention to the shift from the Commodity Exchange Act (CEA) to the Commodity Futures Trading Commission Act (CFTCA) in 1974. A close examination of regulatory stabilization shows the laws, institutions, and regulations that determined values and ownership of stored grains, which facilitated access to asset streams.

The physical stabilization of grain storage is the assemblage of grain management practices and infrastructure that facilitate the storage of grain. As agricultural products are delivered, graded, aggregated, scaled and stored, they are transformed into 'stable' valued commodities (Cronon 1992). Technologies were designed to work with grain, and also shape and structure the environment and physical actions of grain with the aim of stabilizing and maintaining its value for later markets and/or consumption. The stabilization of grain is chronicled at warehouses, grain elevators, or other storage sites, and secured through warehouse receipts. In bulk storage, grain's unstable qualities and vital life as a non-human actor are highlighted. The physical stabilization of grain includes non-humans. Bennett (2010) states that politics is considered a human domain constrained by the material – but material also acts. Grain is inherently unstable for a variety reasons – it is a living organism that can grow, spoil, and die. Grain is not always a solitary actor – it "becomes" in new assemblages. Collectivities of water, heat, mites and molds reconfigure grain into meals and homes for additional insects, and more molds. New kinds of storage technologies were developed during the twentieth century, such as metal bins, fungicides, and dryers, to stabilize grain physically and defend against these collectivities. The technologies and tools of grain storage are critical to successfully storing grain, and I include them in the concept of governance. A close examination of physical stabilization shows how grain management is required to help secure grain as collateral.

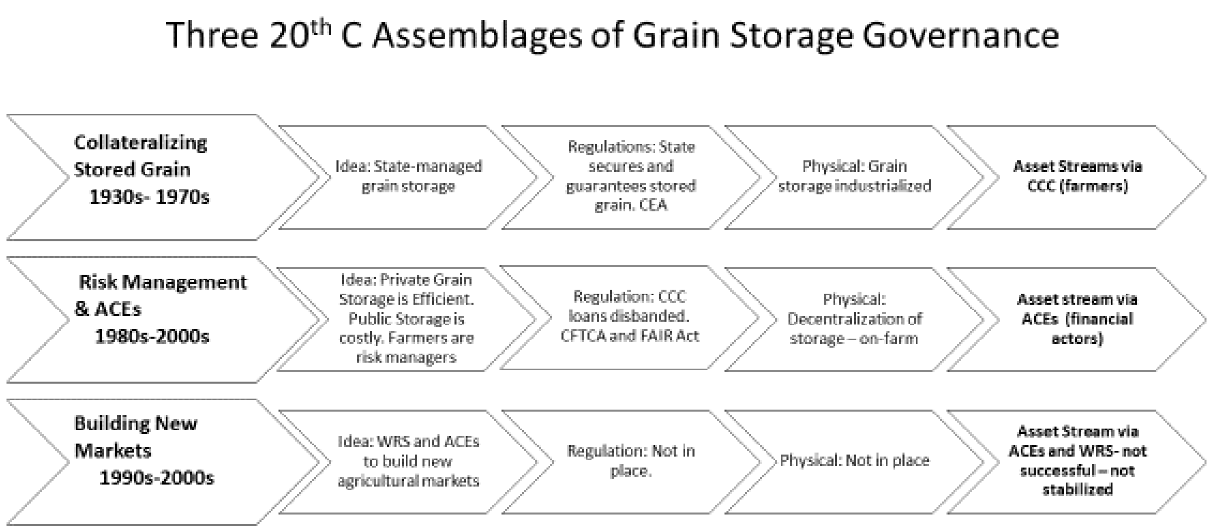

Figure 1: Three 20th Century Assemblages of Grain Storage Governance[5]

[5] The FAIR Act refers to the 1996 the Federal Agricultural Improvement and Reform Act a program to support farmer-centered risk management (see Chapter 4). WRS refers to warehouse receipt systems, an

Upon the establishment of these three stabilization processes, asset streams can be developed (see Figure 1). The stabilization processes change over time, and this has consequences for who can access asset streams. The grain-storage governance lens can also be applied to contemporary sites in order to understand who controls the establishment of asset streams and how they are controlled. In sum, this dissertation develops grain-storage governance as an analytic tool to help explain a less-examined relationship between finance and agriculture.

1.3 Agricultural Commodity Exchanges and Storage

What is an agricultural commodity exchange and how is it connected to grain storage? A commodity exchange is an organized market that provides a centralized platform for trading commodities. A futures market depends on standardized contracts. For example, a contract on the Chicago Board of Trade (CBOT) describes the grade of the commodity (e.g. #1 yellow corn), the amount (e.g. 5000 bushels), and when the corn is to be delivered to the buyer at a designated future date (e.g. December). Importantly, the contract itself is traded – not the physical commodity. Futures contracts are 'derived' from an underlying physical commodity – thus the term *derivatives*. Not all commodity exchanges have futures markets, but experts point to the advantages of these markets, such as sending price signals to farmers to help them plan plantings, adding transparency to trading, and increasing market efficiency (Hieronymus 1977).

Futures markets are financial markets, and futures contracts are "financial instruments" (Hieronymus 1977, 16). Ross states: "Although the underlying commodity may not be a capital asset, financial instruments written on the commodity can be a pure financial instrument" (1978, 468). Speculators can trade futures without taking delivery of the underlying commodity, and need only secure the

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agricultural financing system based on collateralized agricultural goods in regulated and licensed warehouses (see Chapter 7).

purchase with bonds that represent a fraction of the value. Futures markets are therefore a site of credit and financing, which intersects with stored agricultural goods.

Commodity exchanges link futures prices with spot prices, which should “converge” when contracts are settled either through a new contract or through the delivery of stored commodities. The physical delivery mechanism of commodity exchanges tethers futures contracts to the underlying commodity, and at the same time facilitates arbitrage between spot and futures prices (Valiante and Egenhofer 2013, 45). A well-functioning futures market, however, rarely takes delivery, because too much delivery is “an indication of an out of balance contract,” which limits arbitrage opportunities and speculation (Hieronymus 1977, 340).

Futures contracts and the transfer of title to goods are premised on a warehouse receipt. The system of title transfer and warehouse receipts was developed in nineteenth-century Chicago and is directly linked to a change in storage technology (Cronon 1992). Cronon (1992) describes how warehouse receipts were developed alongside bulk storage technologies – railways and grain elevators – which usurped bagged grain. Bagged grain had a provenance, whereas bulk grain was of mixed types. Warehouse receipts represented and certified the quality and quantity of the underlying commodity in storage rather than the provenance of the grain. The new documents of title developed alongside the nineteenth-century US grain storage infrastructure, which was dominated by a few trusts that owned the railways and grain elevators. Initially, early Chicago warehouse receipts were regulated by the elevator operators, but incrementally the Chicago Board of Trade, and, later, state regulation began to govern and certify warehouse receipts. The increased regulation was a reaction to misrepresentations of the quantity or quality of grain on warehouse receipts. ACEs, warehouse receipts, and the physical technologies of storage are one aspect of how stored grain is developed into an asset stream.

Why do I put grain storage at the center of this thesis? There are three primary reasons. First, the storage of grain is unique when compared to that of other foods and most agricultural commodities in a number of ways. First, its durability compared to other food commodities allowed for year round markets, which allowed for the development of year round futures contracts, and underpinned the success of early futures markets. Most other stored agricultural goods and foods are semi-perishable, such as potatoes, yams, and cassava, and not as durable as grains, which can be stored for years.[6] Agricultural commodities such as cocoa and coffee are durable and tradable; however, they require significant processing and handling before being stored and transported. The second reason grain storage is central to this thesis is the scale of its production exceeds other food commodities, and therefore, the control and financing of global grain is a crucial food security issue (Murphy, Burch and Clapp 2012). Third, the scale of grain production, especially US grain production, requires a significant storage and handling infrastructure. Changes in US grain storage technology underpinned the expansion and development of futures markets in the US Midwest during the nineteenth-century, and had effects on the twentieth century ACEs as well, as I will show. What is the relationship between financialization, grain storage and ACEs? For the purposes of the thesis, financialization focuses on the development of asset streams based on grain storage, and especially on the changes that have taken place in the US. Changes in how grain storage is governed in the US has had impacts on who can leverage grain storage and who can access asset streams. Agricultural commodity exchanges are sites where agriculture, grain storage and finance meet. The global growth and expansion of ACEs does not necessarily mean all ACEs are shaped by practices of financialization. But the growth and expansion of ACEs indicates how financial practices and agricultural relations

[6] This refers to large-scale commercial storage, rather than traditional small-scale storage methods (see Diop 1998).

might be changing, and illuminates the complexity of building markets and the varied relations that are required to bring finance and agriculture together.

1.4 US Grain Storage: A Model for Export?

The financialization of stored grain includes a set of ideational, regulatory and physical processes and relations that stabilize commodities in storage so that capital can gain a secure hold in otherwise vital and unruly goods. The US state shaped the governance of storage starting in the late nineteenth century, most visibly through regulations, and through its active promotion of agricultural finance via federal and state institutions throughout the twentieth century. Historians have chronicled the crucial role of agrarian social movements that pushed to increase regulation on speculators and trusts, and the subsequent expansion of US state institutions (E. Sanders 1999; Fitzgerald 2003; Phillips 2007). According to C. Woods Davis, in the late nineteenth century, farmers bore the risks of commodity exchanges and futures trading (C. W. Davis 1892). Turn-of-the-century populists and agrarian political movements pushed for regulations to constrain monopolies, banks, and speculators through anti-trust laws and security regulations that were uniquely structured in comparison to European regulations (Carney 2011).[7] This political pressure helped to form what Sanders (1999) has called the "agrarian statist agenda," an extensive reimagining and expansion of state power. The growth of the US state was an outcome of agrarian pressure and resulted in regulations that constrained industrial and finance capital in agricultural markets.

Agricultural credit provision has been a longstanding problem for farmers and the state. At the beginning of the twentieth century, agricultural credit was expensive and difficult to obtain from private sources such as rural banks (Fitzgerald 2003; E. Sanders 1999). Banks were reluctant to

[7] Farmers had diverse political positions. For example, on early banking regulation, northern wheat farmers did not want interstate banking but plantation owners did because of the different mobility of their assets, which can be summarized by the difference between an interest in land vs. slave labour (Carney 2011).

extend operating credit to farmers without the promise of a return. While CBOT futures traders could leverage their trades, farmers were having difficulty finding credit. The 1909 Country Life Commission recommended new models of cooperative and state-supported finance to help farmers compete with the “middleman system of handling farm products” (Roosevelt 1909, 14).[8]

Early twentieth-century US agriculture was defined by the state expansion of credit to help farmers stay competitive with middlemen and to help industrialize farms (Fitzgerald 2003; Prasad 2012). The establishment of the Federal Reserve System in 1913 created specialized banking and credit agencies for farmers and extended credit to farmers through mortgages (US Department of Agriculture 1923). Commercial banks, insurance companies, and mortgage loan companies, all private lenders of capital, charged high rates. The establishment of Federal Farm Loan Banks relieved rural banks of farm mortgages, which were difficult for commercial banks to service due to the mismatch between the short industrial credit loan cycle and the seasonally determined agricultural credit loan cycle.

When a grain reserve was established by the state as part of the New Deal in 1933, ideas about storage governance were connected to the international political economy, specifically trade, currency, and the stabilization of commodity prices and stocks. For example, in the late 1930s, John Maynard Keynes (1938) proposed a scheme for state-governed, perishable commodity storage in order to help stabilize declining commodity prices. He argued that the competitive system, including such institutions as ACEs, did not supply a sufficient incentive for individual enterprises to store surplus stocks. Storage was unprofitable because carrying charges such as interest, insurance, and warehouse costs exceeded the commodity prices paid at the end of a storage period, especially in a depressed market. Where private actors were unwilling to take on the risk with no foreseeable gain,

[8] The Commission stated that this required a “thoroughgoing investigation by experts of the middleman system of handling farm products, coupled with a general inquiry into the farmer’s disadvantages in respect to taxation, transportation rates, cooperative organizations and credit, and general business systems” (Roosevelt 1909, 15).

Keynes argued that the state should step in – control of storage posed little risk and had a number of benefits. Benefits included "buffering" uneven commodity trade cycles and providing stable supplies for production (Keynes 1938, 47).[9]

The Chicago Futures School of Agricultural Economists challenged Keynes on the governance of storage, using data from ACEs and grain futures trading to establish the superiority of privately managed grain storage over publicly managed storage. The "theory of storage" that was developed during the 1940s is regularly put to work in contemporary debates about speculation (D. R. Sanders, Irwin, and Merrin 2010), national global reserves (B. D. Wright and Williams 1984; B. D. Wright and Williams 1982), and development schemes to establish new agricultural commodity markets and frontier sites (IFPRI 2014). ACEs were central to the development of theories and ideas about how to understand grain storage and its role in managing commodity markets. Many international organization development projects to build new agricultural markets are underpinned by the idea that private storage, especially managed through ACEs, is superior to public storage.

ACEs have an ideational, regulatory, and physical history founded on specific modes of grain-storage governance that emerged from the Chicago markets. Financial derivatives now dominate world markets, but they were preceded by agricultural derivatives on which modern financial-derivatives were based (MacKenzie 2007, 368). For example, the London International Financial Futures Exchange (LIFFE) was more closely modeled on the Chicago exchanges than on any British precedent (MacKenzie 2007, 373). The US provided a model upon which to build agricultural markets. As Clark observed:

[9] New York financier Benjamin Graham (1937) also developed a public plan for storage during the same time period. His book Storage and Stability described how "storage of basic commodities … [is the] backing for a sound and adequate currency" (Graham 1937, v–vi). Like Keynes, Graham connected stable commodity prices to a stable domestic business environment. He stated that stored commodities "should give us a certain meed of strength and power in the world's economy … but instead it seems to afflict us with a peculiar vulnerability" (Graham 1937, 172).

> The insights of law and economics merge, and finally promote the same ends: market integrity, competitive pricing, commercial freedom, and governmental restraint. When the markets can also provide higher prices for producers, lower prices for consumers, and an opportunity for game-players to get rich, their appeal should be irresistible. The made-in-America futures markets provides all this. (Clark 1978, 50)

The US model of ACEs, based on a particular conception of grain storage, was the rationale for building new agricultural markets. Early national and global conceptions of the utility of stored commodities, as exemplified by Keynes, have been usurped by the US model of commodity trade, one built on a strong US state and mid-century storage regulation, a specific ideology, and the CCC physical management of grain.

In a period of agricultural underinvestment and policy neglect (Ghosh 2010; World Bank 2007), ACEs have emerged as a viable policy tool supported by states, international organizations, and non-governmental organizations (NGOs). According to proponents, ACEs are a keystone of modern agriculture because they underpin efficient agricultural production, originate financial products, and facilitate the grain trade (Mercier 1999). In turn, ACEs can operate as an "ecosystem" of agricultural commodity trade that will "transform farmers and the way traders do business" (Gabre-Madhin 2007, np). Within the context of the deepening liberalization and financialization of agriculture, ACEs are a vital source of financial management tools, such as agricultural derivatives, that promise to provide farmers with capital to farm, and act as hedging instruments to protect against market uncertainty (Garcia and Leuthold 2004, 256; UNCTAD Secretariat 2005). Most of the rapid growth and proliferation of ACEs has occurred outside of the US (Garcia and Leuthold 2004), and this growth has been accompanied by increasing consolidation of the corporations that operate commodity exchanges. For example, the Chicago Mercantile Exchange bought out the Chicago Board of Trade in 2007 and is now known as the CME Group, a "huge exchange fortress" (*Economist* 2007, 85).[10] The

[10] The CME Group is categorized as a financial service, and it operates exchanges for agricultural commodities, equity indexes, foreign exchange, interest rates, and other complex derivative products.

CME Group has locations and interests that extend beyond the traditional financial centres of US commodity markets into Africa, Europe and Asia.

The impressive growth of ACEs, and in particular US-style futures markets, were shaped by a unique context. The agrarian statist agenda constrained agricultural commodity trading by speculators with expansive regulations during the 1920s and 1930s until the regulations began to unwind starting in the 1970s. The globalization of finance was shaped by these regulation and deregulation dynamics.

1.5 US Financial Regulation and Agricultural Markets

How have other scholars explained the financialization of agriculture and food? While some scholars have focused the influence of financial actors on land (e.g. Fairbairn 2014) and supply chains (e.g. Isakson, 2014), in the wake of the food and financial crises, scholars have highlighted the role of the deregulation of commodity markets to explain the rise of speculation and the negative influence of financial actors in agricultural commodity markets (e.g. Clapp 2009a; McMichael 2009; Ghosh 2010). These authors highlight the role of regulation and the recent deregulation of financial markets. While changes in the international political economy were reshaping global markets, domestic agricultural commodity regulations were being reconfigured in the US. The US state is a key actor in the regulation of global agricultural and financial markets. The deregulation of financial markets began in the 1980s (Ghosh 2010; Clapp and Helleiner 2012a). But the passing of the Commodity Futures Modernization Act in 2000 led to a sharp increase in global financial actors in agricultural derivatives through a variety of new products and the relaxation of regulatory barriers (Clapp and Helleiner 2012a). The increased activity of financial actors in agricultural commodity markets contributed to a series of crises that linked food prices and financial markets together, and negatively affected poor food-importing countries (e.g. Ghosh 2010; De Schutter 2010). The regulations on finance and commodity trading were incrementally eroded and these shifts intensified speculative links between finance and food, links that had been systematically pulled apart by three decades of state deregulation (Fuchs, Meyer-Eppler, and Hamenstädt 2013; Clapp 2014; Isakson 2014).

International political economy (IPE) scholars note the importance of the 1970s because of the changes that occurred in commodity and financial regulations during that decade (Strange 1986; Strange 1994). IPE scholars have taken a long view, of the changes in finance. For example, some have shown how the globalization of finance reconfigured the international political economy and was partly prompted by the end of the Bretton Woods monetary system, a system of currency controls anchored by the US dollar after the Second World War to stabilize financial markets (Porter 2005; E. Helleiner 1994).[11] They describe how Keynesianism was replaced by the ascent of neoliberalism and a model of deregulated and free markets (Blyth 2013). The 1970s and the end of the Bretton Woods era was also marked by events, including the global oil and food crises that reconfigured energy and agricultural markets (e.g. Friedmann 1982; Clapp 2012a).

The focus on regulation and deregulation is an important part of the explanation of the financialization of agriculture. It helps illuminate the interaction among states, finance, and agriculture and, to a certain degree, how neoliberal ideational projects were implemented through policies such as privatization and deregulation. Scholars who focus on deregulation are providing critical insights into possible political solutions to the increased influence of financial actors in agricultural derivative markets. The scholarship contributes to illustrating important state and market interactions and the crucial role of states in constraining financial actors. But there is a gap. Regulations that do not directly target futures markets and speculations can nevertheless affect them. For example, the regulations that govern documents of title and agricultural collateral affect grain futures contracts. In addition, power and influence is not solely regulatory. Ideational and physical

[11] The critical period, according to Porter, was the 1960s and the start of the Euromarkets in London, while Helleiner traces the growth to the late 1950s and the increase in private international financial activity.

resources are also part of commodity markets. Examining how agricultural markets and commodities became part of financial markets through the construction of asset streams can help reveal what is needed to build and sustain financial markets, including the processes of regulation and deregulation.

1.6 Methodology

Two streams of scholarship inspired my methodology. First, I work in the tradition of many IPE scholars (e.g. Clapp 2012a; Germain 1997; Langley 2002) and approach the issue of agriculture and finance as an "historical enquiry" (Cox 1981, 131). IPE scholars have placed contemporary orders of finance in a historical context (e.g. E. Helleiner 1994; Cox 1996), which reveals the ideational and material base of contemporary world financial orders, according to Langley (2002). Second, I draw from ANT, or what has been termed the new materialist approach (e.g. Barry 2013; McKeen-Edwards and Porter 2013), which draws from sociology, and science and technology studies, and has recently included IPE scholars (eg. Best 2014; Porter 2011). Sociologists have used ANT to examine the operation of financial markets (e.g. Callon 1998; MacKenzie 2008). An historical enquiry led me to examine a wide range of literature from the fields of agricultural history, agricultural economics, historical sociology and IPE. The new materialist approach led me to examine the original texts of agricultural engineers, entomologists and mycologists. By combining these two modes of scholarship, I was able to focus on the the specific context of US grain storage, and how asset streams were built on stored grain. In addition, I was able to put the examination in the context of the international political economy over a long period of time.

My research employed two main methods, which were used to place the contemporary relations of agriculture and finance into a historical context. The principle method was a historical analysis of agricultural economists' writings, international organization (IO) documents, and secondary materials, as well as primary and secondary materials on US grain storage technologies and practices. I traced the history of agricultural economists in the US to understand ideology and ideas of grain storage. This work analyzed the professional formation of agricultural economists through secondary and scholarly material. My starting point was an examination of contemporary work on grain reserves prompted by the food and financial crises of 2007-8. From there, I traced the intellectual heritage of agricultural economists, with a particular focus on storage. For example, contemporary scholars primarily referenced the foundational work of Working, Gustafson and Hieronymus – a narrow but critical link. I worked to understand the theoretical underpinnings of this work through their writings, while also tracing the development of agricultural economy as a profession. In addition, I worked systematically through US governmental documents and scholarly literature on warehouse receipts and storage policies.

As I turned my attention to the US state and grain storage, it was clear that the CCC was a critical institution that not only shaped and managed the infrastructure of grain storage but also shaped the ideas of agricultural economists on the role of ACEs and the state in grain management and control. To explore the role of the state in grain storage, specifically the CCC and the political contestations that surrounded it, I examined scholarly journals (see above), congressional records, CCC annual reports, and newspaper coverage with a particular eye to controversies and problems.

Regulations that govern documents of title and warehouses were key to securing stored grain for collateral. I traced the chronological regulatory shifts in warehouse receipts in relation to agriculture, using US government documents from the National Agricultural Library, USDA, agricultural economists' scholarly work, and especially law journal articles to understand the peculiar and unique problems of securing agricultural commodities for credit and the shifting laws that underpinned the loans agreements. More generally, I traced the regulations that governed US grain storage, including warehouses and grain inspection, as well as commodity exchange regulations, through US state institutions including the USDA, the Commodity Futures Trade Commission, and the state and federal grain inspection agencies.

Grain storage technological change was primarily driven by the US state, through its various institutions. I examined grain management historical literature on "field technologies" through agricultural engineering and agronomy journals and USDA publications. To understand the metrology of grain and the specific problem of grain moisture, I traced the development of moisture meters through primary and secondary literature from grain inspection organizations both private (Chicago Board of Trade) and public (USDA, and Railroad and Warehouse Commission of the State of Illinois). I analyzed primary and secondary literature on mycology, entomology, and grain management in storage facilities, and traced the primary literature on the technological problems with and solutions for grain storage, such as the CCC's grain-management research programs and academic work on agro-chemicals, dryers, fumigation, and the physical containment of grain.

I analyzed documents from IOs including the World Bank and UNCTAD, and their responses to the food and financial crises. I examined over 56 documents and presentations from UNCTAD on warehouse receipts, ACEs, and agricultural and commodity trade risk management. The World Bank analysis included over 60 presentations and documents, including an on-line course on agricultural risk management in which I participated.

The second method was field work at international organizations' conferences and meetings, and agricultural trade shows and farmers' union meetings in the US. The fieldwork provided background and illuminated the contemporary context for a historical enquiry. I attended the meetings as an "observer-as-participant" because I used unobtrusive observation of meetings and workshops (Walliman 2006, 17–18).[12] The fieldwork included interviews with experts from international

[12] The research was conducted with ethics clearance from the University of Waterloo's Research Ethics Officer (ORE #:18388); this clearance required the completion of the Tri-Council Certificate of Ethical Conduct for Research Involving Humans (TCPS 2: CORE, completed October 4, 2012). All interviewees were provided with letters of information, and were required to sign consent forms that were approved by the Research Ethics Officer.

organizations and civil society on the role of agricultural finance and ACEs. The interviews were conducted face-to-face, and were semi-structured and confidential. The interviews provided background information for the dissertation on the role of experts and agricultural economists, as well as civil society activists' views on agricultural investment. At the conferences and meetings, I observed the interaction between agriculture and finance, noting the participation of specific industry representatives from ACEs, finance, and the storage industry. To gain a more textured and detailed analysis of these themes and the practices and physicality of grain management, I observed industry-focused educational seminars on grain management. These forums provided supplementary material and highlighted key themes of contemporary grain management for commodity farmers and grain handlers. I was able to observe the continuities and discontinuities between the everyday problems of contemporary grain management and its relationship to past grain management problems. The field work and observations laid the foundation and direction for later analysis of the political history of storage, focusing on the US and its relation to ACEs.

The fieldwork also provided background material on the physical role of storage in grain markets and contemporary financial risk management. At US agricultural trade shows, grain storage corporations and technologies took centre stage alongside field machinery, agrifood corporations, and financial risk management organizations. For example, large grain traders promoted on-farm storage as a risk management technique, and risk management organizations put grain storage front and centre in promotional material. There was a tension between the very real physical focus on the "things" of agriculture at the US shows, which included grain storage, and the ideas of IOs around the role of ACEs and attracting investment. It was this tension that I was interested in focusing on.

A historical enquiry is driven by the tensions and contradictions of a given world order, and provides a framework to engage with change over a long period of time. By focusing on how new material conditions and ideas emerge IPE scholars have illuminated contemporary orders through a historical enquiries. So too, this research examines a long sweep of time through a historical enquiry. But where it is different is that it approaches material change through an ANT approach. The result is that the first method, a careful analysis of grain storage literature from a variety expert sources, which includes technical and scientific reports, represents the core data of the thesis.

In sum, the methodology is framed through a historical enquiry, which is inspired by IPE scholars who examine agriculture and finance. The contemporary problems and tensions of agriculture and finance provided a starting point to develop a research program which honed in on the crucial role of grain storage. Grain storage can be understood as an assemblage buttressed by scientific, economic and technical expertise, and built on a material foundation. Actor network theory enlivened the data with a focus on non-human actors at various times throughout the twentieth century. The data that would help apprehend grain storage at different points of time was drawn from technical documents and reports that described the problems of grain storage and the potential ideational, regulatory and physical solutions. How the grain assemblage changed over time illuminated the tensions inherent in a given order. In turn, the historical enquiry helped to contextualize the contemporary problems of agriculture and finance.

1.7 Summary of Chapters

How does the examination of twentieth century US grain storage stabilization – the ideas, regulations and physical infrastructures – help us to understand the financialization of agriculture? This thesis explains how US grain storage was restructured during the twentieth century, and the effects of this restructuring on the establishment of asset streams. Grain-storage governance helps to explain how grain storage ideas, regulations and physical tools and technologies are required to collateralize grain to create asset streams. The research shows how US collateralized grain storage was an assemblage of mid-twentieth century economic ideas, agro-chemical technologies, and state regulations, and how a new grain storage assemblage emerged in the late-twentieth century. In turn, changes in grain-storage governance has consequences for who can access credit based on stored grain and who cannot. Specifically, I show how asset streams in the mid-twentieth century were directed to farmers, and how asset streams were accessed by a new set of financial actors in the late twentieth century. The research has applications to contemporary global financial inclusion projects that aim to build new agricultural markets and connect small producers to global markets through projects to collateralize stored grain.

I have structured the empirical chapters (Chapter 3-7) to show how the interaction between ideas, regulations and physical infrastructures come together in varied assemblages at different times and the assemblage's effects on asset streams. Moving from abstract economic ideas to the concrete and physical interactions of grain in storage, I aim to draw out the complex ties of agriculture and finance and how they come together in grain storage.[13] In the penultimate chapter, I use the three stabilization processes to analyze how asset streams are built, or not built, based on how IOs propose particular assemblages of grain storage associated with their programs to develop new agricultural markets.

Chapter 2 begins with a review of the interdisciplinary scholarship on agricultural finance and financialization, with a particular focus on IPE and agrifood scholarship, and outlines how recent scholars have explained the financialization of agriculture. I continue with a review of how ANT has been used by IPE scholars and other social theorists, and highlight some of ANT's limitations. In the third section I put ANT and IPE into conversation and propose a hybrid theoretical framework that helps to explain governance and power through the three stabilization processes. I review the strengths and weaknesses of these approaches, and I finish with the empirical and theoretical insights of the dissertation.

[13] Thanks to Derek Hall who suggested this sequence early on in the crafting of the thesis.

In the third chapter I show how two groups of agricultural economists developed new ideas and new kinds of economic calculations that affected grain-storage governance and policies over the twentieth century. Over the course of the twentieth century, agricultural economists developed economic tools and theories to account for the role of grain storage in an increasingly industrialized agricultural economy. The first group, agricultural economists associated with the US state, developed ideas to support the use of public grain reserves. The second group, the Chicago Futures School, analyzed the role of agricultural commodity exchanges (ACEs) and the public role of grain storage, and developed ideas to support the use of privately managed grain reserves. I call this group the Chicago Futures School because of its close association with the Chicago commodity exchanges, and its shared understanding of the role of futures within a market economy. This shift from public storage programs to private management through ACEs paralleled two important shifts that facilitated financial actors' access to agricultural commodities. First, agricultural commodity exchanges became the primary platform for managing grain storage, which helped contribute to the growth of ACEs. Second, ACEs were increasingly portrayed as financial institutions, not merely a centralized marketplace for agricultural commodities and sites to smooth supply and demand. To help explain the shift in ideas over the twentieth century, I use ideational stabilization, which describes the process or emergence of an idea, its adoption, and how it becomes what is taken for granted, or what Cox (1996) has called "common sense."

In the fourth chapter, I examine the processes of grain storage and US regulations. I show how the unstable character of agricultural credit, specifically the problem of collateralizing agricultural commodities, was stabilized with the backing of state regulations during the twentieth century. The state introduced two sets of regulations to address the problem of establishing credit on stored agricultural commodities. The first was by helping to secure warehouse receipts in the early twentieth century. Warehouse receipts have been used as a tool to secure goods for credit since the mid-nineteenth century, but were legitimized through state regulations, and secured with state resources in the early twentieth century. But these measures were not fully successful because private finance remained reluctant to take on risk associated with credit documents on stored agricultural commodities. The second regulatory process was the establishment of the Commodity Credit Corporation (CCC). The CCC was established in 1933 to manage a national grain reserve and to provide financial support to farmers through a loan program based on stable, stored commodities that acted as collateral; it either directly or indirectly managed the US grain reserve until the 1990s. Regulatory stabilization shifted the control of storage from private hands to public hands then back into private hands. The shifts are marked by the state's involvement in the collateralization and security of stored grain for credit. However, the dynamic character of grain posed problems for securing collateral at grain storage sites.

Chapter 5 describes US grain management and the process of physical stabilization. The chapter shows how grain management helps to explain the establishment of asset streams in three ways. First, US grain management highlights the interaction between grain-management techniques and lively grain. Starting in the 1930s, the US government conducted research and developed new industrial techniques to manage its grain stocks, and in particular, to manage and stabilize surplus grain in long-term storage with agro-chemicals and other technical interventions to prevent spoilage and pests. Second, the technical practices of experts helped to assure the quality of stored grain, which then was valued for collateral and leveraged for credit. Third, grain is vital and inherently unstable – it transforms, or "acts" – it sprouts, holds and releases moisture, and can spoil and become unfit for the market. Grain management is not limited to human actors; non-human actors also shape the politics of grain management, and require new grain-management techniques are enrolled to stabilize grain. To explain the dynamic character of grain and its interaction with grain management, I draw from Bennett (2010) who argues that material things act, and can shape human actions. I also draw from

Barry's (2006) technological zone frame, which highlights how technological practices are political practices. Grain-storage management practices and technologies were exported along with the US grain surplus, which shows how a specific assemblage of grain storage was developed.

Chapter 6 describes a second physical stabilization process, and the development of the CCC's grain containment technology in the 1940s and 50s. Metal bins became part of the assemblage that physically stabilized grain. I highlight how containers changed, and how these changes contributed to a more dispersed model of grain storage, from centralized terminal storage to on-farm storage. In turn, the contained grain became collateral for farmers to access loans from the CCC. When the national reserve was disbanded in the 1970s and abandoned in the 1990s, on-farm grain containers affected the establishment of asset streams by helping to facilitate farmers' risk-management strategies. More specifically, changes in grain containment helped to foster a risk management model that dovetailed with ACE's tools. An examination of the physical infrastructure helps to explain how asset streams shifted from public management by the CCC to private management in the 1990s, and how on-farm storage aligned with new ACE risk management tools in the 1990s.

In Chapter 7, I show how IO experts drew on the US-style model of warehouse receipts and ACEs to support new agricultural market projects. I analyze these projects with the three stabilization processes of grain-storage governance (regulatory, ideational, and physical). Initially, IOs developed plans to access ACEs in OECD countries to help finance commodity trade originating in poor exporting countries during the 1990s, but in the 2000s their attention shifted to developing ACEs and warehouse receipt systems (WRSs) to connect small producers to global markets. In addition, IOs changed their approach to grain storage development projects from one that provided technical support for community and on-farm storage to an approach that supported private grain management, or market-driven storage management (especially WRSs) in order to develop collateralized credit. According to their supporters, many of the ACE-building projects have not succeeded, and there has been limited success in establishing market-driven projects such as WRS and ACEs in new sites (e.g. Sitko and Jayne 2012). I argue that the export of this model has not been successful because of the uniqueness of the US case and the resultant failure of the new projects to implement the stabilization processes necessary to succeed.

In Chapter 8, the conclusion, I present a summary of the thesis and a discussion of its contributions to the literature. In addition, I propose four new research agendas that emerge from the thesis.

Chapter 2- Grain-Storage Governance: Actor-Network Theory and IPE

2.1 Introduction

The role of grain storage is central to this inquiry because of its relationship to the financialization of agricultural commodities. The grain-storage governance lens shifts my focus from financial actors such as speculators to stabilization processes that underpin how asset streams are built. I draw from scholars of international political economy (IPE) and actor-network theory (ANT). Specifically, I analyze ideational and regulatory changes to help explain storage governance in the context of international political economy. I analyze the physical changes that mark the governance of grain storage by drawing on ANT, and bring the material transformations into view along with non-human actors. In sum, I demonstrate how the stabilization of grain requires a constellation of regulations, technologies, and economic ideas that make up the politics of grain storage, and how a close examination of grain-storage governance helps to explain the financialization of agricultural commodities. The thesis defines the financialization of agriculture as the work of assembling and turning a bushel of corn or any other agricultural good – primarily grain – into a financial asset stream. This definition highlights the role that grain storage plays in commodity speculation, and encompasses the mundane practices of collecting and managing amassed grain in containers.

The chapter begins with a review of the interdisciplinary scholarship on finance and financialization, with a particular focus on IPE and agrifood scholarship. Many IPE scholars who study the politics of the global food system have neglected the role of finance, and many scholars who study finance have neglected the role of the global food system (Clapp and Helleiner 2012). This has created two streams of literature that are not often put into conversation: the IPE of finance and the IPE of agrifood (for exceptions see Clapp 2012a; Clapp 2014; Isakson 2014). I also examine the scholarly literature on food regimes and highlight some of its conceptual gaps, and then take a closer look at how recent scholars have explained the financialization of agriculture. The review of approaches to finance will help show how the central thesis question provides an opportunity to fill a gap in the literature. In the second section, I examine how ANT has been used by IPE scholars and other social theorists, and highlight some of its limitations. In the third section I put ANT and IPE into conversation and propose a hybrid theoretical framework that helps to explain governance and power through the three stabilization processes. I review the strengths and weaknesses of these approaches, and I finish with the empirical and theoretical insights of the dissertation.

2.2 IPE Approaches to Finance, Financialization and Agriculture

How have IPE scholars approached finance? Many IPE scholars have paid particular attention to the crucial role of finance in the international political economy since the 1970s by putting finance into a historical context (Strange 1971; 1986; E. Helleiner 1994; Germain 1997; Porter 2005). Robert Cox outlined his approach to a historical enquiry by describing how a framework for action both enables and constrains how a world order is made (Cox 1996). Cox's framework theorizes change by accounting for ideas, material underpinnings and institutions. As the historical conditions change, the framework in which action takes place, or can take place, changes. In turn, the analytic parts of the framework, ideas, material capabilities and institutions also change. An IPE historical enquiry can be used to illustrate the shifting governance patterns of finance in the context of critical theory (Cox 1981, 97-8). Contemporary orders of finance are redefined by placing them in a historical context as situated in time rather than as transhistorical or universal (Amoore et al. 2000).

The historical IPE approach helps to reveal the ideational and material base of contemporary world financial orders (Langley 2002). For example, Langley shows how credit is not an automatic outcome of economic necessity, but rather is a set of practices, norms, and values that are specific to particular times and places (Langley 2002, 27). World finance and credit practices are complex with multiple facets:

> [credit practices] are framed by and draw upon capital, information and technology as material resources; shared meanings as ideational forces; and market, state and civil institutional forces.(Langley 2010, 37)

Other examples of the historical approach include Helleiner's work that shows how states drove the globalization of finance despite the "retreat of the state" (Helleiner 1994; see also Strange 1996). Porter also illustrates how globalization produced the intensification of global institutions and created a set of financial ideas and knowledge that reinforced global rules and practices with the help of elite technocrats (Porter 2005). Germain shows how change has occurred only incrementally despite the recent 2007-8 financial crisis because there has not been a significant shift in ideas or *mentalité* (Germain 2009). These scholars use an IPE approach to explain how historically situated change takes place by focusing on the ideas, institutions and material capabilities of financial actors and practices, and how these changes have shaped global finance at various scales. All these scholars highlight changing financial orders in the context of global actors, ideas and material changes.

The effects of changes in finance are not seen only on a macro scale; IPE scholars have also highlighted the role of finance in the everyday. The policies that expanded credit also created new financial subjects, and some scholars have sought to explain how subjectivities are reshaped by financial practices and technologies (e.g. Langley 2008; 2010; Watson 2009). The expansion of "coupon-pool" finance engages a wider number and class of participants in financial investments, and finance is no longer an exclusive realm limited to the elite (Froud, Johal, and Williams 2002). Actors are connected to finance from the ground up, and households are connected to institutional investors through pensions and other collective investment tools (French, Leyshon, and Wainwright 2011). The new financial subjects are implicated in the rewards of successful investment, becoming self-regulated rentiers, and are caught up in financial failures such as the sub-prime crisis (Watson 2009). These scholars draw attention to how new financial subjects emerge from financial practices such as the expansion of credit through new asset streams based on agricultural commodities. Helleiner

(2011), among others, makes a special mention of the importance of IPE scholars attending to the specific practices and tools of finance, especially the everyday practices of global finance, which can draw together both micro and macro financial processes (see also Seabrooke 2010; S. Hall 2012).

IPE scholars' attention to multiple scales of finance, from macro to micro reflects IPE's eclecticism. One of IPE scholarship's strengths is its eclecticism, which can "beg, borrow and steal" to create a "useful synthesis for understanding a highly complex phenomenon" (Blyth 2009, 9; see also Best and Paterson 2010). In this vein, Helleiner has argued that "analytical eclecticism" is crucial to explaining, for example, the global financial crisis (Helleiner 2011, 84). In turn, the historical and material shifts that help to categorize and periodize changes in everyday practices have reshaped finance and agriculture and also need to be understood in relation to the financialization of agricultural commodities.

I draw from IPE scholars who have traced finance and agriculture governance, and show the importance of the US state in that process (Clapp 2012a; Clapp and Helleiner 2012). The US state reshaped global agricultural trade throughout the twentieth century and used agricultural surpluses as a political tool in the Cold War, and as a means to address the political demands of farmers. In turn, the use of agricultural surpluses had effects on the international political economy (Friedmann 1982; Clapp 2012b). The surpluses had to be managed, moved, and distributed, and an infrastructure had to be in place before they could be used as a political tool.

State policies have shaped twentieth-century agriculture, as shown by environmental and agricultural historians (E. Sanders 1999; Fitzgerald 2003; Phillips 2007; see also Clapp 2012a). In addition, Prasad (2012) showed how increased US state intervention in the early twentieth century resulted in "the agrarian control of finance," which expanded credit, leading to a "mortgage Keynesianism" political economy. The expansion of credit was driven by the expansion of agricultural surplus, according to Prasad. In addition, the unique US financial system was shaped by early twentieth-century agrarian political forces (see also E. Sanders 1999; Carney 2011; Prasad 2012). While a historic approach can sometimes portray a straightforward lineage or evolution, it is important to attend to disruptions, and to how older practices and ideas are sometimes presented as new and innovative (Walters 2012). This thesis draws from these scholars and their attention to changes in the state, the economy, and political structures over time to highlight the shifting intersections of the state, finance and agriculture.

A model for this work is a crucial text from environmental history, Cronon's *Nature's Metropolis* (1992). Cronon shows how changes in US grain storage technologies, specifically the development of the mechanized grain elevator, worked hand-in-hand with futures markets from the nineteenth century onward to build Chicago's commodity exchanges. The physical underpinnings of agricultural markets and the critical role of storage are part of the material assemblages that transformed "grain into capital [and] obscured and distanced its link with physical nature" (1992). Cronon explains the dynamic physical assemblages that extend far beyond the walls of a given exchange, which included a new North American physical infrastructure that involved grain elevators, bills of lading, warehouse receipts, railways, and telegraphs, as well as the massive growth in grain production (Cronon 1992; Mathieson 1942). This is an important work that chronicles the early development of ACEs; little work, however, has been done on the stabilization processes of the twentieth century, which have produced a different set of political problems and solutions, including the extension of credit to farmers based on stored commodities and the management of large post-war grain surpluses.

The state and grain-storage governance have had a long and vital relationship in the US. But the state is not the only regulator. Agrifood scholars in particular have shown how corporations play an important political role in the global political economy (e.g. McMichael 2005). They have highlighted how corporations work both with states and independently to harmonize global regulations in their own self-interest (Newell 2009; Murphy, Burch, and Clapp 2012). For example, the large grain traders, the so-called ABCDs,[14] lobby and work in and outside of government to influence regulations and regulators on a domestic and international scale (Murphy, Burch, and Clapp 2012). State regulation works with other powerful actors to reconfigure agrifood governance, and this also applies to storage governance.

2.2.1 Food regimes and financial capital

Many influential IPE scholars who study agrifood relations use the theoretical framework of the food regime to highlight how capitalism has reshaped labour, and in turn, social relations, from Friedmann and McMichael's (1989) early work on the state and agriculture to more recent work by Fairbairn's work on financialization and farmland (2014). Food regime literature examines agrifood transformations in relation to regimes in which "hegemonic relations privilege industrial and finance capital, with agriculture in shadow" (McMichael 2013a, 48). Food regimes are exemplified by stable patterns of capital accumulation, and finance is often portrayed as a buttress for a specific hegemony, such as a dominant state or a colonial regime. For example, banks extended credit "at both ends" of the metropole-periphery relation, but how credit was extended and to whom was not the focus (Friedmann and McMichael 1989, 105). By applying a historical lens based on world systems theory (following Wallerstein 1974; and Arrighi 1994), scholars show the twentieth-century shifts in agricultural production and capital structures and how these structures produced unequal social relations. A critical driver of change is the transformation of agricultural goods into commodities: "Food chains bind and transform the world's different cultures via commodification" (McMichael 2013a, 1).

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[14] Archer Daniel Midland, Bunge, Cargill, and Louis Dreyfus are commonly known as the ABCDs, and it is estimated they control 73 percent of the global trade in grain (Murphy, Burch, and Clapp 2012, 7).

Recent debates have centred on identifying the capital accumulation patterns of the contemporary, or the third, food regime. Explanations range from Friedmann's Green Capitalism (2005) to McMichael's Corporate Food Regime (2013) to Pritchard's observation that the third food regime has yet to stabilize because there is no contemporary global hegemon, leaving global agricultural institutions "rudderless" (Pritchard 2009, 304). Some scholars have identified financialization as the most recent stable, hegemonic force of capitalism (e.g. Burch and Lawrence 2013; Fairbairn 2014). The third "Financialised Food Regime" describes how financial capital reconfigures agrifood production and retailing, and how, for example, grain corporations extract profits from financial arms rather than production or retail operations (Burch and Lawrence 2009; 2013). Salerno (2014) shows how finance capital is used by Cargill, a large grain trader, to leverage new markets and profits.[15] Fairbairn (2014) uses the term food regime to describe how farmland is being drawn into new circuits of global finance.

Until the most recent work on the third food regime, finance has been an adjunct to capitalism, and at times conflated with capitalism in the food regime literature. There are two forces that underpin scholars' explanations for how food regimes operate. First, food regime literature describes the totalizing force of capital in relation to agriculture by drawing on Kautsky's *The Agrarian Question* (1988 [1906]). Quoting Kautsky, Friedmann notes that "capital organizes and reorganizes agriculture" (Friedmann 2005, 95). Second, food regime literature describes global hegemony in relation to geopolitics. For example, McMichael draws from Arrighi's description of financialization and the decline of US hegemony in relation to industrialists' increasing dependence on financial capital for profits (Arrighi 1994; McMichael 2013b). Food regime literature knits together capitalist relations and capitalism's effects on social relations in agriculture and the global political economy. Hall brings

[15] For an alternative approach to the food regime lens, see Murphy, Burch and Clapp (2012) for a discussion of grain traders and financialization.

attention to the importance of specifying "conceptual clarity" in discussions of capitalism and market relations (2012, 1205). The interaction between agriculture and finance would also benefit from additional conceptual clarity. The historical approach and global scale of food regime literature is a helpful frame for understanding social relations and the means of production as capital is accumulated, but has been less focused on the everyday, material operation of finance.[16]

2.2.2 What are the explanations for the processes of financialization?

Financialization has been increasingly drawn on to explain a wider and wider set of relations, and the explanations of how and where financialization takes place is expanding. For example, financialization occurs on various scales, from individuals' daily lives (Martin 2002) to firms' operations (Froud, Johal, and Williams 2002) to the structural processes of the economy and capitalism generally (Epstein 2005; Krippner 2011). Fuchs et al. discuss the complexity of explaining financialization, stating that there is no "single structural or systemic logic" (Fuchs, Meyer-Eppler, and Hamenstädt 2013, 220). The range of processes and sites to which financialization is applied is broad, and not always clearly defined. A common definition of financialization is drawn from Epstein:

> Financialization refers to the increasing importance of financial markets, financial motives, financial institutions, and financial elites in the operation of the economy and its governing institutions, both at the national and international level. (Epstein 2001, 3)

Epstein's definition has been used to describe and explain a wide variety of changes and is very broad (Orhangazi 2008). Scholars who study the international political economy of food and agriculture also draw from Epstein (e.g. Clapp 2014; Isakson 2014). To narrow the focus, and to help hone the

[16] Food regime scholarship has tended to focus on trade more than the role of finance in agriculture. One explanation could be that the inclusion of agriculture in the WTO/GATT agreements in the 1990s marked an important shift in agrifood governance and the global political economy (Clapp 2006; Margulis 2013). Thanks to Jennifer Clapp for this insight.

definition of financialization, I focus on agricultural commodities, and the work of assembling and turning grain into a financial asset stream following Leyshon and Thrift (2007).

Another approach to explaining financialization of food and agriculture, and to a certain degree agricultural commodities, is to use filières, or commodity chain analysis, to explain how economic forces such as globalization restructure markets and trade relationships (Goodman 2001). For example, Newman (2009) examines the financialization of coffee and shows how speculative activities led to heightened volatility in derivative prices. She narrows her definition of financialization to focus on how commodity chains have been integrated into the financial system and the impact of this integration on social relations. Ducastel and Anseeuw (2013) explore how financial institutions in South Africa such as commodity exchanges act as mediators between global capital and South African farmers. They describe how risks have been borne by smallholders, while banks have protected themselves through the South African Futures Exchange and insurance. As Newman observes, large international traders can access and use hedging, but small domestic exporters face barriers. These scholars show how elite actors are extracting capital and they show the negative effects of the extraction on less powerful actors along the commodity chains. However, while they do focus on commodities and commodity chains, they are less focused on the physical underpinnings that sustain the chains. In a similar vein, Isakson provides a comprehensive survey of the financialization of food along the agrifood chain, drawing on Epstein's definition of financialization to show how elite financial actors are extracting capital and transforming power relations along the agricultural commodity supply chain (2014). These authors show how examining agrifood relations along supply chains can help highlight the role of financial actors, but they focus on global financial forces and actors and their effects, with less focus on how asset streams are produced.

Agrifood scholars who explain the relationship between food and finance in terms of financialization have been criticized for abstracting the tools and practices of finance (J. W. Williams 2014). Williams calls attention to the use of ‘chains’ and other descriptors, to show how financial practices are obscured by some scholars rather than illuminated. As Tsing observes, global commodity chains produce a kind of “big capitalism” that conceals more than it reveals (Tsing 2009). Describing social relationships as chains presumes economic relationships that simplify complex interactions, with a path-dependent drive towards export-oriented commercial relations. Yet it is just as important to underscore that value chains and supply chains are not merely academic conjectures – they genuinely impose governance structures that include some and exclude others. McMichael shows how development projects use the value chain to draw producers into global markets tied together with debt (2013b). Finance is used to structure agrifood market relations by international organization policy makers (e.g. Miller et al. 2010). The value-chain finance model is used to apply new financial relations along agrifood chains. William’s critique cannot fully account for how policy-makers also use chains to structure financial relations. Value-chain financing is not simply an abstraction – it is put to work in new sites (Chapter 7).

The role of financialization in structuring new finance and agricultural development projects has also been noted by IPE and critical scholars. Breger Bush describes how development policies encouraged the use of derivatives and commodity exchanges for poor commodity exporting countries, which she calls the “movement to democratize derivatives” (2012, 4). Breger Bush chronicles how World Bank and UNCTAD programs encouraged the use of financial tools to connect farmers to global markets through the use of derivatives, but the result was that the programs reinforced inequality and increased the influence of finance (2012, 40). This work goes a long way towards explaining the international dynamics of development policy and the emergence of finance as a development tool. In a similar way, Aitken (2013) describes how global financial inclusion projects such as microfinance draw the poor from the margins into the global economy (see also M. Taylor 2012). The work calls attention to how financial practices can depoliticize market relations, and what Hall calls the “inescapability of finance,” to foreclose on political intervention (2012, 406). These authors show how financial practices align with modernization projects, but they ultimately argue that the programs reinforce unequal power relationships.

Clapp’s work explores the historical forces, including financialization, that underpin the world food economy and highlights the key role of the state in creating and supporting new industrial models of agriculture and liberalized market arrangements (Clapp 2012a). Her IPE approach brings attention to the effect of financialization, what she calls “distancing” (2014). Not only is food abstracted via complex relationships and business structures that buy and sell agricultural commodity derivatives, but the “middle spaces” between production and consumption are more populated with financial actors, and their influence and actions are more obscured (Clapp 2012a). Clapp chronicles the undue influence of financial actors and sheds light on their effects, thus offering tools to resist their increased influence. Clapp exemplifies an IPE approach that draws attention to both the macro and micro practices of finance. She has provided a template for this approach, showing, for example, how banks and large grain traders use specific financial tools such as index funds and other derivatives (Clapp 2014). An IPE approach can provide the means to show how the everyday tools and practices of agriculture and finance operate in the context of the international political economy.

This review of agrifood literature on financialization shows how scholars have used various lenses, from regimes to commodity chains to highlighting the middle spaces, to show where and how financial actors exert influence. These explanations of financialization provide a number of theoretical frameworks that primarily examine broad economic trends, and are less focused on the material and physical changes that underpin financial practices. In particular, they are less focused on how asset streams are developed and constituted at storage sites. This requires a different theoretical approach, while at the same time drawing on the historical approach exemplified by many IPE scholars, especially those who study finance.

2.3 ANT, Global Finance and Commodities

Most studies of financialization have focused on the increasing importance of financial practices and actors, and that has meant human actors. The global economy and the sphere of finance is mediated by, and dependent on, a discourse of experts who authoritatively measure and distribute value (De Goede 2001). To foster enrollment in the global economy, ideas are put into place and invested with powers – powers that are developed by, for example, epistemic communities, such as international organization policy-makers as they promote new projects. Best and Walters call attention to the practices that support the production of expert knowledge, such as inscriptions that translate "the messiness of the world into useful abstractions to govern unruly objects" (2013b, 348). These are concrete practices that can be traced. But global finance is a coordinated assembly that involves humans and non-humans (Porter 2013, 335). What steps or approaches can help to examine financialization and take into account non-human actors, and the assemblages that are needed to develop asset streams? More specifically, we can ask what assemblages are needed to sustain a particular storage governance structure. Grain storage and commodity exchanges are founded on an economic logic and supported by regulations, but they are made whole and real through the careful assemblage of non-human actors from the material world.

Actor-network theory decentres humans as sole actors and instead focuses on the assemblages needed to constitute an object, such as a derivative or a market. The approach is credited to Latour (1988), Law (1986) and Callon (1986), all sociologists who were engaged with science and technology studies. Social theorists have used ANT to explore the practices and physical structures of finance and markets (e.g. Callon 1998; MacKenzie 2008). More recently, ANT has attracted scholars who study politics, and who have applied the approach to international politics (Best and Walters 2013a; Porter 2011) and the governance of global finance (McKeen-Edwards and Porter 2013). The ANT approach realigns hierarchies between human and non-human actors by focusing on connections and collectivities. The strength of a political project is the assemblage of human and non-human actors; that is, the relations among actors are the key to understanding an assemblage, not the actors themselves. In what McKeen-Edwards and Porter call an assemblage ontology, "the effects of power need to be carried through humans or objects" often in mundane processes (2013, 7). Grain-storage governance then becomes an unstable, changing assemblage of grain, financial practices, documents, bins, agri-chemicals and human actors, a set of ongoing iterations of ideas and things.

An assemblage is always becoming, and it is presumed to be temporarily stable. The result is that there are myriad relations and negotiations among human and non-human actors that bring, for example, grain storage and asset streams into being. Latour (2005) challenges the conception of categories such as *humans* and *nature*, and offers some ways to explore otherwise invisible or "silent" sites such as grain storage. First, he suggests that we study innovations as they are described in theory, or in a laboratory. The second task is to examine sites that are distant from their origin, where the normally taken-for-granted is rendered clumsy. Third, Latour's approach provides space in which to examine accidents and breakdowns along with the attendant official enquiries (2005, 80–1). This approach highlights the assemblage ontology and renders relationships between humans and non-humans visible.

The strength of actor-network theory is that it is a "style of political analysis that can better account for the contributions of material actors" than theories that are human-focused (Bennett 2010, x). Bennett (2010) states that non-human actors have a vitality. This approach decentres the ontology of economics, and social and natural sciences more generally, by flattening the hierarchies. Rather than focusing on states, IOs, and the power of financiers, this approach sets aside these definitions and instead traces networks and spotlights new actors.

The ANT approach has been applied by agrifood scholars. For example, Busch and Juska (1997), use the ANT approach to examine how new actors, products, and technologies are extended into the realms of commodity production. However, as Goodman (2001) states, agrifood studies in general are constrained by a focus on a Marxian production-consumption binary, and have failed to take into account the liveliness of non-human actors such as "nature." Goodman's binary can be extended to the realms of finance and agriculture, wherein agriculture is aligned with "nature" and grounded, and finance is aligned with humans and abstracted. When agriculture and finance come together, this enlivens how we might conceive of finance. Furthermore, Goodman and Dupuis (2002) observe that a singular focus on production limits our view of alternative sites of political contestation.

Grain must pass through obligatory sites as markets are built, and non-human actors are present at every turn – trains, bins, and elevators. The focus on production is important, but how markets are built, organized, and controlled is also crucial. By examining the processes used to stabilize grain, and grains' unstable and lively character, it becomes evident that previous scholarship, which has focused on production and the role of financial actors, has overlooked the significant role that storage and its effects on the stability of grain play in the overarching financialization of agricultural commodities. Grain must be kept lively if it is to be used for seed or milling, but not too lively if it is to be stored. Nor can grain be left unattended, or it may become "sick" and spoil as it is transformed into a home for mold or a meal for insects.

An assemblage of ideas, regulations, and materiality is needed to enact the financialization of agricultural commodities. To help explain the assemblage required to stabilize grain physically, I draw from Barry's concept of the technological zone, "a space within which differences between technical practices, procedures or forms have been reduced, or common standards have been established" (2006, 240). For Barry, an assemblage of three sets of practices – measurements, infrastructural connections and common standards – structures technological zones. Technological zones are limited to experts who can negotiate the varied measurements, connections, and qualifications that extend, in this case, to grain-storage governance. Barry's (2006) frame has a temporal dimension that accounts for the accumulation over decades of the knowledge that is needed to produce a specific technological zone. But this accumulation of knowledge and expertise is neither stable nor certain and outcomes or initial plans are often reworked. The outcomes are not predictable because an assemblage is iterative and unstable. This helps account for the unpredictable interactions between human and non-human actors.

Barry's (2006) attention to human and non-human elements can help explain how knowledge and expertise were gained in measurement, infrastructure, and standards, and how grain, moisture, and pests usurped plans to stabilize grain. In turn, these collectivities were managed with a series of ongoing grain management techniques such as agrochemicals. Barry's emphasis on the historical formation of zones is especially useful because it provides a framework within which to show the technological transformations that have occurred over a long period of time and the ongoing work brought to bear to manage grain. To this end, Barry's theorizing is helpful in explaining how grain storage emerged, rather than assuming that the form it has taken is inevitable or that it "simply fills some particular political or economic need" (2006, 244). When grain storage is viewed as a technological zone, Barry reminds us, the limits and failures of storage come into view, limits that may not be recognized by those who are promoting its development. A technological zone can include transnational actors and can cut across international territories. In turn, Barry claims, the formation of technological zones has become critical to making a distinction between global political and economic forms and "their non-Western others" (Barry 2006, 251).

Global norms and ideas are put to work in specific material sites "from banks to bodies" (Sassen 2007, 534). Global governance scholars have an opportunity to rework essential categories from the bottom up and ask, "Who acts?" in addition to "Who governs?" (Hobson and Seabrooke 2007, 13). If institutional power can shape the circumstances of distant others, Hobson and Seabrooke (2007) suggest that everyday others also shape their political and economic environmental contexts, even if they are subordinated within broader power relationships (Hobson and Seabrooke 2007, 13–14). Ideas are adopted and applied to new sites, buttressed by expertise and the tools and practices of finance, to solve specific problems. But actors that fall outside these corridors of power may be overlooked, either because they are not recognized as necessary or powerful or just not seen as actors with power. The operation of ideas and norms can be hampered or facilitated by material sites. An examination that starts with storage governance would provide a different view that helps to reveal material actors, and could perhaps provide alternative explanations for the financialization of agricultural commodities.

2.4 Storage Matters: Theoretical Framework

What approach will help explain the role of storage as a crucial link between agricultural commodities and finance? Storage is a site where grain is assembled into large enough quantities to be of value, and where grain can become the start of an asset stream based on the stability of stored grain (drawing from Thrift and Leyshon 2007). The approach should illustrate how an agricultural good such as grain is assembled and how it is made visible as a potential financial asset stream. The governance of storage shows how the financialization of agricultural commodities requires a combination of regulations, ideas, and material "things." I focus on Langley's (2008) question: How does financialization materialize? By structuring the thesis with three stabilization processes in a historical context, I am able to put IPE and ANT into conversation with one another. I am able to explore global power relations from an alternative approach and highlight the strengths and weaknesses of each approach.

2.4.1 IPE and ANT in conversation

To explain the three stabilization processes – ideational, regulatory and physical, I draw on both IPE scholarship and scholars who use ANT. There are key actors in each stabilization process, which requires different approaches to explain the interactions of grain-storage governance. By starting with grain storage, a variety of approaches are drawn together that link global processes of agricultural commodity markets to the dynamic quality of bulk grain in storage. Grain-storage governance is a way to think through the role of the state in regulation, the role of experts and economic ideas, and the role of non-human actors, in particular how the life (and death) of grain in bulk storage is contained, exceeds its containment, and in some respects exceeds finance. This approach allows me to think through finance (and its interaction with agriculture) from the bottom up. Finally, I take grain seriously as an actor that has the power to compel and shape human action. Grain is an actor because it has tendencies according to Bennett (2010). Further to this point, power has been defined as the ability to affect outcomes, and to shape the actions of others, actions they otherwise would not take (Strange 1996, 17). As such, grain has power because it has affected and shaped the actions of humans, as I will show. This approach to power, and to understanding the connections between finance and agriculture provides an alternative account of the financialization of agriculture. As I admit, and will show, there are limitations to this approach.

The strength of IPE scholarship is that it tackles the complex processes and problems of the international political economy, and it draws widely from various disciplines and scholars. IPE literature has been less focused on the physical and everyday manifestations of finance,[17] which means there is a gap that can be narrowed by using an analysis that examines how everyday and physical processes come together and are assembled to stabilize grain storage. This is not to say that these processes have not been examined before (they have been), nor that these approaches are novel

[17] For exceptions, see Langley (2010) and Seabrooke (2010) on everyday finance.

(they are not). But in putting the physical practices and tools of grain storage into conversation with ideas about grain storage and how regulatory webs are assembled around grain storage, a different analysis emerges.

In this section, I think through grain-storage governance. I start with a discussion of regulatory stabilization and the US state and its dominant position in global food and finance governance during the twentieth century. My approach to ideational stabilization is guided by the work of IPE scholars who have focused on international organizations and the role of experts and expertise. To help explain the role of non-human actors in physical stabilization processes, I examine the dynamic quality of grain and the grain-management practices that were used to stabilize grain and put it in service to the grain-storage infrastructure.

Regulatory stabilization is the assemblage of rules, laws and institutions in which stabilization is marked by creating a security or guarantee on stored grains. It describes the legal and regulatory webs built by the US state to support the provision of credit based on stored agricultural commodities. Storage governance can be traced through regulations and state institutions. It is difficult to distinguish where the material and the political part when describing agricultural finance in the US in the twentieth century – one could not have happened without the other. State control of grain storage provided support to US farmers through credit based on stored agricultural commodities, which created a broad foundation from which to access agricultural financing, a notoriously risky site for bankers. To stabilize commodities for credit, the state had to intervene with regulations. I start with the assumption that grain storage is not a stable site for credit provision, and trace the work required to attract credit with regulation and legal support backed by the state through the twentieth century.

Ideational stabilization is marked by a change in the control of grain-storage governance – in particular a change in who can access asset streams. Ideational stabilization accounts for two aspects of this thesis. First, it allows me to map out and trace how grain storage shifted from the idea of a public good to that of a private market over the twentieth century, specifically through the shift of economic ideas that were developed the Chicago Futures School. Second, to trace these ideas and practices, I examine how economic ideas explain grain storage in relation to global commodity and national markets. Experts from international organizations use economic ideas to explain the operation of grain storage in relation to, for example, global grain reserves or commodity markets (e.g. J. Williams and Wright 1991; B. Wright 2009). I map out how these ideas were adopted by international organizations and incorporated into a number of new agricultural market-development projects that used collateralized grain as the basis for creating new asset streams.

To help explain how ideas are used by international organizations I draw from Broome and Seabrooke's explanation of "analytic institutions" (2012, 5). Analytic institutions are the "specialist units, departments, committees, adjudicatory bodies and others housed by or linked to IOs that develop the cognitive framework for understanding and solving policy problems" (Broome and Seabrooke 2012). The institutions deploy generic policy solutions to economic problem sites. Broome and Seabrooke (2012) call this form of governance "seeing like an international organization." They do not depict IOs as coherent epistemic communities, referencing Haas (1992), but focus on how policies are applied to programs. Broome and Seabrooke show how international organizations make states legible through standardized classifications and regulations. The result is an indirect form of political power that shapes policies, and sets agendas, following Barnett and Duvall's (2005) conception of institutional power.

To illustrate how knowledge and expertise are applied by IOs, I trace the theory of storage and its development in Chapter 3, and in Chapter 7 show how this idea has application to contemporary grain-storage governance problems. The theory of storage is connected to ideas about free markets and its advantages as a global trade policy. So while small-i ideas are practical and applied, they are also a way to understand how ideas about liberalized trade are understood and policies emerge. Small-i ideas make economic governance possible and are an example of how indirect forms of power operate (Best and Walters 2013b, 37).

I define physical stabilization as the assemblage of grain management practices and infrastructure that facilitate the storage of grain. Physical stabilization describes grain-storage management practices and technologies such as metal bins, agro-chemicals, aerators, and dryers, as well as the collectivities of pests that make homes in grain. Grain-storage governance helps to explain how the development of the physical and agro-chemical industrial processes stabilized bulk grain in storage for collateral, and in turn made it into a site for developing asset streams. Grains have a unique quality; they can be stored for long periods of time – if they are in good condition, and the storage environment is maintained. But grain is not a “perfectly stable material that can be treated like sand or bricks” (Oxley 1948, 1). The dynamic quality of grain can never be fully stabilized in storage because it respires, sprouts, and spoils. Collectivities of mites, insects, and fungi found homes, and meals in grain. In turn, the grain spoils and the pests habitually create ongoing problems for grain managers. Industrial technologies were applied to stabilize grain physically. Grain management is the ongoing practice of monitoring the storage environment for grain, and maintaining its physical integrity – not too wet or too dry, and protected from pests. The physical stabilization of grain, therefore, is the complex interaction of non-human lively grain and its human management. It is an assemblage that is changeable and dynamic. I examine the consequences of the US state holding grain surpluses by a close examination of the humans and non-human interactions that occurred during the mid-twentieth century, and the development of industrial grain management. The application of industrial grain storage practices – outside grain bins, inside grain bins and the grain bins themselves – was part of an assemblage that physically stabilized and destabilized grain.

Grain and other non-human actors involved in physical stabilization have been overlooked by scholars who examine the financialization of agriculture. The physical stabilization of grain in storage either resists IPE analysis or is overlooked entirely because it does not fit into an IPE ontology. That said, trade wars and dumping of agricultural commodities (grain in bulk) are core political acts of global commodity trade (Murphy, Lilliston, and Lake 2005). In bulk, states, corporations and commodity traders can use grain to shape political relations such as food aid (Clapp 2012b), or speculate on agricultural commodities and stock levels (Ghosh, Heintz, and Pollin 2011). These are political acts. But at what point does grain in storage become a political actor? Actor-network theory helps to answer this question by including non-human actors such as grain or a storage assemblage as part of its ontology because non-human actors have “tendencies of their own” (Bennett 2010, viii).

Grain-storage governance is complicated by the liveliness of grain as a political and dynamic actor. Barry’s (2006) technological zones analytic highlights human and non-human elements and demonstrates how knowledge and expertise were gained in measurement, infrastructure and standards. Barry’s emphasis on the historical formation of zones is useful when examining the technological transformations that occurred over the twentieth century. The historical artifacts of finance can then be revived and resuscitated at different times through labour that uses recruiting regulations, ideas, and material allies to solve contemporary problems.

The following chapters will show how grain-storage governance puts farmers, grain managers and other experts into a political conversation with grain. The continual intervention, management and assemblage of new products, technologies and tools are brought to bear on grain. The transformation of twentieth-century grain storage helps to show how everyday grain management practices contribute to an understanding of complex global markets, and highlights the work required to maintain a foothold for finance in grain. In addition, grain storage is a political project that shows us how agricultural markets are built, fall away, and are rebuilt.

The processes of ideational and regulatory stabilization are critical to explaining the politics of the financialization of agricultural commodities. However, there is a gap – scholarly work has yet to adequately analyze the importance of the materiality of finance, or the physical stabilization processes that underpin the financialization of agricultural commodities. Both ideas and regulation have a kind of power, but the power is put to work and implemented through physical means. Regulation and ideational stabilization are processes that are necessary to provide a stable site to build an asset stream, but they are not sufficient in themselves. The analytic of physical stabilization is a key contribution of this dissertation, because it illuminates a different set of politics, thereby opening up new conceptions of resistance and possible interventions, which may be human or non-human.

A focus on the everyday practices and tools of grain storage can strengthen the explanation of what contributes to the financialization of agricultural commodities and work against the tendency of determinism, whether to a Utopian free market or an inevitable intensification of capitalist crises. In particular, the physical stabilization needed to stabilize lively grain can help to animate this explanation. The dominant economic history of ACEs is that of "scientific marketing,"[18] shaped through technological determinism and propelled by innovative heroic financiers and capitalists. Alternatively, food regime scholars consider ACEs part of capitalist development, the inevitable intensification of finance with its inherent crises and regimes of accumulation. I focus on a different past – a past that is a series of stabilization processes that come together and fall apart, what Walters calls a "counter-memory" (2012, 125).

2.5 Strengths and Weaknesses of the ANT and IPE Approaches

There are three aspects of ANT that are instructive for IPE. First, by focusing on objects, analysis can cut across the concepts that usually structure IPE enquiries, such as states and corporations and

[18] Thanks to Jennifer Clapp for this term.

institutions, and as a result new understandings of what sustains and powers these organizations can be revealed. Second, the processes that structure IPE, whether "markets" or "economies," are constructed through long and contested processes – "they do not lie in wait ready to spring … but they are constructed, often with tremendous amounts of work" (MacKenzie, Muniesa, and Siu 2007, 234). Markets and economies can be considered abstractions, but Mackenzie reminds us that "immateriality can only be expressed through materiality" (MacKenzie 2007, 357 quoting Miller). Rather than replicating the abstractions and calculations that characterize much of the literature on finance, "well-grounded answers to those big questions inevitably must involve the apparent detail of material sociology" (MacKenzie 2007, 372). ANT illuminates the granular ties and relations that make up assemblages. To use a tapestry as a metaphor, from afar, a tapestry may depict a battle scene but close up the scene becomes less clear and the underpinnings, weft and threads that hold the depiction together, are revealed. As with a tapestry, by closely examining the details of the assemblages, we can see not only the strengths of the individual components but also their weaknesses and the connections between them. Third, because the ANT approach illuminates the hard work needed to create and maintain a foothold for asset streams, finance can potentially be contested at multiple points. IPE's strength is that it helps identify powerful entities but it is less successful in showing vulnerabilities and sites of contestation.

There are three aspects of IPE that can inform the ANT approach. First, the ANT approach aims to flatten hierarchies; for example, it aims to give the same attention and agency to non-human actors as to human actors. But hierarchies and categories can bring powerful groupings, organizations, and assemblages into view (Porter 2013). IPE helps to identify and name complex "big actors" that endure and can leverage structural and institutional power to good (and bad) effect. Objects of finance are maintained with ideas and regulations that are more difficult to apprehend and name without categories. While changes occur over time, finance remains a powerful assemblage that should be identified and named. Second, ANT highlights the contingency and fragility of assemblages, but is less helpful in explaining how some assemblages and organizations persist. Even when viewed with an "everyday" lens, there are "imperial and hegemonic financial orders" that can be identified (Seabrooke 2007, 83). Third, a historical IPE approach highlights changes over a long period of time. ANT is focused on the granular, and is less helpful in identifying the structural changes that fostered changes in grain storage throughout the twentieth century. These insights are brought into focus by putting IPE and ANT into conversation.

The weakness of my theoretical approach to putting IPE and ANT into conversation with each other will be expanded upon in the conclusion, but for now suffice it to say that the approach could not fully explain all the interactions and relationships that fall under grain-storage governance. In particular, I was unable to account fully for the liveliness of grain and the processes of physical stabilization. In this respect, the thesis shows the limitations of my approach, and highlights the strengths and the weaknesses of different theoretical tools. I approach the thesis as a "test" of different tools and their successful application, as well as their failures.

2.6 Contributions and Theoretical Insights

Grain storage offers a distinctive starting point from which to think through politics and finance. The starting point connects the vitality of grain with the stability of finance. Carolan has urged scholars to create more entanglements, and "to experiment with the effects of that leap: what it does to thought, what it obliges one to do, what it renders important, and what it makes remain silent" (2013, 425). Focusing attention on the various ideas and regulations, as well as the physical assemblages that draw finance and agriculture together, highlights some of the limits of the financialization of agricultural commodities.

Non-human actors help explain how grain storage is constituted through assemblages and inform how we can examine the governance of grain storage. In turn, this approach can help explain how finance and agriculture come together. The physical character of bulk grain is similar to water. It flows easily with the help of gravity, with the use of mechanics such as elevators. Both critics and supporters of free markets use these characteristics to explain markets and capital.

> Through their constant watchfulness all leading markets are kept in line with one another. Grain, like water, will seek its level. It will move from the center where it is plentiful to where it is not plentiful. Instead of the chaos we are given a harmonious relationship between different markets, between grades, between the several monthly delivery periods, and even between types of grain. (Huebner 1911, 23)

The film *A Corner in Wheat* (Griffith 1909) depicts a wealthy capitalist literally drowning in the grain he has just cornered in the market.[19] In the scene, he falls into the opening of a grain elevator and is buried in grain as it is loaded into the elevator bin. The film's morality tale is that his greed and wealth have literally drowned him. Similar to the Griffith film, scholars have likened the flow of bulk grain to capital and its "liquidity" (e.g. Cronon 1992; Levy 2012; Busch 2011). Both grain and capital are dynamic and can have negative outcomes when uncontrolled. The comparison between bulk grain and capital is apt, as grain can act as a stand-in for the abstractions of capital and markets.

Yet, just as flows are important to trace, it is also important to examine the disruptions and blockages that occur in grain storage. Grain is not always stable, and it is not a unitary actor – it "becomes" in new assemblages. Collectivities of water, heat, insects, and molds can make grain into structures that do not flow but instead block and clog the wheels of commerce. It is in the details and techniques of bundling grain into seemingly stable collateralized commodities that a different kind of politics emerges, one in which grain itself is an actor that has power and can affect outcomes. This approach

[19] The film is based on Frank Norris's book The Pit (Norris 2009 [1903]).

to examining how non-humans can disrupt and can shape human actions directs attention to some of the limits to finance.

This study will show some of those limits to finance. Financialization literature tends to chronicle new frontier sites where finance is ever-expanding – a progressive development that draws attention to the power of finance and financial actors as it colonizes new areas from “daily life” to the “world economy” (Epstein 2005; Martin 2002). By looking back and attending to how grain is stabilized, through ideas, regulation, and physical interventions – human and non-human – for collateral and to develop asset streams, I give definition to the processes and practices of finance. In addition, I show how the process of financialization has not been smooth or continuous, meaning that financialization is not inevitable, nor is it seeping into every crevice. It has limits and thresholds, and those limits become visible when attending to how asset streams are developed through a close examination of grain storage.

The governance of grain storage helps to explain how asset streams are built on agricultural commodities in three ways. First, a focus on storage helps to explain the operation of global commodity markets, and the role of regulation and institutions. Grain storage was at the centre of a regulatory web that stabilized and collateralized grain for credit. US agricultural state institutions, from land grant colleges to the Commodity Credit Corporation, built the regulatory tools and practices that underpin grain-storage governance. Many of these same tools and practices are used today in new global sites. Second, the governance of grain storage helps explain the ideational contestation that shapes debates about agricultural market control and ownership. The ideational tools and practices of twentieth-century grain storage were shaped by agricultural economists based in land grant colleges and in the US Department of Agriculture. The economic theories and ideologies that were developed in the mid-twentieth century by agricultural economists closely associated with Chicago futures markets persist today and shape debates about the role of financial actors in contemporary global agricultural markets. Finally, grain-storage governance helps to explain how the development of the physical and agro-chemical industrial processes were put to work in order to stabilize stored grain for collateral. In order to study grain-storage governance, this work starts with the tools and practices of grain storage. This results in a deeply empirical, analytically eclectic approach.

2.7 Conclusion

At first glance, IPE and ANT appear to be in conflict because they have different starting points: IPE often begins with big categories, while ANT often starts with small things. But this conflict brings to the fore the utility of both approaches in helping to understand and explain how processes are assembled to stabilize grain for credit and debt in agricultural commodities. The processes of grain stabilization call for a fine-grained assessment of the ontological building blocks of global governance, such as ideas and regulations, and the organizations and groups that put them into operation. However, these processes also require a close examination of grain stabilization and the technologies that work to "fix" grain in place so that it may be valued and leveraged for credit and asset streams. To illustrate the materiality of grain, the dissertation draws from ANT. In turn, IPE helps put things in their place by providing the categories and historical context that helps to make sense of changes over the long term, in the context of changing financial and agricultural relations. By focusing on the physicality of grain, a full picture of the extent of stabilization can be depicted, and put into context.

Chapter 3- Ideational Stabilization: Agricultural Economists, Markets, and Theories

3.1 Introduction

During the latter half of the twentieth century, ideas about US grain storage and who should control it shifted from an emphasis on grain storage as a state-managed public good to grain storage as a private actor-managed market function. Agricultural economists were at the centre of this shift because they mediated tensions between agriculture, the state, and the market (Fitzgerald 2003; Burnett 2008). To understand how ideas about grain storage changed and were stabilized – that is, how they were part of an assemblage that facilitated asset streams – I show how two groups of agricultural economists developed new ideas and new kinds of economic calculations that affected grain-storage governance and policies.

First, agricultural economists associated with the US state developed ideas to support the use of public reserves. The second group, the Chicago Futures School, analyzed the role of agricultural commodity exchanges (ACEs) and the public role of grain storage, and developed ideas to support the use of privately managed grain reserves. The Chicago Futures School had a close association with the Chicago commodity exchanges, and a shared understanding of the role of futures within a market economy.[20] Over the course of the twentieth century, agricultural economists developed economic tools and theories to account for the role of grain storage in an increasingly industrialized agricultural economy.

[20] My conceptualization of the Chicago Futures School has overlaps with the Chicago School of economists associated with the University of Chicago, and economists such as Milton Friedman (see Mirowski and Plehwe 2009 for a discussion of the Chicago School). There was a shared ideology on the advantages of free markets, and limited government interference. But the Chicago Futures School is distinguished by its empirical focus on ACEs, and US agriculture. In 1929 after a tour of the US, German economist von Frauendorfer stated the research conducted at the University of Illinois examined Chicago agricultural commodity markets as early as 1901 with a particular focus on the technical side of marketing (von Frauendorfer 1928, 296).

In the early twentieth century, agricultural economists in the US Department of Agriculture developed a new farm economics that prescribed state intervention and policies to help farmers manage and adjust market supply and demand, such as a national grain reserve (H. C. Taylor 1929). But the Chicago Futures School also developed a set of theories in order to help farmers and commercial interests manage supply and demand by providing market information and managing storage based on their analysis of ACEs. The Chicago Futures School argued that ACE-mediated grain storage was more efficient than public storage programs, and these ideas contributed to the eventual dismantling of the state-managed grain reserve in the 1970s through to the 1990s. This shift from public storage programs to private management through ACEs paralleled two important shifts that facilitated financial actors' access to agricultural commodities. First, agricultural commodity exchanges became the primary platform for managing grain storage, which helped contribute to the growth of ACEs. Second, ACEs were increasingly portrayed as financial institutions, not merely a centralized marketplace for agricultural commodities and sites to smooth supply and demand. This chapter shows how the Chicago Futures School developed ideas that highlighted the utility of ACEs in managing grain, and helped to usher in the "Golden Age" of futures markets starting in the 1970s (Irwin 2012, np). To help explain the shift in ideas over the twentieth century, I use ideational stabilization, which describes the process or emergence of an idea, its adoption, and how it becomes what is taken for granted, or what Cox (1996) has called common sense.

Why is ideational stabilization important to trace? The overriding reason is that by tracing ideational stabilization I show how ideas about who should control grain storage have changed by focusing on what Morgan (2001) called economic technologies and tools. The Chicago Futures School used econometric tools to claim new scientific knowledge about the value of private grain storage in relation to public grain storage. The Chicago Futures School worked in a context of tight state regulation over ACES, especially speculation between 1870 and 1970 (Irwin 2012). The regulation on speculation was “very strident and threatened the [futures] industry with extinction” and was blamed for a significant decline in trading in the 1950s and 1960s (Irwin 2012, np). ACEs were “almost dead” (Irwin 2012, np). But new ideas emerged to explain the operation of grain storage and ACEs. The ideas were used to shift policies away from state control and into the technical realm of ACEs. The effect of the change in value and ideas about storage led to changes in who had the authority, and who had the expertise to control grain storage. The Chicago Futures School used new econometric tools to illustrate the efficiency of ACEs and the inefficiency of state-managed storage. These ideas eventually became common sense when the state-managed grain reserve was disbanded starting in the 1970s.

Claims to scientific knowledge, in this case economic claims about how to measure the value of grain storage, can be adopted or rejected by governments and policy-makers as fact (Barry 2013; Porter 2013; McKeen-Edwards and Porter 2013). To explain how ideas operate with economic technologies and tools, I draw from Jacqueline Best’s (2014) work on “small-i” ideas. Small-i ideas are practical and technical, unlike “big-I” ideas, which are ideological (Best 2014). This approach presents the operation of storage governance in a different, more descriptive, step-by-step account, in contrast to describing the shift from public grain reserves to private grain storage as an outcome of neoliberalism (e.g. Patel 2013). The advantage of focusing on small-i ideas is that it helps bring into view the practices of experts, and the small incremental changes that contribute to who has the authority to manage grain. The theory of storage was introduced incrementally, first, as a scientific fact in 1949, it was applied in the 1950s, and then became a foundation for legitimating private management in recent decades.

The power of new ideas about who should manage and control grain storage has implications for who can access and leverage credit based on collateralized grain. By the time regulations were relaxed on ACEs and futures markets in the US, new storage models showed how private stockholders could be “key contributors to price stability,” rather than people to be “mistrusted” by policymakers (Sumner, Alston, and Glauber 2010, 414). The shift from theory to rule to common sense illuminates how ideas emerge. Ideas are necessary to shift the control and governance of grain storage, but they are not enough on their own. They are one part of an assemblage of grain-storage governance. A close examination of the ideas and how they were adopted illuminates how scientific facts and economic tools are stabilized and became common sense.

This chapter traces three shifts in the governance of grain storage in relation to ACEs and how these changes were chronicled and analyzed by agricultural economists. First was the US New Deal project to establish a national grain reserve, which provided a new asset stream to farmers based on the value of stored grain. Second, in the 1940s and 1950s the Chicago Futures School demonstrated the higher cost of public storage programs compared to the superior efficiency of ACE-managed private storage, which led to an early iteration of the efficient market hypothesis. The efficient market hypothesis posits that all known market information is contained in the public price of a given commodity. The efficient market hypothesis provided a rationale for financial actors to interact with agricultural markets with increased legitimacy in the late twentieth century. Third, ACEs were presented as a financial platform rather than solely a centralized agricultural marketplace by the Chicago Futures School, which contributed to new financial actors’ access to agricultural commodities as a source of asset streams. Together, the first two changes show how ideas about grain storage and its relationship to ACEs fostered new understandings of grain storage and its control. The third idea shows how financial actors’ participation in agricultural commodity investment was rationalized by shifting ACEs from an agricultural market to a financial platform.

I argue that the Chicago Futures School promoted the utility of ACEs and their management of grain storage with small-i ideas that leveraged new economic tools and scientific facts. These ideas were underpinned by the ideational stabilization that marked a shift from public to private control and helped to shift ACEs from an agricultural market to a financial institution that facilitated access for financial actors. The chapter proceeds by providing a review of economic historians' scholarship on ACEs and a discussion of agricultural economists' literature on the history of the discipline. I then provide the context for the rise of agricultural economists within the US state, and the problems and issues that they confronted. It provides a foundation for examining how the Chicago Futures School emerged out of a state-driven agricultural economy and rejected state intervention in favour of an ACE- and market-driven agricultural market. The second half of the chapter describes the ideas of three Chicago Futures School economists – Holbrook Working, Robert Gustafson, and Thomas Hieronymus. Holbrook Working (1895-1985) and Thomas Hieronymus (1919-2001), among others, are credited with building "brick by brick" the foundation that allowed contemporary ACEs to thrive (Irwin 2012, np). Working developed the theory of storage; Gustafson built on the theory of storage to show the high cost of public storage programs and the efficiency of privately managed storage; and Hieronymus helped develop a new profile for ACEs as financial institutions. The chapter wraps up with a discussion of the effect of the Chicago Futures School's ideas, and concludes with a summary of the chapter. The chapter shows how a close examination of ideas about grain storage technologies during the twentieth century can help to explain two points about the financialization of agricultural commodities. First, the Chicago Futures School showed that there was a cost to public storage and that ACE-managed storage was more efficient with new economic tools and claims. Second (and somewhat circuitously), ideas about conceptualizing grain storage economics were based on early iterations of the efficient market hypothesis, a hypothesis that was used to facilitate the participation of new financial actors in agricultural commodity markets.

3.2 Approaches to the Study of ACEs and Agricultural Economists

Economists, and business and environmental historians have chronicled the emergence of nineteenth-century ACEs. Scholars point to the long history of agricultural forward contracts and the emergence of futures markets in seventeenth-century Japan (Peck 1985; Baffes 2011). But nineteenth-century ACEs are unique in their environmental and regulatory history (Cronon 1992; Santos 2008; Berg 2011; Levy 2012). On one hand, economic and business historians explain the development of ACEs as a necessary outcome of nineteenth-century commodity trading, and describe a series of technological innovations and improvements that drove the evolutionary trajectory of ACEs (Peck 1985; Pirrong 1999; Santos 2008). On the other hand, environmental and social historians tend to describe the capitalist transformations of the nineteenth century that are exemplified by ACEs, such as capital and environmental relations (Cronon 1992), and capital and risk (Levy 2012). Both sets of scholars agree on the complex governance that meshed private organizations, commodities, and public inspection and regulation to provide a foundation for fungible agricultural commodities (Cronon 1992; Lambert 2011; Santos 2008).

In the twentieth century, ACEs were constrained by state regulation and a number of economists argue that regulation negatively affected the operation of commodity markets and the work of financial actors (Pirrong 1995; Pirrong 1999; Hieronymus 1977). For example, Hieronymus stated that regulation decreased healthy competition and unfairly targeted speculators (1977, viii).

> The goal of the state system is to stop the operation of a competitive market price system to a greater or lesser degree. We have seen that when we follow regulation through to its logical conclusion, complete state ordering is involved. One suppression of a market pricing system leads to another. (Hieronymus 1996, 116)

Economists who write on the history of ACEs, generally viewed regulation as a barrier to ACE evolution and its emergence "out of the crucible of market forces" (Hieronymus 1977, xii). If freed from state regulation, ACEs could serve and encourage the growth of agricultural markets. For example, Belozertsev and Markham (1992) chronicled how Russian ACEs were banned in 1917, but that perestroika provided an opportunity to re-establish ACEs. Once established, they predicted that the new ACEs would help to jump-start grain production (Belozertsev and Markham 1992, 155).

Another theme in the literature is the depiction of ACEs and financial practices as highly technical and complex processes that required specialized knowledge and expertise. For example, Mathieson (1942) stated that the operation of ACEs was similar to aeronautic engineering and difficult for the layperson and regulator to understand. A more recent example is given by Sanders and Irwin:

> [T]rading dynamics are complex, and it is not easy to understand the interplay [among] the varied market participants and their motivations for trading, especially in real time. (2011, 523)

The depiction of ACEs as technical sites sets out problems and solutions as apolitical acts. In turn, this stream of scholars described commodity market problems and explained the steps required to improve market efficiency and transparency and reduce transactional costs (Pirrong 1995; D. R. Sanders, Irwin, and Merrin 2010). Pirrong chronicled the benefits of ACEs, including facilitation of trade, enforcement of property rights and contractual agreements, reduction of transaction costs, mitigation of information asymmetries, and provision of public goods in a variety of environments (Pirrong 1995, 229–30). This depiction of ACEs as technical sites limits conceptions of politics and contestations that shape financial relations.

My approach to the history of the agricultural economics profession differs from the discipline's intellectual histories in two ways. First, the intellectual histories of agricultural economics are less focused on the material changes of agriculture such as the development of storage technologies. Rather, scholars have chronicled the various roles of the profession in the development of econometric tools (e.g. K. Fox 1989; 1996), the profession's relationship to policy and applied economics (Banzhof 2006), and the development of agricultural marketing (Breimyer 1963; 1973). Second, a few of the intellectual histories do chronicle the contributions of some of the members of the Chicago Futures School, but these are brief and are a small part of a larger story about changing agricultural markets (e.g. Myers 2010).[21] By focusing on the economic ideas that underpin storage, I offer a counter-memory (Walters 2012). I take into account agricultural economic ideas, but highlight how these ideas relate to storage and finance rather than describing the evolutionary development of the profession. It is notable that I was unable to find extensive discussions of grain storage in the contemporary agricultural economic literature, save for recent discussions of global grain reserves (e.g. Wright 2009; 2011).[22]

The dynamic political changes that occurred throughout the twentieth century are less-examined by economists, with the exception of the effects of state regulation on the operation of ACEs. In other words, these scholars are focused on problem-solving that "takes the world as it finds it" (Cox 1981, 128). Financialization, for example, is assumed to be part of the evolutionary improvements that are inherent in the operation of commodity markets (e.g. Irwin and Sanders 2012). In sum, the literature that describes the evolution of ACEs is a helpful narrative that provides a rich description of the operation and growth of commodity exchanges. But it is less helpful in explaining the politics and controversies of ACEs.

3.3 Agricultural Economists and the US State: Statesmen, and Intervention

How did twentieth-century agricultural economics develop as a profession? It developed in concert with the expansion of the US state, and in particular the expansion into new areas of agricultural governance. To understand US agricultural economists and their ideas is to understand the development of state-driven industrial agriculture during the twentieth century. US agricultural economics and US agriculture itself were both state-supported projects at in the early twentieth century (E. Sanders 1999; Fitzgerald 2003; Burnett 2008). The discipline of agricultural economics

[21] Myers (2010) highlights how little work is done on ACEs and futures markets, and McCalla et al. only mention Holbrook Working in the context of quantitative methods innovations.

[22] Organizations concerned with global food security have published a number of recent reports on food reserves (eg. Lilleston et al 2012; Murphy 2009).

boomed from the early-to-mid-twentieth century, supported and employed by land grant colleges, the US Department of Agriculture, and allied institutions such as state extension offices (Fitzgerald 2003). The US state built institutions starting in the nineteenth century that developed the new agricultural profession and supported the development of new economic tools. The Federal Department of Agriculture (antecedent to the US Department of Agriculture), and the establishment of land grant colleges through the Morrill Land Grants Act of 1862, became fundamental to forming the discipline of agricultural economics (H. C. Taylor 1952). The Department of Agriculture was at the forefront of collecting statistics on agriculture, and state institutions developed econometrics to analyze and make sense of the statistics. While embedded in state-supported institutions, agricultural economists implemented their ideas by designing regulations and policies that mediated between farmers and powerful market actors, such as grain elevator operators. The result was that the state role in agriculture expanded significantly, and was legitimized as "common sense" through Department of Agriculture institutions.[23] For example, New Deal policies were used to establish a national grain reserve that provided an asset stream for farmers. In turn, agricultural economists' expertise and ideas about agricultural markets and agrarian affairs was strengthened. By mid-twentieth century, agricultural economists had the policies and administrative capacity to smooth the otherwise contentious relationships among businesses, farmers, and consumers with statecraft (Burnett 2008, 56). The ideas that underpinned regulations were developed in concert with the capacity of the state to help plan economies, and curtail market actors. Agricultural economists' claims to scientific knowledge, in this case economic claims supported with econometric analysis, were adopted by governments and policy-makers as fact (Barry 2013).

[23] New Deal policies were instituted, but also contested by financial and business interests (see Finegold 1982; Skocpol and Finegold 1982).

But there were agricultural economists who were against state intervention, both within state institutions and outside state institutions. Agricultural economists can be divided into two schools based on their ideas about the role of the state in agricultural markets. The two schools of agricultural economics[24] emerged from the nineteenth century and US state institutions, but applied their work either on a national scale, or to the management of discrete farms run according to the theory of the firm.[25] In 1907, US agricultural economists debated the discipline at the Annual Meeting of the American Economic Association. At the meeting, Taylor described two different approaches to the discipline, one focused on agricultural practices and one focused on general economics (Carver 1908). The first school conducted detailed studies of farm organization and applied industrial principles to "agriculture [and] assisted in perfecting the farm organization" (Erdman 1928, 531). Farmers were instructed to run their farms like firms, using cost accounting, budgeting, and credit (Allin 1948; Erdman 1928).[26] Taylor continues:

> [B]ut as one whose training has been equally in agriculture and in economics I have the desire to work both phases of the subject, for the reason that the one throws much light upon the other; in fact the two are one (as quoted in Carver 1908, 81).

The second school drew on the power of the state to help implement their ideas and to assure the welfare of farmers and the nation. This school was closely associated with US state institutions and approached agricultural economics from "the statesman's point of view" (Taylor and Taylor 1952, 165).

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[24] See Runge (2006) for an overview of the intellectual history of agricultural economists. He distinguishes between two schools of agricultural economists: the neoclassical school that incorporated the theory of the firm and analyzed input and output costs of farms, and a second school focused on organization and marketing. Banzhaf (2006) makes the distinction between early practitioners of agricultural economics and the field of farm management that was eventually subsumed by agricultural economics.

[25] The theory of the firm seeks to understand an entity, in this case a farm, in relation to the market: Why does a firm exist? How does it operate? What is its relationship to other firms and how is it organized (Schultz 1939)?

[26] The "line fence school" was less likely to heed farmer unrest during economic downturns, and more likely to put the blame on poor farm management and economic ignorance (Burnett 2008; McDean 1983).

Within this milieu of a newly emerging profession, there was a debate about how agricultural economic ideas would be put to work, either through the application of the state farm programs of the statesmen, or by focusing on farmers' practices and securing a free market with the help of ACEs, including the Chicago Futures School. Henry C. Taylor,[27] the father of US agricultural economics (Jones 1958) typified early twentieth century agricultural economists associated with state institutions. He argued for state institutions and protectionist policies to "yield the maximum well-being for the people of the nations through a series of generations" (Taylor and Taylor 1952, 166). The statesmen shifted from a local focus, or "internal agricultural economics," to national policies that protected farmers from competition and paralleled the protection received by other industries at the time (H. C. Taylor 1929, 361).

The statesmen school viewed agricultural production in the context of world markets and farmer welfare. The development of what Taylor (1929) titled the "new farm economics" would implement ideas with state support by providing market information, developing grain reserves, and encouraging farmers to organize into cooperatives to protect themselves from competition. Taylor began to implement his ideas as the first head of the Bureau of Agricultural Economics (BAE), established in 1922. The BAE was tasked by the 1919 Committee on Farm Organization to produce information for farmers to help them meet the demands of the marketplace (H. C. Taylor 1920). The collection and interpretation of statistical data was the BAE's core mission, and the results were used to "quantify and order" farmers' experiences (Fitzgerald 2003, 35). The BAE began to provide market information and developed the new Agricultural Outlook Reports,[28] or the "Outlook" to provide professional and

[27] Taylor worked in the US Department of Agriculture, at a number of land grant colleges, and for the Ford Foundation. He worked in the Department of Agriculture from 1919 to 1925 and established and was the first chief of the newly formed Bureau of Agriculture Economics (BAE) at the Department of Agriculture.

[28] Although the USDA Agriculture Yearbooks began to cover marketing and distribution of agricultural commodities as early as 1909, it was after WWI that the Department of Agriculture began to focus on marketing along with its long-standing interest in production practices and scientific agriculture.

reliable opinion on agricultural markets, free of the suspicion that futures market pricing information was being restricted or misused. Taylor (1929) stated that the Outlook was a tool to fight unnamed forces that benefitted from keeping farmers in the dark. This was a time when futures market speculators were under particular scrutiny. For example, in 1924, a Senate investigation found that some speculators had concealed their trading through the use of several accounts, and that farming organizations had been refused memberships in the markets (Berg 2011). The BAE worked with experts from universities, industry, federal agencies, and banks to provide a wide range of market information, from supply and demand estimates and crop and livestock reports to descriptions of the general business climate and the balance of payments (e.g. United States 1924). The result was public information that put US agriculture in the context of world markets and economic events. The BAE's agricultural economists used their economic tools to try and mediate between famers and the world market.

But the BAE's work to make public agricultural market information and to provide an outlook (as opposed to a future on a commodity exchange) was not universally supported. Despite the fact that the early Outlook Reports included a wide range of industry representatives, the marketing reports were dismissed by some economists because they were inconsequential when compared to the futures market, which could foresee events and value commodities accordingly (e.g. Smith 1922). For some, the futures markets were considered the "combined opinion of the most competent dealers," that, as a result, protected the farmer from fraud and "unscrupulous counselors" (e.g. Huebner 1911, 18–19). In contrast, Taylor (1929) thought that the state and its institutions were necessary to manage agriculture and to ensure that farmers were fairly treated (see also Stewart 1929).

The height of US state authority over agriculture and its industrialization were the New Deal projects in the 1930s. But the implementation of policies that constrained private actors and nationalized grain storage came only after decades of building institutional support and state programs that made state intervention common sense. By the 1930s, US agricultural economics was a well-established discipline embedded in state institutions. Along with the BAE, land grant colleges taught the technical and institutional issues affecting agricultural production and marketing as core subjects. Agricultural economics, then, was well-suited to construct and apply New Deal ideas and aim to manage the US agricultural economy. The ideas that had emerged to make sense of US agriculture had a firm institutional footing and could be applied through state regulations to control powerful private actors. For example, the Agricultural Adjustment Act of 1933 (AAA) was initially established to contain the monopoly power of processors, through production control and marketing agreements. But, the AAA was challenged by traders and industry, and its ambitious plan to put production and marketing controls in place was struck down by the US Supreme Court in 1936.[29] While the focus of this chapter is primarily on the ideas of agricultural economists, how the ideas were implemented and became fact to the government is illustrated with the implementation of regulations that affected agriculture.[30] Where production and marketing policies failed, the development of a national reserve succeeded, and in 1933 the CCC was established to manage grain storage.

The establishment of the national grain reserve along with market information provided by the state would further serve to constrain ACEs' authority. In reaction to the increased state intervention, the Chicago Futures School, some outside state-supported institutions and some within, argued against governmental interference in agricultural markets (e.g. Working 1942), and specifically, against the establishment of a national grain reserve (e.g. Davis 1938). The Chicago Futures School maintained

[29] The Court declared that the federal government could not regulate the agricultural economy under its constitutional power to tax because agriculture was a local concern (Phillips 2007). The AAA was reworked and turned to conservation to control production and raise the income of farmers rather than taxing processors and intervening in the market (Phillips 2007).

[30] Along with the New Deal programs, the Glass-Steagall Act of 1933 separated commercial and investment banking, which further limited financial actors' access to commodity speculation. The 1936 Commodity Exchange Act's establishment of the Commodity Exchange Authority limited speculators and banned options trading on domestic agriculture commodities.

that ACEs and futures markets were a superior method of managing agricultural markets, efficiently distributing information, and mediating supply and demand with grain storage. The Chicago Futures School's ideas about free markets and the utility of ACEs went out of favour during the 1930s and 1940s, but below I will illustrate how they used econometrics to show and explain the utility and efficiency of ACEs in comparison to a state-managed grain reserve.

The Statesmen School and the Chicago Futures School had different ideas about how and where their work should be applied, but they shared the same economic tools. Marshall's (1920) marginal revolution and neoclassical principles of economics provided the tools that were needed to make sense of the data with the application of mathematical statistics. Von Frauendorfer, an agricultural economist from Germany, wrote "the American cannot easily be surpassed in untiring accumulation of data and in their skillful, clear presentation" (von Frauendorfer 1928, 308). Together, the vast accumulation of statistical data and the new econometric tools provided the means to compare, measure, and benchmark US and world agricultural production and markets. Agricultural economists applied the new analytical tools to markets and agricultural prices, and were at the forefront of developing econometric tools in the early twentieth century (K. Fox 1989). The Statesmen School leveraged the vast quantity of statistical data to support state programs. For example, Henry A. Wallace, (Secretary of Agriculture 1933-1940) implemented a rule that every provision under the Agricultural Adjustment Act, which underpinned New Deal policies, "should be preceded by a professional economic study of the current and prospective conditions" (Ezekial 1966, 795). In contrast, the Chicago Futures School leveraged ACEs futures market data, and the collection of price information to support their ideas (e.g. Working 1931; 1933). These examples show how the growth of the agricultural economics profession through the 1930s and the Second World War became increasingly technical and reliant on new kinds of economic tools. Morgan (2001) describes how general economics was characterized by technologies of modelling in the 1930s and the dominance of measurement methods, mathematics, statistics and modelling – so too with agricultural economics. New economic tools were developed, and shared, but ideas about the role of the state were disputed.

Early twentieth century agricultural economic thought was connected to the state and its institutions, and the ideas were stabilized through state institutions. This was an expansive view of state management. Agricultural economics became increasingly theoretical after the Second World War, with the new analytics and tools (e.g. mathematical programming, simulation, regression, flow of funds, and game theory). Agricultural economists portrayed increasingly complex agricultural markets. Factors such as time, space, and varied forms of production began to complicate the calculation of rates of inputs and outputs that previously had been more straightforward, such as calculating the rate of fertilizer application to corn production. The models now accounted for shipping patterns, plant processing techniques, plant size and locations, and so on (K. Fox 1996). One stage of production output became another's stage of production input. By 1955, the reach of agriculture was defined as "the sum-total of all operations involved in the production and distribution of food and fiber," or "agribusiness" (Fusonie 1995, 344). The discipline of agricultural economy was increasingly concerned with more complex economic relations and had moved off the farm. The massive agricultural surplus led agricultural economists to focus on marketing and distribution rather than production, which was seemingly solved through industrialization.

The Department of Agriculture and land grant colleges were critical institutions that helped to build the profession of agricultural economics. The state provided institutional homes for most agricultural economists through posts in government and in universities. As a result the majority of the work focused on a form of institutional economics and supported state intervention in the market through the establishment of a national grain reserve and other supports for agriculture. From the early twentieth century to after the Second World War, agricultural economics was primarily a statesman's profession. But the second school of agricultural economists, the Chicago Futures School, focused specifically on ACEs and supported free competition, rather than state intervention – their ideas emerged to challenge the ideas of the statesman. In turn, their ideas challenged the common sense of state-managed grain reserves.

3.4 Chicago Futures School: Stabilizing Ideas and the High Cost of Public Storage 1930s-1970s

The following section examines the intellectual history of the Chicago Futures School and the legacies of two of its intellectual leaders, Holbrook Working and Thomas Hieronymus. Working was a chief figure because he developed the theory of storage. Hieronymus supported ACEs and deregulation,[31] and was a key figure in popularizing the use of agricultural futures markets among financial actors. While the Department of Agriculture and BAE were managing the New Deal programs and developing a new national grain reserve, the Chicago Futures School was focused on the operation of ACEs. The Chicago Futures School developed explanations of futures markets' utility and function, and the role of speculation and hedging within agricultural and financial realms. During a time of unprecedented state management and support of agriculture, ACEs were placed at the epicentre of US agricultural markets and their agricultural economy by the Chicago Futures School.

The theory of storage is central to the Chicago Futures School's economic ideas about grain-storage governance. The Chicago Futures School demonstrated the efficiency of ACE-managed grain storage with the theory of storage in 1949. About a decade later, the higher cost of public storage programs was demonstrated through econometric calculations, and this facilitated a comparison with the superior efficiency of private storage connected to ACEs. Some of these studies are held up as an early iteration of the efficient market hypothesis (J. Fox 2011; Cristiano and Naldi 2012). Grain

[31] Hieronymus stated in 1951 that "depression-struck farmers [tried to] emasculate the exchange trading system" with federal legislation (1951, 833).

storage underpins the operation of futures markets and prices because inventories and stock levels contribute to the valuation of agricultural commodities. Working's (1949) article, "The Theory of the Price of Storage" was developed based on the relationship among futures prices, spot prices and storage. The theory was an attempt to solve the "conflict of accepted theory with observed price behavior" (Working 1949, 1255). The theory of storage showed the financial cost of grain storage and how private grain traders associated with futures markets were in the best position to manage grain storage. Up to that point, economists had argued that grain storage should be provided by the state (e.g. Keynes 1938). At the same time, these explanations were used to "disprove" long-standing critiques of futures markets (Working 1962b, 438). For example, the primary function of commodity exchanges was not to buy and sell agricultural goods – it was to facilitate the exchange of contracts (Working 1922). By the last twenty-five years of the twentieth century, the work of the Chicago Futures School had contributed to commodity exchanges emerging primarily as financial markets.

The stabilization of the idea that ACE-managed grain storage was more efficient and less costly than public storage helped to usher in policy shifts decades later. The common sense of private grain storage contributed to the unwinding of the national grain reserve starting in the 1970s, and was completed in the 1990s (see Chapter 6). The effect was to shift asset streams built on a national grain reserve and directed to farmers to privately managed storage, which could be leveraged through ACEs by financial actors starting in the 1990s. In the following chapters I will show how regulations and physical stabilization was required before there was a shift in grain-storage governance. In sum, the ideas of the Chicago Futures School emerged from agricultural economists who were products of state agricultural institutions.

3.4.1 Holbrook Working and the Theory of Price Storage

Holbrook Working was a product of two land grant colleges, the University of Wisconsin and the University of Minnesota, but he moved to the Stanford Food Research Institute in 1925, and remained there for the balance of his career. The Stanford Food Research Institute was established in 1921 by the Carnegie Corporation and Stanford University to investigate the production, distribution, and consumption of food. The Institute was considered the first Hoover Institute, and used economic analysis to examine the agricultural commodity and marketing systems, and the role of world markets and trade. A pioneer in quantitative economic methods such as econometrics, Working joined the Institute in 1925 and applied his work to understanding futures markets and prices, and especially to interpreting price behavior (Banzhaf 2006). He thought that futures markets were overlooked platforms that needed to be studied and explained:

> as we drive our automobiles with little thought of … [the] knowledge that has gone into their designing, and of the careful attention of the mechanics who built and who care for them, so we often take too much as a matter of course the technical perfection of the futures markets and the pains that are devoted to maintaining their satisfactory operation. (Working 1937, 310)

Working's primary concern was providing price information for farmers so that they would not be relegated to the status of price takers in the market. For Working, price relationships displayed more regular and understandable patterns of change than did price levels, and thus he focused on price behaviour. He applied his statistical analysis to price behaviour and forecasting by using futures market records such as wheat prices (e.g. Working 1927).

Working was able to bring his sophisticated econometric tools to bear on price relationships and engage in the scientific study of futures markets. In 1962, he wrote:

> [the] research economist with a scientific viewpoint ... does not ask himself whether futures markets are economically important institutions ... he asks instead whether study of futures markets offers favorable opportunity or gaining understanding of the behavior of prices of the class we call anticipatory. He makes his decisions on principles like those that govern the decision of a geneticist considering the study of fruit flies. (Working 1962b, 457)

Working placed himself in the realm of natural sciences with scientists such as Newton, Darwin or Mendl because prices were observed phenomena (Working 1962b, 457). This is notable because it illustrates that he was producing scientific studies and facts about agricultural markets. In turn, as he conducted fieldwork in Chicago at ACEs with traders and speculators, he highlighted the technical nature of futures markets. In 1933, he stated:

> [Price relations have] generally been regarded as a highly technical subject which most traders and students of wheat prices might better leave to specialists – the professional spreaders, and the hedgers who must watch spreads in order to keep their hedges advantageously placed. (Working 1933, 3)

Working was an expert in econometrics and the technical analysis of futures markets, and he approached economic problems (and solutions) with the expectation that there was a rational explanation. An on-going puzzle for Working involved the value of grain in storage. In particular he was interested in why futures market participants, such as millers, held grain in storage even when there appeared to be no economic reward, or rational explanation (Working 1949). Previous research showed that commodity price stabilization was costless and had value because it increased net social welfare (e.g. Waugh 1944; see also Massell 1969). The utility of public storage was partly based on a public good and on research that determined it was cost-free (e.g. Waugh 1944).

But Working was operating in the context of futures markets information. Storage costs were related to the varied prices of commodities on ACEs. In Working's estimation, elevator operators determined the value of storage and their services through "active informed competition" on the futures market (1949, 1257). The puzzle of why elevator operators held stock when the price of wheat in Chicago for a December delivery was more than the price for the following spring remained. Why is grain storage undertaken even though futures contract prices reflect that there will be a loss? How was the carrying cost of storage going to be covered? Working asks: "What *are* the influences that determine inter-temporal price relations?" (1949, 1255).

The partial explanation is Working's use of the "convenience yield" (drawing from Kaldor 1939). The convenience yield represents the productive value of holding grain in storage. Economists put a value on having stock on hand to avoid the cost of frequent restocking or production delays due to low stocks. Added to the calculation is the cost of storing grain, or the "carrying costs," which represents the capital costs of storage construction, maintenance, and financing.

Working built on his initial 1949 article, to make a number of claims that connected grain storage to the operation of futures markets. In 1949, he theorized that the difference between future and spot prices is calculated as the combined function of the carrying charges and the convenience yield. The explanation of valueless grain storage lay beyond the walls of the futures exchange and in the productive activities of storage suppliers, such as milling and manufacturing (Working 1953). The productive arm of a given enterprise is used to carry the capital costs because, in theory, they can be recouped over a long period of time, or through other parts of the enterprise's activities, such as milling (Working 1953). In addition, the theory provided an explanation for how "futures markets facilitated the economical distribution of supplies through time" (Working 1949, 1261).

In sum, the theory of storage explains the value and cost of holding commodities, in particular the price relationship between the futures and spot markets. To function properly, the cash and futures prices must theoretically "converge" when futures contracts are settled at specific times. If prices do not meet at the time of contract settlement, this is "abnormal price behavior," which demands a rational explanation. The calculations give a technical, storage-centred explanation to abnormal price movements. In other words, the theory of storage can contribute to rendering unusual price movements technical rather than political. The prices are settled, and as such, any abnormal price behaviour has a rational and technical explanation.[32]

[32] To be clear, I am not determining whether Working's statistical methodology is correct (Carter and Giha 2007). Rather, I am interested in the underpinnings and assumptions of a theory that is put to work to support the contemporary claims of how futures markets work in relation to storage.

The work of the Chicago Futures School and Working revised futures market theory and price behaviour theory during the mid-century partly through the theory of storage. First, Working showed how the price of storage was calculated based on the relationship between inter-temporal price spreads, or the difference between commodity prices at different points in time based on ACE contract dates (Working 1949). "The Theory of the Price of Storage" highlighted the relationship between futures prices and storage. Starting with the premise that actors were rational, Working determined that there was a rational explanation for why storage was supplied when there was no visible return. Working's focus on price behaviour would lead to a new calculation and valuation of the price of storage.

Second, commodity storage appears valueless, or a losing proposition when the inter-temporal spreads are flat or negative. Working placed a value on storage using Kaldor's (1939) "convenience yield." The convenience yield represents the value of holding physical stock rather than "inconveniently" seeking grain on the open market. Working developed an explanation for "inter-temporal" price relationships, a key facet of futures markets (1926; 1933). Inter-temporal price relationships refer to the price variance between two futures contracts that are settled at different times – for example, July and September. By 1933, Working was already highlighting the importance of supplies and how futures price spreads are "closely related to total supplies or to commercial supplies, or perhaps to the visible supply alone among commercial supplies" (Working 1933, 20). Working could conceptually close a calculative loop between futures markets and storage by highlighting the relationship of prices to supply levels, rather than to the influence of speculators' actions, such as squeezes or corners.

The Chicago Futures School used econometric models to explain ACE price behaviour and the relationship among prices over time. Why the attention to prices? For Working and his colleagues, prices were vital because they represented all known market information in one figure. Contemporary information was contained in prices and was the foundation for determining reliable anticipatory prices (futures prices), foreshadowing the efficient market hypothesis that underpins much of the Chicago Futures School's work (Working 1949). According to Working, futures markets are "reliably anticipatory; … they represent close approximations to the best possible current appraisals of prospects for the future" (Working 1962b, 441). ACEs and futures markets provided a continual stream of both contemporary and futures price information, which the Chicago Futures School mined with econometric tools.

The context of the theory of storage is related to John Maynard Keynes's work on commodity storage within a competitive or market system. Keynes argued that the competitive system did not supply a sufficient incentive for an individual enterprise to store surplus stocks (Keynes 1938). The depressed commodity prices of the 1930s caused what Keynes called a market condition of normal backwardation, where the price of a forward or futures contract is less than the expected future spot price. There is no incentive or "'risk premium" to store commodities because the costs would not be covered by a rise in prices during times of normal backwardation results.

Keynes was concerned about creating a positive business environment and providing stable supplies for manufacturers. He proposed public storage to stabilize supplies and create a predictable business environment. Public storage would provide a public good at a reasonable cost, because governments would have access to low interest rates to help carry the costs of storage in periods of depressed prices (Keynes 1938). Keynes viewed the markets as unsettled and unpredictable. In contrast, Working's explanation of storage pricing was connected to the operation of the futures market and commodity pricing.[33]

[33] For a thorough discussion of the distinctions between Working, Keynes, and associates see Cristano and Naldo (2012).

Working's assumption of an efficient market shaped his writing and his work on the theory of storage. Starting with Cycles in Wheat Prices (1931), Working began to distinguish random from non-random effects on prices, and this informed the work of Fama (1970) and Samuelson (1966, 201) in the 1960s and helped to formalize efficient market hypothesis. Efficient market hypothesis stated that market prices reflect all publicly available information. The belief in the logic of efficient market hypothesis has persisted, despite evidence to the contrary (MacKenzie 2008).34

Working was able to introduce a new idea about how to calculate the economic value and utility of storage using econometric calculations. His small-i idea was underpinned by the assumption that a rational explanation, the theory of storage, could account for seemingly irrational economic behaviour. Keynes viewed markets as irrational and unpredictable, whereas Working viewed markets as rational platforms that presented price as an object that represented all known information. The theory of storage was a minor, technical calculation, a small-i idea. But this technical calculation contributed to the unsettling the common sense of public storage, and its role as a cost-less public good (e.g. Waugh 1944). As a result, agricultural economists were able to build on Working's theory and destabilize the idea that public grain storage was cost-free, and prove that private storage was more efficient and economically rational.

3.4.2 Rules for Storage: Calculating the Cost of Public Storage

After the Second World War, US grain surpluses were becoming larger and more difficult to manage for the national grain reserve manager, the Commodity Credit Corporation (CCC). The initial aim of the CCC was to secure a parity income for farmers but also to put a brake on depressed agricultural commodity prices. As a result, most economic research on commodity price stabilization and storage

[34] Cristiano (2012) shows that Working was only able to make these calculations by limiting his data to specific market actors, single commodities, and a specific hedge that was normalized on the Chicago markets (discretionary hedging). A close examination of one commodity on one futures market was generalized to explain the operation of all ACEs and futures markets.

highlighted the welfare effects of price stabilization policies (and indirectly, government storage programs). For example, Waugh (1944) examined the welfare effects of price stabilization along with later scholars into the 1960s (e.g. Massell 1969). The authors made the assumption that price stabilization was costless and it increased net social welfare. But following Working, Robert Gustafson's technical and theoretical work reframed ideas about the role of state-managed grain and its cost. It is an example of a small-i idea. He determined the ideal conditions for grain storage with rational economic calculations. Under his theoretically driven calculations, state-managed grain storage was not costless.

In 1953, Robert Gustafson, from the University of Chicago, presented at the Cowles Commission,[35] "Rules for Storage" a theoretical model that built on Working's theory of storage and showed that maximum public benefit would accrue from private storage rather than public storage. He modeled a free market in grain that used inter-temporal arbitrage, a central feature of ACEs and futures markets. The model showed that government price stabilization had a calculable cost by accounting for carrying charges and Working's convenience yield. Gustafson challenged the assumption that US price stabilization programs required public storage; rather, he stated that surplus grain was exported and diverted domestically. Government storage programs also constrained the operation of the free market. While Gustafson did afford some latitude for government intervention in times of war and

[35] The Cowles Commission was set up at the University of Chicago (1939–55) to combine economic theory, statistical methods, and observed data for the construction and estimation of a system of simultaneous equations that could describe the workings of the economy. The commission's writ was to shape policy and to provide stock market forecasts for Alfred Cowles, the founder of the commission and a businessman. The commission's work tied investors' practices to the economy through the general equilibrium theory. The theory described how prices were a signaling mechanism that works at a scale above the individual in a competitive market. Prices did things – they signaled to consumers and producers, for example, marginal costs – and individuals reacted. Together, the feedback among prices, producers, and consumers created a smooth, self-correcting mechanism. As a result, the market, when freed, provided an efficient outcome and redistributed resources. The Chicago Futures School used the theory to link the well-being of individuals, futures markets, and the economy as a whole.

emergencies, he concluded that private storage was less expensive and more efficient than public programs.

He built on this theoretical work, presented to the Cowles Commission, and produced a model for storage in *Carryover Levels for Grains: A Method for Determining Amounts That are Optimal Under Specified Conditions* for the Department of Agriculture (Gustafson 1958). The model that Gustafson proposed for private storage management was "identical with the program we would expect private industry to carry out if there were pure and perfect competition" (Gustafson 1958, iv). Gustafson's model used two sets of decision-makers: on the one side was the farmer and the trader, with the government on the other, balancing the private and the public. Farmers and traders made decisions based on future price expectations, whereas government aimed to stabilize prices. He concluded that the government should get out of the storage business because of its cost, and it should be left to private storage.

Gustafson's work had a significant impact for two reasons. First, Gustafson's model of storage foreshadowed the rational expectations theory because he set out calculable and knowable expectations for future grain stocks (B. Wright 2011; Runge 2006).[36] Second, he underscored the importance and economic efficiency of private storage over government programs (Sumner, Alston, and Glauber 2010). The Department of Agriculture published a technical bulletin of Gustafson's work and it is considered to be a significant contribution to economic theory and storage policy (e.g. Myers, Sexton, and Tomek 2010; B. Wright 2011). Since that time, Gustafson's work has informed contemporary policy papers on the role of national and global reserves (e.g. B. Wright 2009).

[36] The demand function of his model was a calculation of the supply of grain, consumer demand for grain, storage costs, and interest rates, and he projected demand into an infinite horizon.

Gustafson's technical and theoretical work reframed ideas about the role of state-managed grain and its cost. He helped to draw attention to the function of ACEs and futures markets, and their relation to storage. In 1967, McKinnon (1967) identified a gap in the economic literature regarding farmers and futures markets. Using a rational-choice frame, he proposed that futures markets could be used by farmers to hedge and manage buffer stocks. Foreshadowing the farmer-owned reserve that would be established a decade later, McKinnon argued that farmers should hold their own buffer stocks because the farmer is connected to both the risk of production and the risk of marketing. The farmer would be in a position to adjust agricultural production, and the grain merchant would adjust to demand variations and usurp CCC's state reserve. In McKinnon's scheme, farmers could manage risks with forward contracts, hedging, and futures markets.[37] As will be shown in Chapter 6, grain storage became a tool in market and risk management as McKinnon had envisioned.

While Gustafson and McKinnon may have identified how futures markets and ACEs could provide the ideal conditions for grain storage, I did not find substantive application of their ideas until the mid-1970s when the US government began to disband its grain storage programs. US grain storage policies and regulations changed in the 1970s as farmers began to administer US grain storage, and state support of the grain reserve was disbanded in 1990s (see Chapter 6). The Chicago Futures School had introduced the idea that private grain storage was more efficient than public reserves but the idea had not been fully adopted, or stabilized until the mid-1990s.

3.4.3 From Agricultural Market to Financial Institution: Speculators Gain Legitimacy

"The disorderly world of commodity trading is a microcosm of an efficient economic system and a show place of assertion of liberty and dignity."

[37] Norton (1953) was an early promoter of farmers using ACEs because they were natural speculators. He stated that public grain storage would end the grain trade and eliminate private traders.

–Hieronymus 1996, 365

Thomas Hieronymus was an agricultural economist at the University of Illinois at Urbana-Champaign and a self-declared champion of futures markets. Throughout his career, he spoke to the general public and to specialized agricultural industry audiences about futures markets. His outreach included textbooks, pamphlets, and curricula, and was directed at grain elevator operators, farmers, and cattlemen throughout the 1950s and 1960s (Hieronymus 1996). As early as 1957, he was advising Congress on the importance of speculation and was calling for government to get out of agricultural marketing (Hieronymus 1977). His book, *Economics of Futures Trading* (Hieronymus 1971), helped to shepherd in the growth of futures markets during the 1970s and 1980s. As a self-declared "outspoken supporter of capitalism and futures market[s]," he tirelessly supported speculation, which he reframed as an essential economic activity (Hieronymus 1996, 9). Futures markets were a platform for rational actors, and were technically and economically efficient, according to Hieronymus:

> Futures market put their trust in the wisdom of people whose self-serving actions form the prices that direct and order the operation of the economic system. This is in sharp contrast to central planning that results in prices designed to maximize distributive justice and efficiency of resource use (1996, 363).

The primary constraint on futures markets, according to Hieronymus, was government interference.

Hieronymus was born and raised on a farm near Atlanta, Illinois, earned three degrees from the University of Illinois, began his career as an assistant professor in the Department of Agricultural Economics in 1949, and retired as Professor Emeritus in 1981. Hieronymus began his research and work on Chicago futures markets in the late 1940s as a graduate student, and had a long relationship with the Chicago Board of Trade's public relations and education programs (Hieronymus 1996). Hieronymus's long association with Chicago commodity exchanges is explained by both his proximity to LaSalle Street, and by the university's long association with the Chicago futures markets, which had started as early as 1901 (von Frauendorfer 1928).

Hieronymus's early research focused on the Chicago Board of Trade's (CBOT) soybean market during the late 1940s. The early soybean market was central to his work for a number of reasons. First, Hieronymus (1983; 1996) credits soybean trading with keeping CBOT afloat after the Second World War as other grain markets declined with government storage programs (1983; 1996). Second, soybeans were an attractive speculative play throughout the 1950s because prices were relatively volatile and there were a number of possible arbitrage plays among soybean, soybean meal, and soybean oil contracts. State interference in grain markets and storage caused a decline in futures market trading, and soybean futures were a success in comparison to other grain futures. Soybean futures trading at the CBOT were representative of what a relatively free market would look like without state control and interference.

Government and regulatory agencies had an unreasonable fixation on price manipulation, according to Hieronymus, who felt that the economic function of futures markets was misunderstood (1996 [1959]). The Commodity Exchange Act established rules to restrict non-agricultural traders and lessen the possibility of price manipulation, but Hieronymus and others viewed this as an "extreme concentrated attack" on speculators (Hieronymus 1996, 128; see also Gray 1962; Working 1962a). The result was that speculators were unfairly vilified and cast as "evil," which curtailed innovation and proper market function (Hieronymus 1996, 127). Speculators advanced the economic system through innovation and their use of ACEs, but the public's misunderstanding of futures markets led to an "anti-speculator bias," and left speculators to "fight with one hand tied behind their back" (Hieronymus 1996, 128).

Hieronymus worked to educate and change the perception of futures markets and speculation throughout his career. During the Agricultural Industry Forum in 1959 at the University of Illinois, he encouraged industry to expand its use of ACEs and to remove position limits (Hieronymus 1996 [1959]). He also worked to expand access to futures markets beyond agriculture and industry hedgers. At the Agricultural Industry Forum in 1971, he argued that futures markets should be used for agribusiness financing, since the demand for capital on farms would only increase. He advocated the use of futures as a source of equity financing and framed futures markets as financial institutions (Hieronymus 1996). Hieronymus would have been familiar with the different regulatory regimes that governed equity financing and commodity futures specifically in order to guard against excessive speculation. His early advocacy work began to blur the line between financial institutions and ACEs.

Following on his interest in expanding the role of speculators, Hieronymus framed futures markets as an investment vehicle that had application beyond the agribusiness hedger. For example, he took this same message to New York investors in 1970, and proposed that investors should consider commodity futures speculation as an investment vehicle (Hieronymus 1996). His book *Economics of Futures Trading for Commercial and Personal Profit* (1971) also began to promote futures markets as an investment vehicle for personal investors.[38]

Hieronymus (1971; 1977) was promoting futures as an investment strategy "for everyone" and working against regulation and position limits. His general attitude was an unapologetic defence of futures markets. In 1963, during a scandal involving warehouse receipts, futures markets and speculation, he wrote to the president of the CBOT:

> Instead of being criticized, the futures markets should have an award for superior performance. I would not defend but attack … there is no rational basis for making the futures market the whipping boy [for the scandal]. (Hieronymus 1996, 211)

[38] Professionals in the Chicago area began to invest in futures markets starting in the mid-1960s, and Hieronymus may have viewed this as having potential for expansion (Lambert 2011).

Hieronymus also took his message of the value of ACEs to Congress starting in the 1950s. In a typical statement prepared for the Senate Committee on Agriculture and Forestry in 1973, he declared his enthusiasm for futures markets as a system of finance, inventory management, and pricing. He reasoned that commodity futures markets were “the closest approximation to a system of pure competition that exists” (Hieronymus 1996, 296). He warned:

> Futures markets are fragile … be careful that legislative changes do not endanger existing markets and that they foster their growth and the development of new ones. (Hieronymus 1996, 296)

Hieronymus put futures markets at the center of a smoothly operating and productively functioning economy and cast them as part of a competitive “economic system, which is operated consistently with the wishes of the people” (Hieronymus 1996, 363–4). Futures markets were the best example of a competitive market, and in his estimation, the market was all-powerful because it could “convert acquisitive behavior of economic men to socially useful contributors” (Hieronymus 1996, 361). Central to the operation of the futures market were prices. In his analysis, prices were a force unto themselves. Governmental interference could suppress and distort prices, but they would inevitably triumph because “no system will function without prices” (Hieronymus 1996, 211). The depiction of the futures market as central to the competitive economy underpins the Chicago Futures School ideas.

Hieronymus rendered the futures market as an ideal, and as such, it was a site at which to assert liberty and freedom. That is, Hieronymus explicitly cited the importance of reflecting human values in market forms. The futures markets were an expression of liberty because they were competitive, produced prices based on the wisdom of the rational actor, and reshaped behaviour. This all resulted in the “excitement of a lifestyle” in which economic freedom served individual freedom (Hieronymus 1996, 365).

3.5 Discussion

What can we draw from the discussion of agricultural economics and, more specifically, the role of the Chicago Futures School? Ideas about grain storage and ACEs changed over the course of the twentieth century, and ACEs were at the centre of the economic explanations that focused on grain storage. The Chicago Futures School showed how inter-temporal prices produced at ACEs were a means to manage grain storage efficiently and avoid gluts and shortages. At the same time, ACEs began to gain currency as a financial institution and platform that would benefit and connect investors to agricultural commodities. These changes legitimized private management of grain storage and financial actors' participation in agricultural commodity investment.

Ideational stabilization is marked by a change in the control of grain-storage governance – in particular a change in who can access asset streams. The shift from the common sense of state-managed storage, to the common sense of private, ACE-managed storage began with ideas. The introduction of small-i ideas that are practical and applied are also a way to understand how ideas about who should control grain storage, and how it should be leveraged for asset streams emerged, but it took decades for these small-i ideas to become common sense. The shift in the assemblage of grain storage from private hands to public hands and back into private hands took decades to shift.

What changed? Ideas cannot become common sense until they become part of an assemblage of grain-storage governance that includes regulatory and physical supports. I will show in the following chapters the extensive regulatory and physical supports of the state-managed grain storage and how they were institutionalized through legal webs, documents and changes in the grain storage infrastructure. The ideas of the Chicago Futures School were not stabilized until they became part of an assemblage that included regulatory and physical stabilization that facilitated support for ACEs.

The small-i ideas about storage led to changes in who had the authority to govern and control storage. New econometric tools were used to develop a scientific explanation of the value of grain storage, and its function in relation to ACEs and the US state-managed grain reserve. Since the 1940s, the theory of storage has been the theoretical foundation of economic theories that explain the operation of ACEs, and it has been strengthened and built upon. Ideas about who should govern and value grain storage emerge as specific claims to scientific knowledge, in this case, economic claims about how its value is measured, and adopted by governments and policy-makers as fact (Barry 2013; Porter 2013; McKeen-Edwards and Porter 2013).

The emergence of the ideas as common sense is illustrated in changes in US storage policy and the emergence of the efficient market hypothesis. First, as mentioned above, Gustafson's work was applied to US storage policy in the 1970s, and by the time the 1980s arrived, "the theory of storage [was] not controversial" – it was settled wisdom (Fama and French 1987, 56). Keynes's normal backwardation had fallen by the wayside, and in its place, storage became a dynamic force in the hands of private operators rather than a stabilizing force in the hands of the state (B. D. Wright and Williams 1984; B. D. Wright and Williams 1982). Agricultural economists, who were part of the Chicago Futures School legacy, portrayed storage as a productive activity that served to "transfer a commodity from one period to the next," connecting it to futures markets (B. D. Wright and Williams 1982, 597). The Chicago Futures School had determined that private, or competitive, storage of commodities was proven to be more effective than government stocks (B. D. Wright and Williams 1984; B. D. Wright and Williams 1982) or buffer stocks (Miranda and Helmberger 1988). This common sense accompanied the dismantling of the state-managed grain reserve.

Second, Working and Gustafson presented early iterations of rational choice theory and the efficient market hypothesis. Models were based on rational-choice actors, and used futures markets to explain the interactions among production, price expectations, and storage. The model of storage was based on an ideal competitive market that does not account for non-rational actions. Hieronymus' work that helped to institutionalize ACEs as a financial institution. This was buttressed with the idea that new kinds of actors from farmers to financial actors had a legitimate interest in participating in speculation. As rational choice actors, they could compete and support an ideal competitive market.

According to this school of thought, the state distorted agricultural markets whereas rational actors' participation contributed to efficient market hypothesis. That is, the efficient market hypothesis states that the market reflects all publicly available existing information, including the expectations and anticipation of predictable future events that are predictable. Increased participation only increases the publicly available existing information reflected in commodity prices. These models were put to work against policies that supported government reserves or buffer stocks, and these studies continue to shape contemporary grain-storage policy.

The Chicago Futures School found an almost perfect market for competition in the futures market. This is not inconsequential. The 2007–8 food and financial crises prompted a number of economists to revisit the role of futures markets and storage. In a familiar refrain, Wright has stated that traders and speculators are "pilloried" in times of crisis (B. Wright 2011, 2). In his report for the World Bank on grain reserves, Wright references Gustafson's work and argues against public holding of stocks except in exceptional circumstances (B. Wright 2009). Futures markets continue to be presented as the most efficient manager of storage. But Makki et al. state (1996) that global equilibrium trade models that analyze commodity flows cannot account for storage. Instead, "the modern theory of storage provides detailed assessment of domestic market dynamics," not global trade (Makki, Tweeten, and Miranda 1996, 879). Despite these limitations, these models continue to be the basis for wide-ranging scholarship, including that on futures markets and commodity index funds (Etienne, Irwin, and Garcia 2014; Irwin and Sanders 2011) and the role of grain storage and food security, as noted above.

Ideational stabilization helps to explain how an idea, in this case, ideas relating to storage governance, become taken for granted, or what Cox (1996) has called common sense. The Chicago Futures School of Agricultural Economists' work used the operation of ACEs to illustrate its efficiency in managing stored grain in comparison to the inefficient management by the state. The theoretical foundation of the theory of storage has been built upon since the 1940s, and has consequences when grain reserves are debated during periods of global market failures, or in the case of the 2007-8, a food crisis. One consequence is that the idea of emergency food reserves became a source of contention between international organizations and civil society organizations, and emergency food reserve projects are relegated to pilot projects rather than significant structural change (Clapp and Murphy 2013).

3.6 Conclusion

How does a close examination of ideas about grain storage contribute to explaining the financialization of agriculture? A close examination of ideas about the economic operation of grain storage shows how private management, through ACEs became common sense because it was more efficient than public storage. Specifically, the Chicago Futures School made three important contributions to grain storage ideas – the theory of grain storage, revealing the cost of public storage, and ACE's role as a financial institution. The theory of storage is regularly put to work in contemporary debates about speculation (D. R. Sanders, Irwin, and Merrin 2010), national global reserves (B. D. Wright and Williams 1984; B. D. Wright and Williams 1982), and development schemes to establish new agricultural commodity markets and frontier sites (IFPRI 2014). The Chicago Futures School applied econometric tools to futures market data, such as prices and price behavior, in the context of nationally regulated storage and subsidized agricultural markets. Agricultural economics used new sets of tools, numbers, data and calculations to explain agriculture in relation to national and world markets, and ACEs were their ideal market template.

A close examination of ideas about US grain storage helps to illustrate how ideas were built over time to link efficient grain-storage management to ACEs and to link ACEs to financial actors. The theory of storage is an example of a small-i idea. By tracing the practical and technical, rather than the large-I ideology, one sees how the operation of storage policy and its underpinnings are illuminated. Working's and Hieronymus's conceptions of the role of futures markets and storage were formed in the context of a complex twentieth-century apparatus of state regulatory webs. The superiority of private control of storage started as a small-i idea and became a recognized truth in US policy, and later adopted by international organizations. In later chapters, I show how development projects used the idea of ACEs and tried to build agricultural markets. Without regulations and physical stabilization to underpin storage, agricultural futures markets cannot be established. Ideational stabilization occurs over a long period of time; it is therefore helpful to trace how expertise and ideas come together, change, and fall away.

Markets were a meeting place for agriculture, farmers, and consumers. But over this time period, futures markets became financial institutions, and speculators provided economic benefits, shifting from "villainous to venerable" (Berg 2011). The farmer-owned reserve would be established in the 1970s, and market and risk management would characterize grain management in the 1990s as McKinnon (1967) predicted. Farmers were asked by the state to become risk managers, and to use forward contracts, hedging, and futures markets. State intervention was replaced by privately held storage and it became a tool in market and risk management. The ideas of agricultural economists helped to change the functions and meaning of futures and ACEs' relationship to storage over the last 70 years. Speculators and futures markets shifted from a force that needed to be policed and regulated by the agrarian statesman, to a misunderstood scientific marketing machine that needed to be explained, freed, and leveraged with financial actors, including farmers.

Chapter 4- Regulatory Stabilization: Securing Grain Storage Collateral

4.1 Introduction

Warehouse receipt financing, including the appropriate legislation, regulatory and supervisory oversight, and licensing of warehouses, represents an opportunity to lower vulnerability of farmers to unfavorable prices and conditions, reduce post-harvest losses, and increase the flow of credit into supply chains. A well-functioning warehouse receipt system can provide broad benefits such as permitting stored goods to be used as collateral; improving quality, control, and inspection of commodities; facilitating investments to increase and improve storage capacity and quality to reduce losses; enhancing marketing within value chains; and supporting the establishment of commodity exchanges.

–Global Partnership for Financial Inclusion and International Financial Corporation 2011, 7–8.

In this chapter I show how the unstable character of agricultural credit, specifically the problem of collateralizing agricultural commodities, was stabilized to varying degrees with the backing of state regulations during the twentieth century. The state addressed the problem of establishing credit on stored agricultural commodities in two ways. First, by the state helping to secure warehouse receipts. Warehouse receipts are woven into US capitalist history, and have been used as a tool to secure goods for credit since the mid-nineteenth century. Warehouse receipts were a product of nineteenth-century ACEs, but were legitimized through state regulations, and secured with state resources. The US state legitimized warehouse receipts, and incorporated them into national agricultural policy in the early twentieth century. But these measures were not fully successful because private finance remained reluctant to take on risk associated with credit documents on stored agricultural commodities. The second regulatory stabilization process was the establishment of the Commodity Credit Corporation (CCC). The CCC was established in 1933 to manage a national grain reserve and to provide financial support to farmers through a loan program based on stable, stored commodities that acted as collateral; it either directly or indirectly managed the US grain reserve until the 1990s. The regulatory shift from a national grain reserve to private storage began in the 1970s with the farmer-owned reserve and was completed in 1996 with the Federal Agricultural Improvement and Reform Act

(FAIR Act), and farmer-centered risk management became part of a new policy agenda. Between 1932 and 1996, US grain storage changed from private ownership to public ownership and back to private ownership. The outcome of these regulatory shifts had consequences for ACEs and farmers, and affected who could access and benefit from asset streams based on stored commodities.

I argue that regulatory stabilization was an on-going process that was required to collateralize and secure stored grain. Without regulatory stabilization and the full backing of the state, problems arose at grain storage sites. In particular, the 1980s farm crisis included problems with securing collateral at elevators. When the state pulled back from supporting the national grain reserve, farmers had difficulty using stored grain for collateral. In addition, the governance of US grain storage affected the growth of the agricultural futures markets. Futures markets were negatively affected when the CCC managed public grain storage and the ACEs were positively affected with the end of the national grain reserve. When the CCC bore the market risk, and managed the grain reserve, ACEs were made superfluous. This chapter examines the interaction of the regulatory tools and practices of ACEs (warehouse receipts) and how these credit practices were adopted by the state in the early twentieth century, and then usurped by the CCC, and a national grain reserve during the mid-twentieth century. The state pulled back from regulating grain storage starting in the 1970s, and there was a return to a reliance on warehouse receipts and ACEs to manage and secure stored grain for credit and asset streams.

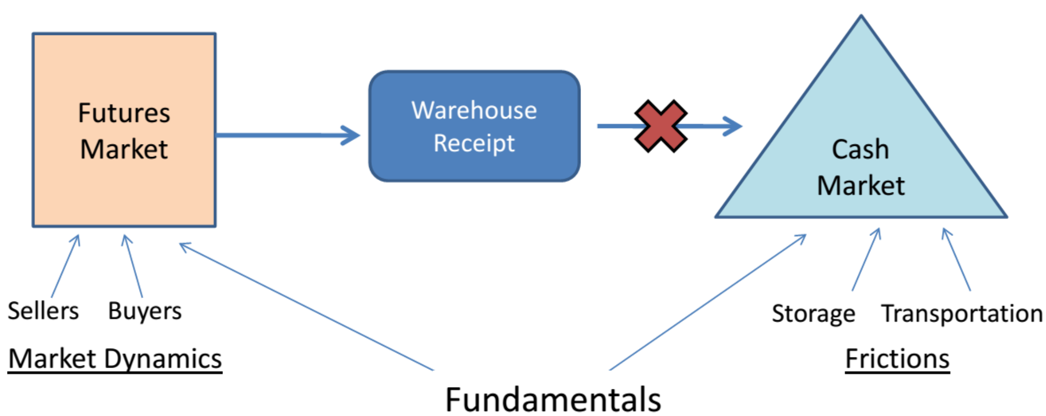
The chapter begins with a discussion of the context of US warehouse receipts and their continued importance in the operation of contemporary ACEs. I then turn to a summary of nineteenth-century Chicago ACEs, the role of warehouse receipts, and the regulatory and legal webs that were needed to stabilize warehouse receipts for financial actors during the twentieth century. The state began to adopt warehouse receipts in the early twentieth century as a means to extend agricultural credit to farmers, and to build asset streams on stored agricultural commodities. However, agricultural credit continued to pose a problem to the state as agricultural incomes continued to decline in the 1920s and 1930s. Agricultural credit remained difficult to establish because collateral was unstable and risky according to bankers. The second half of the chapter shows how the CCC stabilized the value of stored grain by extending loans directly to farmers starting in the 1930s. The CCC stabilized regulations and values via the national grain reserve. However, the interaction between grain traders, and the CCC was complicated because of battles over who could and could not own grain storage facilities. I show how the development of farmer-owned reserves in the 1970s marked the start of the US state's withdrawal from grain reserve management, and a return to privately controlled storage. The 1980s farm crisis led to a number of farm and elevator bankruptcies, and centred on the failure of warehouse receipts. The chapter ends with a discussion of the theoretical implications of the work, and a summary.

4.2 Warehouse Receipts and ACEs

Why a close examination of warehouse receipts? Warehouse receipts are part of US capitalist history. In 1859, for example, John D. Rockefeller of Standard Oil obtained a $2000 USD bank loan, using warehouse receipts as collateral. Leveraging this loan, he purchased his first oil refinery on a Cleveland riverbank a few years later (Weinberg 2008). At the same time, in Chicago, warehouse receipts were being used at emergent ACEs to underpin grain futures contracts. Warehouse receipts are a crucial link between ACE futures markets and cash markets – "a document certifying possession of a commodity in a licensed warehouse that is recognized for delivery purposes by an exchange" (CFTC Office of the Chief Economist 2013). However, less notice has been given to the role of these documents in translating commodities (in this case, grain) into collateral during the twentieth century.[39]

[39] For an extensive discussion of nineteenth-century warehouse receipts see William Cronon's Nature's Metropolis (1992).

What do warehouse receipts do? Warehouse receipts are central to the operation of ACEs, and connect stored agricultural goods to financing. A figure (see Figure 2) used in a 2010 presentation by Nicole Aulerich, a research economist at the Office of the Chief Economist, to the CFTC[40] Agricultural Advisory Committee Meeting shows the centrality of warehouse receipts. She described how futures prices and cash prices were not "converging" because of a problem with pricing and warehouse receipts, which meant that the markets were not operating as expected (Aulerich 2010).[41] Convergence is the narrowing of the price difference between the physical cash market and futures contracts during the delivery period in which contracts are settled. Aulerich stated that the costs of delivery and storage were too low, and contributed to the non-convergence (see also Adjemian et al. 2013). The CBOT addressed the problem by changing the warehouse receipts and delivery prices to better reflect storage prices. At first glance the problem of non-convergence appears to be a technical issue. However, non-convergence was also blamed on excessive speculation by financial actors, specifically, index funds (Levin, Coburn, and Senate Committee on Homeland Security and Governmental Affairs 2009). Either way, warehouse receipts were a central connection between storage and ACEs.



[40] The US Commodity Futures Trading Commission (CFTC) oversees the regulation of futures markets, which have expanded over the last three decades to include financial derivatives that now exceed agricultural derivatives many times over.

[41] Aulerich had made similar presentations and reports to the CFTC on other agricultural commodities.

Figure 2: The Root of Convergence (Aulerich 2010, 3)

Warehouse receipts have also been repurposed into "innovative" new financial practices. For example, warehouse receipts were used to model the first US exchange-traded funds in the early 1990s (Moriarty 2009). International organizations have encouraged the use of "warehouse receipts systems" to connect small farmers to new markets and global value chains. The World Bank and the United Nations Conference on Trade and Development (UNCTAD) promote warehouse receipt systems to smallholder farmers so that they, like Rockefeller, can become consummate capitalists by collateralizing agricultural produce (e.g. Coulter 2009; IFC and GPFI 2011; IFC 2012b; Rutten, Santana-Boado, and UNCTAD 1996). Warehouse receipts are presented as innovative financial tools, but there is very little that is innovative about the documents unless they are being introduced to new frontier sites as part of development projects to build markets.

Examining the development of warehouse receipts is important for two reasons. First, an examination of US warehouse receipts highlights the interaction between contained grain and the regulatory-legal documents that were required to establish collateral and loans. Although warehouse receipts were initially a tool for grain traders, starting in the early 1900s, the US government began to adopt the idea of collateralizing stored grain to provide credit for farmers, and adopted a set of scientific practices to regulate the storage and valuing of grain. Warehouse receipts were backed by the state as documents of title to protect farmers and commerce from fraud. However, warehouse receipts were not enough to secure stored grain as collateral. This leads to the second reason: as the state pulled out of managing grain storage through the CCC, warehouse receipts played a crucial role in translating and stabilizing grain in storage for financial actors. But the grain elevator and farm bankruptcies in the 1980s illustrate the instability of this form of title.

Warehouse receipts are at once a tool of abstraction and a physical document. Scholars have examined warehouse receipts and primarily highlighted practices of abstraction. For example, Levy described the late-nineteenth century trading pits where "futures traders dealt in conceptual entities as if they were corporeal goods" (Levy 2006, 3). This process of translation has been described as a "dematerialization" – that is, financial and legal documents such as warehouse receipts abstracted physical goods (Levy 2006, 311). But abstraction required a series of physical tools and practices to mediate and translate corporeal goods into conceptual entities, and this included warehouse receipts. It is not enough to point out practices of abstraction. The values – weights, condition, grades and location – were recorded on warehouse receipts to create an object that can be collateralized and traded. And yet the document itself is physical. Porter reminds us that it is the very technical quality of financial practices that facilitates the extension of power, and at the same time practices are enacted through material actors (Porter, 2013) such as warehouse receipts. Warehouse receipts help to enact finance by translating stored grain into grades, values, and standards for ACEs, and help to determine the value of collateral. Translations establish equivalence (Best and Walters 2013a). However, when warehouse receipts are an everyday part of the grain trade, the work of "translation" is less visible. The work of translation becomes visible with failures and breakdowns, when equivalence cannot be made. I focus on the breakdowns of translation such as fraud and swindling, following Latour (2005), to help highlight the work of warehouse receipts. The work of warehouse receipts is also made visible by tracing the shifting regulations and laws that help to secure and stabilize the values of agricultural commodities. Regulatory stabilization is an ongoing practice that helps to highlight the unstable and dynamic quality of agricultural goods in storage, and the work required to translate it for financial actors.

4.2.1 Nineteenth-Century ACEs and Warehouse Receipts: Stabilizing the Value of Collateral

The control of warehouse receipts can provide control over collateral in the form of grain. Initial grain-elevator receipts were modeled on the general receipts of metal markets, which became common after 1860 (Huebner 1911, 9; see also Cronon 1992).[42] In theory, the delivery of a receipt was the fulfillment of a contract, and as such, the receipts themselves, rather than the commodity, began to be traded. The nineteenth-century US grain trade was where "the real 'future' became possible" (Huebner 1911, 9). By the end of the nineteenth century, futures had been transformed from gambling based on probability and statistics into "science" and "insurance" (Levy 2006; see also De Goede 2001).

Securing and stabilizing a value is a difficult process, and warehouse receipts translated the messiness of vital grain into an object that could be collateralized. Nineteenth-century bulk handling and storage of grain was a technological innovation, but it produced new problems, especially in determining ownership.[43] Before the development of a bulk-grain infrastructure of railways and steam-powered elevators, grain was moved in bags. Bags of grain could be traced from farmer to buyer to shipper, but the development of bulk storage and transport meant that bags from many farmers were mixed, making it difficult to determine ownership as grain was traded and transported (Cronon 1992). Warehouse receipts were a way to transfer ownership, provided all the grain involved was deemed to be of equal quality, standard, and quantity. Bulk storage required fully fungible receipts, which became the medium for settling accounts after they were sanctioned by the courts (J. C. Williams 1984). Cronon states that the contractual boundaries and regulations that formed around Chicago's grain trade provided openings for market manipulation such as cornering the market (1992, 132).[44]

[42] According to Smith (1922), warrants exist that date back to 1733 when the East India Company used them to facilitate the transfer of ownership without the transfer of the physical commodity. Warrants began to be used with iron in the mid-nineteenth century; the transferable order was held up by the UK courts in 1877 and was codified in 1893, which secured the transferability of warrants. Some authors (e.g. Schaede 1989; Wakita 2001) trace futures to the Dojima Rice Exchange in Osaka, Japan in the 1720s, and standardized finance textbooks, according to Wakita (2001), identify the Osaka exchange as the first institutionalized futures exchange.

[43] See Cronon for a detailed description of the infrastructure of railways and steam-powered elevators, and how Chicago became central to the grain trade and usurped river-bound centres such as St. Louis.

[44] According to Cronon, three key institutions defined the Chicago grain trade: the grain elevator, the grading system, and the privately regulated private market (1992, 120). These institutions combined to create a new kind of money.

Forward and futures contracts existed before the establishment of the CBOT Chicago, but state and federal regulations governing them did not. The transfer of ownership through warehouse receipts provided opportunities for fraud, theft, and price manipulation by warehouse operators; state regulations sought to limit this manipulation.

Nineteenth-century incidences of ACE fraud illustrate how warehouse operators manipulated warehouse receipts and grain storage to their own advantage. In an article entitled "Warehouse Risks," the author outlines the bait-and-switch of grain warehousemen in Chicago (*Chicago Tribune* 1869, 2). Warehouse operators used their knowledge of the condition and inventory of grain to collude on storage prices and exploit both buyers and sellers. Elevator operators had exclusive information about grain supplies and warehouse receipts, which was likened to "printing money" (Cronon 1992, 136). For example, if an owner of grain placed grain in storage in good condition, and paid fees for storage, the warehouse operators could sell the good grain and replace it with spoiled grain, leaving the owner bearing the loss. For this very reason, the author of "Warehouse Risks" was suspicious of warehouse operators' refusal to insure grain. Warehouse operators were in a position to control grain and to sell the receipts when the price was high, claim the grain was out of condition, and then buy up the discounted warehouse receipts (*Chicago Tribune* 1869). Shippers and receivers consistently accused Chicago elevators of inadequate care, and the storage monopoly on grain was, "in plain English, swindling" (*Chicago Tribune* 1870, 2). For example, a warehouse fire in August 1872 led to the discovery that the outstanding warehouse receipts added up to more than double the warehouse's capacity. Upon learning of a planned inspection, warehouse operator Munn & Scott built false bottoms in its grain bins to cover up a shortage of stored grain in comparison to the volume of "paper" grain showing up on warehouse receipts (J. C. Williams 1984, 494). An operator could claim that "deposited" grain spoiled due to natural causes with no provision of insurance or compensation to the owner of the warehouse receipt. Warehouse operators used the dynamic and changing character of grain to their own advantage.

The frauds, swindles, and control of grain by elevator operators were constraining trade and business, and both public and private actors set out to regulate grain storage. The CBOT established uniform weights and measures for the grain trade to protect against fraud, and in 1857, it appointed a grain inspector to oversee grades and measures: “Inspection underpinned the integrity of the grading system, which underpinned the integrity of the elevators, which underpinned the integrity of CBOT’s own markets” (Cronon 1992, 119). Buyers, sellers and critics of the grain trade widely supported the CBOT inspection system, which was written into Illinois law in 1859, and the CBOT became a “quasi juridical entity with substantial legal powers,” according to Cronon (1992, 119). The inspections were efforts to secure the value of the warehouse receipts with the underlying commodity, and inspectors were needed to stabilize the value of warehouse receipts to help secure collateral and make it accessible to banks and the state. However, as the examples listed above show, the CBOT rules and inspections were not enough to limit swindles.

Pushback against the CBOT for inadequate oversight came from farmers and grain merchants, although members of the CBOT also had grievances against the elevator operators. The Granger movement, an agrarian political organization, pressured for regulation, which led to a series of court and legislative interventions.[45] In 1867, the State of Illinois passed legislation making warehouse receipts fully negotiable, and stored grain became fully fungible. Up to 1870, the CBOT oversaw and inspected warehouses and warehouse receipts. It was replaced by a state-appointed Railroad and Warehouse Commission, which inspected grain, registered and canceled receipts, and licensed warehouses. The CBOT remained active and supported the passage of a number of Illinois laws to

[45] The Granger laws were passed in Iowa, Illinois, Minnesota, and Wisconsin between 1871 and 1875 and were aimed to regulate grain storage and railway companies (Carney 2011, 12).

regulate the transport and storage of grain despite strong opposition from railroads and warehouse operators (Pirrong 1995, 249).

In 1877, the Supreme Court upheld the state regulations and called attention to the role of warehouses' commodity trade. The Court said that warehouses "stand at the very gateway of commerce and take a toll from all who pass," and were subject to public regulation because they were "affected with a public interest" (E. Sanders 1999, 399). Agrarian interests called for yet more intervention, however, because the regulations were inadequate in three areas: uniform grading (critical for export), secure storage, and bank credit (E. Sanders 1999, 298). For example, the Southern Farmers' Alliance wanted public warehousing, public information on storage charges and pricing, and consistent quality control to counter the "strict inspection in and easy inspection out" of warehouses (E. Sanders 1999, 299).[46] Farmers' grain was graded low by warehouse operators and graded high for export markets, which gave elevator operators a premium. Critics also raised concerns about poor grain management in warehouses, which reduced the quality of the grain. Banks were reluctant to accept warehouse receipts as collateral because of the monopolistic and poor practices of warehouses (E. Sanders 1999, 299). If warehouses were compelled to stabilize the condition of the grain through regulations that involved grades and standards, and to protect it with insurance, the grain could potentially be used for collateral.

4.3 Securing Collateral and Stabilizing Credit: Warehouses, Standards and Grades

Government regulation and oversight had the potential to produce a new kind of secured site in the name of the public interest, and provide credit to farmers. The state began to adopt ACEs' tools, including "scientific systems of grading" such as standardization and warehouse receipts (Roosevelt 1909, 55). The 1909 Report of the Country Life Commission embraced warehouse receipts and stored

[46] The Southern Farmers' Alliance was mostly concerned with cotton marketing and warehousing, but the point stands for grain as well.

grain as being “good as cash,” which, combined with “good systems of farming,” would produce “most satisfactory results” for farmers and markets (Roosevelt 1909, 55). The Report promoted a public cooperative warehouse model, and combined it with the tools and practices developed by early grain traders and elevator operators in Chicago. Warehouse receipts were becoming accepted and were being compared to securities and bonds. For example, “warehouse receipts for grain are the best collateral and food is more secure than government bonds” (Huebner 1911, 11). In other words, the tools of traders – warehouse receipts – were now being validated by government and were likened to secure financial tools such as government bonds.

By the advent of the twentieth century, credit based on warehouse receipts had become a mechanism to move farmers towards prosperity. Soloman Huebner, professor of Insurance and Commerce, University of Pennsylvania, was widely known as the father of insurance education. He linked warehouse receipts to the promotion of ACEs as insurance institutions that spread risk and provided collateral for the grain trade by virtue of “grain paper,” providing necessary credit (Huebner 1911). He stated:

> The delivery of warehouse receipts on exchange contracts gives to the grain, cotton and produce they represent the same quality of mobility, for purposes of sale or deposit as collateral, as is given to corporate property represented by stocks and bonds listed on our stock exchanges. If it were not for organized markets and the existence of warehouse receipts, the vast quantity of produce lying in warehouses and elevators, aggregating hundreds of millions of dollars, would not be available for business purposes except in a very crude way. (Huebner 1911, 12)

Grain was “rendered mobile,” according to Huebner, and in theory, benefitted the farmer because there was a continual, year-’round market for grain (1911, 13). This was not a minor issue. Huebner estimated that nine-tenths of crops were secured with borrowed funds, making warehouse receipts a necessity for the profitable operation of the grain trade. Credit was a tool, not mere “debt” or a “badge of non-prosperity,” and “[t]he farmer should be educated to the new view of credit” (Boyle 1921b, 213). Credit was central to capitalizing the industrialization of agriculture and to making farming more business-like and efficient (Fitzgerald 2003). Warehouse receipts were a central translation tool to secure agricultural produce for collateral, but they required state backing to be secured.

Before 1916, US states regulated the grading, weighing, and warehousing of grain, and there was substantial evidence that the rules benefited terminal market purchasers and facilitated unfair business practices (E. Sanders 1999). "[C]orruption and unfair business dealings characterized the pre-1916 grain inspection and grading system" (US GAO 1976, 133). The result was that farmers and independent shippers received low prices from the terminal operators who then sent poor-quality grain to purchasers. Warehouse receipts and inspection certificates were at the centre of these controversies because the receipts stated one value while the grain was thought to represent another. The US state stepped in to stabilize values through new regulations and the application of standards with the aim of protecting farmers and securing a stable export market.

The Federal government linked storage, banking, and warehouses together to secure a stable site for collateral between 1916 and 1933 with two regulatory stabilization processes, the newly created Federal Reserve Bank, and second, a series of warehouse regulations to help stabilize the value of collateralized grain. Warehouse receipts were part of the "agrarian statist agenda" and were supported by the expansion of regulations and state institutions (E. Sanders 1999).[47] The Federal Reserve Bank was linked to warehouse receipts. A 1914 House of Representatives report described the importance of linking stored crops to banking systems:

> [T]here is no proper relationship between [storage] and the banking system in the country … A new system of banking is being organized which, for the first time recognizes agricultural products as a proper basis for credit … A warehouse receipt to be the fullest strength as collateral and readily negotiable as possible in the financial markets of the country must be such a receipt as is of undoubted integrity. Such a system would create a form of security good

[47] These regulations were supported by federal legislation, including the Federal Reserve Act (1913), the Federal Farm Loan Act (1916), the Warehouse Act (1916), and the Grain Standards Act (1916) (E. Sanders 1999; Carney 2011; and Prasad 2012).

> beyond all doubt and one that would command the confidence of the commercial and investment banking world. (as quoted in US GAO 1976, 115)

The Department of Agriculture stated that regulated warehouse receipts would provide farmers with the means to access short-term credit – even farmers with poor standing with local banks (USDA 1917, 73). The Federal Reserve directors also spoke to the advantages of the warehouse receipts, which could be used for export trade (US Department of Agriculture 1923, 11). By 1921, James Boyle, an agricultural economist at Cornell, wrote how the newly created Federal Reserve created the "trade acceptance":

> Credit to move the crop can be furnished to the farmers more easily, more readily, and more cheaply, – provided the preceding steps have been taken – if the goods are graded; if the goods are in a warehouse, insured, and represented by a warehouse receipt. Under the federal reserve system [sic], there is the form of credit paper known as the trade acceptance which requires the creation of no new credit machinery, but is now available for farmers individually and collectively. … The farmer will find that he is in as good a position to obtain short-time credit as is any other borrower. (Boyle 1921b, 212)

The regulatory processes were developed to address the demand for asset streams from farmers, and to help secure collateral through stored agricultural commodities.[48] Regulations were designed to use certified warehouses, documents of title such as warehouse receipts, and a system of state-mandated grades and standards to stabilize the value of commodities.

The state secured the documents of title with regulations including the Uniform Warehouse Receipts Act (1909), the Warehouse Act (1916), and the Grain Standards Act (1916). Together, these Acts provided "scientific and workable solutions for farmers' financial and economic problems" (USDA 1917, 72). The Uniform Warehouse Receipts Act defined who could issue a receipt, and specified what needed to be included in the receipt, such as "the location of the warehouse, date of issue, the number, whether the goods will be delivered to bearer, a specified person or his order, [and] the rate of storage charges" (Mohun 1913, 3). The passing of the Warehouse Act faced opposition from large

[48] Warehouse receipts were used for cotton, tobacco and other agricultural commodities.

grain terminals, which resisted federal regulation because, up to that point, state governments (such as that of Illinois) had served their interests (E. Sanders 1999, 300). With the passing of the two Acts, warehouse receipts were codified, and the Department of Agriculture began to license warehouses to promote “better storing of farm products, [and] encourage standardization of storage and of marketing processes” (USDA 1917, 10).

The provision of credit is notable because of the unique problems agriculture poses to lenders. Agricultural credit was expensive and difficult to obtain from private sources such as rural banks at the turn of the twentieth century (Fitzgerald 2003; E. Sanders 1999). Agriculture entails a high level of risk compared to other industries because production is reliant on weather and other conditions that are outside the control of the producer, such as volatile commodity prices. Because of these risks, banks were reluctant to extend operating credit to farmers without the promise of a return, or security. Early twentieth-century state expansion of credit was designed to help farmers be more competitive with so-called middlemen, and to help industrialize farms (Fitzgerald 2003; Prasad 2012). For example, the establishment of the Federal Reserve System in 1913 created specialized banking and credit agencies for farmers (US Department of Agriculture 1923). The establishment of Federal Farm Loan Banks relieved rural banks of farm mortgages, which were difficult for commercial banks to service due to a mismatch between industrial and agricultural credit and the high risk of agricultural production (Gephart 1924). “The formation of Intermediate Credit Banks and the Agricultural Credit Corporations were designed to further relieve the ordinary country banks of the burden of carrying slow assets” (Gephart 1924, 10). The establishment of new sources of credit – in particular, mortgages – was not enough to counter the effects of free trade and free competition, according to Taylor (1929), and farmers’ share of national income continued to decline.

The US state tried to overcome these problems with new models of cooperative and state-supported finance to help farmers compete with the “middleman system of handling agricultural products”

(Roosevelt 1909, 15). The 1909 Country Life Commission recommended the establishment of cooperative warehouses and a warehouse receipt system for grains (Roosevelt 1909).[49] The passing of the Uniform Warehouse Act (1913) codified warehouse receipts for agricultural commodities, which provided farmers with an additional form of credit and an asset stream. In 1921, Boyle, an agricultural economist at Cornell, pointed out the benefit to farmers of owning and operating storage, saying that "control of storage gives certain strategic power" (Boyle 1921b, 212). He linked storage and credit together: "to carry the goods – credit must be furnished" (Boyle 1921b, 113). Boyle predicted a rapid uptake of the new asset streams. But storing agricultural commodities was risky. "It might be thought to be liquid," explained a banker in 1924, "but the demand is fixed and the product is perishable" (Gephart 1924, 13). The state enacted new regulations, standards and rules to secure grain storage and provide a platform to draw credit from stored agricultural goods, but there was little uptake by farmers or bankers. The ideas of Boyle and other agricultural economists did not convince lenders that the risk of agricultural credit had been overcome.

The "agrarian statist agenda" described by Sanders (1999) affected grain-storage governance directly through regulations that expanded credit, establishment of a national grain reserve and certification of warehouses, and indirectly through commodity exchange and banking regulations.[50] The Federal government had established a system to regulate and support warehouses and warehouse receipts, and it worked hard to enroll farmers and warehouse operators in the system. While the licensing was not

[49] "With some crops, notably cotton and the grains, it is advantageous to provide cooperative warehouses in which the grower may hold his products till prices rise, and also in which scientific systems of grading of the products may be introduced ... In the meantime the cotton or grain in the warehouse becomes, for business purposes, practically as good as cash (subject to charge for insurance) in the form of negotiable warehouse receipts. This form of handling products is now coming to be well understood, and, combined with good systems of farming, it is capable of producing most satisfactory results" (Roosevelt 1909, 55).

[50] A series of regulations was instituted by the state to control ACEs and, especially, agricultural commodity speculators and to protect farmers. The state passed the Cotton Futures Act (1916), and further regulated markets with the Grain Futures Act (1922). These acts limited market manipulation and centralized trading on regulated commodity exchanges. In addition, they made trading information public (see below for more details on market information). These regulations included the Federal Reserve Act (1913), the Federal Farm Loan Act (1916), the Warehouse Act (1916), and the Grain Standards Act (1916).

mandatory, it "attracts a better class of warehousemen," which was necessary for the "banking fraternity" to favour this type of collateral (P. M. Williams and USDA 1926, 4). In a brochure designed to explain the advantages of warehouse receipts, the authors explain the system:

> [It is a] uniform national system of public warehouses for the storage of staple farm products, to encourage the storage of such products, and to facilitate the financing of stored products so as to permit orderly marketing … a person placing agricultural product in a warehouse can secure a certain amount of cash without selling the commodity. (US Department of Agriculture 1923, 3)

The advantages of creating a regulated warehouse system with receipts included expanding collateral, ensuring responsible warehouse operators, lower insurance rates, and year-'round grain facilities (US Department of Agriculture 1923, 11). To account for bulk storage "when the identity of the grain is lost in storage," licensed graders and "weighers" were required to inspect and certify the grain for warehouse receipts (US Department of Agriculture 1923, 7). In other words, the warehouse operator was required to stabilize the grain and secure it. Licensed warehouse operators provided expertise and oversight to stabilize the value of the stored good, and to manage the grain's quality and prevent spoilage. On-farm storage for warehouse receipts and credit was discouraged: "Haphazard, careless storage on the farm would be superseded by careful, intelligent warehousing, thus avoiding enormous waste" (P. M. Williams and USDA 1926, 3). The state developed regulations to secure professional and scientific warehouses that could be depended on to secure quality and to secure credit.

But the agricultural credit problem remained. Even with the establishment of regulations and inspection, warehouse receipts were still a problem for private credit providers such as bankers. The notion that the standing of the borrower could be superseded by a warehouse receipt was dismissed by a Kansas banker writing in 1924. He thought that warehouse receipts were a tool for merchandizing, but less successful as collateral for a bank loan. Collateral was misunderstood by the federal government and could not be easily converted into cash. He stated that it was a misunderstanding that goods stored in government warehouses could be converted into cash irrespective of the financial standing of the borrower:

> [I]ndividuals who ordinarily can borrow without collateral turn to the use of warehouse receipts after having consumed other sources of credit available to them, and are surprised to find the banker hesitant about making further loans even with this specific and desirable form of collateral. (Gephart 1924, 12)

Even with the backing of the federal government, bankers were reluctant to accept warehouse receipts. The issue of using stored grain as collateral would continue to pose problems. Despite the growth of federal regulations to establish credit using collateral based on stored grain, agricultural credit posed specific problems to bankers. A new state institution would be established to change how warehouse receipts and storage programs operated, resulting in a new credit regime for agriculture.

4.4 Twentieth-Century State Solution: The Credit Commodity Corporation and Collateralizing Grain Storage

The CCC has never been more than a lending and purchasing agent for the execution of the financial side of price-support programs

– Frischknecht 1953, 570

The US state mediated the grain market in various ways throughout the twentieth century, and the Commodity Credit Corporation (CCC) was part of this intervention. Why have I turned my attention to the CCC, an institution that has been portrayed as a folly and an inefficient manager of storage (e.g. Working 1962b; Hieronymus 1996)? First, my examination of the CCC is crucial because the CCC's operations illustrate the complex interactions between credit and the regulation of grain reserves. The CCC was part of the US New Deal program to raise rural incomes by managing stocks and supporting prices. Starting in the 1930s, stored grain was used to extend loans to farmers who were bearing the brunt of low commodity prices. These loans were established alongside a state-managed grain reserve. The CCC was a lending institution created to serve agricultural producers by supplying credit based on the value of stored agricultural commodities that were used as collateral.[51]

Second, the CCC was big. At one point in the 1950s, the CCC was known as "the largest corporation in the world" (Hughes 1956). By the early 1960s, the CCC storage programs were the largest federal expenditure after servicing the debt and defence spending (Phillips 2013, 316). Third, the CCC's control and management of storage had a significant impact on futures markets because the state bore the risk of storage (see Figure 3). The state control of stocks (and credit) hobbled commodity futures markets, and at the same time provided regulations and a model of agricultural credit based on commodities that helped to build legitimacy for futures markets decades later. The CCC created a stable grain storage site to extend credit to farmers and bore the risk of grain storage, but it was big, expensive and negatively affected private grain traders who actively worked to regain control of storage.

Grain traders actively worked to limit CCC's influence because the CCC, along with other state interventions, had a direct effect on the operation of ACEs. The decline of the ACEs and futures markets began in the 1930s as CCC-managed stocks increased (F. M. Jones 1947).[52] Grain traders focused on the role of risk and the control of grain storage. For example, C.C. Farrington, of Archer Daniels Midland, stated the CCC carried the speculative risk at a cost to taxpayers:

> This, of course, has a tremendous impact on the futures markets and those agencies using them. I hardly need labor the point that to the extent to which the government carries the risk, the mechanism of the futures market is put on the shelf. (Farrington 1950, 952)

[51] The CCC was not the only federal agency providing credit. By 1947, the federal government was using at least six other agencies to give direct loans to farmers, including the Farmers' Home Administration, the Regional Agricultural Credit Corporation, the Rural Electrification Administration, the Federal Farm Mortgage Corporation, the Disaster Loan Corporation, and the Emergency Crop and Feed Loan Division of the Farm Credit Administration (Benedict et al. 1947, 1442).

[52] The outbreak of WWII led to the suspension of trading at the Liverpool Corn Exchange, and at the Buenos Aires, and Winnipeg exchanges. Corn futures were suspended in Chicago trading. The decline was significant – CBOT wheat contracts declined 77 percent between 1936 and 1943 (F. M. Jones 1947, 64).

Grain traders relied on “sensitive markets” with fluctuating prices, whereas the CCC was designed to stabilize prices and manage stock fluctuations, while supporting farmers’ incomes (Shepherd 1942a, 590). The control of grain storage had a direct effect on who could access asset streams.

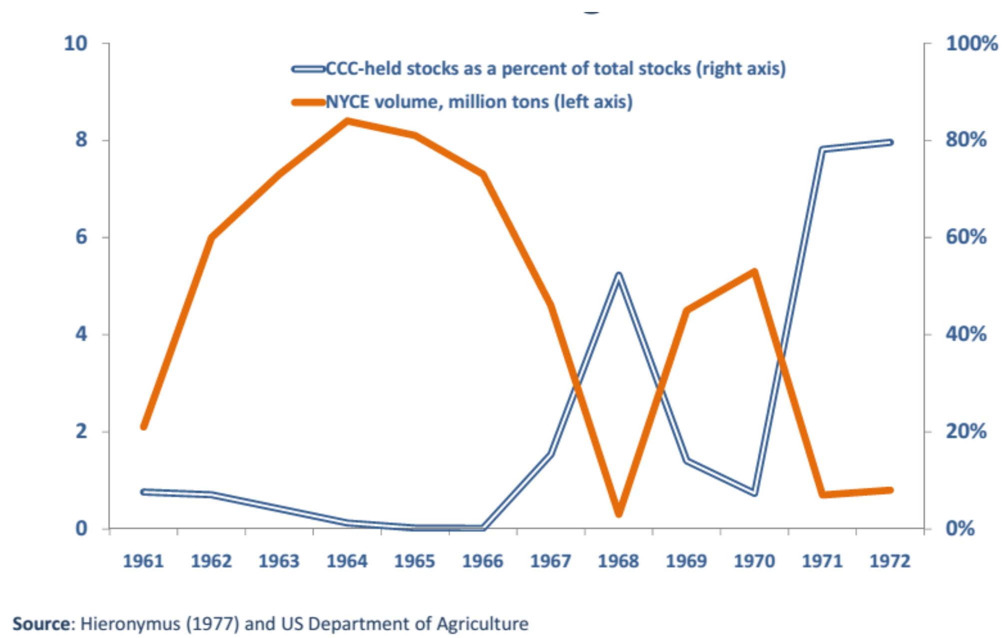


Figure 3: Interaction of CCC stock holding and commodity exchange, entitled: “When governments intervene, commodity futures exchanges suffer” (Baffes 2011, 8).

The design of the CCC was shaped by the failure of an earlier state project that tried to leverage ACEs to support depressed agricultural prices. The Grain Stabilization Corporation (GSC) was established by the Hoover administration in 1930 to buy grain futures and surplus grain in an effort to raise prices. By 1932, the GSC owned one-third of the US wheat crop and accounted for two-thirds of the open interest on three US exchanges (Fausold 1977). But the GSC lost money as world commodity prices continued to slide, and futures traders went short as the government went long (Markham 2013). Critics of state intervention cited the GSC failure to argue against further government interference in the working of the markets because it negatively distorted agricultural prices and the operation of commodity exchanges (Working 1954). The government's venture into speculation was roundly viewed as a failure (e.g. Chicago Tribune 1931, 14).

The CCC was established during the Roosevelt administration in 1933 to manage agricultural commodity marketing along with other New Deal programs. It was a combination of financial and commodity regulation. The Reconstruction Finance Corporation (RFC), an institution designed to renew confidence in, and support for, banks by distributing loans, managed the CCC from 1933 to 1939. Under the RFC, the CCC managed the ever-normal granary, or the national grain reserve. It was designed to buy grain during times of surpluses and sell during times of scarcity – when grain was plentiful, it would buy reserves cheaply, and when grain was scarce, it would distribute and sell stocks at a gain. The RFC connected the grain reserve to the revitalization of US banking, and financial policy. The key mechanism that tied banking to commodity storage was loans to farmers.

4.4.1 CCC Loans: Stabilizing Prices

The structure of CCC's loans was a crucial connection between banking and grain storage because it helped to stabilize prices, and it helped to stabilize the value of stored grain. The loans were designed to support farmers, and to revitalize rural banks by running the credit notes through local county banks. The CCC made loans to farmers based on the market value of crops, and, at times, above the market price (Torgerson 1940). The CCC took on the risk of storing grain, which helped to stabilize prices. The CCC connected grain storage to private lenders through non-recourse loans.

The distinguishing feature of non-recourse loans is that borrowers are not personally liable for the secured collateral. The farmer-borrower could choose to pay interest on the CCC loans, or forfeit the stored commodities in lieu of payment. If the borrower defaulted, the CCC took the grain-collateral as repayment, but had no other claims on the loan. The CCC purchased the loans made by commercial banks and other lenders and extended non-recourse loans to farmers (Torgerson 1940, 205). Most of the loans were closed through lending agencies and banks in farm regions, for which they received a one-percent fee for managing the notes. By 1954 that fee had been raised to three percent (Gilmor 1947; USDA 1954, 355). The result was that the CCC guaranteed the nonrecourse loans and provided a riskless opportunity for banks (Trigg 1948, 17).

The CCC loans had an effect on commodity prices and price differentials by solving a long-standing problem in the US market. The CCC had to administer loans based on the value of grain in storage. The calculation of value was complicated by the varied storage locations, varied grain grades and conditions, and the different times of the year. The price differential, for example, between Iowa City and Chicago was determined by calculating the costs of storage and transportation. It is difficult to value grain because commodity prices rise and fall, and there may be variance in grades and other standards. The CCC had to extend loans to various areas across the grain-producing regions by determining loan rates based on stocks and transportation costs. The CCC standardized price differentials between grades and determined loan rates. The CCC "solved the problem [of price differentials] at one stroke" where "marketing men" had failed (Shepherd 1942b, 609). The flat loan rates also affected storage costs, because prices were expected to rise from a low during harvest (in the fall?) to, generally, a high in the spring – enough to cover storage costs. But the flat rate of the CCC's loans was stable throughout the year and was unaffected by market prices and seasonal price adjustments (Shepherd 1942b). The CCC had established standard prices for grain and for storage by focusing on stability, unlike the variability of prices over the agricultural year that sustained ACEs.

The stabilization of prices was settled by the CCC, but the increasing stocks – the grain that the government took as loan repayment, or that was set aside for collateral – became a concern for the CCC and the Department of Agriculture, which took over the administration of the CCC from the RFC in 1939. US agriculture production was creating larger and larger grain surpluses and the pattern of good and bad harvests was not cyclical. This led to massive surpluses (J. S. Davis 1938; Jesness

1958; Schultz and Wolfe 1942). The ever-normal granary was the "ever abnormal granary … easy to fill; hard to empty" through the 1940s and 1950s (Jesness 1958). The CCC reduced the risk to farmers, and it is credited with creating a significant stimulus for agricultural productivity and industrialization after the Second World War (Gardner 2002).

4.4.2 The CCC and the Grain Trade

The CCC had long been a target for critics, and there was ongoing pressure to disband government reserves. There were three groups who led the attack on the CCC programs. First, as discussed in Chapter 3, the Chicago Futures School argued that any government intervention in the market constrained ACEs and disrupted the free market. Supporters of ACEs stated price signals efficiently determined the supply and demand of a given commodity and stockholding without a high cost (Hieronymus 1977), while government control interfered with the free market and resulted in a high cost (see Chapter 3). In the post-war period, while some economists supported government storage programs that acted "in the public interest," these endorsements came with caveats that government should not interfere more than absolutely necessary (e.g. Tolley 1945, 531). Second, many Congressional and farm leaders attacked the CCC on ideological grounds. Senators from farm states called the CCC's loans on agricultural commodities "socialistic," claiming they gave the CCC the "power of life and death over the agricultural market" (Strand 1942). Senators raised concerns that farmers' "gambling spirit" would be stifled and that the CCC was a "dangerous, dark and ominous cloud" that was the "highest scheme of socialism that has ever been proposed to Congress" (Strand 1942).[53] Oscar Olson, president of the Farmers Elevator Association of Minnesota stated: "If you let grain all pass into government channels you are going to socialize it as has been done in Canada, England and many other countries" (*Chicago Daily Tribune* 1952b, 20). After the Second World War,

[53] The CCC also had its defenders. For example, the Truman administration pointed fingers at the undue influence of the "speculative grain trade" on the Congress (O. P. Williams 1957, 118).

the large grain traders and the Republican-dominated Congress protested that the CCC's grain storage and grain handling was squeezing out the free market and letting socialism creep in (*Chicago Daily Tribune* 1949a; *The Christian Science Monitor* 1950). Third, and the focus of this section, large grain traders opposed the CCC because it constrained their ability to leverage the financial function of futures markets since they no longer had control and ownership of stored grain. However, I will show that the grain trade benefitted significantly from the CCC's payments even though ACEs were of limited use at the time. The CCC also provided new opportunities for the manipulation and swindles that had long been found in the grain-storage business.

The CCC was a direct competitor to large grain traders who pushed back against government control of grain storage. After the Second World War, grain elevator representatives and traders in Chicago represented the CCC as a "big threat" to their operations ("CCC Assailed" 1950, B5). The National Grain Trade Council wanted a curb on CCC storage to prevent direct government competition (*Chicago Daily Tribune* 1949b, B5). For example, *A Declaration of National Marketing Policy,* which came out of the 1949 national meeting of the commodity marketing association, stated:

> We are convinced after careful study that the Department of Agriculture through the Commodity Credit Corporations is steadily invading the field of farm marketing to an extent where the best interests of American agriculture are in jeopardy. Farmers and consumers will not gain [from the] action of the Government. … Instead, such activity by the government will lead to inefficiency, high costs, and to abuse. (as quoted in Stine 1950, 941)

The CCC, according to a representative of Archers Daniel Midland in 1950, was displacing brokers and commission firms and the speculative risk of merchandising had been pushed onto taxpayers. He continued that storing grain in terminals was now a "hand to mouth" business for the grain trade, and the consumer was left bearing the risk (Farrington 1950, 10). The Federation of Cash Grain Commission Merchants stated that the CCC was also displacing terminal representatives and that this was resulting in poor grain management and serious losses due to spoilage (*Chicago Tribune* 1950).

Through the 1950s, the CCC's rising costs, surpluses, and carry-over stock became a target for criticism, in contrast to the efficient workings of ACEs. A Chicago Tribune editorial claimed that the CCC's management was inadequate and resulted in spoiled and missing grain, whereas private brokerages and commission houses could successfully track the grain by using commodity exchanges (*Chicago Daily Tribune* 1952b). M. D. Guild, Indiana Grain Cooperative manager, stated that the economy is "rigged" because of government intervention which created maladjustments, and the CCC had to deal with the surplus, or "bury the corpse" (1958, 112). According to an Archer Daniels Midland representative, futures and open liquid markets "are economically efficient in moving grain in space and time from producer to consumer" (Farrington 1950, 4). CCC ownership of grain restricted the ability of grain firms to leverage the financial function of futures markets. But grain traders were also benefiting from the CCC's ongoing and generous storage payments and guarantees, and this created tensions.

Although the CCC managed and funded the national grain reserve, large grain traders and elevator operators still controlled and owned a large part of the grain storage infrastructure (see Chapter 6). The CCC could not own property under its 1948 Charter (see Chapter 6). The result was that the CCC had to pay and contract large grain traders to store grain. On one hand, the CCC was responsible to manage grain. On the other hand, it was constrained because it could not own property. This meant that elevator operators and grain traders had a monopoly on large scale storage such as terminal elevators, and the CCC was its biggest customer. In a series of presentations and talks at the CBOT, representatives of grain trading companies spoke about the CCC: "The CCC is the terminal elevator operator's biggest customer for warehouse space and his biggest competitor in handling grain" (Westley 1957, 115). The CCC was a "good customer" and operated as the "bread and butter for terminal elevators" (Raskin 1958, 125). In short, the CCC had to bear the cost and risk of stored grain, but at the same time it had to pay grain traders to store the grain. In turn, the instability of grain was used to the grain trader's benefit in its relations with the CCC.

The US Government Accountability Office (GAO) audited the CCC and found numerous problems with the grain-storage management carried out by the contracted elevator operators. These included warehouse operators selling grain that was contracted to stay in multi-year storage, and false bottoms built into bins and rail cars (*Chicago Daily Tribune* 1952a). Some shippers and elevators used "plugging," a practice that placed sand under grain just below the five-foot level of grain inspectors' sampling tools. Harold Tanner of Colorado was contracted to manage $1 million USD of CCC stored crops and he stated that he felt "free to do what he wanted" (*Chicago Daily Tribune* 1952c, 17). Tanner "converted" stored grain – that is, he sold the grain at a high price, hoping to replace it when the price dropped. He easily misled inspectors as he embezzled funds by selling grain contracted for long-term storage (*Chicago Daily Tribune* 1952c). A similar swindling technique involved capitalizing on the "inordinate time lag between the issuance of loading orders and the shipment of grain," which meant that operators could buy grain as needed and also collect storage fees without actually having to store the grain (US Senate 1952).

The GAO report identified a particularly egregious example of a contract between the CCC and Cargill. The contract guaranteed $612,500 USD for storage at Cargill's Norris City Elevator in Norris City, IL, whether or not the facilities were used (US Senate 1952, 1099). This was an unusual agreement because it guaranteed a minimum income rather than guaranteeing storage, which meant Cargill was paid whether or not grain was stored. In total, Cargill was paid over $1.2 million USD between April 1950 and April 1952 for storage at Norris City (US Senate 1952, 1099). The contract was made directly with the son of Cargill's president at the time, and although the contract was questioned by Chicago CCC staff, their doubts were overruled in Washington (US Senate 1952).

Paul J. Cotter was chief counsel to the Senate hearing committee on the CCC, and he summed up the problems with Cargill's contract with the CCC: The facilities were not ready at the start of the contract; the grain was stored in reconditioned fuel oil and ethyl gasoline tanks, which meant that the grain could not be conditioned properly; Cargill lagged on deliveries, which was suspect; and Norris City was an unusual if not inappropriate site at which to store in-transit grain (US Senate 1952). The chair of the Senate hearing stated that "the facts so far confuse me as to the responsibility of the warehouseman," which is reasonable given the fact that the CCC only held warehouse operators responsible when they knowingly let grain get out of condition. This left the warehouseman significant room to sidestep responsibility (US Senate 1952, 1120). Cargill was not held responsible for the loss of spoiled grain, although there was testimony that Cargill did not take proper steps to save grain even though it knew the grain was going out of condition ("Grain Storage Probe" 1953).

The GAO report highlighted the issue of poor grain management, indicating that losses due to poor management exceeded those of embezzlement ("Grain Storage Probe" 1953, 83–5). There were numerous examples of dead storage units in which the grain was difficult to condition or remove from bins. For example, a flood along the Illinois River damaged grain in bins in 1951; the grains could not be emptied properly to separate the good grain from the spoiled grain, and thousands upon thousands of bushels of corn had to be disposed of or sold as feed (*Chicago Tribune* 1951). Secretary of Agriculture Brannan blamed private grain traders' malfeasance and fraud for the losses of the CCC grain, pointing to "misconduct by individuals in the grain trade" (US Senate 1952, 5). He claimed that if the CCC owned and operated elevators, the problems would be minimized. The CCC, with its enormous draw of resources, also paid out an enormous amount of funds to the grain trade to manage grain.

On one hand, the CCC provided new asset streams to farmers through non-recourse loans based on stored grain. On the other hand, the CCC's management of the grain created ongoing opportunities for the grain trade to misrepresent and swindle, similar to the practices of the nineteenth century. Perhaps the most important effect of the CCC was on constraining the operation of ACEs. From the inception of the CCC, the futures markets had not "reflected their normal relationship," to the grain market, which made hedging difficult, according to elevator operator Orrin S. Dowse (quoted in Peck 1978). By the early 1960s, critics were pointing to the CCC's considerable costs and losses,[54] and support for the CCC began to wane. It would take over a decade before the CCC and its influence would give way to a new model of grain storage management.

4.5 Regulatory Destabilization: Market Solutions and Storage Failures

Changes in domestic regulations that governed agricultural commodities were shifting in the 1970s. The 1936 Commodity Exchange Act (CEA) established the Commodity Exchange Authority, together the CEA and the new authority limited commodity speculation and banned options trading on domestic agriculture commodities.[55] But new futures contracts were introduced in the 1960s, involving nonagricultural derivatives like gold futures and securities issues (Peck 1985). The CEA and the Commodity Exchange Authority was limited to regulating agricultural derivatives. Regulators and futures market groups agreed the CEA should be amended to adjust to the introduction of new derivative products (Schief and Markham 1978). In 1974, the Commodity Futures Trading Act was passed, which established the Commodity Futures Trading Commission (CFTC). The Act and the CFTC covered the new futures markets and products, and the definition of commodity was expanded to include "all other services, rights, and interests" related to futures contracts, which opened the door to a much wider set of financial products beyond agricultural derivatives. Futures markets began to grow very quickly beyond agricultural commodities, and were increasingly viewed as "financial or

[54] From 1934 to 1949, loans totaled over $7.5 billion USD, with a loss of $387 million USD (Stine 1950, 395).

[55] Commodity speculation began to be regulated with the Cotton Futures Act (1916), and further regulated with the Grain Futures Act (1922). These acts sought to limit market manipulation by making trading information public and centralizing trading on regulated exchanges.

price markets" designed to execute contracts and financial rights, rather than strictly as commodity markets (Clark 1978, 26). The change to the CFTC provided new pathways for new financial actors to access both agricultural and non-agricultural derivatives. In turn, ACEs would become a more legitimate platform for grain storage by the 1990s (see Chapter 6).

4.5.1 1980s Farm Crisis

Up until the 1970s, the US federal government had managed grain storage and backed warehouse receipts through CCC loan programs and supports. But the costs of the CCC were mounting and in the early 1970s there was increased pressure to reduce the costs of the program. In fiscal year 1973, the CCC reported a $4.09 billion USD loss, second only to 1970's $4.21 billion USD loss (US GAO 1976, 1).[56] The CCC continued to manage the national grain reserve until a major policy shift occurred in 1977 when the US Food and Agriculture Act was passed. The cornerstone of the new policy was a farmer-owned reserve that encouraged farmers to hold grain with the intention that their management and control would help to stabilize prices. The Food and Agriculture Act directed the Secretary of Agriculture to administer a farmer-owned reserve program and pay the annual storage costs of the grain, as well as to waive or adjust interest rates. The Farmer-owned reserve was a voluntary program, and was designed to induce farmers to carry grain stocks even with some support from the government (Chambers and Foster 1983). The control of grain storage was now in the hands of the farmers. While this shift appeared to be straightforward, it had a number of consequences for storage and warehouse receipts. Warehouse receipts were the link between the farmer and the grain

[56] Most of the costs in 1972–73 pertained to Public Law 480 and the sale/donation of agricultural commodities. These figures are qualified by the GAO. The GAO states unequivocally that the "character and vast scope of CCC's operations –particularly commodity inventories and loan collateral – made it impracticable to judge the accuracy of financial statements" (US GAO 1976, 31). The diversity and number of storage facilities meant that they were impossible to quantify, and this was complicated by "domestic and world supply," among other factors (US GAO 1976, 31). This is important because it meant that the CCC could neither easily nor accurately value its inventories.

elevator, and when these conditions changed, farmers were exposed to a number of risks associated with grain storage (Culhane 1983).

The grain trade in the US is dependent on the terminal grain elevators located in ports in places like Chicago and New Orleans, but also the extensive organization of private grain-handling facilities and cooperative elevators.[57] This network provided points of assembly, conditioning, storage, and shipping to processors, terminal elevators, and exporters (Looney and Byrd 1982). Storage and grain management alone was not profitable, and most of the warehouses made their money from grain merchandising, which was risky. In addition, some state regulations required operators to hedge on commodity exchanges to protect their stocks from volatile grain prices. The high-interest loans of the 1980s combined with volatile prices, contributed to a series of grain elevator bankruptcies and, in turn, losses for farmers (Culhane 1983).

Culhane (1983) described how the conditions of the 1980s led to warehouse bankruptcies and how farmers bore the cost. Warehouse operators were required to use the futures markets to hedge, but this exposed them to the risk of margin calls. Many farmers had signed deferred-pricing contracts with warehouses in the hope that prices would rise; however, the combination of volatile prices and high interest rates contributed to warehouse operators having to sell farmers' grain to meet margin calls. The deliberate issuance of storage receipts against nonexistent grain frequently occurred when a warehouse needed to raise cash quickly to meet a margin call from the commodity exchange (Culhane 1983). The risks of the contracts, however, were borne by the producer, according to Culhane (1983); for example, farmers were left with warehouse receipts but no grain. As Looney and Byrd stated:

> [S]ince the collateral may no longer be located in the facility because it is continuously moved along the chain of distribution, the farmer might find himself in the position of a secured creditor, but with no collateral remaining. (Looney and Byrd 1982, 17)

[57] The CCC storage operations contributed to a decline in the use of terminals and shifted storage closer to production (see Chapter 6).

Farmer-owned grain in warehouses secured with warehouse receipts or scale tickets[58] led to a series of problems (Looney and Byrd 1982, 18).

There were extensive bankruptcies during the 1980s, including those of farmers who thought that their grain was secured with bonds, insurance, and warehouse regulations. The problem was that in practice, grain elevators and warehouse receipts were no longer secured by the CCC, and the farmer-managed grain reserve left farmers bearing the risk. Elevators had underinsured much of the grain in storage, and valued an $8.00 USD bushel of grain at as little as 20 US cents (Culhane 1983, 702). The relationships between farmers and storage sites were mediated by warehouse receipts, but these documents of title could not protect farmers (Looney and Byrd 1982, 3). The experience of the 1980s echoed that of early Chicago warehouse operators, who leveraged stored grain in a variety of ways – what Williams (1984) called a form of fractional-reserve banking. However, the beneficiaries here were rarely the sellers, or "depositors."

Since the advent of farmer-owned reserves in 1977 the CCC support for storage had eroded. The commercial sector was expected to step in and provide adequate storage capacity by buying low and selling high and using futures markets to hedge and manage market risks. However, private companies did not want to take on the risk of holding grain stocks (Johnson 2012). By the mid-1990s, CCC grain stocks were negligible because farmers and private industry were not willing to take on the risk of holding stocks (Johnson 2012). The CCC had managed a national grain reserve and bore the cost and risk of carry-over stocks, whereas private actors were less willing to hold onto stock from year to year. The result was that very little buffer stock was available in years of low harvests.

[58] Scale tickets would be treated the same way as warehouse receipts under the UCC.

The risk of grain storage was shifted to farmers, and increasingly to on-farm storage. The risk to farmers was very high: "returns from storage may be measured in pennies. The loss from just one bin of grain is measured in dollars" (Krischik, Cuperus, and Galliart 1995, 14). The storage and marketing of grain required capital investment and careful management as well as marketing skills (Krischik, Cuperus, and Galliart 1995). Agricultural markets were becoming increasingly volatile, which required new kinds of risk management tools to manage the market (see Chapter 6), and a new kind of decentralized physical infrastructure to manage the grain (See Chapter 5 and 6).

4.6 Conclusion

Regulatory stabilization shifted the control of storage from private hands to public hands and back into private hands. I showed that regulatory stabilization was an on-going process that was required to collateralize and secure stored grain. With and without regulatory stabilization, the dynamic character of grain posed obstacles to securing collateral at grain storage sites. The state increasingly produced regulations in an attempt to stabilize the value of grain in storage through warehouse regulations and legitimating documents of title such as warehouse receipts, yet the instability of grain in storage was too risky for bankers. It was too risky for bankers until the state fully backed collateralized stored grain with the CCC's non-recourse loans. This provided secure asset streams for farmers and a revenue stream for bankers who provided the loans, but resulted in a huge cost for the government as it had to pay for the cost of storing massive grain surpluses. When the state started to pull back from supporting stored grain collateral through the CCC in the late 1970s due to increasing political pressure, farmers began to rely on the unstable character of warehouse receipts without the full backing of the state. In addition, the CCC affected the growth of the agricultural futures markets. When the CCC bore the market risk, and managed the grain reserve, ACEs were made superfluous. However, grain traders were able to leverage their storage facilities and use the on-going storage income from the CCC to leverage and gain capital, even as they complained at the loss of access to ACEs.

This chapter examined the interaction of the regulatory tools and practices of ACEs (warehouse receipts) and how these credit practices were adopted by the state in the early twentieth century. The state used regulations to secure and collateralize stored grain, but bankers were still reluctant to extend credit. In turn, the CCC linked credit, stored grain and farmers and was backed by the state with a national grain reserve during the mid-twentieth century. While Levy (2006) has highlighted how warehouse receipts facilitated abstraction and dematerialization, I have highlighted how financial practices are enacted through material actors (Porter, 2013). I also focused on the breakdowns of translation such as fraud and swindling, following Latour (2005). The work of warehouse receipts and the work of creating collateral from stored agricultural commodities is made visible by tracing the shifting regulations that help to secure and stabilize the values of agricultural commodities. The CCC was able to standardize and stabilize agricultural goods, but at a cost. Regulatory stabilization is an ongoing practice that helps to highlight the unstable and dynamic quality of agricultural goods in storage. During the nineteenth century and into the early twentieth, state regulations certified and standardized the warehouses that issued warehouse receipts to establish and secure credit.

The twentieth-century US state legitimized warehouse receipts and incorporated them into national agricultural policy in the early twentieth century through a program of loans, based on the value of stored grain, that helped to establish credit and collateral for farmers and to manage the national granary. The long-standing problem of establishing credit for farmers was partially solved with the creation of a grain reserve backed by the resources and security of the state. Warehouse operators, ACEs, and state institutions used warehouse receipts to translate lively and unruly grain into a stable object that could be used to leverage capital. The warehouse receipts were a crucial link to developing asset streams. Warehouse receipts were a product of nineteenth-century ACEs, but were legitimized through state regulations, and secured with state resources.

Chapter 5– Physical Stabilization I: Assembling Grain Management

Once harvested, grains or seeds are hidden away out of sight in dark bins or tanks or warehouses –- and in most cases - out of mind- until they are loaded out weeks, months, or even years later.

-Clyde M. Christensen 1980, 1068

Farming allys [sic] with living things, fixed in the soil; industry deals with lifeless and mobile materials.

–John M. Brewster 1950, 3

5.1 Introduction

On July 28th, 2010, in Mount Carroll, Illinois, Bin No. 9 held a quarter-million bushels of high-moisture shelled corn. Three young men entered with pick axes and shovels to "walk the grain" (OSHA 2013). The grain was "hung-up" – the corn had been cemented together with mold mycelium, which formed into bridges and clung to the inside of the four-story-high walls – and it could not flow smoothly into the auger at the bottom of the bin. As the grain was broken up by the men, it started to flow, and Wyatt Whitbread, 14, and Alex Pacas, 19, fell into the quicksand-like grain, were engulfed, and suffocated to death. The third young man, Will Piper, 20, survived and said, "I had no idea that someone could get trapped and die in the corn" (Morris 2013, np). A few months earlier, on April 27th, a few hundred miles away in Chester, Illinois, a Con Agra grain bin had exploded, injuring four salvage workers. In the resulting trial, at which the workers were awarded $180 million USD for their injuries, it was reported that the wheat had been smoldering for months and the company had been warned that the bin was dangerous (Fox 32 News 2012). Over the last 35 years, there have been over 500 explosions in grain-handling facilities across the United States, which have killed more than 180 people and injured more than 675 (OSHA 2014, np).

In both examples, the managing corporations were convicted of serious safety violations: a lack of safety training in Mount Carroll, and holding on to dangerous and smoldering grain in order to get a better price on the market in Chester. Bulk grain in storage is dynamic – an unruly force that requires continual management. Ongoing grain management is needed to stabilize grain for the health and safety of both the industry and its workers, and to preserve grain for the market. Clumps of mold mycelium that form within the moist conditions of storage bins can block augers, create dangerous working conditions, and produce mycotoxins that are dangerous for animals and humans to consume. In addition to the dangers described above, workers may also be exposed to unhealthy levels of airborne contaminants, including molds, chemical fumigants, and gases associated with grain storage. It comes as no surprise then that the US Occupational Safety and Health Agency (OSHA) identifies the grain industry as "a high hazard industry" (OSHA 2014, np).

The instability of grain is made visible during sudden accidents. But the conditions that contributed to the accidents took decades to develop. The physical stabilization of grain storage is the assemblage of grain management practices and infrastructure. As agricultural products are delivered, graded, aggregated, scaled and stored, they are transformed into 'stable' valued commodities (Cronon 1992). Technologies were designed to work with grain, and also shape and structure the environment and physical actions of grain with the aim of stabilizing and maintaining its value for later markets and/or consumption.

There are three reasons why a close examination of physical stabilization helps to illuminate how asset streams are accessed. First, starting in the 1930s, the US government conducted research and developed new techniques to physically manage its grain stocks, and in particular, to manage and stabilize surplus grain in long-term storage with agro-chemicals and other technical interventions to prevent spoilage and pests. An analysis of grain management techniques illustrates the crucial role of the US state as a technical manager of grain, and how the agro-chemicals commonly used today were originally developed. Decades later, these same grain-management techniques were exported alongside surplus US grain. The outcome was a model of industrial grain storage that was developed to protect the CCC's grain and collateral. Why have I turned my attention to the aspects of grain management that are usually left to experts such as entomologists, engineers, and other specialists? This leads to the second point, the technical practices of experts help to assure the quality of stored grain, which then can be valued for collateral and leveraged for credit. Grain management is an on-going process that relies on expertise and specialized knowledge, but with the end of the national reserve, that expertise has dwindled. Third, grain storage is not limited to human actors; non-human actors also shape the politics of grain management, and require new grain-management techniques to stabilize grain. Politics is considered a human domain constrained by the material – but Bennett (2010) shows how material things also act, and can shape human actions. Grain is vital and inherently unstable – it transforms, or "acts" – it sprouts, holds and releases moisture, and can spoil and become unfit for the market. Further to this point, a close examination of physical stabilization shows the vital quality of grain in which grain is not a unitary actor but one that is part of a collectivity that creates problems and disruptions for grain managers.

Grain management is a technical practice that does not appear to be a political act, but I show how technical practices are political using Barry's (2006) technological zone frame. A technological zone is "a space within which differences between technical practices, procedures or forms have been reduced, or common standards have been established" (Barry 2006, 240). A technological zone is an assemblage of measurements, infrastructure, and common standards that is path-dependent, according to Barry. Access to the zone is limited experts who can negotiate the varied measurements, connections, and qualifications that extend, in this case, grain-storage governance into new areas. Because technological zones are dependent on this expertise, time is required to generate the knowledge and resources to navigate these zones. So while the zones are path dependent the outcomes are uncertain and changeable because they take decades to establish. Barry's (2006) attention to human and non-human elements can help explain how the dynamic and unpredictable physical characteristics of grains combine with moisture, mites, insects, and molds to make up collectivities of grain. When grain storage is viewed as a technological zone, the limits and failures of storage come into view – limits that may not be recognized by those who are promoting its development. The technological zone frame helps to highlight the long period of time it takes to establish expertise in grain management practices, the role of non-human actors and the unpredictable, or unintended, consequences of grain storage management.

Grain storage management became a key issue for the US because it was confronted with maintaining large grain stocks, an outcome of massive mid-century production surpluses and farmers using stored grain as a source of collateral to access loans from the CCC. More recently, new ACE projects and warehouse receipt projects have developed to build agricultural markets using the same techniques, as will be expanded on in Chapter 7. Financializing agricultural commodities through new ACEs and warehouse receipts projects by aggregating agricultural goods, and establishing collateral relies on industrial grain storage techniques, such as fumigants and dryers as described below. The physical stabilization of grain with industrial practices is one aspect of the assemblage needed to establish asset streams based on collateralized stored grain. Ideational and regulatory stabilization are also required before asset streams can be established and financialized. The industrial model of grain storage was developed to manage an industrially produced grain; initially a state project, it was repurposed as an essential part of contemporary market-building projects. The frame of the technological zone helps outline both the human and non-human actors that make up the physical stabilization processes that contribute to the assemblage of grain-storage governance, and helps map out its changes.

The chapter begins with a brief discussion of grain management, and then ventures into the grain fields, bins, and laboratories to examine the practices of US industrial grain management. To understand the dynamic quality of grain and the impact of new industrial farming techniques, I first examine how agronomy and harvesting technologies affect grain destined for storage. When aggregated in storage, grain can take on new qualities, and transform. For example, bulk grain storage technologies fostered collectivities of fungi, insects, and mites that otherwise did not exist outside storage. The chapter then examines how US agricultural engineers, mycologists, entomologists, and other experts developed grain-management systems to stabilize grain and to battle pests. New technologies such as mechanical dryers were developed to dry grain destined for storage. Conflicts and debates arose about what constituted an accurate measure of moisture and new measuring standards were put in place, which illustrated both the extent of the technological zone of grain management and the challenges associated with trying to stabilize measurements for grain. The chapter then shows how experts, primarily associated with the Department of Agriculture and land grant colleges, developed agro-chemicals such as fungicides and pesticides that worked hand-in-hand with new kinds of grain containers such as grain bins (see Chapter 6). These grain-management technologies and methods were interdependent and co-evolved with the grain as it was dried, binned, protected and managed. The development of new kinds of seeds, mechanization, and the increased mass of grain during the twentieth century fostered new storage problems and new grain management solutions. Grain-storage management practices and technologies were exported along with the US grain surplus, showing how a specific assemblage of grain storage was developed. An example from the 1960s illustrates the roles of a land grant college and USAID in exporting such technologies. The chapter ends with a summary and a discussion of some of the limits of the ANT approach to physical stabilization.

5.1.1 Grain Management

What is grain management, and how is it connected to the futures market? Grain managers work to maintain the "biological, chemical and physical qualities" of grain (Guine and Correia 2013, 23) after the point of harvest. Once grain is harvested and in storage, the quality cannot be improved – it can only be maintained. The management of grain is complicated by the interactions among stored grain and temperature, moisture, insects, mites, fungi, and bacteria. A grain bin is a biological system, or a grain storage "ecosystem," with changing levels of moisture, temperature, and varying lengths of storage time – all factors that affect the stability of grain and its quality (Jayas, White, and Muir 1995; Krischik, Cuperus, and Galliart 1995). Grain-management literature describes the relationship between storage and the market in a variety of ways, including "equilibrating fluctuations between supply and demand," similar to a buffer (Jayas, White, and Muir 1995, 3), and improving the quality and the adoption of efficient technologies and increasing income (Soda, Mazaude, and Troude 1995, 152). Grain managers' work ameliorates physical conditions such as the environment and climate and the flow and distribution of grain from field to market, as well as future market conditions and financial costs (Guine and Correia 2013, 27).

Grain management techniques vary according to market relations and location. For example, US and Canadian grain-management practices are directly linked to the market because of those countries' political and economic systems (Sinh 1995). Sinh (1995) compared grain management in developing countries and developed countries. In developing countries, grain storage is a problem site dominated by pests and "controlled by natural factors," whereas in developed countries stored grain systems are "primarily controlled by the markets" (Sinh 1995, 10). In short, in industrialized countries, the existence of stable grain storage leads to market control, and eases trade and commerce. A close examination of the storage technologies that "controlled natural factors" shows that these technologies were developed over the twentieth century by the US state when the CCC became the custodian of a massive grain surplus. As such, the US state was a major grain manager that developed technological tools that are still used today.

The changes in grain storage over the twentieth century created a series of problems for agricultural engineers and scientists. Grain can be stored for years if properly "conditioned" and handled. But under improper conditions it can spoil quickly. Some of the problems can be managed with proper storage construction and facilities; however, the condition of the grain itself is critical. Injured grain that was mishandled during harvest or that has a high moisture content provides the opportunity for grain to go out of condition. In times of surplus, these problems multiply rapidly. Thus the management of grain is a critical facet of agriculture and markets that goes largely under examined except by experts in agronomy and agricultural engineering.

5.2 Field Technologies

The U.S. farmer, under the excellent tutelage of the chemist and agronomist, has been trying to make two ears of corn grow where only one grew before

– Kenworthy 1955, np

The management of grain in storage changed with the introduction of mechanization, new seeds, and high-yield production. This section shows how four twentieth-century transformations made grain less stable and more vulnerable in storage. First, agronomists produced new seed varieties that had higher yields, but were more likely to have a higher moisture content and thinner skins and be more prone to injury (MacMasters 1953; Wicklaw 1995). Second, mechanical harvesting was hard on grain, and more likely to leave nicks, cracks and breaks, which created openings for insects and fungi, and problems in storage (Oxley 1948). Third, the speed of mechanical harvesting contributed to a rise in high-moisture grain, which further increased the grain's attractiveness to fungi and insects. Last, bin storage containers started to be used, which made it harder to manage the grain in comparison to elevators, which could mechanically move the grain, or corn cribs, which were open to the air (see Chapter 6).

High-yield and long-season hybrid seeds spurred production gains in the early and mid-twentieth century, but the new seeds were less amenable to storage environments. Domesticated grains have been bred to reduce tannins and thick skins (Wicklow 1995), but this makes seeds more vulnerable to insects and other pests. The newly developed hybrid seeds with thinner skins tended to be more vulnerable to pests and injury than older varieties (MacMasters 1953; Proctor 1994; Wicklow 1995). In addition, the hybrid seeds' longer growing season exposed the grain to more moisture, which it carried into storage (MacMasters 1953). On one hand, the new hybrid seeds improved grain production; on the other hand, the new seeds were bred for production rather than storage, which led to increased problems for grain management.

Grain storage problems were also worsened by new mechanical harvesting techniques. The introduction of combine harvesters posed "a modern problem" in that "saving man-power is of the utmost value," but this posed "storage difficulties" (Oxley 1948, 1). Before mechanization, grains such as wheat and corn were dried in the field[59] and "reached the market at a leisurely pace," but harvesting was a labour-intensive and long process (Schruben 1973, 802). Fields of grain were shocked, or stooked, by hand (see Figure 4), and left in place to dry (Oxley 1948). The careful construction of shocks helped to protect the bloom of the grain, and stacking helped "conduct the heat [and moisture] away" from the grain (Fitz 1910, 8).

[59] "Artificial" grain drying is not unknown. For example, furnaces were set up in Roman Britain to dry grain (Applebaum 1958).

Figure 4: Shocks of wheat in field, Wahpeton, N.D. State Historical Society of North Dakota (00006-12

A nineteenth-century agronomist described the management of grain after threshing, which included sunning over two or three days to encourage the bloom of the grain, which prevented “musty flour, or flour that loses its life and capacity to rise well in bread” (W. L. Jones 1888, 13). He advised that wheat could not be stored in “too great bulk,” as that could lead to spoilage (W. L. Jones 1888, 13). In the pamphlet “Handling Wheat from Field to Mill,” a Department of Agriculture agronomist highlighted how “caring for the wheat crop” would increase farmers’ income (Fitz 1910, 5). He continued by describing how field-dried grain “sweats” in the stack, but that little was known about the process except that a “chemical or enzymic action within the plant occurs” (Fitz 1910, 8). Properly field-dried grain resulted in highly desirable milling grain, and field-dried grain would generally command a price superior to mechanically threshed grain (Reynoldson, Martin, and Humphries 1928). Field conditioning was preferred by buyers and processors such as flour millers

(Fitz 1910, 10). Even after combines were introduced, shocked and stacked grain generally received a superior price because of its superior milling and storage qualities (Reynoldson, Martin, and Humphries 1928). In the 1920s, grain combines were promoted by the US state to help move agriculture towards an industrial, modern ideal (Fitzgerald 2003). However, some grain elevators refused to accept the mechanically harvested wheat because it was volatile and more likely to explode in bulk storage (Fitzgerald 2003, 101).

Corn harvesting was transformed when the corn picker-sheller combine was developed and then adopted after World War II. The introduction of field shelling created a number of new problems in the harvesting and marketing of corn. Corn had been a relatively uniform, storable product before the picker-sheller, but the practice of harvesting high-moisture corn meant it sustained "considerable damage" and was now subject to mold and fermentation within days of harvesting. Hill (1970) noted that the most dramatic change was the conditioning requirements, which created new challenges for grain-storage operators. Rapid moisture removal and special handling were now required to maintain quality (Kurtzman and Ciegler 1970). These changes had implications for agricultural engineers and technicians, but agricultural economists also took note and pointed out the implications for warehouse receipts and commodity markets. In a 1964 presentation to the Illinois Grain Dealers' Annual Convention in Peoria, Illinois, Thomas Hieronymus (1996) discussed how corn was being injured by the combines and that the shelled corn produced new storage problems. The shelled corn had a high moisture content and a high level of foreign material, both of which made grain unstable in storage. In turn, he observed that these storage challenges made it difficult to value the stored grain for collateral and financing because of the changing moisture levels. High-moisture corn would be a "difficult problem" to translate the quantity and moisture level on to warehouse receipts (Hieronymus 1996, 200).

5.3 Stabilizing Moisture: Measurement, Dryers, and Aeration

All discussion of grain storage is dominated by considerations of moisture content

–Oxley 1948, 16).

As a technological zone (drawing from Barry 2006), grain storage is defined by metrological relations. In Chapter 4, grain was translated into warehouse receipts to stabilize specific values and qualities. A critical value recorded on early warehouse receipts was moisture level, because it affected the storability and weight of grain. How grain moisture content is measured and how it is valued are complicated matters because of the dynamic quality of grain. Grain storage requires a narrow band of moisture content – not too wet and not too dry (Oxley 1948). The interaction of grain and moisture is also yet another aspect of the assemblage required to stabilize the physical quality of grain. Framing grain moisture measurement and standards illustrates the changeable and unstable quality of metrological zones and also how measuring devices are constructed, take measurements, "resolve controversies, and obtain allies" (Porter 2013, 336).

For grain to be successfully stored, it needs to be of a specific moisture level; depending on the type of grain, this can be anywhere between 12 and 14 percent (McKenzie 1966). But the moisture level of grain is difficult to determine because of its dynamic qualities. Grain is lively and interacts with its environment. Twentieth-century experts highlight its dynamic quality:

> Though they [grains] are alive, and all living things are continually respiring, producing heat, water, and carbon dioxide, they are at a very low ebb. It is the combined effect of their continued life (which enables them to resist decomposition by micro-organisms) and the very low level of that life, which makes cereal grains such pre-eminently stable bodies in store. Dormancy of seeds, however, is very largely controlled by water content and when an attempt is made to store grain which is insufficiently dry, the effect of insufficient dormancy is at once shown. (Oxley 1948, 2)

Grains are permeable and exchange vapour and air with the surrounding atmosphere. Grain in contact with humid air absorbs moisture, whereas humid grains in contact with dry air release moisture into the air and dry out (Cruz, Diop, and FAO 1989, 14). Grain can, therefore, have different moisture content from field to field, and especially among different areas in large grain bins or railway cars. Determining the moisture level of grain is difficult because it is dynamic. Conflicts arose as moisture standards and measurement were put in place by state and private regulation, and new metrological, or measuring devices were developed in an attempt to stabilize grain values.

5.3.1 Measuring Moisture

It is shown, by evidence remarkable for its unison, that the moisture-testing machines now available, will, when properly handled, give perfect and unvarying results, and that a high degree of proficiency can readily be attained by operators of ordinary intelligence

– Railroad and Warehouse Commission of the State of Illinois 1912, 3:524

US commodity exchanges were at the forefront of grain-moisture measurement, along with the US Department of Agriculture. Grain traders and merchants put a low value on high moisture grain, and the standardization of moisture measurement in the early part of the twentieth century helped to stabilize and determine the quality and grade of the grain. Nearly all the North American exchanges provided laboratories that scientifically measured moisture and other grain qualities, thus making moisture measurement "obtainable in all markets [with the] United States Government maintaining laboratories at all shipping centers" (Merrill 1911, 67). Boards of trade and the US Department of Agriculture agreed that "a knowledge of moisture content [was] indispensable in [grains'] commercial movement" according to J.W.T. Duvel, a crop technologist at the Bureau of Plant Industries (Railroad and Warehouse Commission of the State of Illinois 1912, 3:493).[60] The laboratories were environments, or technological zones in which the dynamic nature of grain could be stabilized, if only temporarily, and measuring devices were used to certify moisture levels.

[60] During the 1917–18 season, new standards for wheat were introduced for the federal supervision of grading and inspection at the primary markets. The Department of Agriculture developed standards for inter-state trade and included moisture standards (Eldred 1918, 35–6).

But the measurement of moisture became a political issue when grain dealers, receivers, and shippers in Illinois brought a petition against the CBOT's moisture testing on August 29, 1911. The Railroad and Warehouse Commission of the State of Illinois governed the grain trade and ruled on the grain traders' petition. The petitioners requested

> that the moisture test feature be eliminated at the earliest possible moment from the grain inspection rules of this State … [it has] no legitimate value to any, and it works a great hardship on the producer and a large percentage of the shippers. (Railroad and Warehouse Commission of the State of Illinois 1912, 3:515)

The petitioners' testimonies described the burden of impractical moisture testing and claimed that too much emphasis was put on moisture rather than other qualities (Railroad and Warehouse Commission of the State of Illinois 1912, 3:516). Grain merchants from outside of Illinois also weighed in to the Commission. There was general support for moisture testing from exporters on the US East Coast and from importers at the London Corn Exchange (Railroad and Warehouse Commission of the State of Illinois 1912, 3:498–9). European buyers only took delivery of US grain if they had no other choice due to its poor quality, which included high moisture content (Railroad and Warehouse Commission of the State of Illinois 1912, 3:498–9). Duvel testified that moisture testing was useful for consumers and the grain trade alike (Railroad and Warehouse Commission of the State of Illinois 1912, 3:493).[61] The commission stated that there was no alternative to moisture testing because of demands from the European market. In the end, the petitioners lost their claim, and the moisture test was continued with the support of the US government, which had established the tests during World War I (Eldred 1918).

While the question of whether testing should be done at all was in dispute, measuring the moisture itself would appear to have been straightforward, at least in the laboratories. But it was fraught with complications in practice. The sheer mass and volume of the bulk grain trade made inspection difficult and inexact. According to Oxley, "There are few other commodities, and probably no other

[61] Duvel was also one of the inventors of the Brown-Duvel moisture test

living materials, which are commonly stored in such large bulks as grain … the large size of the bulks exaggerates every physical factor" (Oxley 1948, 7). John Charles Fremont Merrill, president of the CBOT (1911-12), discussed the inspection of grain and the difficulties posed by "track inspection" vs. "room inspection," which is what he called the process when conducted in laboratories (Merrill 1911, 64). Track inspection took place in railway yards, where inspectors sought to measure the moisture of boxcars full of grain under unpredictable conditions. The room inspection assured a more exacting measurement, and any judgement was the "careful analysis and exact determination" of multiple inspectors (Merrill 1911, 63).

The debates regarding moisture were continuous and "unabating" (Hill 1990, 115). Over the twentieth century, there were ongoing shifts and changes to moisture measuring equipment, and Hill states that there were 308 changes to the metrology of moisture and varied standards between 1916 and 1986 (1990, 115). In addition, there were changing standards for measurements as equipment changed and improved. In 1907, the Bureau of Plant Industries developed the Brown-Duvel moisture tester, a distillation process that heated grain in oil and measured the condensed water (Coleman and Boerner 1926).[62] It was bulky and was thus necessarily limited to the "room inspection." Experts agreed that the measurement was "highly arbitrary" (Hunt and Pixton 1974, 24). In 1936, the Tag-Heppenstall electronic tester replaced the distillation method because it was faster and easier to operate outside of the "laboratory" (Hill 1990). The Motomco 919 began to be used in the early 1960s and was considered a further improvement. While fast and easy to use, however, the new testers had limitations.

> It has been obvious for many years that there are problems measuring moisture electronically … The moisture properties may change day to day and from area to area and season to season and therefore calibration charts needed to be distributed [for use with Motomco 919] … there is considerable doubt as to

[62] The apparatus consisted of a heating chamber divided into compartments, a tank for cold water, stands, and numerous accessories, including thermometers, distillation flasks, and graduated measuring cylinders (Coleman and Boerner 1926).

what exactly is meant by "true" moisture content of grain. (Hunt and Pixton 1974, 36)

The equipment continued to be improved, but moisture could never be completely stabilized. In 1986, moisture measurements were removed from Federal grain grading altogether, though they continued for the export market (Hill 1990).[63] Millers and exporters supported standards for moisture content, but farmers and elevator operators did not. The aim of stabilizing measurement led to technological zones in which measurement was more accurate (laboratories) or less accurate (outside in rail yards) and more necessary (export markets) or less necessary (domestic markets). The storage "metrological zone" required the development of common measurement standards and practices that made information comparable, in principle, among different locations (Barry 2006), but the matter was never truly settled. The control and value of moisture content and its measurement helped to stabilize the value of grain destined for storage, and helped secure its value for trade and financing.

5.3.2 Dryers and Aeration

Grain drying for storage was industrialized after the Second World War. The large surplus of high moisture grain, especially corn, became a significant problem for the US state and the CCC (Maier 1992). The CCC was confronted with managing large quantities of spoilage-prone high moisture grain. The solution was to develop mechanized grain drying (Krischik, Cuperus, and Galliart 1995; Maier 1992).[64]

[63] United States Grain Standards Act was assessed by Congress on August 11, 1916. It was amended effective July 1, 1935 to change the test for determining moisture from the Brown-Duvel method to the air-oven method or any method giving similar results. It was revised October 1, 1959 to change the method from the water-oven method to the air-oven method. Effective September 9, 1985, moisture was deleted from the Act as a grade-determining factor (US FGIS 1986).

[64] The increased moisture in corn was compounded by the expansion of irrigation, new corn varieties, and picker-shellers (MacMasters and Bureau of Agricultural and Industrial Chemistry 1953, 3). Mechanically shelled corn generally had a higher moisture level (22 to 28 percent) than corn on the ear (14 to 16 percent) (Kurtzman and Ciegler 1970, 204).

The CCC and Department of Agriculture developed a research program to “aerate” grain in storage. Aeration moved air through the grain, unlike elevators, which moved grain through the air. The Research and Marketing Act of 1946 contributed resources to develop mechanical dryers (Stewart 1979, 211).[65] Aeration was a cheaper and more applicable solution compared to more experimental dryers such as the Purdue University program to re-purpose surplus jet-engine warmers to dry shelled corn (McWethy 1946, 11). This was a significant shift from the traditional practices of field drying, ensilage, and cribbing, and added another industrial practice to grain management. The project enrolled state extension agents, agricultural engineers, county agents, and manufacturers to put the new industrial drying practices to work. All were brought to bear on the “enlarged storage problem” of the state and the CCC (Holman 1957, 1).

The research program on dryers attracted the attention of grain traders, especially those operating in the humid southeast of the US.[66] Private traders wanted to take advantage of the technology to create arbitrage opportunities. For example, the North Carolina State extension service signed a memorandum of agreement with PR Markley Grain Traders of Philadelphia to build a grain-drying and storage facility in eastern North Carolina modelled on the experimental stations in the Midwest (Markley and North Carolina Experimental Station 1948). Markley identified the “basic problems” for? North Carolina grain marketing, which included transportation costs to the US northern market, weevil infestation, and the high moisture content of hybrid corn (Markley and North Carolina Experimental Station 1948). Markley wanted support to establish community and farm-based grain dryers in locations across the region so he could leverage the market to create arbitrage possibilities among the different locations, different standards of grain, and transportation rates. This example

[65] There have long been examples of “artificial” drying, but it was uncommon in the US until after World War II, when industrial processes were adopted.

[66] Agricultural engineers had discounted corn cribs because they were “hazardous” and could not safely contain high-moisture corn or control the development of spring mold (Barre and Kelly 1941, 5).

shows that the expansion of drying capabilities was a state function and that grain traders saw value in leverage and arbitrage.

Mechanical dryers were also a topic of discussion at the Chicago Board of Trade Annual Symposia, where it was common for industry and grain handlers to report on and discuss storage issues. One Indiana Grain Cooperative manager stated, “I have arrived at the conclusion that there is only one way to carry soft red wheat, and that is to apply heat” (Guild 1954 as quoted in Peck 1978, 107). It was expensive, but not as expensive as “waking up one morning and finding an elevator full of ‘sick wheat’” (Guild 1954 as quoted in Peck 1978, 107). Sick wheat, a condition in which the germ is injured by mold, was increasingly a problem because of the long-term storage and carry-over of stocks that accompanied the post-war grain surplus.

General grain management practices were still being developed during the 1950s and 1960s, and there were calls for more engaged and hands-on management of grain. For example:

> The control of moisture content is not simply a matter of drying the grain and leaving it in dead storage … Under present practices, much grain is needlessly shifted from one bin to another, while some which should be shifted is not. Tests that would furnish data on some of the essential characteristics within the bulk would permit more rational and economical handling of grain. (Christensen 1957, 132)

New technologies were developed to condition the grain before it went into storage, to measure and manage moisture, and to address the problems created by new seed and agronomy technologies. At the same time, ‘sick’ grain was developing and new problems were occurring in the fixed storage containers in the US (Oxley 1948).

5.4 Grain Storage Environments: Sick Grain and the Development of Fumigation

A sound kernel is a living organism. Like other living organisms, it breaths [sic] *or respires.*

–MacMasters 1953, 5

It is possible to store grain in this way because it is normally so nearly inert, but the fact that occasionally it breaks out in heating or insect infestation or other form of deterioration, makes it quite important that we should know something of the physical characteristics of grain in bulk.

–Oxley 1948, 1

The industrialization of agriculture and the changes in agronomy transformed grain storage environments. Well-conditioned and non-injured grain stored well. But, grain management was an ongoing labour that required not only conditioning grain before it went into storage, but also managing and protecting grain once it was inside containers and bins. Grain has always been vulnerable to a variety of problems from pests such as rodents and insects, to damage by rain and snow, but new problems were emerging. After World War II, molds became a significant problem, surpassing the traditional pests such as rodents and insects (MacMasters 1953, 1). Grain was especially vulnerable to fungi when in bulk storage and transport (Christensen 1965, 4). Contained grain created a unique environment that was attractive to a specific fungus, previously known as "sick" wheat, a fungal condition in which the germ turned black or brown, and after the war identified as storage fungi.[67] The storage fungus had a significant effect on the processing industry such as brewers and millers because it negatively affected the grain's weight, milling quality and its germination (Christensen 1957). The attention to grain fungi became more urgent in the mid-twentieth century because grain surpluses and carry-over (the stocks of grain that were not used within a year) began to increase – grain was in storage for longer and longer periods of time. In 1953, it was estimated that five to 30 percent of all stored grains were lost to fungi, which created a significant "financial hazard" to grain growers, elevator operators, and grain processors (MacMasters 1953, 1).

[67] "The storage fungi are those which develop on and within seeds at moisture contents often encountered in storage, principally Aspergillus and Penicillium. Aspergillus glaucus is one of the major fungi that invade stored seeds" (Christensen 1957, 110).

This section looks at how new technologies were brought together to control insects and stored-grain fungus. I argue that fumigation was part of the assemblage that assured the values and qualities of grain remained stable so the state could manage collateral in the form of grain. I will show in particular how fungi emerged as a problem for grain management. The state developed fumigation and fungicides as a solution to sick grain and also applied the same fumigation techniques to manage other pests (Christensen 1965). The state developed agro-chemicals to protect and stabilize the value of the CCC's collateralized grain stocks. Fumigation then became part of the mid-century grain management assemblage to physically stabilize stored grain.

The identification of storage fungi had significant consequences for grain managers and elevator owners. Before World War II, elevator operators often held growers responsible for sick wheat, but Christenson said these theories were "fantastic" because they were not supported with evidence (Christensen 1980, 1067). Clyde Christensen, a plant pathologist and expert in fungi at the University of Minnesota, and the author of *The Molds and Man* (1965, first published in 1951) discovered that storage fungi was specific to grain storage environments and was a significant factor in spoilage. Storage technologies and practices, such as bulk grain, longer periods of storage, and higher moisture, had combined with grain to foster "sick" grain. The identification of the cause of sick grain, and specifically the discovery of storage fungi, which was differentiated from field fungi, in the 1940s had ramifications for grain-storage governance (Christensen and Meronuck 1986). The consequence was that the storage manager, such as the grain elevator owner, had some culpability in preventing or fostering sick grain. Before Christensen's research, warehouse and elevator operators would claim that the grain itself was inherently bad.

> [T]herefore the warehouseman could not be held responsible for the damage ... This is absolutely not so. Sick wheat, mustiness, heating, caking and binburning, all are products of storage fungi and are products of poor storage. (Christensen and Kaufmann 1969)

Christensen estimated that grain storage spoilage and sick grain had been a problem since the 1930s (Christensen 1980). His research showed that poor grain management – and, I would add, the new storage practices – contributed to grain spoilage in storage.

The complex handling practices and conditions of industrialized agriculture, including bulk storage, had contributed to a rise in stored grain fungi. Christensen (1957) showed that threshed grain was far more susceptible to mold in comparison to grain subjected to field drying, which left the grain attached to the rachis and surrounded by glumes (see Figure 5). "In no single case have we ever found an appreciable amount of infection of the seed by storage molds prior to harvest" (Christensen 1957, 115). The research on sick grain grew to include the effect of molds more broadly, and included how grain interacted with molds, mites, and insects in storage environments. Christensen determined that insect and mites worked in concert with fungus to spread mold spores (Christensen 1957).

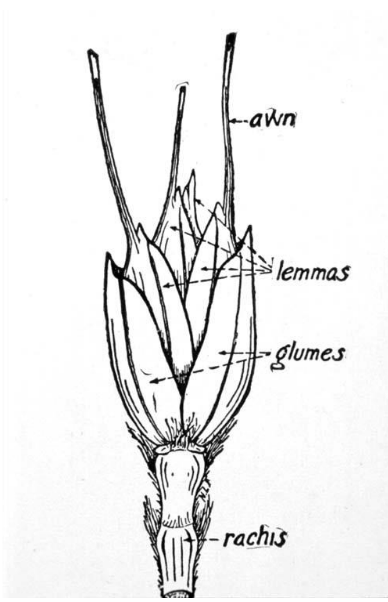


Figure 5: Diagram of Wheat Head (umn.edu/herbarium/images/Hrb-TRZAS-013.jpg)

Warehouse operators tried to sidestep responsibility for allowing grain to heat up, stating that bins of grain were warmed by the sun (US Senate 1952, 152). But Christensen's discovery, and ongoing research by the CCC and the Department of Agriculture, led to a change in focus. The discovery of stored-grain fungi also had an impact on the large grain traders and processors. For example, the large grain-trading concern Cargill created a grain research laboratory in 1952 with entomologists and plant scientists (Christensen 1980). In addition, Christensen and his lab at the University of Minnesota were supported by Cargill and the Malting Corporation of Milwaukee, and he often published with Cargill scientists (e.g. Christensen and Kaufmann 1969; Christensen and Kaufmann 1974). While long-standing practices to control fungi and mycotoxins included improved sanitation practices, better grain-handling to avoid damage (cracks and breakage), sorting and cleaning, and temperature control, the very size and bulk of the US grain trade made these practices very expensive (J. D. Miller et al. 2013, 11). In turn, new agro-chemicals were developed that worked hand-in-hand with contained bulk grain to kill and suppress insects and fungi.

5.4.1 The Development of Fumigation

The grain storage technological zone included the introduction of agro-chemicals, and the development of fumigation to manage the stored grain held by the CCC. But little was known about what actually occurred in bulk storage. Christensen wrote about how difficult it was to examine bulk storage – bins were difficult to enter, and visits were discouraged by operators (1980, 1069). When access was granted and research was conducted, the sheer size and volume of storage made sampling inexact. Consequently, the testing of fumigation and agro-chemicals was conducted in laboratories because it was "impractical and unwise to conduct large-scale tests for [fumigant] products submitted for screening" (Dennis and Whitney 1954, 1). The introduction of fumigation was part of the assemblage that assured that the values and qualities of grain remained stable, but it also left a toxic legacy. This section describes the development of fumigation after the Second World War and shows how the use of agro-chemicals in storage was adopted.

During the 1930s the CCC began to support grain-storage research "in anticipation that new problems would be encountered by long term storage on farms," (Barre and Kelly 1941, 1). Before the CCC's research the control of storage pests consisted mostly of farmer-prepared chemicals (Russell 2005). Early entomologists experimented with industrial lubricants made from vegetable or mineral oil and then coated the ears of corn with a form of coal-tar crystals (see Figure 6) (Flint and Mohr 1930). Contact sprays such as DDT oil, or kerosene with DDT, were also applied to the walls of containers (Cotton et al. 1945). These early technologies were labour intensive and not very successful, especially for large quantities of grain.

The new assemblage of bulk-grain storage, new types of bins, and aeration technology came together to produce a perfect site for fumigation.The introduction of fumigation technologies had a number of advantages. Fumigation worked hand in hand with the newly introduced aeration technologies so that agro-chemicals could be applied throughout a storage container. Fumigation could be used to kill and suppress pests and fungi, often with the same chemical preparations (Golumbic and Laudini 1966). Metal bins worked effectively with agrochemicals because they could be made airtight for fumigation (Cotton and Ashby 1952). While fans were initially used to aerate grain, they were also repurposed to distribute fumigants through grain bins (Dennis and Whitney 1954; Golumbic and Laudini 1966). Fungicide had previously been used with high-value fruits and vegetables, but its usage increased in storage and on grain fields through the 1960s and 1970s (Russell 2005).

Figure 6: Corn cob with industrial lubricant (Flint and Mohr 1930)

Fumigants were used extensively in bulk storage, especially in the CCC large-scale bin construction program, from the 1950s to the 1970s. The CCC grain fumigant was an 80/20 mixture of carbon tetrachloride and carbon disulfide. Methyl bromide was used in flour mills and by grain handlers from the 1920s until 2000, when it was phased out and replaced with phosphine, a slower-acting fumigant (Ryan and Shore 2012, 359). Proponents claimed that fungicides and pesticides posed little danger to humans if applied correctly and time was allowed between application and usage (De Lucia, Assennato, and FAO 1994). However, many fumigants, including carbon tetrachloride and methyl bromide, have been removed from the market over time because of safety and environmental implications. Fumigants used in grain storage can present numerous dangers to humans, including permanent central nervous system damage, heart and vascular disease, lung edema, and cancer

(OSHA 2014). Phosphine has poisoned grain handlers up to one or two weeks after application (see Figure 7), and poisonings have also occurred on grain ships when fumigants have leaked into passenger compartments (Mills 1989, 45). Repeated fumigations with phosphine can significantly reduce seed germination, and phosphine has been detected in grain up to 220 days after treatment (Bond, Monro, and FAO 1984). The utility of phosphine is also under scrutiny in view of reports of insect resistance (Jayas, White, and Muir 1995, 15). The continued use of bulk grain fumigation, however, contributes significantly to US agricultural exports. For example, the National Grain and Feed Association and North American Export Grain Association state that "nearly one-third of the $150 billion USD in total annual U.S. agricultural exports consists of grains and oilseeds" and two-thirds of those exports have been fumigated with phosphine (NGFA and NAEGA 2013, 3).

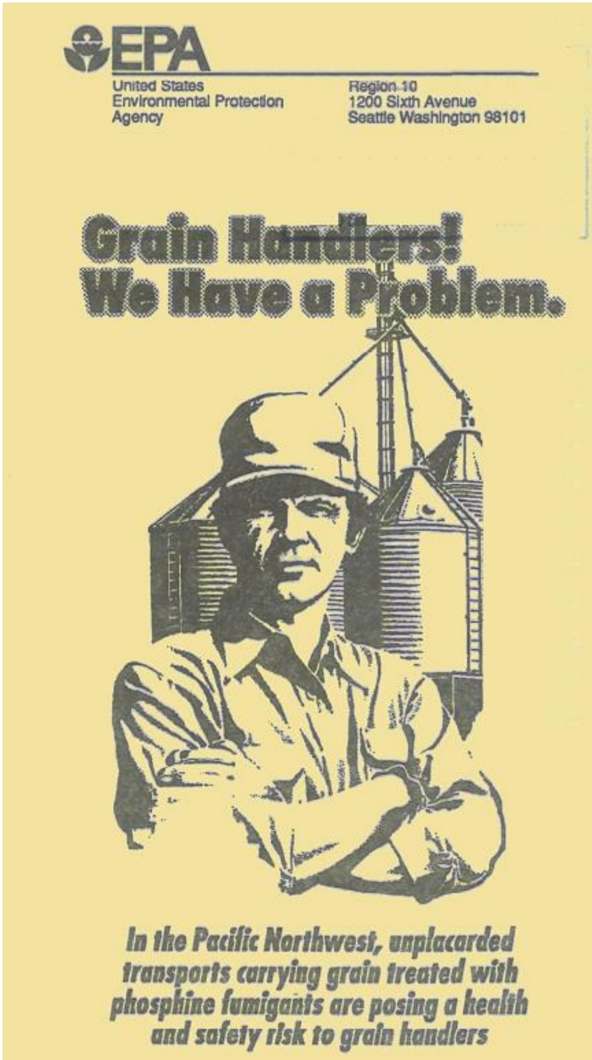


Figure 7: Grain Handlers! We Have a Problem (no date; estimated late 1980s, http://nepis.epa.gov/Exe/ZyPDF.cgi/9100YTIS.PDF?Dockey=9100YTIS.PDF)

The technological zone of grain management is not only extensive, with an assemblage of practices, technologies and agrochemicals, but there is a historic legacy of early chemical usage from the 1950s to 1960s. The US EPA has reported that CCC bins located in Kansas, Iowa, Missouri, and Nebraska have caused ground-water poisoning (Field 2002). Sixty-one out of 130 sites have poisoned ground water in their surrounding areas from “80/20” (fumigant consisting of 80 percent carbon tetrachloride). An infrastructure of bins, containment units, chemicals, and aeration was needed to support and fix grain in place. The fumigation was part of the assemblage that assured that the values and qualities of grain remained stable so that the state could manage collateral in the form of grain.

5.5 Exporting of US Grain Management Techniques: Reassembling Grain Management Technological Zones

One of the capabilities of the Kansas State team is to provide technical training in proper storage, drying, and handling methods. It is obvious from observations in other developing countries that knowledge of proper management of grain in storage is needed.

– Food and Feed Institute 1968, 15

By the 1960s, the US state had extensive expertise in grain management, and had assembled an industrialized system of grain management including bulk grain storage, bins, agrochemicals, and dryers to handle domestic surplus grain. The US was also exporting grain management techniques along with its surplus grain overseas. The surplus was delivered to other countries as food aid and/or by dumping cheap grain (Clapp 2012b). When grain was exported it was shipped in bulk, and at times US grain-management practices were also exported. The export of US grain and grain management arrived with a model of how grain should be marketed. I argue the expansion and export of US grain management practices illustrates Barry's observation that technological zones can help constitute Western political and economic forms, and their "non-Western others" (Barry 2006, 251). More specifically to my thesis, it shows how the same technologies are reassembled and reformed in new sites accompanied by a specific market form. I pick up this argument in Chapter 7 to show how contemporary international organization grain storage programs shift to a model driven by collateralizing stored agricultural goods and connecting to financial actors. By conceptualizing grain management as a technological zone I can examine its historical formation and how the same zones are reassembled in new sites.

In the 1960s, the Kansas State Food and Feed Grain Institute's work with USAID overseas showed how grain management practices and physical transformations in grain handling were woven into understandings of how a market should work. Kansas State University established the Food and Feed Grain Institute (FFGI) in 1966 "to expand services to American agriculture, the processing industries, and to involve the University more fully in growing international food programs" (KSU 1971). The FFGI was based at the same land grant college that already had a legacy of grain-storage management when it was partnered with the CCC in bin and grain-storage management research. The USAID supported the FFGI through contracts, and projects were developed to extend grain management expertise to countries receiving US grain.

John R. Pederson (1968) was an entomologist with FFGI, and made numerous field trips to developing countries on behalf of USAID. His work for the USAID helps to illuminate how US grain management practices were exported with US grain. Pederson visited Jordan in 1967, and toured local grain-storage facilities including the Port of Aqaba. At the time of Pedersen's visit, he estimated that 85 percent of Jordan's grain was imported from the US (Pedersen 1968, 39). The port did not have the infrastructure to handle bulk grain, and instead relied on hand-labour to unload the grain: "One or two men ladle grain into sacks using square five gallon cans. Two men hold the sack and another man sews the sack shut" (Pedersen 1968, 50). Pederson also toured local farms, where he observed that pest control was non-existent. Grain was stored in sacks, cisterns, and local buildings, and had very low moisture content (nine to ten percent), with no observable insects or spoilage – "I observed no insect infestation in farm stored grain I examined" (1968, 29). Domestic grain and its storage appeared to not pose any particular issues to Pedersen.

But Pedersen did observe that imported grain and its management was a problem. As he stated: "Imported grains generally contain higher moisture content than locally produced and harvested grains and are thereby subject to more hazardous storage" (1968, 3). He toured the large grain storage facilities and made recommendations to improve grain management and the handling of the US high moisture grain. His recommendations show how he would reassemble a US grain-storage technological zone in Jordan by improving three of its facets, industrial grain management, the storage infrastructure, and developing grain market standards. First, grain management was inadequate. He stated:

> It was obvious from observations made in farm, dealer, mill and government grain storage situations [in Jordan] that proper grain management methods are not understood or used. As a result, undetermined losses occur to stored grain. (Pedersen 1968, 40)

He was particularly concerned with the disorganized appearance of sacks of grain, which made proper fumigation and inventory-taking difficult, tasks that were "necessary if prices [were] to be stabilized and an adequate stock of food grains maintained" (Pedersen 1968, 7). Second, Pedersen recommended improvements to the port infrastructure in order to handle the bulk grain arriving from the US. Metal silos had been provided to the government of Jordan sometime in the late 1950s, but had not been used because of on-going problems that were blamed on poor construction. For example, the bins leaked, or they had blown down in windy weather. Some of the bins had been used one or two times, but it was reported that "each time they were used the grain went out of condition and was lost" (Pedersen 1968, 31-2). Pedersen proposed that the metal silos (estimated around 50) be refitted with aeration equipment and temperature monitors, and the application of additional technology would prevent future problems (Pedersen 1968, 31-2). The bins would be used along with the bulk port infrastructure to re-create the industrial model of grain storage used in the US. The industrial model described by Pedersen leads to the third point, standards had to be developed before the bulk handling system could be put into operation. Peterson noted that "[t]he most important factor that would stimulate bulk handling" was "a marketing and grading system" (Pedersen 1968, 50). The same bins, standards, grades, and industrial practices came in a package, and were an assemblage of US grain management.

To reassemble the physical stabilization practices of US grain management, all three parts of the technological zone were included, industrial grain management, a storage infrastructure, and standards for grading and marketing. Pederson's recommendations show how a distinction was made between a specific Western conception of grain management and Jordan's indigenous grain management. Jordan's grain management included a dryer grain and the use of traditional containers such as cisterns to store grain, and according to Pedersen, it did not require pest control. The distinction between the US industrial grain storage model and Jordan's grain management brings into view the assemblage of technological zones and how it can constitute Western political and economic forms, and their "non-Western others" (Barry 2006, 251). The US export of grain required a US-style of grain storage. When Pedersen visited Jordan he described the practices required for the physical stabilization of grain, and he connected it to the market practices of bulk grain. The US grain storage assemblage at the end of the 1960s started with the physical containment and management of grain. This example illustrates how the borders of the US grain management did not end at its borders, but were exported along with its grain.

The example from Jordan exemplifies other storage projects and development projects in the 1960s and 1970s. The projects were primarily focused on building and managing physical storage facilities, and were technical and discrete (Zorya et al. 2011). Some of the projects introduced US-modelled storage technology, but these were deemed unsuccessful because of the difficulty of acquiring supplies such as metal for bins, the high cost, and the necessity of engaging outside contractors for fumigation (Zorya et al. 2011; HLPE 2014). Even when grain bins were freely supplied, the storage technology met cultural and functional resistance (Zorya et al. 2011).[68] After the food crisis of the mid-1970s, development programs turned their attention to post-harvest losses and the role of grain-storage management. A similar pattern emerged after the most recent food crisis in 2007–8 as well (Zorya et al. 2011; HLPE 2014). Past strategies focused on providing technical assistance to build and

[68] The report continues that "it appears that there is still considerable potential for extending metal silos in Africa" (Zorya et al. 2011, 46).

maintain community-based storage, and storage was generally viewed as a state and, at times, community-based responsibility.

As will be shown in Chapter 7, the same physical techniques (industrial grain management, the storage infrastructure, and developing standards) are used as a model for recent warehouse-receipt projects (CTA 2013; HLPE 2014). New market projects encourage specific grain-management strategies and tools, such as moisture meters and fumigation supplies, in order to manage grain-storage sites. But there is a crucial difference - the new warehouse receipt projects focus on a market-driven storage underpinned with the provision of credit and collateralized agricultural commodities.

The US state was crucial in developing grain-storage management practices, but the 1970s was a period of decline for the experts in grain management. The USDA closed down its grain research centres and entomology grain centres when it dismantled the national grain reserve in the late 1970s (Hodges and Farrell 2008). In 1980, Clyde Christensen (1980) mourned the loss of storage-fungi research that resulted from the closures. The engagement of entomologists by the state also declined with the end of the state grain reserve (Wicklow 1995, 156). While post-harvest grain centres remain at a number of the land grant colleges in the US (North Dakota State, Kansas State University, Minnesota, Ohio, Georgia and Montana), the state has pulled back from funding grain-storage research, leaving it primarily to private funding (Hodges and Farrell 2008). The grain management practices, however, have continued to be applied in new sites.

5.6 Conclusion

This chapter showed how grain management physically stabilized grain in storage, and how the assembly of grain-management practices, humans, and non-humans interacted to help stabilize and destabilize grain in storage. A close examination of the assemblage of grain-storage management highlights the interaction between non-human actors, such as contained grain, and the grain-management techniques brought to bear to control its vitality. Grain management was a technical practice, but with political consequences from a legacy of agro-chemicals to the export of new grain storage technologies. I used Barry's (2006) concept of a technological zone to identify the assemblage of measurements, infrastructure, and common standards that made up the physical stabilization of grain. The US state was crucial to the development of an industrial assemblage of grain management, and it provided grain-management research, institutional support, and resources. The state helped develop fumigation technology, which worked with metal containers, dryers, aerators, and chemical applications to stabilize grain in new ways. The grain-management practices that were put in place in the mid-twentieth century are still used today to stabilize physically large quantities of grain. The grain is used as collateral and underpins agricultural commodity futures, and thus these practices are a crucial part of developing asset streams and financialization.

A tension exists in grain storage containers between the non-human actors that inhabit it and the on-going human intervention of agrochemicals and other management practices. Bulk storage environments become homes to stored-grain mold, which acts with insects and mites to create blockages in storage units. Even with active grain management, molds, mites, and insects can literally clog up the flow of grain in a bin – reducing the key advantage that bulk grain storage has over other storage techniques such as smaller-scale bags. The dynamic qualities of grains work with moisture and fungus to create blockages and problems in bulk-grain storage, which limits the value of grain and capital flows. As the scale of bins increases, the molds, mites, and insects continue to build homes and elude management. These collectivities build rigid structures within bins. A close examination of the physical stabilization of grain highlights a different kind of politics, one in which non-humans are actors that both provoke human intervention and resist human intervention. Bennett (2010) states that non-human actors have a vitality. Non-human actors provoke human intervention when contained and provoke human management and intervention by clogging bins. Grain managers then apply agro-chemicals and dryers. I have examined how non-human actors live within bulk storage and how grain management works to keep grain flowing despite these actors. There is little value to collateralized grain if it cannot flow and be part of the distribution and marketing system of ACEs. Cronon (1992) showed how bulk storage created and facilitated a whole new grain marketing system in the nineteenth century. But what happens to the system if the grain cannot flow?

By examining the physical stabilization practices that are required for grain management, I have shown the value of the ANT approach, but also its limitations. A close examination of the physical quality of grain storage can help explain some aspects of how asset streams start at the site of storage. Physical interventions are required to create asset streams based on stored grain. But physical "things" that come together to stabilize grain are only one part of the explanation. This chapter illustrates some of the limits of ANT in relation to explaining the financialization of agriculture. The collectivities associated with grain can potentially be conceptualized as actors that shape grain management techniques – without fungi no fungicides, without insects no pesticides. Further to this point, a close examination shows the vital quality of grain where grain is not a unitary actor but one that is part of a collectivity that creates problems and disruptions for grain managers. The limitations of this approach are met when connections are made to the financialization of agricultural commodities. The ANT approach offers an alternative way to explore grain-storage governance, flows of grain, and flows of capital. The connection between mold mycelium and, for example, finance is indirect. Molds, mites, and insects are only one small part of grain-storage infrastructure, but important nonetheless.

In this chapter, I illustrated three crucial points about grain storage. First, the vital role of the US state in developing grain-storage technologies. Second, US grain-management techniques and technologies were exported to new sites along with grain surpluses; in later chapters, I will show how these same grain-management techniques are attached to ACEs at new sites. Third, the chapter showed some of the limits of the ANT approach, and some of the weaknesses of the main thesis regarding the financialization of agricultural commodities. The next chapter shows how US institutions and the CCC contributed to the development of grain containment, and how the state established stored grain as collateral.

Chapter 6– Physical Stabilization II: Grain Containment and Risk Management

6.1 Introduction

Recently, grain storage manufacturing was called a "hidden corner of [the] U.S. farm boom," with the annual global revenue of the global grain storage container sector estimated at $3.5 billion USD (Stebbins 2011). High-profile investors such as George Soros and Warren Buffett have invested in the sector as demand has risen due to growth in oilseed and grain seed, and manufacturers such as GSI and Brock Grain Systems (owned by Berkshire Hathaway) have benefited from the increased demand for on-farm storage (Stebbins 2011). The growth of grain storage manufacturing was facilitated by new metal bins developed by the CCC and private manufacturers to contain the expanding US grain surplus during the mid-century. The CCC initially purchased and developed metal bins to handle "emergency" grain surpluses through the 1930s into the 1960s. The bins are now ubiquitous across the US farm states. It is reported that Cargill and other grain traders are feeling pressure as more and more grain is being held on farms (Singh and Wilson 2011). Reports state that farmers are storing a greater quantity than normal of the 2015 crop, waiting for better prices, and this is affecting large grain traders' profits (Terazono 2015). The CCC helped to develop a container technology that contributed to shifting grain management into private hands, with a particular focus on the development of metal bin containers. This chapter describes the development of the CCC's grain containment technology and then links this technology to the emergence of farmers' risk-management strategies in the 1990s. The shift away from a national reserve to a dispersed farmer-managed reserve in the 1970s was enabled by affordable metal bins that could be located on farms, and repurposed into risk-management tools for farmers in the 1990s.

A new model of containment was developed to hold the massive increases grain production during the post-war era. The new containers were developed alongside the new harvesting and agronomy technologies described in the previous chapter. The CCC had to manage a national granary that was pulling in record harvests year after year in order to protect its investments and loans. Emergency grain storage was needed, and new kinds of bins and storage management techniques were developed. The surpluses, combined with the need to manage collateral for loans, required long-term storage, storage that lasted years rather than from one harvest to the next. The development of bulk storage, specifically elevators, radically changed nineteenth-century grain storage and underpinned the establishment of Chicago ACEs (Cronon 1992), while the spread of metal bin technology, starting in the mid-twentieth century, helped to change grain-storage governance in the US in the late twentieth century. Metal bins became part of the assemblage that physically stabilized grain, and in turn the contained grain became collateral to establish asset streams.

I argue that grain containment is part of the process of physical stabilization. I highlight how containers changed, and how these changes contributed to a more dispersed model of grain storage, from centralized terminal storage to on-farm storage. More specifically, changes in grain containment helped to foster a risk management model of grain marketing developed in the 1990s. An examination of the physical infrastructure helps to explain how asset streams shifted from the oversight of the CCC and to a model that encouraged farmers to use on-farm storage in concert with ACE risk management tools in the 1990s. The chapter shows how a close examination of US grain storage technologies during the twentieth century helps to explain three points about the financialization of agricultural commodities – first, by supporting the argument from Chapter 5 that physical stabilization is crucial, and second, showing the importance of the US state in developing grain storage technologies, specifically metal bins that helped to secure collateral and manage grain surplus after World War II. Third, the metal bins developed through the CCC facilitated new 1990s risk management strategies of farmers and went hand-in-hand with on-farm storage and ACE tools such as futures contracts.

The chapter begins by describing the technological changes in grain containers from elevators to metal bins. It highlights how the CCC containers changed, and how these changes contributed to a more dispersed model of grain storage, from centralized terminal storage to on-farm storage. The CCC came to rely on metal bins because large grain traders had a monopoly on grain elevators and other large grain storage facilities. I then outline how the Commodity Futures Trading Commission (CFTC) and the US Department of Agriculture (USDA) promoted risk management strategies for farmers. I conclude with a summary of physical, regulatory and ideational stabilization that came together as a grain storage assemblage in the 1990s.

6.2 Grain Bin Administration and Management: Containing Grain

Thieves, rodents, birds, poultry, insects, and objectionable odors.

–Cotton and Ashby summarize the problems of grain storage (1952, 632)

This section provides an overview of the technological changes in grain containers from grain elevators to metal bins. Initially the metal bins were used only for emergency storage to handle large grain surpluses starting in 1939, but the CCC continued to develop the grain bin after World War II. There were two main effects of this shift to metal bins. First, the metal bin worked in concert with the new agrochemicals and fumigation. The effect was to implement a model of grain management that could be dispersed and managed on farms starting with the farmer-owned grain reserve in the 1970s. The changes in grain storage technologies worked in concert with the shift from public to private grain management.

The grain handling and elevator storage system developed in the US during the nineteenth century mechanically moved grain into bulk containers. The US development of mechanical grain elevators was part of a grain-handling infrastructure based on bulk grain handling (Pirrong 1995, 239). Before elevators and railways, grain was moved in bags by hand, and transported primarily by water (Cronon

1992). The development of the grain elevator and railways facilitated bulk transport and bulk storage. In an elevator, a combination of mechanization and gravity was used. The grain was mechanically moved with buckets on a chain into a bulk container and gravity was used to load, for example, barges, or trains. The grain was moved through the air by the buckets, and from bin to bin. This served a number of purposes, from mixing different grades of grain to drying the grain and disrupting insects, mites, and mold that would lead to spoilage.

It was an efficient system that facilitated the storage and distribution of large volumes of agricultural surpluses. However, the efficiency came at a cost. At the beginning of the twentieth century, grain elevator operators used new technologies to increase the size of elevators, and to replace the fire-prone wooden elevators. Terminal grain handlers turned to cement elevators, which became their material of choice after the development of reinforced concrete and slip-form technology.[69] Large grain elevators were very capital-intensive methods of managing and handling grain. They worked well for large quantities, but in years of low harvest, with little volume they were expensive to operate in an industry that had a poor gross margin (Cruz, Diop, and FAO 1989, 33; Soda, Mazaude, and Troude 1995, 117). The cost of these massive facilities was manageable as long as large quantities of grain were handled, storage costs were collected, and there was a means for elevator operators to leverage the commodities for credit and speculation.

In the 1920s, the National Association of Farm Equipment Manufacturers promoted on-farm storage using metal bins as a solution to the "marketing problem" of depressed agricultural commodities in the 1920s and as protection against fire, rodents, and weather (*Wall Street Journal* 1930, 9). On-farm storage could also make grain less visible in comparison to elevators, in which "it is notice to the

[69] For example, the Great Northern Elevator in Buffalo was built with metal cylinders and an outer shell of brick in 1897.

world", or visible (*Wall Street Journal* 1930). However, metal bins were uncommon until the CCC had to confront long-term grain-storage problems in 1939 (McWethy 1946).

The CCC turned to metal bins when the surplus grain overran elevator capacity. Prior to 1939, the CCC stored grain for the national reserve primarily with terminal and county elevators; farmer-owned storage was used to some degree, but this consisted primarily of corn cribs for livestock feed rather than for bulk grain such as shelled corn. The problem of surplus grain caused storage problems as carry-over, the amount of inventory "carried over" from one growing year to the next, increased as the CCC's loan portfolio grew. For example, from 1928 to 1932 grain carry-over was 163 million bushels, and by 1941 it was 646 million bushels (Cotton and Ashby 1952). The increased carry-over reserves meant that "every conceivable type of storage was pressed into service," including the use of metal bins or "farm-type bins" (Cotton and Ashby 1952, 629).

The Department of Agriculture took over the administration of the CCC in 1939 from the Reconstruction Finance Corporation and the new administration led to a number of policy changes, including changes that affected the management of grain stocks. In a policy change, the CCC put a call out for bids for containers to store up to 1000 million bushels –specifically, metal bins that would hold 1000 to 2000 bushels each – to help manage the surplus (*Chicago Sunday Tribune* 1939, B7). The initial call was for 30,666 steel bins, an order one-and-a-half times greater than all the bins produced in the previous year. Butler Manufacturing of Kansas City provided 20,500 of the bins, which it credits as the "spark" that propelled its growth (Butler Manufacturing 2014).[70] The CCC actively kept grain off the market, either through the grain reserves or by securing farmers' collateral on loans. But the addition of metal bin storage space was still not enough to contain the surplus. Farmers did not heed the warnings from the Department of Agriculture to build more on-farm storage

[70] The early Butler grain bins were the inspiration and modified basis for Buckminster Fuller's early design of the Dymaxion Deployment Units.

in anticipation of a large harvest, and millions of bushels of grain were being piled on the ground and spoiling (Geissler 1942). More and more grain was being grain was being produced, but the storage infrastructure was insufficient to contain it.

The CCC was confronted with a number of technical grain management problems. First, agricultural engineers and other experts claimed that farmers did not have the expertise or the proper technology to manage grain; on-farm grain storage was thus viewed as risky because the job of maintaining stored grain quality was beyond the expertise of farmers (T. E. Hall 1954). For example, corn cribs were called "hazardous" because they could not repel pests and weather or effectively contain the "dangerously" high grain moisture associated with harvesting mechanization and hybrid seeds (Barre and Kelly 1941, 5; Stewart 1979, 159). Second, the standard on-farm grain storage containers did not work well with the new fumigation techniques because permeable wood containers were not amenable to fumigation, and were blamed for insect infestations. Cotton and Ashby describe how the wooden bins were "a constant source of infestation" and fumigation could not reach insects that had burrowed into the wood (1952, 636). Changes in grain storage, such as the shift from ear corn to shelled corn, put additional stresses on bins – the heavier weight of the shelled hybrid corn sometimes resulted in bins collapsing (*Chicago Daily Tribune* 1939, B7; see Chapter 5). Third, although metal bins were not a perfect answer, agricultural engineers deemed them more effective than the traditional corn cribs. Storage over the winter kept the grain cool, but multi-year storage posed problems, especially in the warmer and more humid areas of the US such as the Midwest. Stored grain often suffered "heavy deterioration from insect attacks" (*Chicago Tribune* 1939, 33). The increased reports of insect infestation led to a demand for fumigation technology (Farrington 1950, 8 also see Chapter 5). The result was that the increasing surplus had to be contained, and new containment technology was developed to work with the new grain management technology such as fumigation.

The CCC researched the problems of long-term storage with the cooperation of federal and state agencies. Research sites in North Dakota (see Figure 8) and Kansas were set up to study long-term storage and bin technologies along with the “preventative and curative treatments” for grain described in Chapter 5 (Barre and Kelly 1941). Industry and manufacturers provided bins on loan, and researchers provided tools such as thermocouplers to measure grain conditions and moisture meters to measure and record conditions. Curative treatments included fumigants, ventilation, and practices for turning and cleaning grain (Barre and Kelly 1941, 2). Ultimately, a model of airtight, sealed storage was developed to keep weather and insects out, and to keep fumigants in.

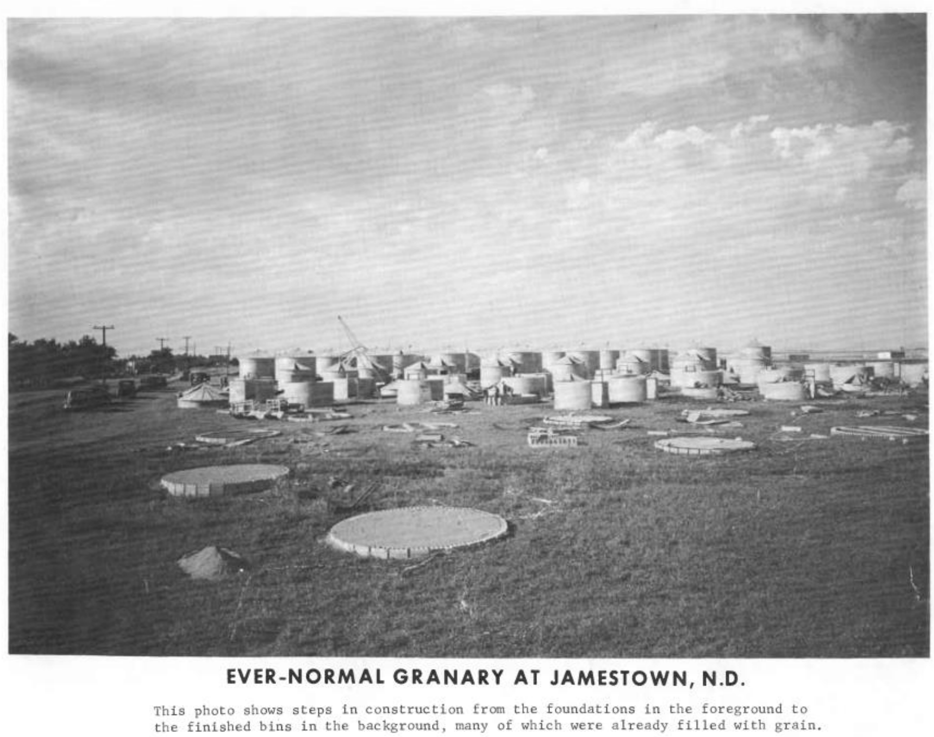


Figure 8: Picture of North Dakota storage site estimate 1950s (USDA and Agricultural Stabilization and Conservation Service 1975).

By 1945, the “technical groundwork” of the ever-normal granary was thought to have been standardized (Stewart 1979, 160). Agricultural engineers, technicians, and other experts had developed a consolidated approach to dealing with long-term storage. The CCC had developed a collateral system based on stored grain, which was tied to the national grain reserve. However, new problems would be encountered in coming years.

6.2.1 Emergency Grain Storage and Storage Expansion[71]

After World War II, the CCC continued its "storage expansion program" to protect producers' stocks against price declines, protect the CCC's investments, and "properly care for" the grain that was used to settle loans (Trigg 1948, 10). Demand for storage continued to grow after World War II, and "emergency bins" were pressed into service by the CCC. There are two reasons why the CCC's development of grain bins is important for explaining access to collateralized grain storage. First, the expansion of metal bins was not challenged directly by the grain trade because, I argue, metal bins were not considered to be a threat to the large terminal elevators and their owners. Second, detractors of the CCC used the term "dead storage" to refer to two aspects of the CCC storage program, the CCC's relationship to the market, and the use of non-elevator grain storage technologies. In short, dead storage referred to grain stored outside of market circulation and outside of the grain traders' infrastructure. A large part of the CCC grain was "outside" the market because it was acting as collateral for loans and was therefore 'dead'.[72] In addition, emergency storage facilities did not have the means to move grain easily in comparison to elevator, and thus it was "dead" because it was more vulnerable to spoilage (Holman 1957). The grain management techniques began to overcome some of the constraints of fixed storage, but the technology did not become widespread until the 1970s. This section describes how the CCC used "emergency" metal bins to contain grain for loans, and the reaction of the grain trade to the CCC.

[71] The CCC was also forced to store grain in a variety of fixed structures such as flat buildings, converted oil tanks, airplane hangars and other emergency stores during the 1950s (Holman 1957, 2).

[72] During World War II the term "dead storage" was used for grain cars that had been taken out of operation due to rationing.

The CCC and its grain storage program became a significant political issue for US domestic politics. When the CCC was reincorporated on July 1, 1948 as a federal corporation by the Commodity Credit Corporation Charter Act, the US Congress made some important changes to the CCC's mandate that had consequences for who could and could not own grain storage facilities. The CCC's new charter allowed it to continue with the programs of price-support loans, and to buy, sell, export, or store commodities. But the new charter limited the CCC's ownership of real property, and as a result, the CCC could not own grain terminals.

The growing grain surplus after World War II combined with limits placed on the CCC by the new Charter created a grain storage crisis in the lead up to the 1948 Presidential election. If the CCC could not expand storage under the 1948 charter restrictions, producers could not secure loans because there was not enough storage capacity – no storage, no collateral, no loan (Trigg 1948). The emergency bins became an election issue during harvest time. President Truman said:

> Republican Congress has already stuck a pitchfork in the farmer's back … Congress rewrote the charter of the Commodity Credit Corporation this year, [and] there were certain lobbyists in Washington representing the speculative grain trade. These big-business lobbyists and speculators persuaded the Congress not to provide storage bins for the farmers. They tied the hands of the Administration. They are preventing us from setting up the storage bins that you will need in order to get the support price for your grain. When farmers have to sell their wheat below the support price because they have no place to store it, they can thank this same Republican Congress-the Congress that gave the speculative grain trade a rakeoff at your expense. (Truman 1948, np)

The grain traders were accused of pushing for changes in the CCC's charter which restricted it from acquiring or leasing any real property, including plants, and facilities (McCune 1958, 117). Commercial operators wanted the government to use the normal channels of trade, meaning private grain trade facilities. McCune stated that an "obscure" change in the CCC's charter had important ramifications for the election, and as we will see for the use of emergency bins (McCune 1958, 46). The critical issue of this change was the interpretation and definition of real property and how it related to CCC's emergency bins.

The CCC could not own land according to the charter but, the bins were always temporary, and therefore could not be real property. In this legal sense they were interpreted as "personality". Personality is a legal distinction that exists somewhere between ownership of real property and something that is not considered real property under the law. The issue of the relationship of the CCC to emergency bins was discussed in the Committee on Banking and Currency hearings (O. P. Williams 1957). Three representatives from the grain trade told the committee metal bins were not considered to be real property by the grain trade, and were not part of normal trade as defined by the charter (O. P. Williams 1957, 119). So while it appeared that the grain traders were influencing how the CCC operated through their proxies in Congress, they did not seem concerned about the bin program (O. P. Williams 1957). The grain trade representatives made the distinction between real property, including "farm lands, warehouses, elevators, railroads, terminal facilities, barges, boats, and wharves" and bins (O. P. Williams 1957, 119). Their interpretation was complicated and difficult to decipher because US law defined barges and boats in the as personality, the same category as bins (O. P. Williams 1957). Either the grain trade representatives had no understanding of the legal distinction, or metal bins were insignificant in the eyes of the grain trade, and outside of "normal" trade. The latter explanation seems the most plausible.

The grain trade's list of real property sums up the elements of grain transportation and storage infrastructure after World War II - warehouses, elevators, railroads, terminal facilities. Their key concern was that the CCC not infringe on the infrastructure through the control of, for example, larger facilities such as terminal elevators. But bins were not viewed as important. The grain trade had a hold on terminals and sub-terminals, which were the gateways to the lucrative export markets.[73] The

[73] Chicago terminal markets have declined in volume and number over the last two decades.

CCC had little to no stake in the larger facilities because of ownership restrictions, and, as will be shown below, the grain trade made considerable income from leasing facilities to the CCC.

Williams (1957) examined grain trader publications and meeting minutes in the lead up to the 1948 change in the CCC's charter, and he found little to no concern with the bin program. Bins were not directly connected to the export market, and were dispersed and outside the market. For example, the bulk of the CCC's stocks was corn, and at the time, corn usually remained on the farm for animal feed and was not part of the export market. Another part of the explanation for why the grain trade was not concerned with bins was that grain stored in bins was difficult to manage before dryers and aeration became commonplace (USDA and Agricultural Stabilization and Conservation Service 1975, 16). The problems with spoilage described in Chapter 5 had yet to be overcome.

There was an additional reason why the grain traders and elevator owners were not concerned with the expansion of the CCC metal bin program. In 1949 the CCC started a program to grant low-cost loans to grain elevator operators to construct and expand existing granaries and to buy new equipment. The CCC guaranteed it would fill 75 percent of the new capacity for three years in the case of a new facility, and for two years for an addition or annex to an existing facility (Trigg 1948, 11).[74] Farmers' cooperatives and commercial warehouse operators added an additional 82 million bushels of storage capacity during this time and commercial storage capacity tripled from 1.125 million bushels in 1950 to 3.55 million bushels in 1959 (United States. 1959, 3). In 1962, government-approved storage totaled 4.5 billion bushels (Blair 1962, 180). But the demand for storage still exceeded capacity, and the CCC turned its resources to expanding metal bins.

[74] The CCC occupancy program was offered through 1953 and into 1954. The occupancy rate was guaranteed to be from 50 to 75 percent, and was dependent on length of time, which ranged from three years to six years (United States 1959, 9).

The CCC bin storage capacity was increasing at a fast pace, from 45 million bushels in 1949 to 886 million in 1955 (Shepherd and Richards 1957, 15), and to about 990 million bushels after completion of the bin-purchase program in 1956 (USDA and Agricultural Stabilization and Conservation Service 1975, 16). An additional 55 million bushels were financed by the CCC through loans to producers for on-farm storage facilities during this time (Shepherd and Richards 1957, 15). The CCC came to rely on metal bins for a large percentage of its storage. From 1954 to 1962, bins held anywhere from 22 to 42 percent of CCC total grain storage (Haberer 1964, 23). As noted above, manufacturers had been supplying the government with thousands of bins. The purchases were not insignificant. For example, in 1950 the CCC purchased 32,895 bins at a cost of almost $29 million USD (USDA and Agricultural Stabilization and Conservation Service 1975, 19).[75] The bin expansion program helped to develop standardized containers, and helped to reduce the public cost of storing grain.

6.2.2 The CCC, Public and Private Storage Costs

Bins were part of the solution to storing and stabilizing an asset stream for farmers, but the fact that the CCC was forbidden from owning elevators meant that vast stores of grain continued to be managed by private grain traders and elevator operators. The result was that grain trading companies were paid enormous amounts of cash to store CCC's grain. Because grain storage rarely pays for itself, the fact that the government paid for storage was a boon to the companies. In the words of one operator: "the government was a good customer" and "was good bread and butter for terminal elevators" (Raskin 1958 as quoted in Peck, 1974, 125). This, combined with low-cost loans to expand their facilities and guaranteed storage levels, meant that the elevator owners benefitted directly from the public grain reserve.

[75] The demand for galvanized steel due to the bin program was so large that it was thought to have constricted steel supplies during the Korean War effort (Chicago Daily Tribune 1950).

During the 1950s the government had lent millions of dollars to cooperatives and private operators to build up storage capacity. By 1959, the CCC was supporting the vast expansion of storage. More than 90 percent of the CCC's storage costs were connected to grain, and it was estimated to be spending over $1 million USD a day to store it (United States. 1959, 3). Grain elevator operators raised concerns that insecure warehouse operators would go bankrupt without government support through CCC payments (Wiese 1963, 24). Elevator operators were concerned about "empty capacity" because of the expansion of private storage (T. E. Hall 1954, 20).[76] On the one hand, the CCC made it difficult for elevator operators to hedge and leverage their ownership of storage facilities, and on the other hand, the government payments supported private grain storage with generous payments at the same time it backed the loans to farmers.

The CCC was scrutinized for the rising costs of storage. A series of Congressional hearings examined CCC's storage operations and reported that grain elevator operators were making profits of anywhere from 85 to 265 percent by storing CCC grain (Storage Costs 1960). At the hearing, CCC officials were questioned on why fees for commercial storage were so high. The CCC officials gave a variety of reasons, from the fact that elevator operators had to maintain and condition grain, to the high capital costs of storage facilities. The storage fees paid to a farmer versus those paid to a commercial operator (farmer 15 cents vs. 22 cents for the operator) were justified because elevator operator's extra handling costs "add value," whereas bin storage did not add value because it was "dead storage" (United States. 1959, 79–80).

The Congressional hearing helps to illuminate two points about the CCC and its relationship to metal bins and its relationship to the grain traders and elevator operators. First, it was difficult for the CCC to manage and administer grain in private facilities. Private grain storage had long been a site for

[76] Farmer cooperatives in the US were aligned with business interests rather than agrarian ideals, a legacy of Hoover's corporatism (Hamilton 2014).

swindles and other fraudulent acts (see Chapter 5), which made it hard for the government to secure oversight. Second, government costs of its own facilities, and in particular grain bins was presented as a straightforward calculation. A CCC official, when pressed, stated that it was easy to determine costs associated with bin storage (on-farm, or managed by the CCC) because

> we have an excellent cost figures on round steel bins. We were in the markets buying them year after year for several years and we have those actual costs. Now as regards to new [storage] designs today – there are as many designs as people building them ... so it is very difficult to state the cost [of new designs]. (United States. 1959, 84)

As this CCC official implies, standardized bins helped to stabilize the value of grain and to calculate its storage costs. Metal bins helped to facilitate a new model of physical stabilization for grain management that was initially outside the realm of private grain storage operators.

Although metal bins were initially used for emergencies, over two decades they became an established part of the grain-marketing landscape. Grain traders were unconcerned with the use of bins, but maintained control of the terminal elevators and were able to leverage their positions to benefit from the generous CCC payments. However, due to the increasing costs of the CCC, there was political pressure to reduce its holdings through the 1960s. By 1968, CCC storage space had declined by 60 percent from the late 1950s, partially in response to the implementation of production controls (USDA and Agricultural Stabilization and Conservation Service 1975, 19). Hieronymus states that reduced government storage led to an increase in hedging strategies (Hieronymus 1977). This is an important point because it shows that as the CCC pulled back from grain storage, grain traders began to return to using ACEs to leverage storage in the 1960s.

The CCC began to sell off bins in the 1960s-’70s to encourage farmers to take on more on-farm storage, either through purchase of used CCC bins or through the purchase of new bins under the Farm Storage Facility Loan Program (USDA and Agricultural Stabilization and Conservation Service 1975). The CCC’s last few structures were sold in 1975, laying the groundwork for new grain-storage governance (USDA and Agricultural Stabilization and Conservation Service 1975, 19). The CCC bin sell off had the backing of agricultural economists who calculated that elevators could not continue to maintain a cost advantage over on-farm storage once capital investments were made by farmers in on-farm bins and dryers (Hill 1970, 9). The ideas that were described in Chapter 3 were beginning to take hold and stabilize the idea of privately held on-farm storage. In addition, the shift to metal bin technology was portrayed as part of a wise modernization program that had to be adopted or farmers would go out of business (Hill 1970).

The regulatory shifts, the ideational shifts and the new physical containment all began to come together to form a new kind of grain-storage governance assemblage. Farmer-owned reserves were also thought to be more effective at managing production and reacting to demand than the CCC-managed reserve (Schaffer et al. 2013). In Illinois and Iowa, metal-bin capacity was on the upswing before the farmer-owned reserve was established in 1977. Farms saw an increase in metal-bin capacity of over 40 percent from 1972 to 1977 (Dixon, Hill, and Saffell 1980, 62). The ideas described in Chapter 3 and physical stabilization of metal bins were both in place to help support the regulations that shifted to a farmer-owned grain reserve in 1977. In turn, the federal government granted almost $1 billion USD worth of low-cost loans for grain storage and equipment. Over 80 percent of the loans were used to purchase additional storage and/or drying equipment between 1977 and 1979 (Gunset 1979). The CCC's work had made bins commonplace and had supported the expansion of bin manufacturers and the development of new technologies, which made grain-bin storage and a farmer-owned reserve possible.

6.3 1990s Spreading the Risk: Farmers' On-Farm Storage

This section describes how the US state shifted the risk of agricultural marketing to US farmers in the 1990s, after decades of supporting grain marketing through the CCC and other state institutions. I argue that the changes in regulations show the influence of the Chicago Futures School ideas and their support of ACEs as a tool to help manage agricultural markets as the central role of stored grain shifted from a public concern to a private market. Further to my argument about the crucial character of storage at the center of assemblages that secure asset streams from stored grain is the control and management of storage; these regulatory shifts illustrate how the state support of grain reserves declined, and in its place a model of grain storage and market risk management emerged. Finally, dispersed on-farm grain storage was facilitated by the development of metal bins, and the physical stabilization technologies described in Chapter 5.

A critical tool for farmers in risk management was on-farm storage – a personal buffer stock to help manage the ups and downs of commodity market volatility. Recall in Chapter 3 that McKinnon (1967) maintained that farmers should hold their own buffer stocks because the farmer is connected to both the risk of production and the risk of marketing. He reasoned that farmers could manage risks with derivatives such as forward contracts and futures markets with the aid of on-farm storage. The changes in regulations unwound CCC support of grain storage, and provided supports for farmers to use derivatives to manage risk. In short, the assemblage that supported farmers' access to asset streams through state-backed grain storage was reconfigured towards the private management of grain storage and was accompanied by an education program to encourage farmers to use ACEs and other derivative platforms to manage risk.

The regulatory destabilization described in Chapter 4 was accompanied by three regulatory changes, which show how grain-storage governance was reconfigured, and how the changes reconfigured who had access to asset streams from stored grain. First, US agricultural policy ended the public support of grain reserves. The Federal Agricultural Improvement and Reform Act of 1996 (FAIR Act) rendered CCC and farmer-managed storage ineffective (Ray 1996). The CCC was, for all intents and purposes, shuttered, and no longer managed grain storage, directly or indirectly. The FAIR Act was accompanied by a CFTC and USDA education program to help ease farmers into their new role as risk managers. Second, the CFTC began to allow over-the-counter (OTC) agricultural options to encourage farmer-based agricultural risk management. Third, the Commodity Futures Modernization Act of 2000, an amendment to the Commodity Exchange Act incorporated section 4P, which required the CFTC to increase agricultural producers' access to futures and options markets (CFTC 2001). Together, these shifts reshaped agricultural financing, and re-imagined farmers as individualized risk managers.

Joseph Dial, a CFTC commissioner who advocated for the increased use of futures markets called the restructuring of the US agricultural regulations and policies a "grand experiment" (Dial 1997a). In a speech to the National Council of Farm Cooperatives, Dial stated that there were two possibilities for farmers in the new liberalized market: to become large production farmers and use the market to manage risk, or to become contract farmers as part of a virtual integration modelled on Walmart (Dial 1997b). In other words, without government programs and protections, there were two ways to farm – under contract with a vertically integrated company that would supply inputs and buy outputs, or as a large production farmer managing risk through financial tools such as options. Concurrently, financial actors began to gain increased access to ACEs, access that had previously been restricted through regulations (Clapp and Helleiner 2012; Ghosh 2010; Martin and Clapp 2015).

The context for a shift from farmer-managed grain reserves to farmer risk management was shaped by global shifts in agricultural trade policy. The Uruguay Round Agreement on Agriculture was finalized in 1994 and included liberalized agricultural trade. Liberalized trade meant that farmers' incomes were linked more closely with market forces (World Bank 1999, 51). The liberalization of agriculture meshed well with the ideas that had been developed by the Chicago Futures School about the free market and limited government interference as outlined in Chapter 3. Farmers were experiencing an increased exposure to volatile commodity markets with fewer state protections.

But access to on-farm storage was presented as a possible protection from volatile prices when used hand-in-hand with derivatives and information from ACEs. Proponents of on-farm storage conceptualized it as a risk-management tool, a kind of individualized buffer stock that was facilitated by the development of on-farm grain-storage technology (Dial 1997a). Programs were established to transform farmers from solely producers to modern risk managers who used futures markets, swaps, and options to create their own safety nets (Dial 1997c).[77] The development of on-farm grain storage technology was a tool to hold grain, and facilitated farmers' capacity for risk management, by using forward contracts and hedging. The increase of liberalized agricultural trade, and the move to limit government programs contributed to reimagining farmers as risk managers, and one of their tools was stored grain in conjunction with ACEs.[78] Three regulatory changes show how grain-storage governance was shifted into private hands, and how regulations encouraged farmers to use storage and derivative markets to secure asset streams. In turn, the regulations fostered an increasing number of financial actor's access to speculate on agricultural commodities through ACEs.

The first regulatory change was the FAIR Act. The Act affected many of the subsidies that had been in effect since the 1930s. Importantly, for the focus of this thesis, the FAIR Act set out the conditions that suspended the farmer-owned grain reserve, and removed supports for state-supported grain reserves. The support for the change came from two quarters. First, the demand to end the grain reserve aligned with Congressional interests who wanted to limit government intervention, and trade pressures to liberalize agricultural markets. Second, agribusiness interests wanted the end of the

[77] Risk management strategies include "(1) forward contracts, which enable farmers to lock in a price for their crop or livestock production prior to harvest or slaughter, (2) crop insurance, which ensures compensation if crop yields are substantially lower than expected, and (3) hedging--buying or selling futures or options contracts on a commodity exchange, such as the Chicago Board of Trade--which reduces the risk of receiving lower prices for crops or livestock" (USGAO 1999, 6).

[78] The liberalization of agriculture has yet to be fully realized, and there are many contradictions in US agricultural policy that calls for increased liberalization of global agricultural markets, at the same time it continues to support its domestic farm constituencies with subsidies and other resources (Wise 2009; Clapp 2015).

farmer-owned grain reserve because it limited the amount of storable commodities reaching the market (Ray 1996, 74). On one hand, it was expected that private interests would become active in grain storage management, and buy grain at a low price and sell at a high price (Johnson 2012). This would fall into line with the Chicago Futures School theories that predicted that commercial interests would bear the market risk while benefitting from volatile prices. On the other hand, it was expected that the same price volatility and risk would make agricultural financing less attractive to bankers (Ray 1996, 90). The problem of agricultural risk had been partly ameliorated by the national grain reserve. The concern was that agriculture financing would again become unattractive without state backing, the same backing that has been provided by the CCC since the 1930s.

The market orientation of the FAIR Act led to a greater emphasis on risk management tools. One of the programs established by the FAIR Act to help support farmers in an increasingly risky market was the Risk Management Agency, a joint education program of the USDA and the CFTC. The FAIR legislation stated in Section 192:

> In consultation with the Commodity Futures Trading Commission, the Secretary [of Agriculture] shall provide such education in management of the financial risks inherent in the production and marketing of agricultural commodities [to] develop and implement programs to facilitate the participation of agricultural producers in commodity futures trading programs, forward contracting options, and insurance protection programs by assisting and training producers. (USDA Risk Management Agency 1996)

The Risk Management Education Initiative promoted the utility of futures and options, and crop insurance to farmers, and to third parties (such as insurance agents and commodity brokers) who dealt directly with farmers (CFTC 1997b).

One of the strongest advocates for the increased use of risk management tools for farmers was Joseph Dial, a CFTC commissioner from 1991 to 1997. Dial was a rancher and farmer from Texas who championed the use of derivatives, specifically options, for farmers and ranchers. One of his aims as chair of the CFTC Agricultural Advisory Committee was to “raise the level of farmers’ understandings of the economic benefits that could be derived from learning how to shift the production and price risks in a prudent manner" (Dial 1996, np). In a presentation titled "Everybody Wins with Agricultural Risk Management Education," Dial stated that "being a good farmer won't be enough to assure success or even survival"; instead, a farmer needed not only to till the soil, but also to exercise "**daily** use of astute business management practices" (Dial 1996, np, bold in text). The FAIR Act gave producers "the freedom to farm for the market and not the government" (Dial 1996, np).[79]

The second regulatory change was the CFTC's decision to allow over-the-counter (OTC) agricultural options to encourage farmer-based agricultural risk management. Options give the buyer the right but not the obligation to buy or sell a commodity (in this case, grain) at a specified price and date. Agricultural options had been restricted since the 1930s, but in the early 1990s, the CFTC floated the idea of off-exchange agricultural options because exchange contracts such as futures were too large and financially inaccessible to farmers (CFTC 2001). Dial supported the use of off-exchange, or over-the-counter (OTC), options because these instruments could be customized for farmers and ranchers.[80] The CFTC established a pilot program in 1998, and option contracts were made available to farmers. But there is little indication that options attracted much interest from farmers (Frechette 2003). Few merchants offered them, and fewer farmers used the options due to their high cost, which included premium to the third-party merchants (Frechette 2003).

[79] "The second innovative use of derivatives is in a pilot program initiated by the Enron Company of Houston, Texas. Simply stated, it allows potato growers in Idaho and dairy farmers in New Hampshire to tie the cost of the electricity they use for irrigation and milking, respectively, to the prices of the commodities they produce" (National Grain Farmers Presentation – Dial 1997).

[80] The CBOT pushed back on the proposal because they wanted to keep trade on the exchange (Lucchetti 1997). Despite CBOT's opposition to the plan, Dial's support of off-exchange options led Illinois Senator Carol Moseley-Braun to block his reappointment to the CFTC, which was attributed to pressure from LaSalle Street who wanted to keep their monopoly on agricultural derivatives in place (Lucchetti 1997).

The third regulatory change was the Commodity Futures Modernization Act of 2000. This amendment to the Commodity Exchange Act incorporated section 4P, which required the CFTC to increase agricultural producers' access to futures and options markets (CFTC 2001). The amendment required the CFTC to improve its service to "the underlying cash market as well as speculators" (CFTC 2001, 47). At the time, the CFTC hoped that electronic trading and an education program by the CBOT[81] would encourage lower costs and a wider variety and size of contracts (CFTC 2001). The size and details of the contracts were set by the exchange, and the CFTC had no direct influence. This meant that the CFTC could encourage but not directly determine how agricultural futures contracts were designed. The CFTC considered the indirect benefits sufficient for farmers; these included price discovery and the benefits producers received through their membership in producer-owned cooperatives that used ACEs to hedge (CFTC 2001).

The FAIR Act effectively ended the state reserve program and in its place farmers were encouraged to use derivatives to help manage risk. However, the changes effected through legislation policy and regulation over the 1990s did not, in fact, increase producers' use of futures and other risk management derivatives. A 2008 GAO report estimated that hedging was limited to 10 to 25 percent of all producers (NCGA 2008, 3). Large-scale farmers were more likely to hedge than small-scale farmers (above and below $100,000 USD in sales) (USGAO 1999, 5). The GAO report identified barriers to farmers using futures markets. These included high costs, the excessive capital requirements of the contracts, and margin calls. The focus on the design and structure of futures contracts is one aspect of the barriers experienced by farmers.

There has been little uptake by farmers to use derivatives despite pilot projects and educational programs. Part of the explanation is that farmers are also at a disadvantage because of the relation

[81] The educational program and outreach offered by CBOT included a number of experiments with smaller contracts.

between storage and ACEs. Futures markets are based on the efficient physical delivery of the underlying commodity. Exchanges are responsible for setting storage and loading rates that reflected the cash market, as well as determining delivery sites. Delivery point operators effectively controlled access because they could refuse to take deliveries for futures and/or charge high fees for deliveries. If producers could not deliver on futures contracts, they could not effectively hedge. In addition, the exchange-approved delivery points were limited. In fact, the balance between too many and too few delivery points has been the cause of numerous complaints and conflicts over the last three decades (CFTC 1996; CFTC 1997a; CFTC 2009).

The physical control over delivery on a futures contract should give farmers an advantage. To settle futures contracts, farmers can deliver, for example, 5000 bushels of corn. But elevators can refuse delivery if the market is unfavourable, and that advantage is lost. The advantage then leans toward the cash settlement on futures contracts. In fact, cash settlement of contracts has displaced the physical (commodity) settlement of contracts. According to the National Corn Growers Association (2008) large investment funds and speculators have had overwhelming influence on the futures markets. These non-commercial traders are trading based on "a market basket of futures prices, not a market basket of physical commodities" (NCGA 2008, 5). The ACE physical delivery system has created barriers to farmers and made effective risk management through ACEs difficult.

Risk management through derivatives has a high cost, and leaves farmers carrying the margin risks, or options premiums, that were previously carried by many grain elevator operators (NCGA 2008:3). Basis volatility (the difference between cash and futures prices) across the Corn Belt rose significantly from 2006 to 2011 when compared to the previous 15 years; from 1990 to 2005 the average price range was $.93 USD, and from 2006 to 2011 it was $2.42 USD (Kowalski 2012, 6).[82] In

[82] Wheat price range averages were $1.40 from 1990 to 2005, and $4.20 from 2006 to 2011. Soy price range averages were $1.96 from 1990 to 2005, and $4.76 from 2006 to 2011 (Kowalski 2012, 6). The result is

addition, farmers require access to significant amounts of working capital to manage storage risk, levels of capital that were “improbable” just a few years ago (Kowalski 2012, 5). Compounding the financial issue are record-level production costs for farmers (Kowalski 2012, 5). The effect of the high costs, price volatility, and increased risk is that grain storage continues to consolidate with larger bins, fewer facilities, and fewer grain-handling firms (Kowalski 2012, 5).

Farmers became individualized risk managers, but there was little uptake of the tools available through the futures markets. The state-backed farmer-reserve was suspended by the FAIR Act (Ray 1996). On-farm storage became an individualized risk-management site, dependent on futures markets. This was not only a story of deregulation, or state versus private control of storage; farmers were reimagined as risk managers, and in turn, hedgers who would benefit from the services of futures markets as other options were stripped away, whether they used futures markets or not. The project of encouraging farmers-as-risk-managers was facilitated by the development of the on-farm grain storage technology that is ubiquitous today.

ACEs have become central to US agriculture and global food security according to Commissioner J. Christopher Giancarlo of the Commodity Futures Trading Commission. In an opening statement to the CFTC Agricultural Advisory Committee Meeting he stated: “America’s farmers supported by America’s derivatives markets stand ready, willing, and able to feed the world’s growing population” (Giancarlo 2014, 8). He concludes his statement: “When it comes to agriculture derivatives markets, our actions could have a larger impact than we realize – feeding the world – not only next month but thirty years from now. It is a hungry world and getting hungrier. Thank goodness for the American

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that margin calls are more unpredictable. Kowalski reports that elevators require $50 million USD lines of credit to operate (2012, 5).

farmer and US markets" (Giancarlo 2014, 8). These statements illustrate how ACEs have become "common sense", and central to US agriculture.

Hernando De Soto stated that assets can "lead a parallel life as capital outside of the physical world" (de Soto 2001, np). What he famously termed "dead capital" had potential untapped energy that could be financially engineered to be unleashed when collateralized (de Soto 2001, np).[83] With the backing of the CCC, dead storage did indeed stand-in for collateral. However, grain in storage does not automatically become collateral. Ownership and control of the market is crucial. Even with grain in hand, farmers cannot easily sell it, as evidenced by the issues of delivery chronicled above. Without the backing of the state, on-farm storage is indeed "dead storage."

While there have been significant shifts in the structure of the US grain market over the last few decades, there has also been a significant shift in on-farm grain storage. It has increased dramatically over the last decade due to a huge increase in corn ethanol production, which requires year-'round grain-storage technologies, including dryers, agro-chemicals, and corrugated galvanized metal bins. The federal mandate to increase ethanol production (Energy Policy Act of 2005, and the Energy Independence Act of 2007) accounts for 90 percent of new grain-storage capacity (Kowalski 2012, 6). On-farm storage is expensive and carries great risk because, while grain can potentially increase in value, it has to be maintained and monitored.

6.4 Conclusion

Metal bins facilitated on-farm storage, and the legacy of the CCC showed how grain storage could be used for collateral. State backing had originally been needed to secure grain storage for collateral. Now, decades later, on-farm storage is a risk-management strategy. A close examination of the emergence of metal bins helps to show how stored grains happened to be the place in which collateral

[83] Thanks to Derek Hall for bringing de Soto's work to my attention.

was fixed by the state, leading to an expansion of bin use and facilitating the eventual, if incomplete, project of casting farmers as risk managers. On-farm storage has become a risk-management tool, a kind of individualized buffer stock, and it was facilitated by the development of the on-farm grain storage technology that is ubiquitous today.

The Commodity Credit Corporation (CCC) was pivotal to changes in US grain-storage governance in the twentieth century. Together, physical storage, regulation, and ideas worked to shift grain-storage governance. Physical infrastructures are part of the explanation of how finance finds a foothold in grain storage. The CCC played a significant role in developing and contributing to the physical containment of grain through its expansion of metal bins as a means to secure grain as collateral for extending loans to farmers. The stabilization of grain through on-farm storage and "emergency" bin storage helped to diminish centralized storage facilities. The physical infrastructure of bins meant that market-risk management could also be distributed to spheres outside the Chicago markets.

The spread of metal bin technology, starting in the mid-twentieth century, helped to change grain-storage governance in the US from a national reserve to a farmer-owned reserve in the 1970s, and from government risk management to farmer-centered risk management in the 1990s. As a result, physical technologies, ideas and regulation all came together in a new grain-storage governance assemblage. The relationship among state-backed loans, storage bins, and regulatory shifts had an impact on storage governance and its relationship to futures markets. Grain also has to be "contained" and physically stabilized. Storage containers stabilize grain physically, and in turn, the grain starts to become legible to financial markets.

Chapter 7– Building Markets Revisited: Lifeless and Mobile Ideas

Commodity exchanges are increasingly central to the policy debate – [as] trade-facilitating institutions they can meet critical development challenges.

– Gross 2007, 25

With the liberalization of agricultural trade and the withdrawal of government support from agricultural producers outside the OECD, there is in many countries a new need for price discovery and even physical trading mechanisms, a need that can often be met by commodity exchanges.

–Santana-Boado, Gross, and UNCTAD secretariat 2006, 1

During the twentieth century, the US state developed a model of agricultural finance that was based on collateralizing agricultural goods in storage to support farmers. The model relied on mid-century economic ideas, agro-chemical technologies, and state regulation. When the US state pulled out of managing the national grain reserve, a new model of risk management that included on-farm storage and leveraging agricultural commodity exchanges (ACEs) and futures markets emerged. International organizations' policymakers drew on this model to help build new agricultural markets in frontier sites. Starting in the 1990s, commodity market arrangements – specifically, agricultural commodity exchanges and warehouse receipt systems (WRSs) – were promoted by international organizations (IOs) to poor countries as a pathway to agricultural development and a means to facilitate investment.[84] The World Bank and UNCTAD stated that underdeveloped agriculture, especially in sub-Saharan Africa, could be strengthened by improving farmers' access to credit, capitalizing agriculture and building connections with global markets. Global market connections would facilitate free trade and improve food security. At the centre of many projects was the establishment of ACEs.

[84] Risk management strategies include "(1) forward contracts, which enable farmers to lock in a price for their crop or livestock production prior to harvest or slaughter, (2) crop insurance, which ensures compensation if crop yields are substantially lower than expected, and (3) hedging--buying or selling futures or options contracts on a commodity exchange, such as the Chicago Board of Trade--which reduces the risk of receiving lower prices for crops or livestock" (USGAO 1999, 6).

More specifically, promotion of, and support for, ACEs was shaped by an aspiration to build "the ultimate open" and free market (Rutten 2001, 8).

I will show that IO experts drew on the success of the US-style model to support the new agricultural market projects without recognizing the crucial role of the US context. In the 1990s, the IOs developed plans to use existing ACEs and futures markets in OECD countries to help finance commodity trade originating in poor exporting countries, but in the 2000s their attention shifted to developing new ACEs and WRS to connect smallholders directly to global markets. In addition, IOs changed their approach to grain storage development projects from one that provided technical support for community and on-farm storage to an approach that supported private grain management, or market-driven storage management (especially WRSs) in order to develop collateralized credit. I analyze these projects by thinking through the three stabilization processes of grain-storage governance (regulatory, ideational, and physical). According to their supporters many of the ACE-building projects have not succeeded, and there has been limited success in establishing market-driven projects such as WRS and ACEs in new sites (e.g. Sitko and Jayne 2012). I argue that the export of this model has not been successful because the conditions that support WRS and ACEs, described in the earlier chapters, were not present.[85] The Chicago Futures School theorized the role of grain storage in relation to ACEs in the political economy context of a state-built and -managed grain-storage management. In the wake of structural adjustment policies and market liberalization, IOs drew on these ideas to plan and establish new agricultural markets. Agricultural commodity exchanges would provide "modern market-based financial instruments," such as futures markets, that had the potential to manage the post-structural adjustment context and build new markets in the 1990s

[85] ACEs have been established in many countries. For example, in 1993 the Dalian Commodity Exchange was established in China and the Multi Commodity Exchange of India was established in 2003. The state is active in both countries in two ways, first, managing state supported grain storage and reserves, and second, the state has stepped in to both support the establishment of ACEs and to constrain trading on essential commodities.

(UNCTAD secretariat 1998, 8). US-style ACEs were used to exemplify successful markets, and IOs provided templates for best practices (Brenton and World Bank 2012, 75). The promoters of ACEs urged governments to create "enabling environments" for ACEs and WRSs with new regulations and storage infrastructure (e.g. IFC and GPFI 2011, 20). But establishing regulatory and physical stabilization was more difficult when compared to theorizing and planning for new markets. IOs have been less successful in persuading governments and private actors to develop the institutions, regulations, and physical infrastructure described in the previous chapters. As such, ideas about ACEs and storage were applied as a technical tool, in new "global" sites, free from local histories and material contexts.

The relationship between financialization, grain storage and the promotion of ACEs is not necessarily direct, or connected. Agricultural commodity exchanges are sites where agriculture, grain storage and finance meet, but the global growth and expansion of ACEs does not necessarily mean all ACEs are shaped by practices of financialization. The value of an examination of the IO promotion of ACEs illuminates the complexity of building markets and the varied relations that are required to bring finance and agriculture together.

To explain the actions of the IOs, I draw from IPE scholars Broome and Seabrooke (2012) and their conception of "seeing like an international organization," and from Barry's (2006) framework for technological zones. Broome and Seabrooke (2012) stated that IOs use their intellectual resources and ideas to persuade policymakers to adopt and enroll in new programs. These concepts are a form of structural power because they set agendas and produce new classifications that include some and exclude others (Barnett and Duvall 2005). Acts of classification – for example, placing agricultural goods into new market arrangements – and other forms of structural power are difficult to contest because these acts are not overtly political. ACEs and WRSs provide frameworks to build asset streams by establishing collateral for financing. Both ACEs and WRSs make agricultural markets and financing legible, and these analytic concepts are a form of structural power.

Barry's (2006) work draws our attention to the creation of transnational technological zones and the role of both human and non-human actors. Transnational technological zones are the purview of IOs, NGOs, and multinational corporations. Technological zones, and an examination of the metrology, infrastructure, and standards that define these zones, can illuminate the discrepancies between an IOs' public statements and the historical construction of particular economic spaces. In addition, the lens of technological zones can illuminate how distinctions are made between "global/Western political and economic forms and their non-Western others" (Barry 2006, 251). Together, I use Broome and Seabrooke's and Barry's analyses to show how an IPE conceptualization of power and a close examination of how grain storage, as a technological zone, can help explain how IOs are promoting a model of agricultural commodity financialization.

This chapter draws from almost three decades of documents from the United Nations Conference on Trade and Development (UNCTAD) and the World Bank on WRSs and ACEs. Both UNCTAD and the World Bank were at the forefront of projects to develop new agricultural markets. In turn, their documents show how these projects were depicted, and I am able to analyze how ACEs and WRS were promoted in policy documents. It illuminates how these two IOs portray the problem of agricultural markets and how they promote a model of agricultural markets that is reliant on grain storage to develop a site for credit and asset streams. The weakness of this literature is that it cannot fully account for why the projects have not been successful. Grain storage is not central to these documents. But ideas about agricultural markets and credit are central to them. I focus on how these documents represent the relationship between grain storage and credit in the context of global agricultural markets.

This chapter begins with an introduction to the changing context of trade liberalization during the 1980s and 1990s, and how UNCTAD and the World Bank confronted the problem of financing international commodity trade in the wake of structural adjustment policies. Structural adjustment policies prompted the shift in IO policies towards helping to develop new models of trade financing, and IOs used their intellectual resources and ideas to promote the adoption of ACEs and WRSs. The chapter then moves to a discussion of how the role of storage changed with the promotion of market-based storage projects such as WRSs. This section shows how the creation and conception of WRSs included the establishment of collateral to facilitate credit. The quest to establish an enabling environment to foster WRS and ACEs shows how public storage programs were eroded and private storage was promoted with the promise of collateralized commodities. The third section examines how ACEs were promoted in the aftermath of the food and financial crises of 2007-8. Regulatory stabilization can be found in the documents because of calls for enabling legal and regulatory environments, but regulatory stabilization is an unfinished project in these documents. Traces of physical stabilization can be found through descriptions of physical infrastructures, but ideational stabilization is at the forefront of these documents. The chapter then concludes with a discussion of the effect on ideas of these documents, and how the projects have not met with success.

7.1 Trade Liberalization and International Organizations

Modern market-based financial instruments, such as futures, options, swaps and various forms of collateralized finance may not be the ideal solution to the problems caused by market instability, but no better alternatives are currently available

– UNCTAD secretariat 1998, 2

The liberalization of commodity markets in the 1980s and 1990s was facilitated by the unwinding of international commodity agreements and the dismantling of state trading organizations and marketing boards (Gilbert 1996; Clapp 1997). This shift created space for new models of risk management to emerge – ACEs and WRSs. International organization documents were in agreement about how WRS worked in conjunction with specific patterns of agricultural price changes – low prices are paid at harvest, and prices steadily increase before the next harvest. The rise in prices would cover storage costs, benefit farmers who accessed storage and potentially increase their income. Once up and running, the system provides incentives for farmers to commercialize and increase their efficiency as well as provide incentives to improve the quality of their agricultural goods. Warehouse receipt systems aligned with liberalized markets because the production of credit was "crucial to the success of reforms," and would attract private investment (Lacroix and Varangis 1996a, 39).

These models could only emerge if the state-supported market arrangements – in particular, public reserves and storage – were discouraged. The assertion was that private markets were better equipped, more efficient, and less costly than state-run reserves, and free trade would facilitate efficient distribution and improve food security (B. D. Wright and Williams 1982; B. D. Wright and Williams 1984). The World Bank and the International Monetary Fund privatized production and marketing and limited government intervention in agriculture – and, according to Bello, "destroyed" African agriculture (2009, 68). This section describes the rollout of structural adjustment programs and their particular effects on the export of commodities. After structural adjustment, state and business capacity was unable to financially support export commodity trade, and farmers were left bearing more risk (UNCTAD Secretariat 2002). The policies, according to UNCTAD, created "a completely new environment for commodity trade in eastern and southern Africa" (Rutten, Santana-Boado, and UNCTAD 1996, 24). To help show how this shift occurred, I outline the financing of commodities before and after structural adjustment.

After World War II, international commodity trading companies (both private and public) became the traditional providers of credit to commodity producers located in African countries (van Der Laan 1987; Budd 1995). Colonial marketing boards and state trading enterprises were able to provide financing backed by states (van Der Laan 1987; Budd 1995). Banks were generally not involved in the terms and conditions of these transactions. Rather, financing was based on long-term relationships with trading companies, and credit was granted with minimal security and documentation (Budd 1995).

State intervention in commodity markets took a variety of forms including

> monopsonistic arrangements such as commodity marketing boards, government-controlled stabilization funds, exchange rate manipulations, tariffs, price bands, and so on. (UNCTAD 1997, 7)

International commodity agreements used supply management, export controls and buffer stock intervention to stabilize prices, but these schemes, along with state support, were criticized for being ineffective. For example, Wright and Williams argued that commodity stabilization schemes could not manage the inherently volatile nature of commodity prices with state-managed storage (J. Williams and Wright 1991). Williams and Wright (1991) wrote that state-managed storage crowded out private storage and did not deliver public goods efficiently – in other words, it was too expensive, echoing Working's and the Chicago Futures School's earlier arguments. Critics of state support also highlighted the inefficiency and expense of state intervention and marketing boards, and pointed out the negative effects on peasants and small farmers (e.g. Bates 2005). State intervention was costly and inefficient because it distorted prices, misallocated funds, and was protectionist (UNCTAD 1997, 7). But the liberalization of agricultural trade increased price volatility and complicated the commodity trade for exporting countries (Wierenga et al. 1997).

After structural adjustment, commodity exporters and traders' capacity was limited in poor countries, which ultimately resulted in a reliance on outside finance (Rutten, Santana-Boado, and UNCTAD 1996). During this time, export financing was also complicated by tight international credit in the wake of the 1980s Latin American debt crisis and the policies and loan agreements of international financial institutions (IFIs) (e.g. World Bank, International Monetary Fund, European Bank for Reconstruction and Development, and Asian Development Bank), or structural adjustment (Rutten, Santana-Boado, and UNCTAD 1996). The IFIs included negative pledge clauses, or covenants in their policies which generally prohibited government agencies or "instrumentalities" (such as state enterprises) from using export commodities as security for financing (Belozertsev, Rutten, and Hollinger 2011, 46). Pre-export financing was also affected and support for inland transport and warehouse costs was restricted (Rutten, Santana-Boado, and UNCTAD 1996, 25). The question for credit providers was how to secure collateral and protect their capital without state-backed institutions such as marketing boards.

The concern for stability was an outcome of the specific problems of financing global commodity trade. Commodities were not considered to be a good form of security: "The notorious variability of world prices made stocks of produce a poor form of security" (van Der Laan 1987, 22). Volatile commodity prices meant that the value of a shipment could change dramatically between the sale of the commodities it contained and the receipt of those commodities. In areas where there was an absence of private capital, the specialized needs of the commodity trade and the risky world market were supported by state-backed finance before structural adjustment. Since a borrower's ability to repay the loan largely depended on future commodity prices, volatile commodity prices exposed the lender to higher price risks.

Global commodity markets were unsettled as the ICAs unwound and commodity trade financing was restructured (Gilbert 1996). Budd (1995) states that in the 1980s trading companies experienced large losses, which led to large losses for some international banks and, in turn, to more restrictive loans. The remaining trading companies became more conservative in extending loans on a non-recourse basis.[86] Banks applied security and credit controls that were more restrictive than traditional trading

[86] A non-recourse loan is secured by a pledge of collateral, such as commodities, for which the borrower is not personally liable. Recall that the Commodity Credit Corporation used non-recourse loans (Chapter 4).

standards (Budd 1995, 100). For example, banks relied on commercial and bankruptcy laws and regulations, which required secured collateral that had clear title (Budd 1995) – a change from the past that had implications for warehouses, storage, and documents of title.

At the same time, new risk-management tools were emerging for commodity trade and agriculture to help manage these new conditions (Larson, Varangis, and Yabuki 1998; Morgan 2001). UNCTAD and the World Bank promoted the use of risk-management tools because “[t]he question of who will finance crop exports is crucial for countries contemplating the removal of government commodity marketing boards” (Varangis and Larson 1996, 22). The liberalization of markets included the relaxing capital controls by lifting of foreign exchange controls, which meant that financing sources would potentially be easier to access across international borders, including ACEs (Larson Varangis, and Yabuki 1998, 17). A World Bank working paper presented market-based programs as an alternative to state-based distributional programs, and asked how IOs and governments could help increase access to “derivative markets and risk management tools” to “solve public sector problems” (Larson, Varangis, and Yabuki 1998, i) .Agricultural commodity exchanges were promoted in the international organization literature as a means for poor countries to benefit from global commodity trade to access financing and to better manage volatile commodity prices (e.g. UNCTAD 1992; Claessens, Duncan, and World Bank 1993).

Futures markets had the added benefit of contributing to the efficient management of commodity storage. By accessing risk-management tools such as futures markets, storage could be managed privately, with less cost and, in general, more efficiently. As described in Chapter 3, public storage was promoted by some economists because it stabilized commodity prices, and contributed to the public good. But, Gilbert (1996) challenged the assumption that public storage contributed to stabilizing commodity prices. He argued that public storage inefficiently displaces private storage, and the assumption is only valid in the absence of efficient futures markets (Gilbert 1996, 3; see also

Wright and Williams 1982; Williams and Wright 1991). Private storage, managed through futures markets becomes "near riskless" because the structure of ACEs allows the separation of speculative and storage decisions (Gilbert 1996, 3). Gilbert continues by stating that the claim that high commodity price volatility can be managed through public storage is unproven, and in fact, public storage should be governed by the same criteria as private storage. In sum, efficient futures markets were ideal managers of commodity storage, or at minimum, superior to public storage. In turn, the World Bank and UNCTAD promoted ACEs and WRSs as risk-management tools that could assist in exporting commodities as state marketing agencies were set aside by structural adjustment.

In the early 1990s, UNCTAD and the World Bank began to promote and develop new ACE and WRS projects in their policy documents. In addition, they began to apply these policy documents to sub-Saharan Africa as a development tool. For example, UNCTAD described ACEs as a "powerful instrument of integration" for African countries (UNCTAD 1992, 4). Initially, these projects were well-received. The Organisation for African Unity envisioned an African Commodity Exchange that would "protect the prices of export commodities on the international market", and included it in the Abuja Treaty of 1991, which established the African Economic Union (OAU 1991, Chapter VIII, Article 46, d). There have been 20 primarily national projects to establish new commodity exchanges since then, but only South Africa has established a futures market.[87] What has been the outcome of these projects, and what have IOs such as UNCTAD and the World Bank done to promote the projects?

[87] The Ethiopian Commodity Exchange was established in 2008, but it has yet to trade futures contracts.

7.2 UNCTAD and Financing Commodities: From International Trade to Small Producers

Since 1964, UNCTAD had been "taming commodity" markets to create a stable commodity trade in order to advance domestic economic development (Corea 1991). UNCTAD oversaw the ICAs, and it worked to create a fairer world trade system through international agreements and governmental policies. However, rather than taming commodity market volatility, starting in the 1980s, UNCTAD changed focus and began to promote new market-based risk-management tools with a focus on commodity exchanges and WRSs. UNCTAD provided technical assistance on commodity trade with training seminars, expert group meetings, and "high-level information events" for ministers on market-based risk management tools with a focus on institutions "in particular, commodity exchanges" and credit tools such as warehouse receipts (World Bank 1999, 25-26).

UNCTAD began to explore incrementally the role of commodity exchanges and their impact on the trade of developed countries in 1983 (Rutten 2000). But the context for commodity trade was changing rapidly, and UNCTAD met in 1992 "in the midst of profound transformation in the world order" (UNCTAD 1992, 3) and set *A New Partnership for Development: The Cartagena Commitment*. The Cartagena Commitment (1992) was a development program to alleviate poverty, improve rural development, and protect the environment. UNCTAD recognized that "trade, money, finance, debt and commodities" were more closely integrated with each other than before structural adjustment and "growing denser" (UNCTAD 1992, 10). The Cartagena Commitment included exploring the utility of commodity exchanges and new price-risk instruments:

> The UNCTAD secretariat should explore various mechanisms, including market linked price hedging mechanisms, such as commodity futures, options, swaps, and bonds, obstacles to their potential use, including sovereign risk and problems with credit worthiness, and modalities for overcoming such obstacles and should provide information and assistance in this regard. [Experts should examine] (a) the conditions, both technical and regulatory, for encouraging maximum participation in, and usage of, commodity exchanges by both buyers

> and sellers of commodities and (b) proposals to address these conditions. (UNCTAD 1992, para 233)

UNCTAD's work on commodity exchanges was initially targeted at commodity exporting states. The Cartagena Commitment highlighted the utility of commodity exchanges for states (and buyers and sellers of commodities) for overcoming obstacles to credit worthiness.

The World Bank was also exploring the relationship between commodities and financial markets. *Commodity Risk Management and Finance* (Duncan and Priovolos 1991) promoted the idea of using financial markets and commodity exchanges to manage price risks in developing countries. The book was a theory-focused study of commodity-linked financing instruments, such as commodity bonds and securities. A follow-up edition, *Managing Commodity Price Risk in Developing Countries* (Claessens, Duncan, and World Bank 1993), presented practical applications of commodity risk-management. The explicit aim of the two books was to shift policy away from national and international price stabilization schemes and toward financial derivatives to manage price risk. It was during this time that IOs began to adopt commodity price-risk management as a development tool (e.g., CFC, FAO, UNCTAD, donor governments) to address the problem of financing commodities without state institutions.

In 1993, the Group of Experts on Commodity Exchanges, comprised of representatives from commodity exchanges, global grain trading companies, and the academy, met and set out a number of recommendations for the UNCTAD secretariat (Rutten 2000, 5). These recommendations were endorsed by UNCTAD's member governments (Rutten 2000). The policy proposals included the development of a worldwide consultation between exchanges and regulatory authorities, a call to strengthen warehouse receipt finance and improve the capacity of local financial sectors, and a call to governments not to impede "the proper function of commodity markets" (Rutten 2000, 2). Finally, the Group highlighted the need for technical assistance to reshape legislation in order to facilitate domestic exchanges. Possible solutions to commodity financing included securitization and warehouse receipts that used commodities for collateral. The Ad Hoc Group of Experts on Risk Management and Commodity Trade, which met in October of 1994, offered “warehouse receipt finance, and other forms of finance backed by commodity assets” as a solution as well (Rutten 2000, 4). As a result, UNCTAD began to develop training materials for domestic banks and farmers’ associations to explain “modern financial instruments” (Rutten 2000, 4).

UNCTAD policy analysts and economists examined the problem of collateralizing commodities in order to facilitate development and global trade, and to provide asset streams for creditors. Collateralized commodities had a number of advantages. Collateralizing commodities would provide a guarantee for international creditors and increase exporters’ competitiveness. Collateralized credit was “cheaper” than uncollateralized loans (Rutten, Santana-Boado, and UNCTAD 1996, 5). In addition, once commodities were collateralized, financing was more flexible. “Commodities can be used as collateral in various ways such as warehouse receipts, a specially created entity (a ‘special purpose vehicle’), which issues securities (‘asset-backed securities’)” (Rutten, Santana-Boado, and UNCTAD 1996, 12).

UNCTAD documents highlighted new risk management tools and explored ways to apply the new tools to poorer, commodity exporting countries. Sophisticated risk management tools were “new, and still relatively unexplored in poorer countries,” and provided opportunities for “securitizing commodities” (Rutten, Santana-Boado, and UNCTAD 1996, 12).[88] On one hand, risk management tools were encouraged in many of the UNCTAD documents related to trade financing. On the other

[88] Securitization was one possible solution. It linked capital in rich countries with commodities in exporting countries. For example, the “Pemex Receivables U.S. Masters Trust” was a sophisticated forward contract that used expected resource flows as security in concert with warehouse receipts (Rutten, Santana-Boado, and UNCTAD 1996, 13; Varangis and Larson 1996). “This financing form is quite new, and still relatively unexplored in developing countries, completely unexplored in the countries with economies in transition” (Rutten, Santana-Boado, and UNCTAD 1996, 13).

hand, because of the sophistication and complexity of these tools, they were difficult to use. UNCTAD provided warnings "that the risks of using risk management markets can be large" (UNCTAD secretariat 1998, 17). In addition:

> It should be clear that modern, market-based financial tools are not a panacea and that, if improperly applied, they can be dangerous. Especially for complex deals, there is often an information imbalance: the fair costs of structuring the financing, or of the risk management instrument, are only known to the provider. (UNCTAD secretariat 1998, 17)

UNCTAD also provided reassurances:

> Nevertheless, assistance can be found by those who feel they do not have the specialized skills to evaluate such complex financial deals. (UNCTAD secretariat 1998, 17)89

And there were additional tensions. The report, *Examination of the Effectiveness and Usefulness for Commodity-Dependent Countries of New Tools in Commodity Markets: Risk Management and Collateralized Finance,* continues by describing swaps, options, and over-the-counter markets, stating that these sophisticated risk management tools "involve little risk, as long as decision-makers have ensured that the pricing is fair" (UNCTAD secretariat 1998, 17). While a "sophisticated control environment" was required, and this information was widely available, "entities may be better off refraining from such use until these conditions have been built up" (UNCTAD secretariat 1998, 17). The financial tools described in the previous chapters were introduced into new contexts as innovative tools.[90] In sum, throughout the 1990s, UNCTAD and the World Bank promoted futures markets and derivatives to states to overcome structural changes in international commodity markets.

[89] Many documents describe the benefits of ACEs and WRSs, and then state that they are not a "panacea." For example, Goggin and Longhurst 2005; Kang and Mahajan 2006; Gross 2007; UNCTAD secretariat 2007; Syroka et al. 2008; Coulter 2009; Onumah 2009; Santana-Boado 2011.

[90] The report Innovative Agricultural SME Finance Models describes an innovative model as "adoption of established models and approaches used elsewhere but adopted in the context of emerging markets" in low-income countries with smallholder farmers (IFC 2012b, 27).

But by 2000, UNCTAD and the World Bank had changed how they portrayed the benefits of ACEs. They were actively targeting smallholders (see Breger Bush 2012 for an excellent discussion). Specifically, commodity exchanges were promoted as "Empowering small farmers in supply chains" (Rutten 2006), and were portrayed as an important "financial engineering technique" to manage small farmers' risks (UNCTAD secretariat 2002, 4). In short,

> [ACEs] could greatly help developing country farmers to improve their lives, particularly as the vast majority of them can now cope with these price risks only by avoiding "risky" investment decisions, relying on their meager savings and adjusting their consumption – at the best, inefficient solutions, and often locking them in a vicious cycle of poverty. (UNCTAD secretariat 2002, 3)

UNCTAD recognized that the newly liberalized trade regime had effects on smallholders, and that ACEs and WRSs could be used to help protect small producers. "In a liberalized environment, there are few other institutional mechanisms [besides ACEs] that can easily provide these functions" (UNCTAD secretariat 2005, 7). These functions included "levelling the playing field between farmers and traders," reducing waste, improving access to financing for producers, processors, traders, and distributors, and reducing market inefficiencies (UNCTAD secretariat 2005, 7). Consequently, commodity exchanges were described as powerful market organizers:

> Where an economy is to a certain extent disorganized and markets are imperfect, the presence of an exchange can impose discipline on the commodity sector. A well-functioning exchange acts as an "island of excellence", and can extend high levels of performance and integrity attained in its core functions to other areas of commodity-sector activity. (Santana-Boado, Gross, and UNCTAD secretariat 2006, 15)

And:

> In a way, an exchange provides an "island of excellence" in an otherwise disorganized economy, where at least some of the problems and constraints of normal business can be forgotten for some time, for those users who are willing to pay for this privilege. (UNCTAD secretariat 2005)

According to Lamon Rutten, an UNCTAD official,[91] commodity exchanges and warehouse receipts were mechanisms that could help with "opening up" a market system (Rutten 2001, 8). Rutten stated that commodity exchanges would facilitate "a new era for agriculture" in India (Rutten 2006, 17).

> By its very nature, a commodity exchange will help to make growth inclusive: it will act as a catalyst for bringing the new to the old world. Even small farmers can become part of the national and global market place, for inputs, credit and outputs. This model can work in many other countries. Governments and international agencies should consider how they can use commodity exchanges to leverage their own programmes. (Rutten 2006, 29)

A whole new market "ecosystem" could be built with warehouse receipts and ACEs that was bureaucracy-free, and according to Rutten, these ACEs ecosystems had effects – they changed "unresponsive and non-competitive agriculture" to "flexible and profitable agriculture" (Rutten 2006, 17).

Leading up to the 2007– 8 food and financial crises, UNCTAD's focus remained on commodity exchanges and "a new geography of international trade in commodities" (UNCTAD secretariat 2007, 3). *The Development Role of Commodity Exchanges* was now a project (UNCTAD secretariat 2007). The "triple mission" of commodity exchanges in developing countries was to "build liquid and efficient markets," "include some of the world's most impoverished people," and "make market instruments relevant for, and usable by, the ordinary citizen" (UNCTAD secretariat 2007, 6). The documents reflect an aim to build markets for poor and ordinary people, and they highlighted how ACEs were a mechanism to create new geographies of trade, new ecosystems and islands of excellence.

There are three key points to underscore about these documents and their portrayal of ACEs. First, the documents echo the Chicago Futures School's ideas about ACEs. To add authority to these claims,

[91] Rutten also worked for the FAO, the World Bank, and the Multi-Commodity Exchange of India. At UNCTAD, he was in charge of commodity risk-management.

the longstanding experience of ACEs, traced back to the Chicago Board of Trade (CBOT), is often cited in these documents. There are three ways the CBOT is cited. First, the documents use the CBOT to illustrate market modernization and improvement, and the evolutionary trajectory of ACEs (e.g. UNCTAD 1998; UNCTAD secretariat 2006). Second, the documents use the CBOT as an exemplar for technical documents and information (e.g. UNCTAD secretariat 2002; UNCTAD secretariat, and UNCTAD Commodities Branch. 2006). Third, the documents use the CBOT to illustrate how ACEs have benefitted farmers (e.g. UNCTAD secretariat 2007). The authors make specific claims to technical knowledge and expertise and then make claims that ACEs play a crucial role in a liberalized market. In turn, ACEs become an exceptional technical site that organizes and builds market ecosystems. The twenty-first-century markets, and reorientation towards global markets and trade, were linked directly to the US experience (AAACP and UNCTAD 2007, 9).

The second key point, is that the IO's documents make a distinction between agricultural markets before ACEs and after ACEs. This distinction, or frontier, is also a distinction between a global model – ACEs – and "its non-Western others" (Barry 2006, 251). Before ACEs is a site of problems, and disorganization. After ACEs is a site of connections and benefits. And this leads to the third point. According to the UNCTAD documents, the introduction of ACEs to new frontier sites produces a number of benefits – protections from liberalized markets through risk management tools, better access to liberalized global markets by connecting with larger traders, and overall more efficient markets. While some caveats and tensions were discussed in the documents, the overall impression is about the benefits of ACEs to development, farmers and their role in facilitating free markets.

The work on WRSs and ACEs by UNCTAD was an outcome of its long focus on commodities. The IO promotion of these projects paralleled, in part, the commodities super-cycle, seemingly an opportunity for producers and commodity-exporting countries to gain from higher prices. World Bank documents often overlapped the work of UNCTAD, and reveal a long-standing interest in the potential of commodity exchanges to manage commodity price risks for poor exporting countries and enable more robust economic growth (Claessens, Duncan, and World Bank 1993; Varangis and Larson 1996; World Bank 2011). Commodity exchanges could overcome the constraints of poor economic growth and provide access to risk-management tools that would help the poor and vulnerable and would "mitigate, if not solve agricultural development problems by extending the reach of markets" (Varangis, Larson, and Anderson 2002, 19). These ideas persisted after the 2007– 8 crisis, and were taken up in new ways as discussed below. As ideas were stabilized about the role of ACEs and WRSs in promoting commodity trade and developing agriculture, ideas about storage management were also shifting.

7.3 The Changing Role of Storage Development Projects: Warehouse Receipt Systems and Market-Driven Storage.

Grain storage development projects changed from supporting community and on-farm storage to supporting private grain management, or market-driven storage management (especially WRSs) in order to develop collateralized credit. The change in focus to market-based grain management and storage started with market liberalization in the 1980s and 1990s. The FAO and World Bank point to the underperformance of cooperative and community grain bank programs and look to "warehousing receipt systems [which] seem to offer greater potential" for storage development (FAO and World Bank 2010, 17). Warehouse receipts are discussed in Chapter 4 extensively, but two different kinds of warehouse systems are highlighted in the IO documents. The first category is populated by NGOs and farmer groups who operate and support small capacity warehouse receipt systems. The second category is state regulated and legislated warehouse receipt systems (Onumah 2015). Warehouse receipt systems use regulated storage sites to secure and value agricultural commodities for credit, and can be used to underpin commodity exchanges.

Warehouse receipt systems provided a range of services, or "protections" that linked storage, farms, banks and credit together. The benefits would accrue to farmers, as well as traders and bankers, as everyone would benefit from the increased income and financial services that would be leveraged by stored grain and a system of collateral. This is in contrast to Keynes' early observation that storage is not economically viable and therefore should be managed by the state to secure a predictable business environment (see Chapter 3), but it is in accordance with Working and the Chicago Futures School theories which showed that privately managed storage when connected to market actors was more efficient than publicly managed grain storage.

Proponents of warehouse receipts systems claim that warehouse receipts "enhance competition" because they facilitate cash and forward markets, "increase the volume of trade and reduce transaction costs," and "provide secure collateral for banks … sight unseen" (Lacroix and Varangis 1996b, 37–8). In addition, the use of warehouse receipts is presented as a means to reduce government intervention in the market (Lacroix and Varangis 1996b; e.g. Coulter and Onumah 2002; Onumah 2010; Onumah 2013b). But the history of US warehouse receipts is about regulation and government intervention rather than a reduction of regulation. Lacroix and Varangis state that warehouse receipts were crucial to successfully managing the US 1980s grain surplus:

> it is widely recognized that the United States would have found it difficult to manage and liquidate the huge grain inventories its farmers accumulated during the mid-1980s in the absence of a system of warehouse receipts as negotiable instruments. (1996b, 36)

This statement elided the unstable character of warehouse receipts and their effect on the farm crisis as illustrated by elevator bankruptcies of the 1980s.[92]

Warehouse receipt systems mark a change in how the World Bank approaches storage projects. Development strategies had changed from a singular focus on technology in the 1970s to a market-

[92] This is not to state that other factors were not in play in the 1980s farm crisis.

based approach with a value-chain focus (see Figure 9). A recent report on post-harvest waste, *Missing Food: The Case of Postharvest Grain Losses in Sub-Saharan Africa*, authored by the World Bank, described how a "market-driven system" such as a WRS would reward farmers (Zorya et al. 2011, xv). The "systemic" strategy would intervene all along a value chain with the help of "synergies with the private sector," and the "adoption by smallholders" (Zorya et al. 2011, xv). In another recent example, the FAO used the same post-harvest-loss strategy through "up-grading of value chains and linking farmers to markets" with the incorporation of "inventory credit and the warehouse receipt system projects" (FAO and World Bank 2010, 12). The focus on post-harvest loss and its connection to market organization is in contrast to earlier IO publications that focused on building and designing infrastructure and evaluation in the context of a "system" and the unequal distribution of food (e.g. Harris and Lindblad 1978, 1; FAO and UNEP 1981; Cruz, Diop, and FAO 1989). In contrast, market-driven storage programs were focused on making new connections to global markets and value chains to help increase incomes. The market was the prime focus.

Year	Intervention	Development/Theory	Approach
1970s	Community Stores	Self Sufficiency Import Substitution	Single-entry-point/single technology
1980/1990s	Grain Banks Improved on-farm Storage	Structural Adjustment Farming Systems Participatory approaches	Single-entry-point/multiple interventions
2000s	Various stages of the supply chain Market Information systems Warehouse Receipts Commodity Exchanges	Export Orientation Free trade Learning Alliances Innovative systems	Market-based approaches, increasingly with a value-chain focus

Figure 9: The Changing Development Approaches to Grain Storage Projects. Adopted from "Chronology of postharvest-related interventions and approaches in grain chains" (Zorya et al. 2011, 51).

The recent focus on market-based strategies by IOs is built on "marketing or business systems" and "adopting a value chain approach" (FAO and World Bank 2010, 7). The market-based approach draws in new relationships with credit (or asset streams) at the centre. For example, the value chain approach incorporates credit access, warehouse receipts, and ACEs into a system that connects and drives a cycle of credit provision, lower transaction costs, and commercialized agriculture (e.g. FAO and World Bank 2010; C. Miller and Jones 2010). In this approach, storage creates a stable site from which to extend credit to small producers. With access to credit, small producers could commercialize their agriculture, which would lead to more efficiencies, lower costs and higher incomes. Producers with higher incomes lead to a more stable credit risk. The cycle is circular and self-driving, as reflected in the illustration "How a system of warehouse receipts works" (see Figure 10) taken from an article written by two World Bank economists in the International Monetary Fund's journal

Finance and Development (Lacroix and Varangis 1996a, 37). The "umbrella" of the warehouse receipt provides the farm with protection (inspection, insurance, bond and indemnity fund), and connects the farm to the bank with credit (Lacroix and Varangis 1996a, 37). The market-based grain-management and storage system would leverage stored grains for credit. Two more recent diagrams from the Technical Centre for Agriculture and Rural Cooperation (CTA) animates the warehouse receipt system (Figure 11 and Figure 12). Figure 11 illustrates how storage is the first step in the WRS system. It also starts to bring in the scales, documents and institutions that help to create the WRS. The second diagram (Figure 12) shows an illustration of a farmer and a banker, and how maize can be used to obtain a payment.

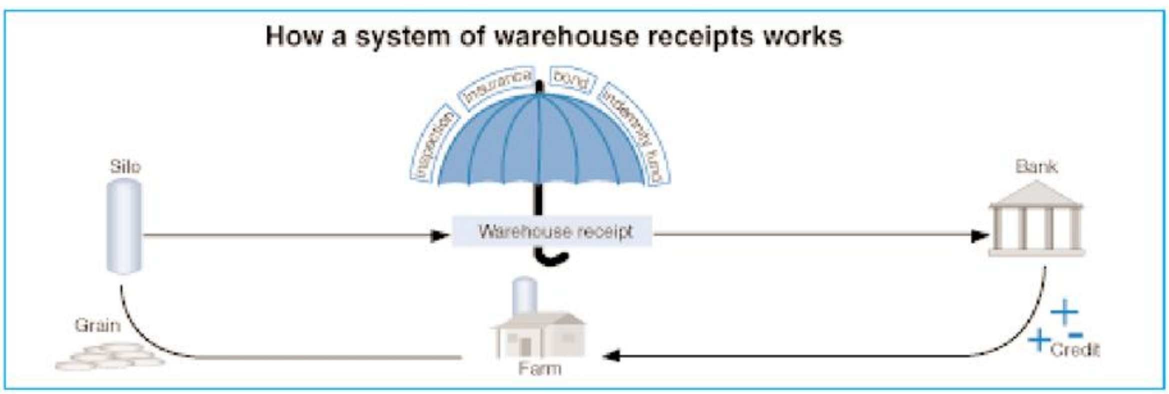

Figure 10: How a system of warehouse receipts works (Lacroix and Varangis 1996a, 37)

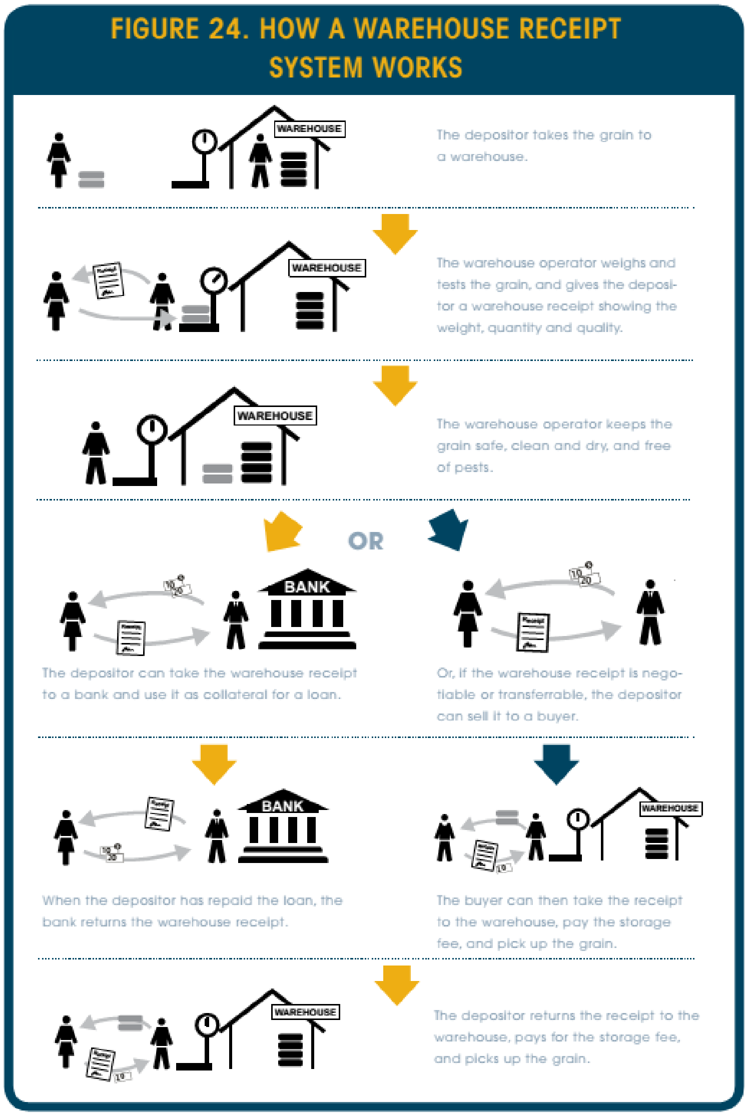

Figure 11: How a Warehouse Receipt System Works (CTA 2013)

Figure 12: An illustration of WRS (CTA 2013).

Warehouse receipt systems include a storage infrastructure. Many of the storage techniques and practices covered in chapters 5 and 6 are integrated into WRS. For example, plans for WRS included an infrastructure of shellers, dryers, sieves, moisture meters, weighing scales, and fumigation kits including sheets, protective clothing, and chemicals, with the requisite pest-management programs (e.g. Coulter 2009; Zorya et al. 2011). In the technical report, "Structured Grain Trading Systems in Africa," the advantages of commercial storage are described, including access to industrial grain management such as dryers and pest management (CTA 2013, 39). The report also described how stored products could be leveraged for credit, and facilitate the transfer of ownership.

But this model of grain management is expensive and requires extensive capital investment. Reliable warehouses are a precondition for WRS. The physical infrastructure can require a significant investment to manage, for example grain and to maintain its quality. For example, fumigation was the highest cost associated with WRSs in a Zambian pilot project – constituting anywhere from 32 percent to 44 percent of costs (Coulter 2009, 96). The physical infrastructure of storage is less examined in these IO reports. However, as shown in Chapter 5 and 6, physical stabilization is crucial to establishing and stabilizing commodities for collateral. IOs shifted their approach to grain storage with finance at its center. The change to a market-driven storage approach that integrates credit provision illustrates how finance is the central concern, and there is less focus on the physical infrastructure. Part of the explanation for this focus is that there has been a shift to putting financial inclusion at the center of new agricultural development projects.

7.4 Financial Inclusion after the Food Crisis

A sharp rise in prices during the food and financial crises in 2007–8 affected poor food-importing countries. The crises prompted renewed attention to volatile food prices and the role of new financial actors in commodity markets, and put ACEs under new scrutiny (Clapp 2009a; Ghosh 2010). As the food crisis hit, the World Bank published the 30th *World Development Report* (WDR) on agriculture, which highlighted the need for increased investment in agriculture with the explicit aim of moving the rural poor away from subsistence agriculture. The 2008 WDR stated that the "path out of poverty" would be led by "market modernization," including "marketing information systems, commodity exchanges, and price-risk management" (World Bank 2007, 139). In short, the report highlighted the long-term decline in agricultural investment in poor countries' agriculture and the opportunity to leverage commodity trade investors in rich countries. The 2008 WDR echoed earlier IO reports on ACEs and WRSs by highlighting how these projects could quickly restructure inefficient and disorderly markets with minimal costs (World Bank 2007, 140).

Global leaders at G8 and G20 meetings also turned their attention to the food crisis. At the G8 meetings in L'Aquila, Italy, in 2009, and at the G20 meeting in Seoul, Korea, in 2010, global leaders discussed the relationships between finance, agriculture, and global food security (G20 2012a, 2012b). The meetings prompted two programs that linked finance and agriculture. The first program was the Global Agriculture and Food Security Program (GAFSP), a trust fund established to manage pledges from the G8 Summit in L'Aquila. GAFSP was launched in 2010 by the World Bank with two “windows,” public-[93] and private-sector. The Private Sector Window was managed by the International Financing Corporation (IFC) and funded by the Netherlands, Canada, Japan, the UK, and the US, along with agribusinesses based in those countries. It provided investment and advisory services to eligible private-sector companies in the agribusiness field, with a budget of US$309 million USD (Sethi 2013).[94]

The second program was the G20’s Global Partnership for Financial Inclusion (GPFI). The IFC was the lead technical adviser on the agricultural financing arm of the program.[95] The IFC proposed three programs to align the “mismatch” between agriculture and finance – providing new financing models, risk management, and lowering transaction costs (IFC 2012). In line with the WDR 2008, the project highlighted the problem of underinvestment in agriculture, and in turn, the solution was to foster investment and to provide poor countries and their farmers with better access to finance and credit. An inclusive financial system had become “a development objective of its own” (IFC and GPFI 2011, 22).[96] The persistent problem of securing finance and credit for farmers had emerged with a new name, the Financial Systems Approach.

The “Financial Systems Approach” asserts that financial relations are crucial to any development project. More specifically, this approach leverages financial intermediation to improve economic development and reduce poverty: “efficient financial intermediation is ... a means to achieve other development objectives” (IFC and GPFI 2011, 20). In practice, the Financial Systems Approach

[93] The World Bank serves as the trustee of the public sector window and works with a number of partners to implement projects, although funding is directed by sovereign governments. Its governance system consists of the Asia Development Bank, American Development Bank, African Development Bank, WB, WFP, FAO, and IFAD, and includes CSOs, donors, and recipient countries.

[94] Between 2010 and 2014, almost $1 billion USD was received by the public-sector window, compared to $238 million USD for the private sector window (GAFSP 2014 7).

[95] Global Partnership for Financial Inclusion’s sub-group, the Small and Medium Enterprise’s Sub Group, included agricultural financing.

[96] The World Bank drew on the financial systems approach starting in the 1980s, called the “Ohio State School” by its progenitors. The approach is applied to the market-based frontier between formal and informal finance (Von Pischke 1991).

means that governments do not intervene in financial markets, but rather support development by creating enabling "environments" such as contract rights, collateral systems, contract farming, and out-grower schemes, which align with financial liberalization (IFC and GPFI 2011, 9). Financial liberalization fosters competition and the expansion of financial services to "the so-called "frontier of formal finance" towards rural areas, low-income clients, and riskier economic activities such as agriculture" (IFC and GPFI 2011, 20).

The GPFI literature highlighted how financial intermediation could help reduce barriers to accessing risk management tools for agricultural small and medium-sized enterprises and producers (e.g. GPFI and IFC 2013). On one hand, farmers would benefit from warehouse receipt financing, which would make collateral possible. On the other hand, programs that created collateral and other "promising solutions" such as registering land would make it "easily foreclosed upon and resold" (GPFI and IFC 2013, 15). Warehouse receipts and commodity exchanges are interdependent in the IFC literature (e.g. World Bank and International Monetary Fund 2012). There is not necessarily a clear chronology to establishing WRSs in relation to ACEs, but the documents state that warehouse receipts were a way to ramp up financial inclusion, or a "step towards building an enabling environment" for commodity exchanges (IFC 2012b, 32). There is a tension in the documents between the expansive opportunities presented by financial inclusion and intermediation, and the barriers behind the frontier of informal finance. The authors of the reports recognized that the expansion of financial intermediation such as WRSs required regulatory and legal frameworks to expand the frontier of formal finance.

Similar to the experience in the US in the early twentieth century, the IFC and World Bank reports list a constellation of regulations including establishing grades, warehouse standards, insurance, and licensing that are required to support a well-functioning WRS (e.g. GPFI and IFC 2013, 30-1). Regulatory gaps are barriers to and inhibit "private sector instruments that could provide financing solutions in the agriculture sector" (IFC 2012b, 18). These systems also require an enabling environment to be provided by the government because the "failure" of commodity exchanges was due "directly to government interventions" (Brenton and World Bank 2012, 78). The IFC documents show how regulations are a key component to foster market-driven storage arrangements. In other words, regulatory stabilization must be secured before WRSs and other private storage arrangements can be leveraged. The persistence and centrality of financial inclusion and the promotion of WRSs in the aftermath of the food and financial crises of 2007-8 illustrates how IOs presented the opportunities of finance as a development tool, but also highlights how specific regulatory environments or ecosystems were required. The ideas of finance persisted but there was less success establishing the state-backed regulatory stabilization that was illustrated in Chapter 4.

7.5 Discussion

The UNCTAD and World Bank documents showed how the proponents of risk-management tools including commodity exchanges were confronted by a problem: How do you build and promote a market structure for agricultural commodities? The ideas used to promote ACEs and WRS can be summarized in three points. First, IOs targeted financial frontiers in which there appeared to be no markets, or the markets need to be strengthened. The IOs promoted the establishment of new financing models such as collateral at varied market scales, from developing financing for international commodity trade to improving small agricultural producers' access to markets. Second, IOs called for new legal and regulatory environments to secure and stabilize collateral. Third, IOs designed WRS technological zones to grade, standardize, and measure commodities in order to establish a value and collateral and that can work hand-in-hand with commodity exchanges (e.g. Deve 2009; Onumah 2013a). But the decades long effort to establish commodity market arrangements – specifically, ACEs and WRSs, has yet to be successful. The persistent promotion of these projects by IOs since the 1990s is notable.

International organizations have consistently directed training and education to policymakers so that legal, regulatory, and policy structures could be established. Their documents, reports, and meeting summaries consistently defaulted to the need for technical training, particularly for policy-makers. For example, UNCTAD's efforts to establish and promote the use of commodity risk-management tools such as warehouse receipts have focused on research, training policymakers and technical assistance (UNCTAD 1997, 4). The problem, according to Rutten, was "a lack of awareness and understanding by developing country policymakers and bankers," which created "bottlenecks," the solution for which was more training (Rutten 2000, 3). The projects illustrates Broome and Seabrooke's statement, "persuasion remains an ongoing process" (2012, 7).

The IOs' efforts focused on policy-makers, but the shift to farmers occurred in the late 1990s. The influence of the US risk management approach on UNCTAD and the World Bank's policies can be connected to Joseph Dial, a CFTC commissioner and advocate of the new risk-management tools for farmers (see Chapter 5). Dial was one of the consulting experts on UNCTAD's Ad Hoc Group of Experts on Risk Management and Commodity Trade. Recall that Dial advocated liberalizing the US agricultural market and promoting farmers as risk managers during his time as CFTC commissioner from 1993 to 1997. Dial described the opportunities that the new tools offered, as well as identifying the barriers to more efficient commodity markets. His presentations drew attention to the benefits of including farmers in new risk-management strategies, and to farmers' resistance to change (UNCTAD 1997, 9). While Dial's participation cannot be directly tied to a change in IOs' focus on farmers, his participation in the expert panel parallels the shift in UNCTAD's focus on farmers (e.g. UNCTAD secretariat 2002; Roche 1999).

But many of the documents from 2000 on highlight potential problems for farmers. In 2002, the World Bank report acknowledged that ACE transaction costs were high for small operators, and very risky because of the potential for high margin calls (Varangis, Larson, and Anderson 2002, 14). In addition, poorer farmers would not necessarily be included in the programs: "price risk management is not really for the poorest of the poor. The main clients for such insurance are commercially-oriented farmers" (Varangis, Larson, and Anderson 2002, 21). According to the IFC:

> As most farmers in developing countries lack basic financial literacy, they are not likely to benefit from this kind of risk management in the near future. Basic market information systems that allow farmers to gain valuable information on market and price developments are more realistic in terms of timely implementation and unfolding positive effects. (IFC and GPFI 2011, 68)

This suggests that these markets required farmers to scale up.

However, at some point the IO's ambition to include farmers, especially the poorest farmers, seemed to wane. Zorya et al. highlighted how donors had set up ACEs and WRS projects that cost millions of dollars and stated that "even if they did work, they would not help smallholders, which they are often claimed to do" (2011, 53). This claim is supported by Lence: "[T]he availability of futures among producers may ultimately enhance the lot of consumers in developed economies, while reducing the welfare of producers in developing countries" (Lence 2009, 167). Breger Bush (2012) has argued that IOs put small farmers at the centre of the work to justify the promotion of derivatives (2012, 161). Agricultural commodity exchanges are structured to benefit large players and as a result exclude small players (Breger Bush 2012); yet, as Breger Bush observed, smallholders remain at the centre of IOs' discourse.

Many development projects were established to set up ACEs and WRSs, but there is evidence that the projects end once donor support ends (UNCTAD secretariat 2005; Robbins 2011). In UNCTAD's words, commodity exchanges had "not met much success" (UNCTAD secretariat 2005, 2). More recently, proponents have declared the projects to establish ACEs in sub-Saharan Africa outright failures (Sitko and Jayne 2012; Jayne et al. 2014). Why do these projects persist? Part of the explanation is the persistence of IOs' ideas about how markets should work.

7.6 Conclusion

Projects to develop new ACEs and warehouse receipts were promoted as a means to finance agriculture. But the building of global markets is a difficult process. The promises were expansive, but the results were uncertain. Many of the World Bank and UNCTAD documents stated that market barriers to smallholders would be overcome and incomes would be improved with the adoption of new market arrangements. The new market arrangements would strengthen supply and value chains and help to connect farmers to global markets. The promotion of, and support for, establishing and using ACEs was shaped by an aspiration to build free markets, free of government intervention – yet requiring regulatory and legal means to secure title, enforce contracts, and police grain storage. In the previous chapters, it has been shown that three historically specific stabilization processes – ideational, regulatory, and physical – emerged during a period of unprecedented control by the US government of grain stocks in the mid-twentieth century. Ideas from the US example are mobile. Yet there has yet to be the regulatory stabilization, nor the investment required to establish a storage infrastructure, and physical stabilization in these frontier sites. What has been persistent is the promotion of the ideas of ACEs and WRS. The US context produced varied stabilization processes over decades, and the resultant regulations and physical stabilization are not mobile, yet the ideas are easily transferred. While the ideas from the US experience are easily transferred, their regulations and physical stabilization are not because they were developed over decades under very specific conditions.

To explain the actions of the IOs, I draw from IPE scholars Broome and Seabrooke (2012) and their conception of "seeing like an international organization," and from Barry's (2006) framework for technological zones. International Organizations used their expertise and resources to target policy makers to adopt and enroll in new programs. New market classifications were established such as placing agricultural goods into new market arrangements through ACEs and WRSs to build asset streams by establishing collateral for financing. Barry's (2006) technological zone helps draw attention to the creation of frontiers, and in particular the frontier between formal and informal finance.

Ideas were drawn upon as a development tool, underpinned by assumptions about how markets should work – leaving those assumptions unchallenged. The failure and incompleteness of new projects has not lead to a re-evaluation of the model itself or the ideas that underpin it – those remain stable. Yet the other two processes – regulatory and physical stabilization – are not in place in these sites. Promoters of new ACEs and WRSs reacted to the incompleteness of projects with continuing efforts at enrollment and an expansion of a specific market and financial frontier. The development of US ACEs, and the development of US-style storage was built over a long period of time by a wide variety of actors. IOs projects have effects, but the mobilization of these techniques is contingent and contested, and efforts are provisional and subject to challenge and revision (Best 2014). The context of US storage projects – private or public – cannot be easily transferred to new sites.

Chapter 8 – Conclusion

Through a careful examination of twentieth century US grain storage I analyzed changes in ideational, regulatory and physical stabilization processes over the twentieth century. I focused on the US in the twentieth century because of its crucial role in shaping global agricultural markets and regulation of global financial markets. Following Thrift and Leyshon (2007), I defined the financialization of agriculture as the work of assembling and turning a bushel of corn, or any other agricultural good – primarily grain – into a financial asset stream. This definition drew my attention to the central role that grain storage plays in commodity speculation and ACEs, and encompassed the mundane practices of collecting and managing amassed grain in containers.

How does the examination of twentieth century US grain storage stabilization – the ideas, regulations and physical infrastructures – help us to understand the financialization of agriculture? To answer this question, I built an argument on three stabilization processes – ideational, regulatory, and physical – which, once combined, facilitated and secured grain-storage collateral for credit. Once collateral was established, grain could be used to build asset streams. I showed how grain-storage stabilization processes developed over the twentieth century, and their connection – sometimes direct, sometimes indirect – to finance. The grain-storage governance lens provided an entryway to examine how asset streams are established, leveraged, and controlled.

Why grain storage to think through the financialization of agriculture? Grain storage is a crucial political site for three reasons. First, over the twentieth century there were significant changes in the regulation and management of grain storage and global reserves, which had implications for who could and who could not access and leverage the value of stored grains. Public grain reserves have been shifted into private hands over the last 40 years for a variety of reasons, including trade liberalization and structural adjustment policies. Second, speculation in grain commodities without large scale grain storage is difficult, because futures markets rely on regulated, stable storage to write and secure derivative contracts, and speculators rely on reported levels of stored grain supplies, along with anticipated demand, to estimate prices and price movements. Third, the operation and control of grain storage has implications for food security and who can access vital goods. A focus on grain storage politics helps to illuminate phenomena that would otherwise resist narrow analysis or be overlooked entirely. Stable and secured agricultural commodities, amassed in regulated storage sites are crucial to the operation of global agricultural commodity trade and exchanges.

But, and here is where theorizing is helpful, agricultural commodities are not stable. Grains are intrinsically unstable - they respire, they transform, they grow, they spoil, and they die. Grain becomes even more vulnerable and volatile, explosive at times, when amassed in bulk storage to serve commodity trade and finance. The result is that there are a number of physical stabilization processes that must be assembled to secure unruly grain and provide a commodity that can be collateralized, secured and leveraged by financial actors for credit/debt. Non-human actors help explain how grain storage is constituted through assemblages and inform how we can examine the governance of grain storage. Strange (1996) has defined power as the ability to affect outcomes, and to shape the actions of others, actions they otherwise would not take. By including non-humans in this definition, the thesis has demonstrated the vital and lively power of grain to shape human action, specifically, through the practices of grain management. In turn, this approach can help explain how finance and agriculture come together.

The shift in the control and governance of storage includes the regulatory and ideological shifts, which are traditional IPE analytics. In addition, the shift over the twentieth century in how grain was physically contained and managed requires that any exploration take into account non-human actors that stabilize and destabilize grain in storage. A focus on storage governance, and taking into account non-human actors, means that the physical containment and management of grain also has to be taken seriously and requires a theoretical intervention.

This thesis aimed to fill a gap in agrifood studies and in IPE scholarship. Agrifood scholars often consider the material qualities of food and agriculture, but they are less focused on the material qualities of finance. IPE literature often highlights the role of powerful global actors, but has been less focused on the physical and everyday manifestations of finance (with exceptions, e.g. Hobson and Seabrooke). This dissertation contributes to both IPE and food studies. I used the example of stored agricultural commodities to put international political economy and actor network theory into conversation, and I focused on agricultural commodities to examine the financialization of agriculture and financial actors outside elite realms.

The theoretical scope included material "things" such as commodities and their role in processes of financialization. Agricultural commodities are not necessarily considered actors that help to constitute global finance and speculation. But I argued that non-human actors, such as grain itself, can be considered actors that affect how asset streams are formed. I focused on asset streams because I defined the work of turning a bushel of corn, or any other aggregated agricultural good – primarily grain - into a financial asset stream, as financialization drawing from Leyshon and Thrift (2007).

I explained my argument by putting IPE approaches into conversation with actor network theory (ANT) approaches to theorize about power and finance. Actor network theory helped this theorizing by assuming grain commodities are already an "actor". The IPE approach helped to theorize the operation of powerful organizations and assemblages within the global political economy. At first glance IPE and ANT appear to be in conflict. But it is this conflict that brings to the fore the utility of both approaches.

Scholars have previously examined grain storage and finance (e.g. Cronon 1992). Both critics of capitalism and supporters of free markets use the physical characteristics of grain to explain the operation of markets and capital. Both flow easily when "freed" – to good and bad effect. The comparison between bulk grain and capital is apt, as grain can act as a stand-in for the abstractions of capital and markets.

Yet, just as flows are important to trace, it is also important to examine the disruptions and blockages that occur in grain storage. Grain is not always stable, and it is not a unitary actor – it "becomes" in new assemblages. Collectivities of water, heat, insects, and molds can make grain into structures that do not flow but instead block and clog the wheels of commerce. It is in the details and techniques of bundling grain into seemingly stable collateralized commodities that a different kind of politics emerges, one in which grain itself is an actor with power that shapes human activities, and in which there are limits to finance. And the limits are defined by non-human actors.

The three stabilization processes structured the examination in this thesis of US grain storage and the changes that occurred over the twentieth century. The first stabilization process involved ideas about grain storage. Ideas about grain storage and ACEs changed over the course of the twentieth century, and ACEs were at the centre of the economic explanations that focused on grain storage. The Chicago Futures School showed how ACEs were a means to manage grain storage efficiently and avoid supply gluts and shortages. The Chicago Futures School made three important contributions to grain storage ideas – the theory of grain storage, revealing the cost of public storage, and ACE's role as a financial institution. The theory of storage is regularly put to work in contemporary debates about speculation (D. R. Sanders, Irwin, and Merrin 2010), national global reserves (B. D. Wright and Williams 1984; B. D. Wright and Williams 1982), and development schemes to establish new agricultural commodity markets and frontier sites (IFPRI 2014). At the same time, ACEs began to gain currency as a financial institution and platform that would benefit and connect investors to agricultural commodities. These changes legitimized private management of grain storage and financial actors' participation in agricultural commodity investment.

Since the 1940s, the theory of storage has been the theoretical foundation of economic theories that explain the operation of ACEs, and it has been strengthened and built upon. Small-i ideas about storage led to changes in who had the authority to govern and control storage (Best 2014). New econometric tools were used to develop a scientific explanation of the value of grain storage, and its function in relation to ACEs and the US state-managed grain reserve. The introduction of new scientific facts, for example the theory of storage, changed how grain storage was valued and compared the value and efficiency of ACE-managed, private storage to costly and inefficient public storage. This led to a change in who could easily and legitimately access asset streams based on stored grain – from farmers through the CCC, to financial actors through ACEs. US grain storage helps to illustrate how ideas were built over time to link efficient grain-storage management to ACEs and to link ACEs to financial actors. Working's and Hieronymus's conceptions of the role of futures markets and storage were formed in the context of a complex twentieth-century apparatus of state regulatory webs. The superiority of private control of storage started as a small-i idea and became a recognized truth about grain storage, and the role of ACE-managed storage. Ideas were one part of the assemblage of grain-storage governance.

The second stabilization process, regulatory stabilization, illustrated the collection of rules, laws, and institutions that created the security or guarantee on stored grains. Regulations shifted the control of storage from private hands to public hands and back into private hands. The state increasingly produced regulations in an attempt to stabilize the value of grain in storage through warehouse regulations and legitimating documents of title such as warehouse receipts, yet the instability of grain in storage was too risky for bankers without the backing of the state. The CCC was able to standardize and stabilize agricultural goods, but at a cost. Regulatory stabilization is an ongoing practice that highlights the unstable and dynamic quality of agricultural goods in storage. During the nineteenth century and into the early twentieth, state regulations certified and standardized the warehouses that issued warehouse receipts to establish and secure credit. The twentieth-century US state legitimized warehouse receipts and incorporated them into national agricultural policy in the early twentieth century through a program of loans. The long-standing problem of establishing credit for farmers was partially solved with the creation of a grain reserve backed by the resources and security of the state. Warehouse operators, ACEs, and state institutions used warehouse receipts to translate lively and unruly grain into a stable object that could be used to leverage capital. Warehouse receipts were a product of nineteenth-century ACEs, but were legitimized through state regulations, and secured with state resources.

But state regulated warehouse receipts did not attract credit provision from bankers. The CCC implemented non-recourse loans based on stored grain, and this provided secure asset streams for farmers and a revenue stream for bankers who provided the loans starting in the 1930s. When the state started to pull back from supporting stored grain collateral through the CCC in the late 1970s, farmers began to rely on the unstable character of warehouse receipts without the full backing of the state. In addition, the CCC affected the growth of the agricultural futures markets. When the CCC bore managed the national grain reserve, ACEs declined.

The physical stabilization of grain storage involved the assemblage of grain-management practices and infrastructure that facilitated the storage of grain. I described the changes in grain-management technologies that shaped and structured the grain storage ecosystem. I used Barry's (2006) concept of a technological zone to identify the assemblage of measurements, infrastructure, and common standards that made up the physical stabilization of grain. Stored grain has a vital life as a non-human actor. The physical stabilization of grain storage illustrates the vital role of the US state in developing grain-storage technologies during the twentieth century, such as metal bins, fungicides, and dryers, to stabilize grain physically and defend against these collectivities. The grain-management practices that were put in place in the mid-twentieth century are still used today to stabilize physically large quantities of grain, which are used as collateral and underpin agricultural commodity futures.

A tension exists in grain storage containers between the non-human actors that inhabit it and the on-going human intervention of agrochemicals and other management practices. Bulk storage environments become homes to stored-grain mold, which acts with insects and mites to create blockages in storage units. Bennett (2010) states that non-human actors have a vitality. Non-human actors provoke human intervention and management. Even with active grain management, molds, mites, and insects can literally clog up the flow of grain in a bin – reducing the critical advantage that bulk grain storage has over other storage techniques such as smaller-scale bags. Physical stabilization is the third aspect of the grain storage assemblage.

An assemblage is always becoming, that is it is presumed to be temporarily stable. The mid-century assemblage of grain storage included state-backed regulations, physical infrastructure, and the contributions from US agricultural economists, and others such as Keynes that public storage was a low cost public good. Together this assemblage produced asset streams directed to farmers, while also serving large commercial interests through storage fees and payment for services through the CCC. The grain storage assemblage was incrementally transformed as new ideas about storage costs and value were introduced by the Chicago Futures School. By the 1990s the grain storage assemblage had transformed. State regulations and the CCC had been eroded, and for all intents and purposes the public grain storage in the US ended. But the physical stabilization through industrial grain management techniques remained. The grain storage assemblage included private management and an industrial model of grain management. In addition, this assemblage included farmers' risk management strategies that included ACEs.

In the last chapter I analyzed IO documents to examine the promotion of ACEs and WRSs for financing agriculture. World Bank and UNCTAD documents stated that market barriers to smallholders would be overcome and incomes would be improved with the adoption of new market arrangements. The US example of successful ACEs and WRSs was cited to bring authority to these projects. But there has yet to be the regulatory stabilization, nor the physical stabilization that underpin these projects. What has been persistent is the promotion of the ideas of ACEs and WRSs.

International Organizations used their expertise and resources to target policy makers to adopt and enroll in new programs. New market classifications were established such as placing agricultural goods into new market arrangements through ACEs and WRSs to build asset streams by establishing collateral for financing. The chapter showed how IOs' documents on agricultural markets present ACEs and warehouse receipt systems as an idealized agricultural market. The promotion of ACEs is indicative of how financial practices and agricultural relations might be changing, and highlights complex relations that are required to bring finance and agriculture together. I argued that the US model developed over a long period of time. The ideas were mobile, but the conditions that developed over a long period of time could not be easily transferred to new sites without all three stabilization processes in place.

By putting ANT and IPE into conversation, the strengths and weaknesses of each approach is highlighted. There are two aspects of ANT that are instructive for IPE. First, markets are constructed through long and contested processes. Rather than replicating the abstractions and calculations that characterize much of the literature on finance, ANT draws attention to relationships and ties that include human and non-human actors. Second, the ANT approach highlights how powerful actors such as finance can potentially be contested at multiple points. ANT helps to identify different power relationships that sustain asset streams. In turn, political contestation occurs in new sites. Barry states that ANT "thrives on details and fragments of evidence, which are never likely to add up to a complete picture, but will nevertheless reveal something that was perhaps unexpected or unanticipated"(Barry 2013, 419).

There are three aspects of IPE that can inform the ANT approach. First, the ANT approach aims to flatten hierarchies by focusing on relationships between non-human actors and human actors. But hierarchies and categories can bring powerful groupings, organizations, and assemblages into view. IPE helps to identify and name complex "big actors" that endure and can leverage structural and institutional power to good (and bad) effect. While changes occur over time, finance remains a powerful assemblage that should be identified and named. Second, ANT highlights the contingency and fragility of assemblages, but is less helpful in explaining how some assemblages and organizations persist. There are "imperial and hegemonic financial orders" that can be identified and named. The IPE approach can help show the persistence of modes of commodity trade over time, and how "stability and order" are structurally contingent (Langley 2002, 8). The approach contributes to explaining the processes of stabilization, and the patterns of an order. Finally, a historical IPE approach illuminates changes over a long period of time, and contributes to highlighting the material and ideological base of financial orders (Langley 2002). ANT is focused on the granular, and is less helpful in identifying the structural changes that reshaped grain storage through the twentieth century. These insights are brought into focus by putting IPE and ANT into conversation.

Grain storage offers a distinctive starting point from which to think through and theorize politics and finance. The starting point connects the vitality of grain with the seeming power and stability of finance. Focusing attention on the various ideas and regulations as well as the physical assemblages that draw finance and agriculture together can highlight some of the limits of the financialization of agricultural commodities. This dissertation aimed to make an empirical contribution to existing IPE literature by showing the relationship between twentieth-century grain storage and finance, and connecting these processes to contemporary understandings of financialization and agriculture. It made theoretical contributions to IPE literature by providing a framework that includes material "actors" by drawing from ANT. This dissertation has shown how ideas and state regulations are materially bound and constituted over the long term to stabilize grain. By delving into the on-the-ground material and practices, I explored the governance and politics of grain storage.

The thesis also provides at least four new research agendas. A different IPE approach could help explain the growth and consolidation of grain-storage corporations. Grain traders are increasingly providing grain storage to farmers, and storage manufacturers have been consolidating with other agricultural companies. What is the effect of this consolidation, and how are grain traders and equipment manufacturers interacting in different sites? A second agenda could focus on the role of the Indian and Chinese states in grain storage. Both countries have state-managed grain reserves, and both have been relaxing commodity exchange regulations on agricultural goods. What explains this shift, and what is the effect of the state reserves on commodity markets? A third agenda, using an ANT approach, could examine the role of "containment" as a political act, and focus solely on sites of grain storage as an industrial ecology (e.g. White and Wilbert 2009). A fourth agenda could be to examine grain as a political actor in the political ecology of corn ethanol distillers' grains in the US, and the role of distillers' grains as an animal feed.

A close examination of the history of grain-storage governance – ideational, physical, and regulatory – leads to new insights about finance, agricultural markets, and global governance. Clapp and Helleiner (2012) remind us to ask big questions and not to narrow research. In turn, Tsing also reminds us to ask big questions and answer with small details, and not to default to scaling up conceptually, but to what she calls living in the environmental ruins of contemporary life (Tsing 2012). Industrial agriculture is in ruins, and yet if we look closely, there is resistance – things that are escaping and resisting capital. Rather than looking away, it is important that we examine the entanglements that live among the ruins of industrial agriculture. A new or different politics of resistance is possible with different actors, even as they are less than ideal (Tsing 2012). Scholars have likened the flow of bulk grain to capital and its “liquidity” because it is a stand-in for the abstractions of capital and markets (e.g. Cronon 1992; J. Levy 2012; Busch 2011). But it is just as important to examine the disruptions and blockages that occur in grain storage. Grain is not always stable, and it is not a unitary actor – it “becomes” in new assemblages. Collectivities of water, heat, insects, and molds reconfigure grain into structures that do not flow, but block and clog the wheels of commerce. It is in the details and techniques of bundling grain into seemingly stable collateralized commodities that a different kind of politics emerges, one in which grain itself is a political actor, and in which there are limits to finance.

This entanglement offers a different way to understand “financial actors.” As Bennett asks, “How would political responses to public problems change were we to take seriously the vitality of [non-human] bodies?” (Bennett 2010, viii). Bennett observes that politics is considered a human domain constrained by the material, but material things also act (Bennett 2010). This thesis added to the conception of what constitutes a political or financial actor. Creating more entanglements and experimenting with what is considered important and what remains silent can shift how we engage with the world. This approach may not change the way finance or agriculture operates, but it can change us. It is a way to see the small anew, and a way to think about finance and agriculture differently. When we scale up, we miss the life and vitality of grain that exists even as fumigants, containment, and agro-chemicals are used to excise fungi, kill insects, and control germination. A close examination of grain storage helps to illuminate our connectedness and what Latour has called the “science of living together” (Latour 2005, 2).

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