Why don't they just change? Contract farming, informational influence, and barriers to agricultural climate change mitigation

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Abstract

Using a mixed-methods study of contract seed-corn farmers in Southwest Michigan, we examine the effect of interlocking macro and micro social forces on climate change behavior and apply the theoretical frames of Treadmills of Production (Gould, Pellow, and Schnaiberg 2004) and Informational Influence (Baron, Vandello, and Brunsman 1996). We find that competitive agricultural contracts in the seed-corn industry impose significant structural barriers to adopting climate change mitigation behaviors. Seed-corn contracts constrain adoption of climate mitigation behaviors through competitive rankings based solely on net commodity production and by limiting farmers' access to information to make judicious management decisions. At the micro-level, findings suggest that informational influence – where farmers turn for trusted information – also affects climate mitigation behaviors, and that these informational networks are embedded within structural constraints. Our findings suggest that agricultural contracts serve as a significant structural constraint on the adoption of climate mitigation practices and that climate scholarship and policy must address both macro and micro dimensions simultaneously to encourage adoption of climate change mitigation.

Introduction

As climate projections become increasingly dire and calls for mitigation and adaptation actions more pressing (Gillis 2014), a fundamental question remains: what can be done to change individual climate behaviors? What keeps individuals – farmers in this case – from adopting climate change mitigation behaviors that natural scientists say are effective? The "information deficit model" of behavior (Burgess, Harrison, and Filius 1998; Hargreaves 2011; Kollmuss and Agyeman 2002; Owens 2000) that theorizes that knowledge and information about climate change are the key to driving behavioral change has been widely dismissed by social theorists and empirical studies (Attari et al. 2011; Coles, Zschiegner, and Dinan 2013; Hayles et al. 2013; Schulte and Miller 2010; Semenza et al. 2008; Wells, Ponting, and Peattie 2010). So if lack of knowledge is not the barrier to individual climate behavior, then what is? We apply this question to agriculture to examine corn farmers' climate change behavior. In other words, as one extension specialist asked: "Why don't farmers just do what we tell them to do?"

We explore this question through a mixed-method study of contract seed-corn farmers in Southwest Michigan, comparing contract farmers to conventional commodity producers and examining the application of Nitrogen fertilizer as a climate change behavior. Moving beyond a focus on climate change knowledge and attitudes, we highlight mutually reinforcing structural and micro-level barriers to adopting climate change mitigation behaviors. We identify several features of seed-corn contract farming that inhibit reducing Nitrogen fertilizer as a climate change mitigation behavior, as well as the role that informational influence – the influence of trusted sources of information – plays in shaping these behaviors.

Our study simultaneously analyzes both macro and micro social forces as they shape individual behavior. Specifically, we examine the structural influence of seed-corn contracts and how those contracts constrain individual farmers' behaviors. Concurrently, we examine the more micro-level influence of trusted informational networks on individual behavior. By examining these social forces simultaneously, we are able to demonstrate how they act in concert to shape behaviors and norms. The structural political economy creates the context for informational networks and defines the stakes for behaviors, while informational networks may serve as an important mechanism to transmit and/or mediate structural effects. Our findings suggest that social scientists must examine multiple levels of social systems simultaneously to more fully understand the constraints and drivers of behaviors such as climate change mitigation.

In this study, we focus specifically on seed-corn farmers who grow corn under contract with seed companies, comparing them to commercial corn growers who grow for the conventional commodity market. Seed-corn farmers enter into annual production contracts with seed companies, agreeing to grow whichever variety of corn the company assigns to them and to sell that corn back exclusively to said company. The company will then later sell that corn as seed to other producers. Payment for seed-corn contracts is not agreed upon ex-ante or paid as a fixed-rate per quantity of yield. Instead, "payments to seed producers are comprised of a fixed payment plus a bonus or penalty" (Preckel et al. 2000:470). Bonus payment and penalties (and future contract renewals) are based upon a "tournament" in which contract farmers are ranked against each other based on their net commodity production (i.e. how much corn they grew). This tournament contract structure is a key feature of seed-corn contract farming. Seed-corn farming is an instructive case to examine contract farming and is distinct from conventional commercial corn production in which growers sell commodity corn on the "open" commodity market. The structure of the seed-corn industry and contracts are discussed in further detail below.

While seed-corn farms are a minority of corn farms within the US, seed-corn contract farming is an illustrative case in which to examine structural constraints on farmers' management decisions because contracts make visible, through formal contractual restrictions, the often-invisible structural effects of political and economic systems. Investigating seed-corn contract farmers' climate behaviors reveals specific features of production contracts that constrain management behaviors. Then, we can compare the effects of these production contracts to the effects of other variables such as information networks and agronomic features. This case study of seed-corn contract farming elucidates the macro-structural constraints on farmers' behavior and how these structural constraints interact with micro-level effects of informational and trust networks.

Contract farming has reemerged as a prominent topic of study in contemporary agrifood studies. Across agricultural sectors, contract farming allows corporations and growers to limit liability and externalize risks (Ashwood, Diamond, and Thu 2014) and complicates the role of individual farmers (Pechlaner 2013). Scholars have explored agricultural contracts across a variety of agricultural sectors and geographic regions to highlight the overwhelmingly adverse impacts of contract farming on environmental and labor outcomes (Ashwood et al. 2014; Borlu 2015; Burch 1994; Dixon 1982; Goss, Skladany, and Middendorf 2001; Mabbett and Carter 1999; Vandergeest, Flaherty, and Miller 1999; Welsh 1997) and the constraints that contracts place upon farmers' practices (Little and Watts 1994; Stuart 2009; Wells 1981, 1984, 1996; Wolf, Hueth, and Ligon 2001). We extend this literature by studying contract farming within corn production, the most common crop grown in the US (USDA, Economic Research Service 2014), by examining specific features of seed-corn contracts that may constraint behavior, and by linking contract production to a specific climate change mitigation behavior.

We also build upon a literature that questions an often-assumed link between climate change knowledge/attitudes and adoption of mitigation behaviors. Several empirical studies have questioned this link, finding that climate change knowledge/attitudes poorly predict climate change behaviors (Attari et al. 2011; Coles, Zschiegner, and Dinan 2013; Hayles et al. 2013; Schulte and Miller 2010; Semenza et al. 2008; Wells, Ponting, and Peattie 2010). Many have emphasized the importance of a sense of efficacy in predicting climate change mitigation behaviors (Choi, Price, and Vinokur 2003; Gifford 2011; Kollmuss and Agyeman 2002; Leiserowitz 2006; O'Neill and Nicholson-Cole 2009; Sampaio, Thomas, and Font 2012; Spence, Poortinga, and Pidgeon 2012). Others have found that the relative cost of adaptation/mitigation behaviors is related to their likelihood of adoption, particularly when short-term costs are high and potential benefits are diffuse and long-term (Coles et al. 2013; Hall 2006; Hobson and Essex 2001; Lorenzoni, Nicholson-Cole, and Whitmarsh 2007; Semenza et al. 2008). This climate-specific literature builds upon a much broader literature concerning the adoption and diffusion of innovations in agriculture (for examples, see Levins and Cochrane 1996; Napier and Tucker 2001; Rogers 2003).

We extend these literatures by combining two distinct theoretical frames –Treadmills of Production and Informational Influence – and by studying micro and macro-level social forces simultaneously. By using these lenses to examine our case, we demonstrate the ways in which structural features can constrain climate mitigation behaviors and how norms and informational influence may mediate those effects. Our findings suggest that scholarship and policy to address climate change must incorporate these structural and micro dimensions simultaneously.

Background: Nitrogen and Corn Production

The use of Nitrogen fertilizer is nearly ubiquitous in contemporary agriculture, with American farmers applying approximately 13.5 million tons of Nitrogen fertilizer in 2012 (Association of American Plant Food Control Officials and The Fertilizer Institute 2013). Although Nitrogen fertilizer has played an important role in increasing global crop production, it is associated with a number of environmental concerns, particularly ground and surface-water contamination (Dowd, Press, and Huertos 2008) and climate change. Nitrogen fertilizer use contributes to anthropogenic climate change through the release of Nitrous Oxide gas. In 2011, Nitrous Oxide comprised about 5% of greenhouse gasses released by human activity, and agriculture is responsible for approximately 70% of US Nitrous Oxide emissions (US EPA 2011). Although Nitrous Oxide is a smaller proportion of greenhouse gasses than Carbon Dioxide, its Global Warming Potential is 298 times higher than Carbon Dioxide (US EPA 2011). One of the most effective climate change mitigation strategies in agriculture is reducing the application of Nitrogen fertilizer, therefore reducing release of Nitrous Oxide (Snyder et al. 2009). Despite the effectiveness of this climate change mitigation strategy, use of Nitrogen fertilizer increased 16% between 1990 and 2007 in the US (USDA Economic Research Service 2012) and agronomists estimate that at least 50% of US farms still apply more fertilizer than recommended (Millar et al. 2010).

We focus on corn production for several reasons. First, approximately 50% of all Nitrogen fertilizer is applied to corn production in the US (USDA Economic Research Service, 2012) and corn has an especially low Nitrogen Use Efficiency – approximately half of the fertilizer applied is lost to the environment (Cassman, Dobermann, and Walters 2002). Corn is also the most widely grown crop in the US, constituting approximately 96% of annual US feed grain production with approximately 80 million acres of corn planted annually (USDA, Economic Research Service 2014).

Previous studies have demonstrated a failure to acknowledge anthropogenic climate change amongst American farmers (Arbuckle Jr. et al. 2013; Haden et al. 2012; Stuart, Schewe, and McDermott 2012; White and Selfa 2013), consistent with larger American climate change beliefs (McCright and Dunlap 2000, 2011). Additional studies have demonstrated the failure of American farmers to adopt climate change mitigation practices (Arbuckle Jr. et al. 2013), particularly the reduction of Nitrogen fertilizer (Millar et al. 2010). We offer an explanation of *why* this might be the case, focusing on both structural and micro social forces.

Contract Farming Literature

Seed-corn contract farming, and contracting farming more generally, are best understood within the context of the significant agricultural restructuring that has occurred in recent decades (Goodman and Watts 1997; McMichael 1994). The contemporary agrifood system is increasingly concentrated in nearly all stages and sectors (Hendrickson and Heffernan 2007; Howard 2009, 2016), from consolidation amongst seed companies (Howard 2009) to grocery retailers (Hollingsworth 2004; Messinger and Narasimhan 1995; Tennent and Lockie 2012). Bonanno and Constance (2001) place agricultural contracts within an even broader context of globalization and increasing capital mobility that allows transnational corporations to source products globally and limits the possible regulatory responses of nation-states. Welsh (1997) demonstrates the rising use of agricultural contracts across a variety of commodity sectors, using an index to measure the “movement of decision-making control off the farm” and into the hands of agribusiness firms (1997:496). He finds that "an increasing amount of agricultural production is being accounted for by contracts" (Welsh 1997:495), including within the seed crop sector.

Within this environment of consolidation and restructuring, contracts are a complementary alternative to vertical integration – direct control of the different nodes of a commodity chain by a single entity (Kilmer 1986). A broad literature has developed to examine the functions of contemporary agricultural contracts (Constance 2008; Constance and Tuinstra 2005; Goss et al. 2001; Stuart 2008; Vandergeest et al. 1999; Welsh 1997; Wolf et al. 2001) and firms' motivations to engage farmers in contract farming. Wolf et al. (2001), in a study of contract farming in California's fruit and vegetable sector, outline three key functions for agricultural contracts: 1) coordinating production, 2) providing incentives to induce particular behaviors amongst growers, and 3) sharing risk amongst the different actors from growers to intermediaries to firms. In these ways, Wolf et al. argue that contracts serve to overcome some of the limits of capital penetration into agriculture. Wolf and colleagues examine agricultural contracts from the perspective of the firms and processors who engage farmers in contracts, examining the policing mechanisms that firms employ to ensure that growers meet their quality and production standards (Wolf et al. 2001). Mooney (1983) and others (Wells 1984, 1987, 1996) have argued that contracts allow firms to treat growers as employees, in that they can control their behaviors and practices, without the actual legal and ethical responsibilities of having them as employees.

This study does not examine the perspective of the seed companies that engage in seed-corn contracts nor the vertical integration of the seed-corn industry broadly, although they must be considered as an important context to the specific reality of seed-corn contract farmers' experiences. We discuss the specific structure and function of seed-corn contracts in more detail below. Generally, however, seed-corn contracts allow companies to coordinate production with projected demand for seed (Jones et al. 2001, 2003), to mitigate risks (Jones et al. 2003), and to incentivize growers to increase yield (Preckel et al. 2000), serving functions similar to those described by Wolf and colleagues (Wolf et al. 2001).

A corresponding literature examines farmers' responses to agricultural contracts, including a variety of alternative marketing strategies, collective bargaining of different types, and pursuing regulatory responses. Welsh (1997) highlights a wide range of grower responses and (sometimes) resistance to coercive contracts and argues that these responses are best understood within the social movement literature. Growers have resisted the constraints of vertical integration and/or contract farming through alternative marketing strategies (Cone and Myhre 2000; Grey 2000; Hinrichs 2000, 2003; Sharp, Imerman, and Peters 2002; Starr et al. 2003), through a variety of collective bargaining or networks (Ashwood et al. 2014; Koehler, Lazarus, and Buhr 1996; Welsh 1997), and through demands for regulatory responses (Hamilton 1994). Within hog farming, particularly, growers have utilized collective bargaining and networks to respond to contract farming conditions (Koehler et al. 1996) and to limit liability (Ashwood et al. 2014). Ashwood and colleagues argue that hog farmers are not passive victims of contract farming, but rather have effectively utilized collectivities and limited liability corporations (LLCs) to limit their own liability and place risks of concentrated hog farming onto local communities (Ashwood et al. 2014). A number of empirical studies have examined the impact of agricultural contracts across commodity sectors and sites, highlighting effects on labor (Borlu 2015; Burch 1994; Dixon 1982; Goss et al. 2001), environment (Mabbett and Carter 1999; Vandergeest et al. 1999), and rural communities comprehensively (Ashwood et al. 2014; Bonanno and Constance 2001; Constance and Tuinstra 2005).

However, it is crucial to recognize that, although agricultural contracts have increased in penetration of the agrifood system broadly and are part of broader restructuring trends (Mooney 1983; Welsh 1997; Wolf et al. 2001), there is significant heterogeneity amongst agricultural contracts and they intersect with unique features of different commodity systems in diverse ways. Welsh (1997) outlines three primary types of agricultural contracts: 1) marketing contracts that "require the producer to sell the production to a particular buyer on a predetermined schedule" (1997:494) but the producer maintains most control over production, 2) production management contracts in which a buyer defines "one or more production practices" (1997:494) but does not control an input directly, and 3) resource providing contracts in which a buyer controls one or more production practices and also controls a specific (or more than one) input directly. The extent of off-farm control and coercion increases across the three contract types, respectively. In this study, seed-corn contracts can be understood as the most restrictive "resource providing contracts" since the seed company retains ownership of the seed/crop itself (Jones et al. 2003). Agricultural contracts also vary significantly in their time span, with some fruit and vegetable (Wolf et al. 2001) and swine (Ashwood et al. 2014; Koehler et al. 1996) contracts being for multiple years and offering relative stability. Contracts for leafy greens (Stuart 2008), broiler chickens (Constance 2008; Constance and Tuinstra 2005), and our case of seed-corn (Jones et al. 2001, 2003; Preckel et al. 2000) are typically for only one season or year.

Further, agricultural contracts can be either fixed-rate contracts or tournament contracts. In fixed-rate contracts, a rate or price is secured at the onset of the contract, as is the case with most fruit and vegetable (Stuart 2008; Wolf et al. 2001) and swine contracts (Koehler et al. 1996). Tournament contracts, in contrast, are "ex post payment" contracts in which contracted growers are ranked against each other on some measure of commodity quality or quantity and payment is based on this tournament ranking (Preckel et al. 2000). Tournament contracts are commonly used in broiler chicken production (Constance 2008; Constance and Tuinstra 2005) and in our case of seed-corn contracts (Jones et al. 2001, 2003; Preckel et al. 2000).

Our contribution to this diverse literature on contract farming is three-fold: firstly we study contract farming within corn production, the most widely grown crop in the US (USDA, Economic Research Service 2014). Secondly, we examine climate change mitigation behavior specifically. Thirdly, we recognize the heterogeneity of contract farming and focus on identifying specific features of seed-corn contracts that shape impacts and outcomes. Contract farming must be examined with appropriate historicity and specificity in order to address the diversity of potential impacts; we combine the theoretical frames of Treadmill of Production and Informational Influence with this contract farming literature to highlight the complex reality of seed-corn contract farming and its effect on farmers' climate change mitigation behavior.

Seed-Corn Contract Farming

In this study, we examine seed-corn contract farmers, as compared to commercial corn farmers. Commercial corn farmers grow for the conventional commercial market: corn that is sold to distributors and processors, ultimately becoming a variety of commodities such as animal feed, corn syrup, ethanol, and/or other processed goods. In contrast, seed-corn contract farmers enter into annual production contracts with seed companies to grow varieties of corn that will later be sold by that company as seed. Seed companies use contracts to ensure that they have an adequate supply of different seed varieties available for the global market (Jones et al. 2001, 2003) and to "align incentives" of growers and the company (Jones et al. 2001, 2003; Preckel et al. 2000). From the firms' perspective, seed-corn contracts serve the three key functions of agricultural contracts described by Wolf et al. (2001): 1) coordinating production, 2) providing incentives to induce particular behaviors amongst growers, and 3) sharing risk amongst the different actors from growers to intermediaries to firms. Seed contracts typically offer growers significantly higher profitability than the commercial corn market (Preckel et al. 2000), but are highly competitive and risky, and can result in significant income losses if a contract is not renewed or production suffers.

In seed-corn contract farming, "an agricultural producer grows a crop expressly to provide seed for a supplier" (Preckel et al. 2000:470). Seed-corn contracts have several key features: they are short-term annual contracts, they are exclusive (i.e. the contracted farmer can only sell the contracted seed to one company), the company retains ownership of the seed, and they are tournament contracts. In tournament contracts, growers are ranked against other growers and then receive bonus and penalty payments based upon that ranking. Importantly, the higher potential level of profitability of seed-corn contract farming versus commercial corn farming ensures that:

> Typically the number of producers seeking such contracts exceeds the number of contracts available. In response, seed companies allocate contracts to preferred producers, usually on the basis of high yields. As a result, a producer has two incentives to seek a high yield: the bonus payment and the increased likelihood of future contract allocations. (Preckel et al. 2000:470)

Preckel (2000) argues that the primary mechanism by which seed-corn contracts shape grower behavior is through fear of losing their contract, similar to the fear of leafy green growers described by Stuart (2008). Seed company representatives estimate that, on average, seed-corn contract growers have profits-per-acre 20-50% higher than commercial corn growers. However, seed-corn growers at the top of tournament rankings can have incomes three or four times higher than commercial growers. Inversely, growers at the bottom of tournament rankings can have extremely high annual losses and face contract non-renewal (personal communication).

While seed-corn represents the minority of corn farms in the US, it is an illustrative case in which to study the effects of production contracts on farmers' management decisions, to highlight specific features of contract production that constrain farmers' behaviors, and to explore how these structural constraints interact with micro-level informational influence. Seed-corn farmers have formal production contracts with seed companies that may have important impacts on their climate change – or other – management behavior and that is what we explore in this case study.

In recent decades there have been significant developments in corn production and biotechnology, with new varieties of corn that are high producing, hardy, and have a number of modifications such as herbicide resistance and higher oil content (Darrah, McMullen, and Zuber 2003). Seed-corn contracts have played an important role in these developments, as seed-corn farmers are under contract to grow these new and experimental varieties of corn for seed. Contracts give individual growers responsibility for production risks while allowing seed companies to manage fluctuating global production and demand and ensuring access to a wide array of corn varieties (Jones et al. 2001). Seed companies rely on contracts as a cost-effective way to produce seed, mitigating risks associated with weather, pests, and other production conditions by contracting with growers from around the world (Jones et al. 2003). Rather than using contracts to police "quality control" as within the fresh fruit and vegetable sectors (Stuart 2008; Wolf et al. 2001), within the seed-corn sector the firms' primary policing objective is to ensure quantity/yield, and contracts are structured in order to prioritize yield through tournament ranking.

It is difficult to estimate the extent of contract seed-corn production in the US because the Agricultural Census does not differentiate between commercial and seed-corn farms. However seed-corn company representatives estimated that at least 100,000 acres in Southwest Michigan are in seed-corn production (personal communication). Reflective of broader restructuring trends, the seed-corn industry is highly concentrated; together Monsanto and Pioneer control 65% of the US seed-corn market (Howard 2009). According to industry representatives, in Southwest Michigan these two companies control about 75% of the seed-corn market and have a major influence over regional production practices (personal communication).

Amongst our sample, 17% of respondents grow any contract seed-corn, 12% grow majority contract seed-corn, and only 7% of respondents grow only contract seed-corn (Table 1). While a minority of the corn industry, seed-corn contract farms are significantly larger, on average than commercial corn farms (Table 2). While few studies have empirically examined seed-corn contract production, some studies have found that contracts were associated with higher chemical inputs and use of non-family labor (Winters, Simmons, and Patrick 2005) and higher rates of Nitrogen fertilizer use specifically (Jolejole 2009; Preckel et al. 2000). We build upon these preliminary studies by examining why this may be the case.

<Table 1 here>

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Treadmills of Production

We bring together two theoretical perspectives to explore barriers to adopting climate change mitigation behaviors in seed-corn production: Treadmills of Production and Informational Influence. Treadmill of Production theory (Gould et al. 2004; Gould, Pellow, and Schnaiberg 2008; Schnaiberg 1980; Schnaiberg and Gould 2000) offers a Marxian structural perspective, highlighting the ways in which a competitive capitalist system creates an unavoidable speeding up of production and associated social and environmental costs. Firms (in this case, farms) compete to increase production and lower costs, through technology adoption and/or labor exploitation, in order to capture a larger portion of the market than competitors. This relentless pursuit of growth is the defining feature of capitalist systems, the "dominating social good" (Schnaiberg and Gould 2000:viii). Increased production relies on increased extraction and new technologies that are often more input-intensive ("withdrawals"). Conversely, increased production and consumption also generate increased waste and increasing pollution ("additions"). Schnaiberg, Gould, and colleagues argue that this Treadmill is both environmentally and socially unsustainable (Gould et al. 2004, 2008; Schnaiberg 1980; Schnaiberg and Gould 2000).

Specifically within the study of agriculture, Treadmill of Technology theory (Cochrane 1958; Levins and Cochrane 1996) makes a similar theoretical argument highlighting structural pressures to continuously increase production within capitalist systems. Cochrane and colleagues (Cochrane 1958; Levins and Cochrane 1996) emphasize that increasing production, primarily through technology, is the primary way for farmers to increase income. However, investment in technology increases debt burdens and industry-wide production increases suppress commodity prices, placing farmers under further pressure to increase production (hence, the Treadmill analogy). Treadmill of Production and Treadmill of Technology theory highlight the ways in which individual farms and actors are constrained by the larger capitalist political economy that creates structural demands for increased production.

Rural sociologists and agricultural economists have also explored the Treadmill of Production within a political context, highlighting how the structure of political and economic systems emphasize continuously increasing production (Buttel 2001; Buttel, Jr, and Larson 1990; Marsden 1989; Ploeg 1990; Wilson 2001). The majority of Western nation-states have agricultural price supports and an agricultural regulatory system built to prioritize production, built on narratives of modernity and "feeding the world."

This structural perspective offers a theoretical basis for our examination of the role political economy may play in constraining climate mitigation behaviors in agriculture. Specifically, we engage with Treadmill of Production theory to answer three research questions: do seed-corn contracts create or reinforce a competitive pursuit of production at almost any cost, as described in the Treadmill of Production? To answer this question, we use survey data to compare seed-corn contract growers to conventional growers. If so, what specific features of contract production may serve to underpin the Treadmill? To answer this question, we analyze interview and focus group data for constraints identified by producers themselves. And does this competition to increase production lead to increased 'additions' – in this case Nitrous Oxide gas from Nitrogen fertilizer – as described in the Treadmill of Production? By examining Treadmill of Production theory within the context of agricultural production contracts, we extend existing theory to identify some specific structural features that may serve to create and reinforce the pressures of the treadmill.

Informational Influence

Informational influence is a social psychological theory to explain behavior. Informational influence (Deutsch and Gerard 1955) argues that normative influence occurs when individuals accept information from others as accurate and valid, particularly in cases of uncertainty (Kaplan and Miller 1987) and/or high "task importance" (i.e. when a decision has a potentially large impact) (Baron et al. 1996). In the absence of certainty or complete information when making decisions, individuals are more likely to rely on information from others and to conform their behavior to the normative expectations of others. "More concretely, informational influence often occurs in situations where members are trying to solve a complex problem unfamiliar to them" (Michener, DeLamater, and Myers 2004:340).

The relative importance of tasks/decisions at hand is also crucial to understandings of informational influence. Baron and colleagues conceptualize task importance as "the extent to which making correct or accurate judgments mediates important rewards and punishments" (1996:915). In "high stakes" situations in which there is a lot to gain or lose as a result of a decision, individuals are more susceptible to informational influence. In these ways, informational influence is a key mechanism for the creation and transmission of norms and behaviors (Michener et al. 2004).

In this study, we engage with informational influence to answer two research questions: do trusted sources of information affect farmers' climate change behavior? To answer this question, we examine the impact of trusted sources of information for all producers. Secondly, does the high-risk, low-information context of seed-corn farming increase the salience of informational influence? To answer this question, we again turn to a comparison between seed-corn contract growers and commercial corn growers. Decisions surrounding Nitrogen fertilizer use are a situation of both high uncertainty and high task importance, exactly the type of scenario in which informational influence is most pronounced. All farmers face an absence of complete information regarding their crop and agronomic conditions, and extremely unpredictable and influential "forces of nature" (Nafzinger, Sawyer, and Hoeft 2004; Roberts 2007; Robertson and Vitousek 2009). Further, corn farmers' decisions surrounding Nitrogen fertilizer are of crucial importance to the success of their crop and livelihood (Robertson and Vitousek 2009). A misstep in Nitrogen management can have significant effects on the outcome for a corn crop and have long-lasting effects on farmers' livelihoods, creating a situation of low information and high risk. However, as we will discuss in depth in our findings, the structure of seed-corn contracts exaggerates this high-risk/low-information environment through competitive ranking and extremely limited agronomic information available to growers. Therefore, seed-corn contract farming provides the sort of high stakes and low information environment in which we would expect high levels of informational influence.

We bring these diverse theoretical perspectives together to demonstrate the mutually reinforcing relationship between the capitalist political economy and informational influence and how these social forces affect farmers' use of Nitrogen fertilizer as a climate change behavior.

Methods

This study relies on interviews, focus groups, and a mail survey with corn farmers in Branch, Calhoun, Kalamazoo, and St. Joseph counties in Southwest Michigan. This data was collected as a social science supplement to the Long Term Ecological Research project at Kellogg Biological Station (Michigan State University) and was part of a larger interdisciplinary research project focused on climate change mitigation and adaptation in row-crop agriculture.

Together, the four study counties contain 1,200 corn farms and over 300,000 acres of corn (USDA 2007). Both Pioneer and Monsanto's North American seed-corn subdivisions are located in St. Joseph County, and St. Joseph, and Kalamazoo counties have a large number of seed-corn acres while Branch and Calhoun Counties are primarily composed of commercial corn growers.

Between January and May 2011, in-depth, semi-structured interviews were conducted with farmers in each county. 40 farmers were interviewed: 11 farmers in Calhoun County, 9 in Kalamazoo County, 12 in St. Joseph County, and 8 in Branch County. Michigan State University Extension agents recommended initial contacts and we used snowball sampling for subsequent interviews. Interviews included 23 commercial corn growers, 11 seed-corn growers, and 11 growers of both commercial and seed-corn. Questions focused on factors influencing Nitrogen fertilizer application, willingness to reduce application, and interest in climate offsets, as well as questions concerning climate change knowledge and belief and the relationship between Nitrogen fertilizer and climate change. Recordings and notes were transcribed and analyzed using NVivo software (QSR International 2010), iteratively coded by both authors for major themes and subthemes using a grounded theory approach (Charmaz 2006). Following preliminary analysis of survey and focus group data (described below), a second round of iterative coding was conducted to triangulate and extend survey and focus group findings.

During February and March 2011, we conducted four focus groups with corn farmers, one per county. The Branch, Calhoun, and Kalamazoo County focus groups included commercial corn growers and growers who grew both commercial and seed-corn, while the St. Joseph County focus group included six growers who grew only seed-corn. The Branch focus group included six growers, two of which grew seed-corn. The Calhoun focus group included four growers, all of whom grew commercial corn. The Kalamazoo focus group included eight growers, three of whom also grew seed corn. The group format and discussion amongst participants allowed us to observe points of consensus and disagreement amongst growers and the diversity and commonalities of practices and beliefs. The data generated by the focus groups was particularly helpful for answering questions related to the role of informational influence and peer influence. Focus group participants were recruited by the co-authors introducing the research project and passing a sign-up sheet at local meetings of the Michigan Corn Growers' Association, the annual Michigan Ag Action Day, the Michigan Agricultural Conference on the Environment, and through recommendations from Michigan State University Extension. All focus groups followed the same list of questions and were recorded. Early questions focused on what factors influence Nitrogen fertilizer use and tools and challenges to increasing Nitrogen efficiency. Then, a possible climate offsets program focused on reducing Nitrogen fertilizer use as a climate change mitigation strategy was introduced. The second set of questions focused on such a potential offsets program, climate change knowledge and beliefs, and the link between Nitrogen fertilizer and climate change. Focus groups were transcribed and analyzed using NVivo software (QSR International 2010) and grounded theory coding (Charmaz 2006). After preliminary analysis of survey data, we conducted a second round of iterative coding of focus group transcripts to triangulate and extend survey findings.

To generate a third and more representative data set, in February and March 2011 we sent a mail survey to a stratified random sample of 1,000 corn farmers in the four counties. The survey was administered with the National Agricultural Statistical Service (NASS) and used the Census of Agriculture as the sampling frame. To ensure that the final sample included an adequate number of large farms, the sample was stratified by acreage (Table 3). All survey analysis was conducted using Stata's svy prefix and appropriate weights to reflect that both the sampling rate and strata size vary in the survey design (StataCorp 2013).

<Table 3 here>

Because of sociopolitical division regarding climate change in the US (McCright and Dunlap 2000, 2011), survey packaging emphasized the study of Nitrogen fertilizer and questions specific to climate change were reserved for the survey's second half. Using methods recommended by Dillman (Dillman 2007; Dillman et al. 2009), we used four points of contact with the sample. 274 completed surveys (27% response rate) were returned. Such a low response rate does raise questions concerning potential non-response bias. Unfortunately, limited access to the sampling frame from NASS due to privacy restrictions prohibited conventional non-response analysis. However, we found no significant differences between our respondents and the Census of Agriculture or a previous statewide survey (Jolejole 2009) on key measures including age and farm size (acreage) (see Appendix A).

Survey analysis

Our dependent variable is self-reported total Nitrogen fertilizer applied per acre in the most recent season. Agricultural scientists have argued that "fertilizer Nitrogen (N) rate is the best single predictor of Nitrous Oxide emissions in rowcrop agriculture in the US Midwest"

(Millar et al. 2010:185). Further, "although other management and environmental factors can influence Nitrous Oxide emissions, fertilizer Nitrogen rate can be viewed as a single unambiguous proxy" (Millar et al. 2010:185) for GHG emissions in corn production. Therefore we are confident in the use of overall Nitrogen fertilizer per acre as an effective proxy for Nitrous Oxide emissions and, as introduced previously, an effective measure of increased 'additions' theorized in the Treadmill of Production (Buttel 2004; Gould et al. 2004).

To arrive at our dependent variable, we combined several survey questions. First, respondents were asked how many acres of commercial corn and how many acres of seed-corn they grow in a typical season. Secondly, respondents were asked four questions concerning total Nitrogen application: total Nitrogen application for unirrigated commercial corn acreage, for irrigated commercial corn acreage, for unirrigated seed-corn acreage, and for irrigated seed-corn acreage. From these, we calculated an average Nitrogen application rate per acre for commercial corn and for seed-corn. Third, we determined if the respondent grew only commercial corn, only seed-corn, or a combination of commercial and seed-corn. If they grew only commercial or seed-corn, then the average Nitrogen application per acreage for the appropriate type of corn was assigned as their overall Nitrogen application rate per acre. If they grew a combination of commercial corn and seed-corn, then whichever type of corn constituted the majority of their corn acreage was assigned as the their overall Nitrogen application rate per acre. Finally, since analysis of the distribution of the overall Nitrogen application rate per acre failed to confirm normality, we performed a Box-Cox transformation to ensure normality. Tests of skewness and kurtosis indicated no significant difference from normality (see Appendix B).

We then conducted bivariate comparison of means (Table 4), using Wald tests for significance and OLS regression[1] with the Nitrogen fertilizer application rate as the dependent variable (Table 5). Model 1 includes all respondents, with sociodemographic controls[2] and a dummy variable for the whether the respondent grew seed-corn. In order to test the role of informational influence, it also includes independent variables representing farmers' trusted information sources. Respondents were asked: "Where do you get information that is influential in determining Nitrogen fertilizer application?" [3] with responses including: 1) fertilizer dealers, 2) seed company agronomists/dealers/newsletters, 3) other farmers, 4) industry trade magazines, 5) company fieldman/contract production, 6) private consultants, 7) university recommendations, or 8) other sources, all coded as dummy variables. We also included a variety of agronomic variables as controls: type of Nitrogen fertilizer used (urea or UAN solution of urea and anhydrous ammonia, anhydrous ammonia, or manure), percent of cropland that is irrigated, whether the respondent plants cover crops[4], the most common soil type of cropland, whether the respondent uses side-dressing to apply Nitrogen fertilizer[5], whether the farm is part of any USDA conservation programs[6], whether the respondent uses Pre-sidedress Nitrate Testing (PSNT) to determine how much Nitrogen fertilizer is needed[7], and corn acreage in a typical season. In addition, we asked respondents "How important is each factor in determining how much Nitrogen fertilizer you apply?" with potential factors including: 1) fertilizer price, 2) corn price, 3) yield, 4) and the balance of costs and expected returns. Model 2 includes the full collection of independent variables but is limited to the subpopulation of respondents who grow majority seed-corn.

These multivariate analyses allow us to better isolate the effects of our key variables of interest to answer our research questions. We are able to isolate the effect of production contracts from other potential influences in order to determine whether contracts do, in fact, reinforce the Treadmill of Production and ultimately increase 'additions.' We are also able to isolate the effects of informational sources to determine whether trusted sources of information do, in fact, influence behavior and whether the high-risk, low-information context of seed-corn contract farming does ultimately increase the salience of informational influence (Model 2).

Results

Political Economy of Contract Corn Production

The political economy of seed-corn contract production provides structural reinforcement that encourages over-application of Nitrogen fertilizer and makes farmers unlikely to reduce Nitrogen fertilizer as a climate change mitigation behavior. Rather than farmers being irrational or wasteful in over-application of Nitrogen fertilizer, our findings suggest that seed-corn farming creates a context in which it is rational for farmers to focus on production as the key measure of success and to apply high rates of Nitrogen fertilizer to ensure that production. Seed-corn growers do, in our study, apply 20% more pounds of Nitrogen fertilizer per acre than commercial corn growers (Table 4). Amongst the small subpopulation of growers who grow both commercial corn and some of their acreage under seed-corn contracts, they apply nearly four times as much Nitrogen per acre on their seed-corn acreage as on their commercial acreage (Table 4).

<Table 4 here>

Regression analysis (Table 5, Model 1) confirms that seed-corn farmers apply significantly more Nitrogen fertilizer than commercial corn growers, even when controlling for a number of other variables. In fact, growing seed-corn has a larger effect than any other independent variable.

Interview and focus group data confirm the role of seed-corn production structures in reinforcing over-application of Nitrogen fertilizer, elucidating the processes by which this occurs. In particular, interviewees and focus group participants highlighted three features of seed-corn production that reinforced excessive Nitrogen application: 1) unpredictable introduction of new corn varieties, 2) protection of intellectual property rights by seed companies, and 3) a competitive "tournament contract" ranking system.

Firstly, seed companies assign corn varieties to growers based on projected global market demand, with virtually no input from growers themselves (Jones et al. 2001, 2003). Contract growers report having no input in which varieties they are assigned, often being assigned and expected to manage several different varieties in a single season, and having assigned varieties changed frequently. This constant changing of corn varieties prohibits seed-corn growers from accumulating knowledge from growing the same or similar varieties over several years in your own fields, limiting their ability to make judicious decisions regarding how much Nitrogen to apply. Contract growers spoke frequently about the difficulties of this rapid change and lack of accumulated knowledge about different varieties, as a focus group participant explained: "I don't have two fields with the same variety. I get so many different things…. We don't know the history." Another seed-corn grower in a focus group explained: "You really don't know {how much Nitrogen to apply} unless you build some kind of history and get some knowledge behind it." The unpredictability of seed-corn assignments limits farmers' ability and willingness to reduce Nitrogen fertilizer.

Secondly, to protect the intellectual property rights of the seed companies and patented corn varieties, growers report that they are provided extremely limited information about the corn varieties they are assigned. One contract grower in a focus group said: “Well, some inbreds will only produce 60 bushels and some inbreds will produce 120, 130, 140, 150. So, you have no idea what you’re really putting out there…. We can’t calculate anything.” Another seed-corn grower and focus group participant expressed his frustration with the lack of information provided by seed companies:

> The thing that does cost us is that [seed company] is turning over product and wanting us to grow inbreds that they’re not familiar with. We’re getting less and less testing and less information with regard to what we should do as growers.

Contract growers report that seed companies provide extremely limited information on new varieties, especially crucial information on expected yield and nutrient demands that would allow them to make reductions to Nitrogen fertilizer. Without this information their response is to apply large amounts of Nitrogen fertilizer in order to ensure production. In this way, seed-corn contracts reinforce high Nitrogen application.

Finally, competition to secure and maintain seed contracts is fierce, and most seed contracts are “tournament contracts” based on competitive ranking amongst growers. Growers are ranked by net production in comparison to other growers of the same variety and receive bonus payments or penalties based on ranking. Low production may also result in the seed company not renewing the contract the following season. These competitive contract structures have previously been shown to result in over-application of Nitrogen fertilizer (Preckel et al. 2000). One contract grower and focus group participant spoke of the widespread unwillingness to reduce Nitrogen fertilizer because of contracts: “We have a fear of losing our contracts, we need to protect our position." During an interview, one contract grower explained: "In our company there have been a lot of cutbacks and it's always those five guys at the bottom who get cut, it's a big motivation." Failure to renew contracts places farmers' livelihoods at risk. This makes farmers extremely risk averse concerning any behavior, such as reduction of Nitrogen fertilizer, which may threaten their production, again reinforcing production as the key measure of success and incentivizing Nitrogen over-application.

The competitive ranking structure of seed-corn contracts involves pitting growers against each other based on net production, discouraging any practice that might reduce yield. One seed-corn grower said during an interview:

> Contracts are based off of yield goals, so therefore, if you don't have the amount of nutrients out there and you don't meet your yield goal, you won't get paid for it. You're expected to make a goal, and if you don't, you run the risk of being cut as a grower.

Bonus payments for high yield rankings further incentivize Nitrogen application and production by distorting the cost/benefit ratios of fertilizer. A focus group participant said: "That last little bit {of Nitrogen} could give you 17-19 bushels {of additional production}, which makes it worth a fortune" if it bumps a farmer up in the rankings to receive a bonus. Another contract grower and focus group participant said: "Our contracts give us complete flexibility in how much {N} to apply, but the competitive structure locks us in." Although contracts do not formally require high Nitrogen application, their competitive structure creates a formal mechanism to incentivize over-application.

During a focus group that included both commercial and seed-corn growers, growers discussed the different incentives between commercial growers and seed-corn contract growers regarding applying Nitrogen fertilizer. In the following discussion between two farmers at the focus group, Farmer 1 grew both commercial and seed-corn, while Farmer 2 grew only commercial corn:

> Farmer 1: Well I equate {efficient use of Nitrogen} with milking. That, in the dairy world people talk about how many pounds or gallons {of} production, and that's kind of a measuring stick, but it's not really a great measuring stick of profitability or efficiency. I don't know if that's kind of the same thing in the grain world but I don't think people are really hog wild {about applying Nitrogen}, you know. I kind of kid about the seed corn, but seed corn is such a unique product, and you can have hybrids that can go from 20 bushels to 120 bushels, so it's really tough… and I don't know what the rest of the seed corn guys do, but the incentive to over-apply is a lot more than commercial guys. I'm just trying to think of the people that I know in the {commercial corn} grains. I don't think you have too many people that really go hog wild on N anymore. Do you?
>
> Farmer 2: I don't believe so, no.
>
> Farmer 1: Just because of the economics.

During the focus group that included all seed-corn growers, participants openly discussed, from the very start of conversation, how concepts of efficiency or cost/benefit analysis related to Nitrogen application are shaped by their competitive contracts:

> Focus group coordinator: OK. Great. OK. So, um, the first question is, for your seed corn farming operations, how do you determine how much nitrogen fertilizer to use?

> Farmer 1: Darn good question.
>
> Farmer 2: That is a good question.
>
> Farmer 3: We're given suggestions by the companies…. And you take that with a kind of grain of salt…But I'm sure as the conversation's going to go along, you'll be filled in on the competitiveness of the contracts and how that skews our thought pattern. At least, mine. I don't want to speak for the whole group, but it does skew mine.
>
> Farmer 2: Margin analysis goes out the window on most inputs in the seed corn contract. So you wont hear much of that here, I don't think.

Again, the competitive tournament structure of contracts incentivizes over-application of Nitrogen and undermines any potential focus on "efficient" use of this input.

Mediation by Informational Influence

Given the importance of Nitrogen fertilizer decisions and the lack of complete information, farmers are particularly susceptible to informational influence. We find that informational influence, represented by where farmers turn for trusted information regarding Nitrogen fertilizer, is related to how much Nitrogen fertilizer they apply. Informational influence may mediate the relationship between the political economy, social norms, and climate behaviors, particularly for contract growers.

Regression results demonstrate the significance of trusted sources of information on this climate mitigation behavior (Table 5). Amongst all respondents, those who report that fertilizer dealers are their most trusted source of information regarding Nitrogen fertilizer apply significantly more Nitrogen per acre (Table 5, Model 1). This is perhaps not surprising, given that there is little incentive for fertilizer dealers to encourage reduced Nitrogen application rates, but may serve as a significant informational barrier to adopting this climate change mitigation behavior.

Amongst the subpopulation of seed-corn farmers (Table 5, Model 2), the impact of informational influence appears even stronger (larger effect sizes). This suggests that the effect of informational influence is stronger for seed-corn farmers than for corn farmers generally. This is consistent with theories of informational influence (Deutsch and Gerard 1955), particularly the role of "task importance" in increasing informational influence (Baron et al. 1996; Michener et al. 2004). Seed-corn farmers, as outlined above, must make decisions with even less information and even higher risk/reward than commercial corn growers. In these conditions, seed-corn farmers are more susceptible to informational influence. Sources of trusted information not only were associated with Nitrogen behavior, but that influence varied between commercial and seed-corn growers, suggesting that a more complex relationship exists between the structural variable – contract farming – and the informational variable. Those seed-corn farmers who rely on other farmers as their most important source of advice apply significantly higher rates of Nitrogen fertilizer, while those who are part of a USDA conservation program apply significantly lower rates of Nitrogen fertilizer. Taken comprehensively, these results suggest that informational influence may be an important mediator in the relationship between the political economy of corn production and Nitrogen fertilizer application rates.

Interview and focus group data further illustrate the importance of trusted sources of information. When we asked where farmers turned for information about Nitrogen fertilizer decisions, interview and focus group participants echoed survey findings: they predominantly rely on fertilizer dealers and/or seed companies. One contract grower discussed his trusted relationship with both fertilizer dealer and seed company agronomists during an interview:

> Farmer: I used to take my soil samples to one {fertilizer} dealership and buy my fertilizer from another so that I didn't get bad feedback based on them wanting to make a sale.
>
> Interviewer: You don't do that anymore?
>
> Farmer: I don't need to. I'm okay with who we're using as a distributor now to the point where I'm okay with it.

Another seed-corn farmer emphasized the importance of advice from his fertilizer dealer during an interview: "I don't want to sound like I don't take advice, because I do take advice…{Fertilizer dealer 1} was one and {Fertilizer dealer 2} was the other one…. Their manager is a pretty good agronomist and he helps us though questions we have and things like that."

Overwhelmingly, seed-corn farmers spoke of a reluctance to share information with peers or to ask for advice from other farmers. When asked if he was willing to share Nitrogen information or advice with other farmers, one seed-corn farmer said during an interview: "Actually, not too many…. generally speaking, it's only if you have a neighbor or a friend that wants to know what you are doing." Seed-corn growers emphasized the competitive nature to their peer relationships. During an interview, one seed-corn grower lamented the competitive edge to his peer relationships because of the contracts:

> One of the things that is difficult about growing seed-corn is that if the field across the road is planted the same as mine, and I'm competing against it, then it's hard for me to ever feel good about seed on my neighbor's ground. And you wish

> for back in the day when you could just say ‘Well, it’s all just commercial corn and I don’t care how much corn he grows…’ But now I’m thinking: ‘Geeze, when’s the hail going to get here?’ You know, it’s that kind of thing that you can’t be happy for the neighbor because it means so much to you. We’re all friendly to each other, but we all know the stakes of competition.

During a focus group one seed-corn farmer shared his experience with different types of Nitrogen fertilizer, but then added an important aside to the authors:

> You know, I didn’t know if I should put out some of these figures I have. But this is a real good group here. I mean, good people that I trust and I know that, you know, I can share this information with. So, I wanted to make sure you understood that.

He wanted the authors and focus group coordinators to understand that ordinarily he would not, and did not, share advice or information regarding Nitrogen fertilizer with other contract farmers. Later in the focus group, mistrust amongst competitive seed-corn farmers came up again:

> Focus group coordinator: Do you think there’s a disincentive to share information amongst seed-corn farmers?
>
> <Group Laughter>
>
> Farmer 2: You didn’t catch the implication with {Farmer 1}? I trust the people in this room, but I don’t trust anybody else.

Again, the causal direction is unclear, but the informational influence of trusted sources of information is clearly related to Nitrogen application rates for producers, and may serve as an important context for transmission of structural constraints into practices.

Discussion: Implications for Climate Change Mitigation

Our findings suggest that much more significant barriers exist to the adoption of climate change mitigation behaviors than lack of information or climate change denialism: competitive seed-corn contracts that reinforce excessive Nitrogen application and informational networks that interlock with these structural constraints. Within row-crop agriculture, overall Nitrogen application rate is the most parsimonious and appropriate proxy for Nitrous Oxide emissions and overall climate impacts of production (Millar et al. 2010). Therefore, higher rates of Nitrogen fertilizer application translate directly to higher climate impacts for seed-corn contract production, as compared to commercial corn production.

Rather than being irrational or willfully wasteful in use of Nitrogen fertilizer, however, we argue that over-application of Nitrogen fertilizer is a logical response to the structure of contract seed-corn production and the constraints it places on producers. Rather than sell a crop on the “open” commodity corn market, seed-corn farmers enter into annual, exclusive, production contracts with seed companies to grow whichever varieties of corn they are assigned by the company. These production contracts are “tournament contracts” in which growers’ payment and penalties are based on overall yield. Contracts limit farmers’ access to information and change their economic incentives through this competitive ranking, reinforcing net production as the key measure of success and Nitrogen fertilizer as the strategy to ensure production. In these ways, seed-corn contracts place farmers squarely on the Treadmill of Production (Gould et al. 2004) and/or Treadmill of Technology (Levins and Cochrane 1996), chasing higher and higher production through intensification and technology, in this case the use of Nitrogen fertilizer.

Our findings also clearly demonstrate how the structural features of contract farming interact with the micro-level phenomena of information sources. We find that the reinforcement between structure and behavior may be mediated by where farmers turn for trusted information – informational influence. Farmers who rely on fertilizer dealers for information also apply significantly more Nitrogen fertilizer per acre than others. Amongst seed-corn contract farmers, those who rely on other farmers for information actually apply substantially more Nitrogen fertilizer per acre than others, suggesting that the competitive peer influence created by tournament contracts may further negatively affect their climate behaviors through information transfer. Those seed-corn farmers who are part of a USDA conservation program, however, report applying substantially less Nitrogen fertilizer per acre than others, suggesting a continued important role for traditional conservation programs in encouraging climate mitigation behaviors.

Together, our findings illustrate the reciprocal and mutually reinforcing relationships amongst the structural forces of contracts, micro forces of informational influence, and climate mitigation behaviors, and the necessity for social scientists and policy makers to acknowledge their simultaneity in order to understand (and change) individuals' climate change mitigation behaviors. The mediating role of informational influence and sources of information regarding Nitrogen fertilizer suggests that information networks may be a key component of behavioral change but that their influence is not uniformly positive. Programs/policies supporting information sharing and trust networks, outside of competitive contract systems, or information sources outside of direct industry control may play a key role in changing climate behaviors.

However, the Treadmill of Production reinforced by seed-corn contracts serves as a structural barrier to potential climate mitigation programs. Without structural reforms, specifically reforms to agricultural contracts to provide more information, continuity, and autonomy to farmers and to reduce competitive incentives, individual farmers are unlikely to change behaviors. While there is no easy solution to structural problems facing climate policy and agriculture, the political economy of contract farming must be considered in the design of climate policy and reforms must move beyond a focus on individual farmers and their behaviors.

Conclusion

In this study, we have examined mutually reinforcing structural and informational influences on climate change mitigation practices. Using a mixed-methods study of seed-corn contract farmers, we find that the structure of seed-corn contracts encourages over-application of Nitrogen fertilizer. We have demonstrated the ways in which specific features of seed-corn contracts reinforce excessive Nitrogen fertilizer application and how these structural forces constrain climate mitigation behaviors. Importantly, we find that these effects may be mediated by informational influence, specifically where farmers turn for trusted sources of information.

We have focused on seed-corn contract farmers, specifically, as a case study in which to examine the structural constraints on farmers' management and climate change behaviors and how those structural constraints interact with micro-level informational influence. This case allows us to highlight specific features of production contracts and how they constrain farmers' behaviors. While a minority of corn production, seed-corn contract production is an excellent case study to illustrate the complexity of climate change behaviors and illuminate the interlocking micro and macro social processes that shape that behavior.

On the structural level, we identify three key features of seed-corn contracts that serve to reinforce over-application of Nitrogen fertilizer: 1) unpredictable introduction of new corn varieties, 2) protection of intellectual property rights by seed companies, and 3) a competitive "tournament contract" ranking system. These serve to reinforce and create formal mechanisms to reward excessive application of Nitrogen fertilizer and a focus on production as the key measure of success, keeping farmers on the Treadmill of Production (Gould et al. 2004, 2008). These structural forces make individual farmers extremely unwilling to adopt any new behavior that might threaten production even if that behavior provides demonstrated environmental benefits.

However, we also find a potentially important role of informational influence (Deutsch and Gerard 1955; Kaplan and Miller 1987) operating at the micro level to mediate the relationship between structure and behaviors. Amongst seed-corn contract growers, those who rely on peers for influential information report higher rates of actual Nitrogen application, suggesting peer-to-peer informational influence is important, but that competitive peer relationships may actually discourage climate mitigation behaviors. Our findings also suggest the informational influence of other key sources of information, such as fertilizer dealers, are related to this climate behavior. Together, this suggests that informational influence may mediate the relationship between structural forces and behavior or be a mechanism by which structural features are translated into behaviors. Thus, information and knowledge networks may provide a key component to explaining variation in climate change mitigation behavior and social behavior more generally.

Our findings make a significant contribution to the growing literature on contract farming by highlighting the specific mechanisms by which seed-corn contracts shape farmer behavior and by examining a new empirical case. There are a number of unique features of seed-corn production that demonstrate the heterogeneity of contract farming: contracts are short-term with high risk of non-renewal; the concept of quality control is less salient than in fruit and vegetable production, instead yield is the primary conceptualization of quality; and farmers operate with very little information due to the rapid introduction of varieties and protection of intellectual property rights (Hamilton 1994). These circumstances differ from those described in other agricultural contracts in fruit and vegetable (Wells 1981; Wolf et al. 2001) or livestock production (Ashwood et al. 2014; Bonanno and Constance 2001; Constance 2008; Constance and Tuinstra 2005; Koehler et al. 1996).

We identify several unique features of seed-corn contracts that constrain farmers' behavior: unpredictable introduction of new varieties, protection of intellectual property rights by seed companies, and a competitive "tournament contract" ranking system. Identifying these specific features of seed-corn contracts that operate as structural constraints makes an important extension to the existing literature on contract farming by recognizing the potential heterogeneity of contract impacts. The diversity of contract structures (Welsh 1997) and the way that they intersect with features of specific commodity systems have important implications for the diversity of effects of contract farming. For example, while swine farmers have resisted contract coercion through collectivities and LLCs (Ashwood et al. 2014; Koehler et al. 1996), broiler chicken farmers have exercised little collective resistance to restrictive contracts (Constance 2008; Constance and Tuinstra 2005) and neither have leafy greens growers (Stuart 2008). Our findings demonstrate that this is likely related to the competitive structure of the contract systems in those sectors: tournament contracts in which producers are competing against each other for payment and short-term contracts in which growers have a constant fear of losing their contracts. Stuart (2008) makes a similar argument when she explains:

> The {leafy green} market can be very competitive: growers indicated that if a buyer is not satisfied, they can usually find another grower who is willing to

> comply with their requests. Growers interviewed also acknowledged that in this competitive market they primarily work alone and there are currently no attempts to organize a unified response to buyers' requests, no matter how outlandish they seem. (Stuart 2008:63)

Preckel (2000) theorizes that "the primary goal of a tournament contract is to foster competition between {growers} by basing rewards for the {buyer} on some measure of {grower} performance" (Preckel et al. 2000:469). Our findings demonstrate that this competition and fear of contract non-renewal operate as a powerful constraint upon farmers' behaviors and that producers in tournament contracts are significantly motivated by this fear of losing their contracts. This is in contrast to the emphasis on quality control as the primary constraint described by Wolf et al. (2001) in the fruit and vegetable sectors and with the opportunity for collectivities described in the hog sector (Ashwood et al. 2014; Koehler et al. 1996). Together, our findings demonstrate the need for historicity and specificity in discussions of contract farming, recognizing the diversity of contract structures and how they may uniquely intersect with commodity systems.

Our findings both confirm and extend the Treadmill of Production and Informational Influence theoretical frames by revealing the interlocking mechanisms of micro and macro social forces. We confirm Treadmill of Production theory with our finding that seed-corn contracts do, ultimately, reinforce an emphasis on production at almost any cost and the use of technology – Nitrogen fertilizer – to achieve that production. We also confirm that tournament contract production does ultimately boost increased 'additions' of pollution, in this case the greenhouse gas Nitrous Oxide, as would be theorized by the Treadmill of Production. However, Treadmill of Production theory is so structural in perspective that it often verges on a tone of linear inevitability and has been critiqued for not adequately addressing avenues for social change (Gould et al. 2004). In our case study, we are able address this critique by examining specific features of contract production that reinforce the Treadmill and therefore highlighting potential avenues for revision, and by simultaneously examining micro-level information networks. Our findings also confirm the theory of informational influence by demonstrating how where farmers turn for trusted information ultimately affects their behavior. By showing how informational influence is amplified within the high-risk, low-information context of seed-corn contract farming, we specifically confirm theories of task importance.

Our most significant extension comes from examining macro and micro constraints on individual behavior simultaneously. By incorporating a focus on informational influence, we are able to extend the structural perspective of Treadmill of Production and highlight the ways in which micro and macro-level interactions may help transmit, and possibly transform, these structural forces. Conversely, the Treadmill of Production perspective extends the theory of Informational Influence by demonstrating how the structure of the political economy creates the context in which interactions occur and information is exchanged. Together, these perspectives demonstrate the mutually reinforcing micro and macro social forces that shape individual behaviors.

These findings have significant implications for understanding barriers to adopting climate change mitigation behaviors, specifically, and the relationship amongst macro and micro social forces generally. They suggest that social scientists and policy makers must be engage with multiple levels of analysis simultaneously in order to capture the full complexity of social systems and human behaviors. Political and economic structures create the context for interaction and informational networks, and define the stakes for decisions. But informational influence may serve as a key mechanism for the transmission or moderation of structural influences into normative values and behaviors. Together, these social forces interact to constrain individual behaviors and decisions. Theorizing macro, meso, and micro-level factors as integrated social systems, rather than distinct social forms, demands a social science that is simultaneously attentive to all levels.

The interaction amongst these macro and micro social forces creates a context in which individual farmers are unwilling and/or unable to adopt an important climate change mitigation behavior. Nitrogen application rate is the most direct proxy for overall climate impacts of row-crop production (Millar et al. 2010), and reducing Nitrogen fertilizer use is a highly effective climate change mitigation practice (Snyder et al. 2009) that could dramatically reduce the climate impacts of contemporary agriculture and improve long-term climate prospects. However, contract seed-corn production and the informational influence of sources such as fertilizer dealers make it very unlikely to be widely adopted without significant changes across all dimensions. As climate models and their predicted effects become increasingly dire (Gillis 2014), it is unreasonable to expect widespread individual behavioral change without changes that address these multiple levels of social forces systemically.

The interlocking effects of macro and micro social forces also suggest that education and outreach targeted at climate change "awareness" will not be enough to expect widespread behavioral changes. As has been demonstrated with a variety of climate change behaviors and environmental behaviors more generally (Attari et al. 2011; Schulte and Miller 2010; Wells et al. 2010), education and awareness are unlikely to directly increase adoption of climate change mitigation behaviors if they conflict with structural constraints and normative values.

ENDNOTES

[1] Standardized effect sizes were estimated using the "listcoef" command for survey weighted data in Stata. The estimates standardize both the X and Y variables with a mean of zero and a standard deviation of one (Long and Freese 2014:179).

[2] The sample included no non-white respondents and only two women so these variables were omitted from the regression model. This reflects the composition of corn growers in the region and US generally (USDA 2007).

[3] Categories were not mutually exclusive, respondents were asked to mark all that apply.

[4] Cover crops are crops, usually legumes, planted to support the primary crop and/or soil health by reducing nutrient loss through leaching, preventing erosion, reducing weeds, and adding nitrogen to the soil through nitrogen fixation (SARE 2007). Cover crops are generally considered to be a conservation farming practice that may reduce the need for Nitrogen fertilizer (McVay, Radcliffe, and Hargrove 1989).

[5] Side-dressing is applying the fertilizer in lines close to the rows of corn. Side-dressing is considered to be an efficient method of supplying fertilizer to the crop directly where and when it is needed, possibly reducing overall Nitrogen fertilizer used (Mulvaney, Khan, and Ellsworth 2006).

[6] USDA conservation programs include the Environmental Quality Incentive Program, Conservation Reserve Program, and/or Conservation Stewardship Program that provide financial and other incentives for conservation practices.

[7] PSNT is a soil test to evaluate existing nitrate resources in soil to determine if additional Nitrogen fertilizer supplementation is needed, and how much (Mulvaney et al. 2006).

[8] Social psychological theories of "productivism" highlight the importance of norms surrounding success in agriculture that use net production as the central conceptualization of farmers' identity (Bell 2004; Burton and Wilson 2006; McGuire, Morton, and Cast 2013). Productivism involves a definition of success and a "good farmer" identity tied to net production, rather than other measures of success.

Works Cited

Arbuckle Jr., J. Gordon et al. 2013. "Climate Change Beliefs, Concerns, and Attitudes toward Adaptation and Mitigation among Farmers in the Midwestern United States." *Climatic Change* 117(4):943–50.

Ashwood, Loka, Danielle Diamond, and Kendall Thu. 2014. "Where's the Farmer? Limiting Liability in Midwestern Industrial Hog Production." *Rural Sociology* 79(1):2–27.

Association of American Plant Food Control Officials and The Fertilizer Institute. 2013. *History of U.S. Fertilizer Use*. Wash: The Fertilizer Institute. Retrieved December 31, 2014 (http://www.tfi.org/sites/default/files/images/history_of_us_fert_use.pdf).

Attari, Shahzeen Z., Michael L. DeKay, Cliff I. Davidson, and Wändi Bruine de Bruin. 2011. "Changing Household Behaviors to Curb Climate Change: How Hard Can It Be?" *Sustainability: The Journal of Record* 4(1):9–11.

Baron, Robert S., Joseph A. Vandello, and Bethany Brunsman. 1996. "The Forgotten Variable in Conformity Research: Impact of Task Importance on Social Influence." *Journal of Personality and Social Psychology* 71(5):915–27.

Bell, Michael Mayerfeld. 2004. *Farming for Us All: Practical Agriculture & the Cultivation of Sustainability*. University Park, Pennsylvania: Pennsylvania State University Press.

Bonanno, Alessandro and Douglas Constance. 2001. "Corporate Strategies in the Global Era: The Case of Mega-Hog Farms in the Texas Panhandle Region." *International Journal for the Sociology of Agriculture and Food* 9:5–28.

Borlu, Yetkin. 2015. "A Story of Post-Fordist Exploitation: Financialization and Small-Scale Maize Farmers in Turkey." *Rural Sociology* 80(2):173–97.

Burch, David. 1994. "Agribusiness, Peasant Agriculture and the State: The Case of Contract Farming in Thailand." in *Poverty, Inequality and Rural Development*, edited by T. Lloyd and O. Morrissey. London: St. Martin's.

Burgess, J., C. M. Harrison, and P. Filius. 1998. "Environmental Communication and the Cultural Politics of Environmental Citizenship." *Environment and Planning A* 30(8):1445–60.

Burton, Rob JF and Geoff A. Wilson. 2006. "Injecting Social Psychology Theory into Conceptualisations of Agricultural Agency: Towards a Post-Productivist Farmer Self-Identity?" *Journal of Rural Studies* 22(1):95–115.

Buttel, Frederick H. 2001. "Some Reflections on Late Twentieth Century Agrarian Political Economy." *Sociologia Ruralis* 41(2):165.

Buttel, Frederick H. 2004. “The Treadmill of Production An Appreciation, Assessment, and Agenda for Research.” *Organization & Environment* 17(3):323–36.

Buttel, Frederick H., Gilbert W. Gillespie Jr, and Olaf F. Larson. 1990. *The Sociology of Agriculture:*. New York: Praeger.

Cassman, Kenneth G., Achim Dobermann, and Daniel T. Walters. 2002. “Agroecosystems, Nitrogen-Use Efficiency, and Nitrogen Management.” *AMBIO: A Journal of the Human Environment* 31(2):132–40.

Charmaz, Kathy. 2006. *Constructing Grounded Theory: A Practical Guide through Qualitative Analysis*. 1st ed. Sage Publications Ltd.

Choi, Jin Nam, Richard H. Price, and Amiram D. Vinokur. 2003. “Self-Efficacy Changes in Groups: Effects of Diversity, Leadership, and Group Climate.” *Journal of Organizational Behavior* 24(4):357–72.

Cochrane, Willard Wesley. 1958. *Farm Prices, Myth and Reality*. U of Minnesota Press.

Coles, Tim, Anne-Kathrin Zschiegner, and Claire Dinan. 2013. “A Cluster Analysis of Climate Change Mitigation Behaviours among SMTEs.” *Tourism Geographies*.

Cone, Cynthia and Andrea Myhre. 2000. “Community-Supported Agriculture: A Sustainable Alternative to Industrial Agriculture?” *Human organization* 59(2):187–97.

Constance, Douglas H. 2008. “The Southern Model of Broiler Production and Its Global Implications.” *Culture & Agriculture* 30(1-2):17–31.

Constance, Douglas H. and Reny Tuinstra. 2005. “Corporate Chickens and Community Conflict in East Texas.” *Culture & Agriculture* 27(1):45–60.

Darrah, L. L., M. D. McMullen, and M. S. Zuber. 2003. “Breeding, Genetics, and Seed Corn Production.” Pp. 35–68 in *Corn: chemistry and technology*, edited by P. J. White and L. A. Johnson. St. Paul, MN: American Association of Cereal Chemists.

Deutsch, Morton and Harold B. Gerard. 1955. “A Study of Normative and Informational Social Influences upon Individual Judgment.” *The Journal of Abnormal and Social Psychology* 51(3):629–36.

Dillman, D. A. 2007. *Mail and Internet Surveys: The Tailored Design Method*. John Wiley & Sons Inc.

Dillman, Don A. et al. 2009. “Response Rate and Measurement Differences in Mixed-Mode Surveys Using Mail, Telephone, Interactive Voice Response (IVR) and the Internet.” *Social Science Research* 38(1):1–18.

Dixon, Ruth B. 1982. “Women in Agriculture: Counting the Labor Force in Developing Countries.” *Population and Development Review* 8(3):539–66.

Dowd, Brian M., Daniel Press, and Marc Los Huertos. 2008. “Agricultural Nonpoint Source Water Pollution Policy: The Case of California’s Central Coast.” *Agriculture, Ecosystems & Environment* 128(3):151–61.

Gifford, Robert. 2011. “The Dragons of Inaction: Psychological Barriers That Limit Climate Change Mitigation and Adaptation.” *American Psychologist* 66(4):290.

Gillis, Justin. 2014. “Panel’s Warning on Climate Risk: Worst Is Yet to Come.” *The New York Times*, March 31. Retrieved October 24, 2014 (http://www.nytimes.com/2014/04/01/science/earth/climate.html).

Goodman, David and Michael Watts. 1997. *Globalising Food: Agrarian Questions and Global Restructuring*. Psychology Press.

Goss, Jasper, Mike Skladany, and Gerad Middendorf. 2001. “Dialogue: Shrimp Aquaculture in Thailand: A Response to Vandergeest, Flaherty, and Miller*.” *Rural Sociology* 66(3):451–60.

Gould, Kenneth A., David N. Pellow, and Allan Schnaiberg. 2004. “Interrogating the Treadmill of Production Everything You Wanted to Know about the Treadmill but Were Afraid to Ask.” *Organization & Environment* 17(3):296–316.

Gould, Kenneth A., David N. Pellow, and Allan Schnaiberg. 2008. *The Treadmill of Production: Injustice and Unsustainability in the Global Economy*. Paradigm Publishers.

Grey, Mark. 2000. “‘ Those Bastards Can Go to Hell!’ Small-Farmer Resistance to Vertical Integration and Concentration in the Pork Industry.” *Human organization* 59(2):169–76.

Groth, P. E. and T. W. Bressi. 1997. *Understanding Ordinary Landscapes*. Yale Univ Pr.

Haden, Van R., Meredith T. Niles, Mark Lubell, Joshua Perlman, and Louise E. Jackson. 2012. “Global and Local Concerns: What Attitudes and Beliefs Motivate Farmers to Mitigate and Adapt to Climate Change?” *PLoS ONE* 7(12):e52882.

Hall, C. Michael. 2006. “New Zealand Tourism Entrepreneur Attitudes and Behaviours with Respect to Climate Change Adaptation and Mitigation.” *International Journal of Innovation and Sustainable Development* 1(3):229–37.

Hamilton, Neil D. 1994. “Why Own the Farm If You Can Own the Farmer (and the Crop): Contract Production and Intellectual Property Protection of Grain Crops.” *Nebraska Law Review* 73:48.

Hargreaves, Tom. 2011. “Practice-Ing Behaviour Change: Applying Social Practice Theory to pro-Environmental Behaviour Change.” *Journal of Consumer Culture* 11(1):79–99.

Hayles, Carolyn S., Moira Dean, Sarah A. Lappin, and Jane E. McCullough. 2013. “Climate Change Adaptation.” *Smart and Sustainable Built Environment* 2(2):192.

Hendrickson, M. and W. Heffernan. 2007. “Concentration of Agricultural Markets.” *Columbia, MO, Department of Rural Sociology, University of Missouri*. Retrieved September 19, 2012 (http://www.foodcircles.missouri.edu/CRJanuary02.pdf).

Hinrichs, C. Clare. 2000. “Embeddedness and Local Food Systems: Notes on Two Types of Direct Agricultural Market.” *Journal of rural studies* 16(3):295–303.

Hinrichs, C. Clare. 2003. “The Practice and Politics of Food System Localization.” *Journal of Rural Studies* 19(1):33–45.

Hobson, K. and S. Essex. 2001. “Sustainable Tourism: A View from Accommodation Businesses.” *The Service Industries Journal* 21(4):133–46.

Hollingsworth, Andrew. 2004. “Increasing Retail Concentration: Evidence from the UK Food Retail Sector.” *British Food Journal* 106(8):629–38.

Howard, Philip H. 2009. “Visualizing Consolidation in the Global Seed Industry: 1996–2008.” *Sustainability* 1(4):1266–87.

Howard, Philip H. 2016. *Concentration and Power in the Food System: Who Controls What We Eat?*. Bloomsbury Academic.

Jolejole, M. C. B. 2009. “Trade-Offs, Incentives, and the Supply of Ecosystem Services from Cropland.” M.S. Thesis in Agricultural, Food and Resource Economics, Michigan State University, East Lansing, MI.

Jones, Philip C., Greg Kegler, Timothy J. Lowe, and Rodney D. Traub. 2003. “Managing the Seed-Corn Supply Chain at Syngenta.” *Interfaces* 33(1):80–90.

Jones, Philip C., Timothy J. Lowe, Rodney D. Traub, and Greg Kegler. 2001. “Matching Supply and Demand: The Value of a Second Chance in Producing Hybrid Seed Corn.” *Manufacturing & Service Operations Management* 3(2):122–37.

Kaplan, Martin F. and Charles E. Miller. 1987. “Group Decision Making and Normative versus Informational Influence: Effects of Type of Issue and Assigned Decision Rule.” *Journal of Personality and Social Psychology* 53(2):306–13.

Kilmer, Richard L. 1986. “Vertical Integration in Agricultural and Food Marketing.” *American Journal of Agricultural Economics* 68(5):1155–60.

Koehler, Bob, William F. Lazarus, and Brian L. Buhr. 1996. *Swine Production Networks In Minnesota: Resources For Decision Making*. University of Minnesota, Department of Applied Economics. Retrieved October 9, 2015 (https://ideas.repec.org/p/ags/umaesp/14232.html).

Kollmuss, Anja and Julian Agyeman. 2002. “Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to pro-Environmental Behavior?” *Environmental education research* 8(3):239–60.

Leiserowitz, Anthony. 2006. “Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values.” *Climatic change* 77(1-2):45–72.

Levins, Richard A. and Willard W. Cochrane. 1996. “The Treadmill Revisited.” *Land Economics* 72(4):550.

Little, Peter D. and Michael Watts. 1994. *Living under Contract: Contract Farming and Agrarian Transformation in Sub-Saharan Africa*. Univ of Wisconsin Press.

Long, J. Scott and Jeremy Freese. 2014. *Regression Models for Categorical Dependent Variables Using Stata*. 3rd ed. College Station, Tex.: Stata Press.

Lorenzoni, Irene, Sophie Nicholson-Cole, and Lorraine Whitmarsh. 2007. “Barriers Perceived to Engaging with Climate Change among the UK Public and Their Policy Implications.” *Global Environmental Change* 17(3–4):445–59.

Mabbett, J. and I. Carter. 1999. “Contract Farming in the New Zealand Wine Industry: An Example of Real Substitution.” in *Restructuring Global and Regional Agricultures: Transformations in Australasian Agri-Food Economies and Spaces*, edited by D. Burch, J. Goss, and G. Lawrence. Aldershot: Ashgate.

Marsden, Terry. 1989. “Restructuring Rurality.” *Sociologia Ruralis* 29(3/4):312.

McCright, Aaron M. and Riley E. Dunlap. 2000. “Challenging Global Warming as a Social Problem: An Analysis of the Conservative Movement’s Counter-Claims.” *Social Problems* 47:499.

McCright, Aaron M. and Riley E. Dunlap. 2011. “The Politicization of Climate Change and Polarization in the American Public’s Views of Global Warming, 2001–2010.” *Sociological Quarterly* 52(2):155–94.

McGuire, Jean, Lois Wright Morton, and Alicia D. Cast. 2013. “Reconstructing the Good Farmer Identity: Shifts in Farmer Identities and Farm Management Practices to Improve Water Quality.” *Agriculture and Human Values* 30(1):57–69.

McMichael, Philip. 1994. *The Global Restructuring of Agro-Food Systems*. Cornell University Press.

McVay, K. A., D. E. Radcliffe, and W. L. Hargrove. 1989. “Winter Legume Effects on Soil Properties and Nitrogen Fertilizer Requirements.” *Soil Science Society of America Journal* 53(6):1856.

Messinger, Paul R. and Chakravarthi Narasimhan. 1995. “Has Power Shifted in the Grocery Channel?” *Marketing Science* 14(2):189–223.

Michener, H. Andrew, John D. DeLamater, and Daniel J. Myers. 2004. *Social Psychology*. 5th ed. Belmont, CA: Wadsworth Publishing.

Millar, Neville, G. Philip Robertson, Peter R. Grace, Ron J. Gehl, and John P. Hoben. 2010. “Nitrogen Fertilizer Management for Nitrous Oxide (N2O) Mitigation in Intensive Corn (Maize) Production: An Emissions Reduction Protocol for US Midwest Agriculture.” *Mitigation and Adaptation Strategies for Global Change* 15(2):185–204.

Mooney, Patrick H. 1983. “Toward a Class Analysis of Midwestern Agriculture.” *Rural Sociology* 48:563–84.

Mulvaney, R. L., S. A. Khan, and T. R. Ellsworth. 2006. “Need for a Soil-Based Approach in Managing Nitrogen Fertilizers for Profitable Corn Production.” *Soil Science Society of America Journal* 70(1):172.

Nafzinger, ED, JE Sawyer, and RG Hoeft. 2004. “Formulating N Recommendations for Corn in the Corn Belt Using Recent Data.” Brookings, South Dakota: Potash and Phosphate Institute.

Napier, Ted L. and Mark Tucker. 2001. “Use of Soil and Water Protection Practices Among Farmers in Three Midwest Watersheds.” *Environmental Management* 27(2):269–79.

O’Neill, Saffron and Sophie Nicholson-Cole. 2009. “‘Fear Won’t Do It’ Promoting Positive Engagement With Climate Change Through Visual and Iconic Representations.” *Science Communication* 30(3):355–79.

Outreach, SARE. 2007. *Managing Cover Crops Profitably*. 3rd edition. edited by A. Clark. College Park, MD: SARE Outreach.

Owens, Susan. 2000. “‘Engaging the Public’: Information and Deliberation in Environmental Policy.” *Environment and Planning A* 32(7):1141–48.

Pechlaner, Gabriela. 2013. *Corporate Crops: Biotechnology, Agriculture, and the Struggle for Control*. Austin: University of Texas Press.

Ploeg, Jan Douwe van der. 1990. “Labor, Markets, and Agricultural Production.” *Labor, markets, and agricultural production*. Retrieved October 24, 2014 (http://library.wur.nl/WebQuery/clc/529563).

Preckel, P. V., G. E. Shively, T. G. Baker, M. C. Chu, and J. E. Burrell. 2000. “Contract Incentives and Excessive Nitrogen Use in Agriculture.” *Journal of Agricultural and Resource Economics* 25(2):468–84.

QSR International. 2010. *Nvivo 9*. Melbourne, Australia: QSR International PL.

Robertson, G. Philip and Peter M. Vitousek. 2009. “Nitrogen in Agriculture: Balancing the Cost of an Essential Resource.” *Annual Review of Environment and Resources* 34(1):97–125.

Roberts, TL. 2007. “Right Product, Right Rate, Right Time and Right Place...the Foundation of Best Management Practices for Fertilizer.” Pp. 29–32 in. Brussels, Belgium.

Rogers, Everett M. 2003. *Diffusion of Innovations, 5th Edition*. Original. New York: Free Press.

Sampaio, Ana Rita, Rhodri Thomas, and Xavier Font. 2012. “Why Are Some Engaged and Not Others? Explaining Environmental Engagement among Small Firms in Tourism.” *International Journal of Tourism Research* 14(3):235–49.

Schnaiberg, Allan. 1980. *The Environment: From Surplus to Scarcity*. Oxford University Press, USA.

Schnaiberg, Allan and Kenneth Alan Gould. 2000. *Environment and Society : The Enduring Conflict*. The Blackburn Press.

Schulte, S. and K. A. Miller. 2010. “Wildfire Risk and Climate Change: The Influence on Homeowner Mitigation Behavior in the Wildland-Urban Interface.” *SOCIETY & NATURAL RESOURCES* 23(5):417–35.

Semenza, Jan C. et al. 2008. “Public Perception of Climate Change: Voluntary Mitigation and Barriers to Behavior Change.” *American Journal of Preventive Medicine* 35(5):479–87.

Sharp, J., E. Imerman, and G. Peters. 2002. “Community Supported Agriculture (CSA): Building Community among Farmers and Non-Farmers.” *Journal of extension* 40(3):5.

Snyder, C. S., T. W. Bruulsema, T. L. Jensen, and P. E. Fixen. 2009. “Review of Greenhouse Gas Emissions from Crop Production Systems and Fertilizer Management Effects.” *Agriculture, Ecosystems & Environment* 133(3–4):247–66.

Spence, Alexa, Wouter Poortinga, and Nick Pidgeon. 2012. “The Psychological Distance of Climate Change.” *Risk Analysis* 32(6):957–72.

Starr, Amory et al. 2003. “Sustaining Local Agriculture Barriers and Opportunities to Direct Marketing between Farms and Restaurants in Colorado.” *Agriculture and Human Values* 20(3):301–21.

StataCorp. 2013. *Stata: Release 13*. College Station, Tex.: StataCorp LP.

Stuart, D. 2009. “Constrained Choice and Ethical Dilemmas in Land Management: Environmental Quality and Food Safety in California Agriculture.” *JOURNAL OF AGRICULTURAL & ENVIRONMENTAL ETHICS* 22(1):53–71.

Stuart, Diana. 2008. “Constrained Choice and Ethical Dilemmas in Land Management: Environmental Quality and Food Safety in California Agriculture.” *Journal of Agricultural and Environmental Ethics* 22(1):53–71.

Stuart, Diana, Rebecca L. Schewe, and Matthew McDermott. 2012. “Responding to Climate Change Barriers to Reflexive Modernization in U.S. Agriculture.” *Organization & Environment* 25(3):308–27.

Tennent, Rebeka and Stewart Lockie. 2012. “Production Relations under GLOBALG.A.P: The Relative Influence of Standards and Retail Market Structure.” *Sociologia Ruralis* 52(1):31–47.

USDA. 2007. *US Census of Agriculture 2007*. Retrieved (http://www.agcensus.usda.gov/Publications/2007/index.php).

USDA Economic Research Service. 2012. *Fertilizer Use and Price*. Retrieved (http://www.ers.usda.gov/data-products/fertilizer-use-and-price.aspx#.UZZtwIJAt2U).

USDA, Economic Research Service. 2014. “Background: Corn.” Retrieved September 30, 2014 (http://www.ers.usda.gov/topics/crops/corn/background.aspx#.VCsAZildXUc).

US EPA, Climate Change Division. 2011. “Nitrous Oxide Emissions.” Retrieved May 17, 2013 (http://epa.gov/climatechange/ghgemissions/gases/n2o.html).

Vandergeest, Peter, Mark Flaherty, and Paul Miller. 1999. “A Political Ecology of Shrimp Aquaculture in Thailand1.” *Rural Sociology* 64(4):573–96.

Wells, Miriam J. 1981. “Social Conflict, Commodity Constraints, and Labor Market Structure in Agriculture.” *Comparative Studies in Society and History* 23(04):679–704.

Wells, Miriam J. 1984. “The Resurgence of Sharecropping: Historical Anomaly or Political Strategy?” *American Journal of Sociology* 90(1):1–29.

Wells, Miriam J. 1987. “Sharecropping in the United States: A Political Economy Perspective.” Retrieved April 11, 2014 (http://agris.fao.org/agris-search/search/display.do?f=1989/US/US89166.xml;US8863645).

Wells, Miriam J. 1996. *Strawberry Fields: Politics, Class, and Work in California Agriculture*. Cornell University Press.

Wells, Victoria K., Cerys A. Ponting, and Ken Peattie. 2010. “Behaviour and Climate Change: Consumer Perceptions of Responsibility.” *Journal of Marketing Management* 27(7-8):808–33.

Welsh, Rick. 1997. “Vertical Coordination, Producer Response, and the Locus of Control over Agricultural Production Decisions1.” *Rural Sociology* 62(4):491–507.

White, Stacey Swearingen and Theresa Selfa. 2013. “Shifting Lands: Exploring Kansas Farmer Decision-Making in an Era of Climate Change and Biofuels Production.” *Environmental Management* 51(2):379–91.

Wilson, Geoff A. 2001. “From Productivism to Post-Productivism … and Back Again? Exploring the (un)changed Natural and Mental Landscapes of European Agriculture.” *Transactions of the Institute of British Geographers* 26(1):77–102.

Winters, Paul, Phil Simmons, and Ian Patrick. 2005. “Evaluation of a Hybrid Seed Contract between Smallholders and a Multinational Company in East Java, Indonesia.” *Journal of Development Studies* 41(1):62–89.

Wolf, Steven, Brent Hueth, and Ethan Ligon. 2001. “Policing Mechanisms in Agricultural Contracts*.” *Rural Sociology* 66(3):359–81.

Table 1: Seed-corn contract growers

	Grow Any Seed-corn	Grow Majority Seed-corn	Grow Only Seed-corn
No	83%	88%	93%
Yes	17%	12%	7%

Table 2: Mean corn acreage

	Grow Any Seed-corn	Grow Majority Seed-corn	Grow Only Seed-corn
	Mean Acres	Mean Acres	Mean Acres
No	271	281	296
Yes	498	517	426
F	10.46	6.28	1.64
Prob > F	0.0014	0.0128	0.2008

Table 3: Sample

	Population					Sample	
acres	Branch	Calhoun	K’zoo	St. Joseph	Total farms (N)	Sampled farms (n)	pweight
1-49	194	176	82	182	634	340	1.86
50-199	124	149	62	103	438	300	1.46
200-499	63	74	36	61	234	200	1.17
500+	45	37	34	45	161	160	1.00
all	426	436	214	391	1467	1000	
Total Respondents	84 (weighted n=128)	83 (weighted n=139)	29 (weighted n=37)	75 (weighted n=108)		271 (weighted n=380)	
Grow any seed-corn	13 (weighted n=15)	8 (weighted n=9)	8 (weighted n=11)	29 (weighted n=36)		58 (weighted n=66)	
Grow majority seed-corn	7 (weighted n=9)	5 (weighted n=6)	5 (weighted n=7)	20 (weighted n=26)		37 (weighted n=45)	
Grow only seed-corn	3 (weighted n=4)	7 (weighted n=9)	2 (weighted n=3)	10 (weighted n=13)		22 (weighted n=28)	

Table 4: Mean pounds of Nitrogen applied per acre

	All Growers			Subpopulation: Grow both Commercial and Seed	
	Mean lbs. N per Acre	Std. Err.		Mean lbs. N per Acre	Std. Err.
Commercial growers	30.64	0.84	Commercial acres	42.64	1.73
Seed-corn growers	36.09	1.67	Seed-corn acres	167.69	16.04
F statistic	8.48		T statistic	7.75	
Prob > F	0.004			0.0001	

Table 5: OLS regression on pounds of Nitrogen applied per acre (Box Cox transformed)

	Model 1 All Respondents	Model 2 Subpopulation: Seed-corn Growers
	β (standardized)	β (standardized)
Grow seed-corn[1]	15.40**	------
Branch County	-1.17	-9.75*
Kalamazoo County	2.7	-8.91*
Age[2]	0.15	0.40
Education[3]	-0.08	-0.62
Fertilizer dealer most significant advice[4]	4.34**	-6.49
Other farmers most significant advice[4]	1.14	13.15**
University recommendations most significant advice[4]	2.25	-7.45
Seed company most significant advice[4]	3.02	0.78
Interaction: Seed company most imp. * seed-corn grower	-7.13	------
UAN or Urea most common type of N[4]	2.26	3.71
Manure most common type of N[4]	6.45	34.61**
Anhydrous ammonia most common type of N[4]	3.15	4.49
Percent of cropland that is irrigated	0.10***	-0.10
Use of cover crops[4]	-2.35	3.01
Most common soil type of cropland[5]	-0.62	1.69
Use of side-dressing to apply N[4]	1.80	14.91
Participate in a USDA conservation program[4]	-2.96	-9.08*
Use of preside-dress nitrate test[4]	1.31	3.65
Corn acreage in a typical season	0.01***	0.01*
Importance of fertilizer price in Nitrogen decisions[6]	-1.72	1.38
Importance of corn price in Nitrogen decisions[6]	2.02	0.53
Importance of yield in Nitrogen decisions[6]	-0.29	-1.81
Importance of balance of costs and expected returns in Nitrogen decisions[6]	0.36	-3.39

Interaction: yield importance * seed-corn grower	-5.35*	------
constant	21.30***	23.79
R-squared	0.3458	0.5278
F	6.77	8.76
Prob > F	0.000	0.000
VIF	1.53	2.12
Tolerance	0.6542	0.4722

* p <.05, ** p < .01, *** p <.001

1: 1= yes, 0= no, grow any seed-corn acres

2: 1=<30, 2=31-40, 3=41-50, 4=51-60, 5=61-70, 6=>70

3: 1 = <12 years, 2= high school diploma, 3= vocational/trade, 4= some college, 5= college degree, 6= graduate training

4: 1= yes, 0= no

5: 1= sand, 2= silt, 3= clay, 4= loam, 5= clay-loam, 6= sandy-loam, 7= silty-loam, 8= other, 9= Multiple

6: "How significant is the factor in determining how much Nitrogen you apply?" (0=Not, 1=Slightly, 2=Somewhat, 3=Very)