Complying with conservation compliance? An assessment of recent evidence in the US Corn Belt

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Abstract
Conservation provisions of US farm bills since 1985 have been aimed at mitigating negative environmental impacts of US agriculture. One of the long term goals has been to protect against soil erosion, with a focus specifically on highly erodible land (HEL). Conservation Compliance (CC) mandates that, in order to receive federal subsidies, farmers who plant annual crops on HEL must implement a conservation plan, with practices such as rotating crops and no-till farming. When crop prices increase, however, the incentives not to follow the plan increase, as conservation activities can reduce farmers’ profits. This study is the first to assess the performance of conservation compliance between 2007 and 2019, a period of historically high and variable crop prices, using geographical information system tools and crop data in a critical agricultural production region, the US Corn Belt. Our results indicate there was a substantial increase in continuous corn on HEL, a proxy measure for non-compliance, in several portions of the study area in correspondence with higher crop prices following the 2007 Energy Bill. This mirrored the change in crop rotations on all cropland. The increase was positively correlated with both absolute and relative corn prices. While at the height of absolute and relative corn prices there were increases in continuous corn on HEL everywhere across the study region except parts of Missouri, some of the largest changes occurred in environmentally sensitive regions and areas which use irrigation, thereby potentially creating disproportionate environmental impacts. Similar changes in continuous corn also occurred in all cropland in the region, indicating that mandatory conservation programs are as vulnerable to periods of high crop prices as voluntary programs. Better monitoring for both CC and other conservation programs is critical to ensure the policies work as intended.

1. Introduction
Conservation policy in United States (US) agriculture has historically been based on purely voluntary programs that couple environmental and economic goals through single policy mechanisms. These policies typically pay crop and livestock producers who choose to participate in land retirement programs or to use Best Management Practices (BMPs) to reduce their environmental impacts. At the same time, these programs are often designed to supplement farmer income, and therefore are described as being dual-goal. Dual goal polices are not optimal from an economic perspective, because achieving one goal may at times interfere with the other (Secchi et al 2008). In fact, there is evidence that the environmental provisions of these policies are vulnerable to factors impacting farmer income such as input and output price changes (Secchi et al 2008). The voluntary approach to agricultural policy is not unique to the US. However, other developed countries also use some form of mandatory policies or cross-compliance measures that either fine or withdraw funding from producers who do not comply with environmental standards (Parris 2011, OECD 2015). These mandatory policies are unpopular in the US, and only one of them exists there, Conservation Compliance (CC). This paper contributes to the policy discussion by evaluating the recent performance of the US lone mandatory policy.
CC was enacted in the 1985 farm bill, and only applies to highly erodible lands (HEL). HEL fields used for annual crop production are considered the nation’s most sensitive working lands in terms of soil erosion, which has been an environmental focus in US conservation programs since the Dust Bowl (Kramer and Batie 1985, Batie 1985). The CC program is essentially a cross-compliance mechanism. When a field is designated as HEL, a US Department of Agriculture (USDA) approved conservation plan is required, or farmers can be denied federal subsidies. USDA conservation plans are site-specific combinations of conservation practices that reduce soil erosion, such as rotating crops, terraces, and no-till agriculture (US GAO 2003). Conservation crop rotation and conservation tillage are the most commonly used practices in CC conservation plans because they can mitigate the negative effects of intensive agricultural production on marginal lands (Karlen et al 2013, Zuber et al 2017, Behnke et al 2018). Conservation practices have been associated with short-term lower yields, which can affect farmers’ willingness to adopt them, especially when crop prices are high (Ogle et al 2012). USDA’s Natural Resources Conservation Service (NRCS) is tasked with monitoring these sites to ensure that farmers are following their plans. If farmers are found to be non-compliant, they could lose access to subsidies such as commodity payments, the main subsidies from 1985 to 2014, and subsidized crop insurance, the main form of subsidy since the 2014 farm bill (Stubbs 2016, 2019).

Conservation compliance is based in the implicit assumption that the public has the right to a minimum level of environmental quality. Unlike other federal conservation programs in which the public has to subsidize the farmer to reduce its levels of pollution, in this case, the ‘polluter pays’ principle is followed (Secchi and Soman 2010). CC has largely been seen as a policy success and it is credited with a substantial reduction of soil erosion from US cropland (Claassen 2006, Claassen et al 2017). However, there is very little literature on the effectiveness of the program and its performance in recent years. Notable exceptions are Claassen (2006) and Claassen et al (2017). The former analyzes the performance of the program in terms of erosion reduction until 1997, and finds that the reduction in soil erosion, though concentrated in HEL, also occurred in non-HEL cropland, and it concludes that other factors such as technology and low crop prices were at play besides CC in modifying farmers’ adoption of BMPs on all cropland, but CC was the main driver behind soil erosion reduction on HEL (Claassen 2006). The second publication looks ex ante at the impact of the 2014 farm bill on CC, and finds that the cross compliance element with crop insurance is critical to the success of the program, as it creates incentives for farmers to abide by their conservation plans (Claassen et al 2017). Thus, even though other factors play a role in soil erosion reduction practices, tying the eligibility to receive subsidies to CC is essential to the success of the policy.

Other information on the performance of CC comes from two reports conducted by the Government Accountability Office (GAO) and the USDA Office of the Inspector General (OIG). Both found that CC is not being properly monitored by the NRCS (US GAO 2003, USDA OIG 2016a). The GAO found that 20% of the NRCS sample tracts for compliance review did not need conservation plans, for example because they were used for pasture, so they should not have been monitored. Furthermore, NRCS field staff would not return to HEL fields to monitor after they had been previously warned for non-compliance. The OIG audit found that the NRCS sampling method was excluding ten states from the random sample. Additionally, fields categorized under multiple USDA programs were excluded from the NRCS sample (USDA OIG 2016a). This lack of monitoring and enforcement could mean that those who are using non-compliant management practices are still receiving benefits.

Our analysis focuses on the Corn Belt, a region important because of intensive agricultural production and associated levels of water pollution. Notably, five of the states in our study (Illinois, Indiana, Iowa, Minnesota and Missouri) were among those omitted from the compliance random sampling as noted in the OIG report (USDA OIG 2016b, National Sustainable Agriculture Coalition 2018). For context, the national cultivated HEL area was estimated to be 92.8 million acres in 2012 (the latest year for which survey data was available nationally) in a recent USDA report (Claassen et al 2017). Our estimate of cultivated HEL in the study area is 26 million acres, or 28% of the national total.

We use continuous corn as a proxy for potential non-compliance with the program. Continuous corn is not allowed in CC conservation plans in some regions because it will cause erosion in areas with steep slopes (Illinois USDA NRCS 2007). In areas where continuous corn is allowed in the conservation plan, conservation tillage is required. However, planting continuous corn is difficult with continuous no-till or conservation tillage due to the high stover content left from the previous harvest, which interferes with planting and results in lower yields (Cox et al 1992, Katsvairo and Cox 2000, Halvorson et al 2006). This agronomic evidence is supported by USDA surveys of production practices showing that continuous corn is rarely planted with continuous conservation tillage (USDA Economic Research Service 2015). Therefore, continuous corn is also a potential indicator that farmers might not be following the tillage restrictions in their conservation plan, and might be tilling their HEL fields. Nonstructural BMPs such as tillage are more difficult to monitor than crop choices, thus, the presence of continuous corn, even if the crop
choice is allowed in a conservation plan, could signal non-compliance.

We specifically focus our analysis on the changes in continuous corn for land subject to CC in the period 2006–2007 to 2018–2019 because the passage of the 2007 energy bill containing an ethanol mandate was associated with increases in the price of corn, which reached a peak in 2012. The incentives to ignore a conservation plan and plant continuous corn increase as the price of corn increases more than that of other commodities such as soybean, with which it is typically rotated in a conservation plan. For comparison purposes, we also estimate the acreage in continuous corn for all cropland in the study region for the same period. Finally, we report correlation results for continuous corn on all cropland and HEL using both prior year corn/soybeans ratios, prior year corn price and futures prices and price ratios. These are proxies for expected prices widely used in the literature (Miao et al. 2016).

Thus, we assess how CC was faring in a critical agricultural region before the rise in crop prices (and the increase in the relative price of corn) associated with the passage of the 2007 federal energy bill, which included the second Renewable Fuel Standard (RFS) and an associated ethanol mandate, and how the changes in commodity prices affected the program’s performance. In this respect, our work extends the results of previous papers on the environmental impacts of the RFS. Previous work has focused on the extensive margin impact and cropland expansion at a national level (Lark et al. 2015) and specifically on areas around ethanol refineries (Wright et al. 2017) and on the Western corn belt, which overlaps with our study area (Wright and Wimberly 2013). Other studies have looked specifically at continuous corn expansion on overall cropland (Plourde et al. 2013) and the impact of the RFS on the Conservation Reserve Program, the largest land set-aside program in the US (Chen and Khanna 2018).

The impact of changes in crop prices on the decision to comply can also be directly related to the probability of being monitored and fined. Farmers face this choice: comply (or perform a practice as promised) and obtain a profit of \( π^C \), or do not comply and obtain a profit of \( π^NC \) if they are not caught, with probability \( (1−p) \) or a profit of \( π^NC \) minus a fine \( F \) if they are caught, with probability \( p \). Therefore, farmers compare \( π^C \) to \( π^NC(1−p)+(π^NC−F)p = π^NC−F(p) \). The choice depends on crop prices (which influence profits and the difference between \( π^C \) and \( π^NC \)), the size of the fine and the probability of being caught. If, for a certain set of prices, \( π^C > π^NC−F(p) \), farmers will find it beneficial to comply, because the expected value of the fine is higher than the extra profit from not complying: \( F(p) > π^NC−π^C \). However, if prices change, as they did after 2007, making corn more attractive than soybeans, farmers may find that the profits of not complying exceed the fines. We discuss how to improve program performance, and more generally how it is critical for all conservation programs to adjust monitoring as the relative costs of participation change.

2. Data and methods

The study area is the US Corn Belt, defined as Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, and Nebraska. There are two primary datasets used in this study. The first is the Cropland Data Layer (CDL), produced by the United States Department of Agriculture’s National Agricultural Statistics Service (NASS). The CDL is a raster dataset published annually with a 56 by 56 or 30 by 30 meter resolution (USDA NASS Research and Development Division 2017). Error and error propagation are endemic to spatial datasets and spatial analysis. However, managing issues related to error is particularly challenging in studies like this that address change across administrative boundaries and through time. Analysts must, for example, develop strategies to make resolution and classification schemes comparable across datasets developed using different technologies and for different purposes (Lark et al. 2017). Lark et al. (2017) provide remedies for these issues specific to the CDL that we incorporated into this study. We resampled the 2006 and 2007 CDL to 30 m resolution to coincide with the other CDL layers, combined value classes to reduce misclassification, and used the majority focal statistic to remove any misclassifications that could have occurred during analysis (Lark et al. 2017). Because our focus is in identifying corn after corn, two contiguous years were used as the temporal resolution for detecting potential non-compliance. We report results on a two year rolling basis from 2006–2007 to 2018–2019.

The second dataset is a HEL layer that was created from USDA’s 2008 Common Land Unit (CLU) data set for each state acquired via Freedom Of Information Act (FOIA) requests. The CLU dataset is a field-level vector data, which was converted to raster at a 30 by 30 meter resolution. Fields/CLUs are considered HEL on the basis of soil maps. HEL classification is assigned if either a minimum of 33.33% of the acreage or 50 acres are identified as highly erodible soil map units. Land is classified as highly erodible if it has an Erodibility Index (EI) of 8 or higher (Office of the Secretary of Agriculture 1996). The EI is determined by dividing the potential erodibility of a soil, which depends on climatic variables, susceptibility of the soil to erosion, and the combined effects of slope length and steepness, by the soil loss tolerance, or the maximum rate of annual soil erosion that allows sustained crop productivity (Skidmore 1982).

The HEL determination is based on USDA’s Field Office Technical Guide as of January 1, 1990, and is frozen: ‘Under no circumstances will the
soil map units previously included on the January 1, 1990, Highly Erodible Map Unit List have their classification changed' (USDA Natural Resources Conservation Service 2010). Therefore, while it is possible that some HEL fields might have been added to the list, all the fields included in our analysis are still under the provisions of CC. Our approach is different from previous work that relied on indirect soil map indicators of suitability for cropping to determine changes in land use on Midwest’s marginal lands (Wright and Wimberly 2013).

All layers were projected to Albers Conic Equal Area. ESRI’s ArcGIS 10.7.1 was used for the analysis. With this information, we created a Potentially Non-Compliant (PNC) layer using continuous corn as our proxy for non-compliance. To do this, we merged all the state CDLs to create one mosaic, then created continuous corn layers by reclassifying each CDL year starting with 2006 to a binary 1 = corn and 0 = other. Then raster calculator was used to add the next year. These were then reclassified to a binary 1 = continuous corn and 0 = other. Then a majority filter was used (4 x 4 neighborhood), to remove isolated pixels within the fields and, thus, reduce classification errors (i.e. the image was ‘despeckled’). Raster calculator was then used to add the continuous corn layer and the HEL layer. This layer was then reclassified to represent 1 = PNC and 0 = other (figure 1). Then Zonal Statistics was used to calculate the number of cells within state and Crop Reporting District boundaries. This procedure was performed on a rolling basis until 2019, the latest year for which the CDL data is available. Because of our procedure, we could be overestimating cropland as the 30 by 30 meter resolution might not capture fencerows. Classification errors for parcels bordering with forest should balance out for patches larger than 60 meters.

We report both state-level results and Crop Reporting District (CRD) results. CRDs are aggregations of counties determined by USDA’s National Agricultural Statistics Service (NASS) and widely used to report agricultural statistics. They are defined as ‘multi-county areas that share similar geographic attributes, including soil type, terrain, elevation, and climatic factors, such as mean temperature, annual precipitation, and length of growing season’ (Thelin and Stone 2013). Aggregating to this level ensures similar characteristics within each CRD, while also providing anonymity for landowners.

To assess the correlation between continuous corn and crop prices for both cultivated HEL and all cropland (SI table 1 (available online at stacks.iop.org/ERL/15/084035/mmedia)), following a well-established literature (Miao et al 2016, Li et al 2018), we use prior crop year and futures prices and price ratios as proxies for expected prices. Prior year corn prices and corn/soybean price ratios and their relationship for the study period are harvest month prices for the Heartland region.
Figure 2. Continuous corn on HEL and total cropland (,000 acres).

Table 1. Correlations between Continuous Corn areas, corn prices and corn to soybean price ratios.

| HEL Continuous Corn ac 2006–2019 | All cropland Continuous Corn ac 2006–2019 |
|-----------------------------------|------------------------------------------|
| PRIOR YEAR PRICES                 |                                          |
| corn to soybean price ratio       | 0.491                                    | 0.693                                    |
| corn price $/bu                   | 0.790                                    | 0.784                                    |
| FUTURES PRICES                   |                                          |
| corn to soybean price ratio       | 0.472                                    | 0.702                                    |
| corn price $/bu                   | 0.532                                    | 0.491                                    |

according to USDA’s Economic Research Service (USDA Economic Research Service 2019). The Heartland region includes all of Iowa, Illinois, and Indiana and parts of Missouri, Nebraska and Minnesota and is therefore the most appropriate for our study area (Heimlich 2000). We also use October futures in December/November from USDA’s database on seasonal price forecasts (USDA Economic Research Service 2020).

3. Results

We estimate that there are over 53 million acres of HEL land in the study region. It is important to note that not all the HEL acreage is used to produce annual crops, and that the intensity of cropping varies—some fields may be pasture during low price periods and be converted to annual crops if prices change. Thus, when we report percentage of HEL acreage being out of compliance, we are being conservative in our estimate, since the denominator is the total HEL acreage (which may or may not be under annual crop), not HEL being used in annual crop production. We estimate that in 2006 there were about 22.6

million acres of cultivated HEL, and that total cropland in annual crops for the study area was 92 million acres.

Our study shows that a substantial percentage of HEL acreage, over 3 million acres, was planted in continuous corn in the baseline years 2006–07 (figure 2(a)). For all cropland, the acreage was over 16 million acres (figure 2(b)). See SI table 1 for all the data by CRD.

In 2011–2012, when corn prices were strongest in both relative and absolute terms (SI table 2), there were over 4.5 million acres of continuous corn in land subject to Conservation Compliance, or 8.4% of HEL. As the attractiveness of corn relative to soybeans decreased in 2018–2019, so did the continuous corn acres, which went down to 3.9 million acres, or about 7.3% of HEL. This same phenomenon occurred for all cropland in the study region, with continuous corn going from 16.3 million acres in 2006–07 to 20.3 million acres in 2011–12 and 15.2 million acres in 2018–19 (figure 2(b)).

While we cannot claim that the changes in continuous corn acreage are due to changes in prices and price ratios, due to lack of a formal identification strategy in our approach, we find that there
are moderate to strong positive correlations between corn prices and corn to soybeans price ratios for all cropland and HEL (table 1). Our results are consistent with those of studies that used an econometric approach, which found that increases in absolute and relative corn prices increase the acreage in continuous corn for the Corn Belt (Langpap and Wu 2011, Hendricks et al 2014). To our knowledge, however, no study prior to ours has specifically identified changes in HEL crop rotations.

Spatially, the relationship between price and non-compliance was largely consistent across state and Crop Reporting District geographies. When the absolute and relative corn prices rose from 2007 to 2012, so did continuous corn on HEL in all 7 study states (figure 2(a)). Nebraska, Iowa, Illinois, and Kansas all increased over 200,000 acres, with Nebraska increasing the most. In terms of percentage changes, Minnesota had the highest and Missouri had the lowest percent increase. The low changes in continuous corn in Missouri could be linked to the 2011 Missouri River flood that placed 133,000 acres out of production in just one section of the state (Olson and Morton 2012).

When prices decreased from 2012 to 2019, all states in our study area but Kansas decreased their continuous corn acreage in land subject to Conservation Compliance. The additional acres in Kansas could be due to an overall increase in planted corn acres from 2013 to 2018 (USDA FSA 2018), since Kansas is viewed as an area that could increase corn production for biofuels, which is resulting in land use change (Yasarer et al 2016).

Of the 62 CRDs in our study, 55 increased continuous corn acreage from 2007 to 2012 (figure 3). MO-80 had the highest percentage increase (588%), and IL-10 had the highest total absolute increase, adding 167,540 acres from 2007 to 2012. Only six Crop Reporting District had a decrease in continuous corn. Three Districts saw increases of over 100,000 acres in continuous corn: IA-30, IL-10 and NE-70. IA-40, IA-60, MN-90, NE-30, NE-90, KS-10 and KS-30 had increases of over 50,000 acres. Overall, the changes in Missouri and Indiana were small. Our results suggest that several Districts at the Western edge of the Corn Belt in Nebraska and Kansas, which use irrigation (U.S. Department of Agriculture National Agricultural Statistical Service 2019), saw significant increases in continuous corn on HEL. This has clear implications for water availability in the region. The most dramatic increases overall occurred in the Driftless Area between Illinois, Iowa, and Minnesota. The Driftless Area is characterized by karst geology, and is therefore very vulnerable.
to water pollution from intensive agricultural practices such as continuous corn (Schilling, Wolter, and McLellan 2015).

From 2012 to 2019, 49 of the 62 CRDs saw decreases in continuous corn acres in areas subject to CC (figure 4). The CRD with the largest reduction was IL-10, which decreased by over 120,000 acres. The increases in continuous corn were concentrated in Missouri and Kansas. In Kansas, this trend was more pronounced, with 2 CRDs increasing by more than 50,000 acres, and reflective of the changes in rotation across all cropland (figure 2(b)).

4. Conclusion

Our results on the increase of continuous corn in land subject to Conservation Compliance are consistent with those of other studies that have shown that the overall intensity of corn production increased in our study region in the same period (Plourde et al. 2013, Hendricks et al. 2014) in response to price drivers. The Renewable Fuel Standard appears to have had a wide range of negative environmental effects in terms of intensification and extensification of production and cropland expansion (Wright and Wimberly 2013, Lark et al. 2015, Wright et al. 2017) and impacts on the Conservation Reserve Program specifically (Chen and Khanna 2018).

Our results also align with studies indicating that management challenges for conservation programs become more apparent in high price periods, regardless of whether they are regulatory or voluntary (based on incentives or pure goodwill and information), dual goal or single goal. A US example is the Conservation Reserve Program (CRP), a voluntary, incentive-based dual goal program that retires marginal land from crop production for 10 to 15 years to provide environmental benefits and increase crop prices by reducing supply. When crop prices increased between 2008 and 2012, the second goal became less relevant, and the policy becomes less attractive (Secchi et al. 2009, Morefield et al. 2016). This resulted in two phenomena: farmers were less interested in the program, because the returns from growing annual crops, or the opportunity cost of enrolling in CRP, increased; policy makers, on the other hand, did not want to spend more money on the program to maintain the level of participation they had before, so the 2014 farm bill decreased the maximum amount of land to enroll by 8 million acres (Stubbs 2014). Notably, as crop prices decreased, the CRP cap was raised by 3 million acres in the 2018 farm bill (Stubbs 2019).

Another voluntary, incentive-based dual goal program whose management issues share characteristics with CC is the Environmental Quality...
Incentives Program (EQIP). EQIP is a voluntary program that pays farmers a portion of the costs to incorporate Best Management Practices (BMPs, e.g. non-structural practices such as conservation tillage) on their working lands. While the main goal of EQIP is to promote environmental quality on cropland and in livestock operations (half the funding has to go to livestock by law), the program can act as a ‘green’ income support mechanism (Batie 1999, McCann and Núñez 2005).

For both CC and EQIP, data collection and monitoring can be costly (Cattaneo 2003, Claassen et al 2008). Furthermore, changes in absolute and relative crop prices affect the incentives to comply with or follow the program practices for farmers. This is due to the fact that in practice the fine and the probability of getting caught are not modified in high price periods, so it is more likely that $F(p) < \pi_{NC} - \pi_C$. There is evidence that participation in EQIP will drop if farmers view it as detrimental to their income. For example, a recent study found that the 2006 E. coli outbreak resulted in a reduction in half of the EQIP participants in one region of California. This outbreak was partly blamed on wildlife contaminating fields, despite evidence that wildlife very rarely carry E. coli. Due to these food safety concerns, vegetable buyers preferred farmers to have ‘clean fields’, which required measures to deter and/or eliminate wildlife from fields. To accomplish this new standard, producers removed buffers that were funded through EQIP (Stuart and Gillon 2013). Note that in EQIP, the compliance problem is compounded by moral hazard issues: farmers get enrolled by promising to perform certain activities, but once enrolled, they can withdraw promised practices, because they know there is little or no penalty for doing so (Cattaneo 2003).

As noted in the introduction, there is evidence that the monitoring for Conservation Compliance is not focused on areas of potentially high non-compliance (USDA OIG 2016b). Similar problems plague the EQIP program. For example, a recent OIG audit found that program participants were not monitored for practice adoption but were allowed to self-certify (USDA OIG 2014a). Another OIG audit report of non-CRP easements (combined under the in the Agricultural Conservation Easement Program since the 2014 farm bill) found that monitoring was inadequate, and violations in a quarter of the easements assessed (USDA OIG 2014b). We note that since the 2008 farm bill, under section 1619, FOIA requests such as the ones that allowed us to complete this study are no longer allowed. This makes policy assessment on the part of researchers more challenging and further decreases likelihood of compliance.

Thus, the broader issue is that both voluntary schemes and cross compliance regulatory-based mechanisms are dependent on effective monitoring and enforcement. Agencies in charge have to consider how external factors, such as changes in prices, impact farmers’ behavior. The dichotomy between regulatory and incentive-based compliance collapses when thinking about monitoring and enforcement. Whether it is following through with voluntary measures that the farmer is being compensated for, or complying with mandatory and with cross-compliance programs, it is critical that all these programs consider the changes in incentives associated with changes in crop prices, profitability and relative benefits of cheating or unenrollment.

More specifically, in order to modify incentives for farmers in high commodity price periods, more funding needs to be allocated to monitoring agencies, which would increase $p$, the probability of being caught. If increased funds are not available, there are at least two other choices. One is to concentrate sampling in areas that have historic high levels of potentially non-compliant practices that can be cheaply and rapidly assessed. (i.e. selectively increase $p$ in areas where impact may be greatest). In our study area, that could mean focusing on Crop Reporting Districts with high continuous corn acreage or with the largest changes in continuous corn. A second possibility is to increase the size of the fine $F$. In order to automatically address the changes in incentives, and ensure that farmers are aware of the changes, the fine could be tied to profit margins or key crop prices. Monitoring issues need to be addressed for conservation programs to cost-effectively achieve their goals.

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**Data Availability Statement**

The data that support the findings of this study are available upon request from the authors.

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