

NO TRAIN NO GRAIN: THE IMPACT OF INCREASED DEMAND FOR RAIL SERVICES BY THE ENERGY SECTOR ON WHEAT PRICES—A PRELIMINARY ANALYSIS

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Abstract

Rail service is often the most cost-effective available alternative for shipping agricultural commodities in the Upper Midwest Region of the United States. The recent energy boom has created new competition for the use of shipping services. As oil has taken up freight space on railways, it has become more costly for farmers in states like Minnesota, Montana, North Dakota and South Dakota to reach grain markets, resulting in millionaire losses. Using oil nearby prices as the proxy, I study three particular effects of increased competition for rail services. First, I use national measures to study the impact of track congestion on wheat basis. Then, I examine how the expansion of the energy sector may have had different effects on prices received by wheat producers in the Midwest and in the Gulf Coast. Finally, I investigate whether the construction of new regional liquid pipeline networks is linked to regional wheat prices.

Keywords: *Transportation Costs, Wheat Prices, Rail Services, Oil Boom, Pipeline*

JEL Codes: *Q11, Q41, R40, L92*

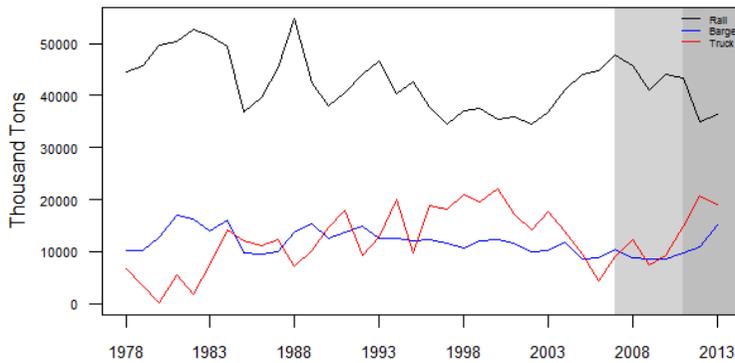
1. Introduction

Transportation plays a principal role in agricultural economics research. The fact that location of agricultural production centers is mostly (if not entirely) determined by land availability, land quality, and climate together with the immobile nature of many agricultural processes (crop fields and pastures) make production locations, by definition, not transferable; therefore, transportation is the single most crucial factor for linking producers to consumers in agricultural markets. It is then perhaps unsurprising to find that an extensive inland waterway system, a fairly well connected and efficient rail transportation system, and a complete highway network have been critical to the historical competitiveness of U.S. agriculture in international markets.

The United States is third in global production of wheat and ranks first in crop export value (almost 50% of wheat produced in the U.S. is exported). Wheat is produced in nearly every state of the country and is the third largest crop in terms of both value and acreage, behind only corn and soybeans. The leading wheat producing states in 2013 and 2014 were North Dakota, Kansas, Montana, South Dakota, Washington, Idaho, Colorado, Nebraska, Texas and Minnesota.¹ The largest wheat producer in the country, North Dakota produces around 300 million bushels of hard red spring and durum wheat annually—more or less 41% above Kansas' output in 2014.

Over a given distance, barge transportation is the most cost-effective mode of transportation for low-value, bulky commodities, followed closely by rail. Figure 1 breaks down by mode the historical transportation of wheat in the U.S. from 1978 to 2013. Rail has

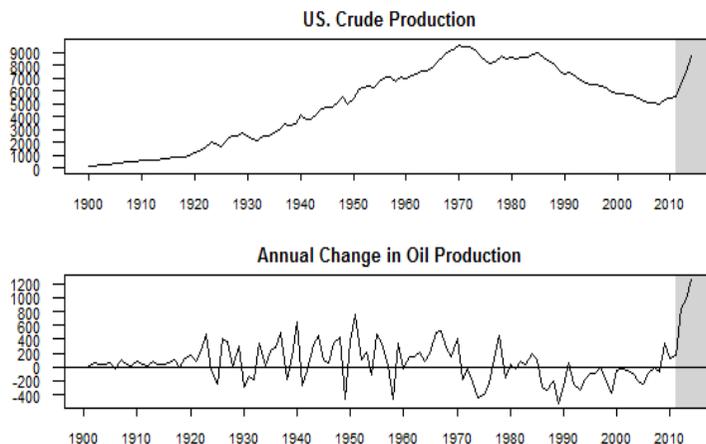
historically been the dominant method of shipping wheat.² However, since 2007, there has been an important decline in the use of rail for transporting wheat concomitant with a sharp increase in the use of truck and a slight augment in the use of barge. The timing of the decline matches the time periods that concern this study: the 2007-2015 period of non-convergence between the futures and spot wheat prices, and the 2011-2015 period of oil bonanza.



Source: USDA

Figure 1. Transportation of Wheat in the US by Mode

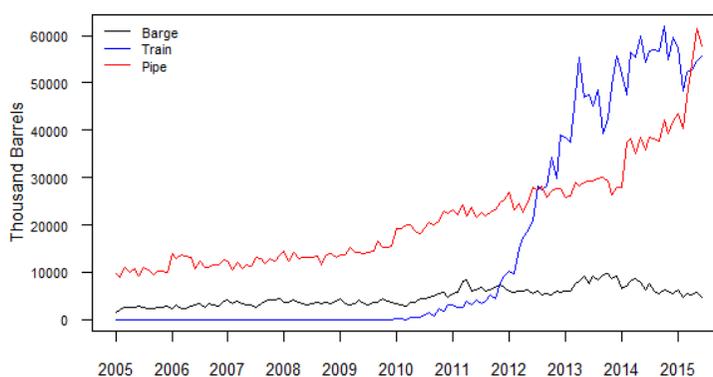
Since 2011, oil production in the US has increased rapidly mostly due to recent technological innovations in the drilling and extracting processes that have expanded the country's pool of exploitable oil and shale gas deposits (See Figure 2). Today, the U.S. is the third largest oil producer after Russia and Saudi Arabia. The leading oil-producing states in the country in 2014 were Texas (3.17 million barrels per day), North Dakota (1.09 million barrels per day) and California (0.5 million barrels per day). Texas and North Dakota alone account for over 50% of all the oil produced in the country. In North Dakota, the application of horizontal drilling and hydraulic fracturing technologies (or fracking) lead to a rapid expansion in oil extraction from the Bakken formation. By the end of 2010, oil production rates reached 458,000 barrels per day, thereby outgrowing the pipeline capacity to ship oil out of the Bakken. Therefore, oil producers have increasingly relied on rail transportation to ship the material out of the state.



Source: EIA

Figure 2. Oil Production in the U.S.

There is an imminent connection between recent developments in the energy sector and the trends in grain transportation mentioned above. North Dakota is part of the Midwest region or the Second Petroleum Administrative Defense District (PADD) along with 14 other states. Shipments of crude oil out of the upper Midwest region to other U.S. regions were largely flat until 2010 when shipments through pipeline began to increase. However, it was not until 2011 that the region became a net shipper of crude oil all due to the dramatic increase in rail movements out of the region (see Figure 3).³ The EIA recognizes that without these rail movements, the Midwest region would still be a net recipient. Besides North Dakota, the other large crude oil-producer state of the U.S. is Texas. Texas is part of the Gulf Coast region (PADD 3) along with 5 other states, and crude oil produced in this region is mainly shipped out through pipelines rather than trains. This fact, together with the recorded increase in rail movements of crude oil in the Midwest, can be used to test whether changes in the energy sector have disproportionately impacted wheat farmers in the Midwest compared to farmers in the Gulf Coast.



Source: U.S. EIA.

Figure 3. Oil Shipments from the Midwest to Other U.S. Regions by Mode of Transportation

The background exposed above frames the context of the three questions posed in this study: (1) Has the recent oil boom in the US had a significant negative impact on wheat prices? (2) Have Midwest farmers been disproportionately affected by changes in crude oil production and shipment relative to farmers in the Gulf Coast Region? and (3) Does the construction of new pipelines alleviate some of the demand pressure on rail services therefore lowering transportation costs for wheat producers and ameliorating the impact of increased regional oil production and shipment?

The remainder of this paper is organized as follows. Section 2 presents a short summary of the recent literature exploring the connections between transportations costs and grain prices. In Section 3 a basic theoretical framework of futures markets is developed to justify the use of oil prices as an instrumental variable and to derive predictions on wheat prices after changes in oil prices. Section 4 describes the empirical strategy for estimating the three effects previously introduced. Section 5 describes the data used for the econometric estimation and presents descriptive statistics. Section 6 exhibits and interprets the results the econometric estimations. Section 7 discusses policy implications from the findings shown in section 6, while section 8 presents suggestions for future research. Concluding remarks are in Section 9.

2. Literature Review

The idea that rail car disruptions and delays affect commodity basis values is utterly non-controversial, and multiple studies have empirically examined the impacts of changes in some of the dimensions of transportation cost on grain prices. Moreover, concerned with threats to the competitiveness of Midwest farmers, senators from Minnesota, South Dakota and North Dakota requested official studies explicitly examining the role of recent rail service disruptions in the Upper Midwest following the 2013-2014 rail delays crisis (with the height of the backlog occurring in March, 2014).⁴ Despite the completeness of some of these works, I am not aware of previous efforts to test whether the interaction between pipeline construction and surging demand for rail services from the oil sector is empirically important. In addition, previous analyses are characterized by a large degree of uncertainty in the explanatory power of transportation rail costs as a determinant of changes in local commodity prices. In this regard, my paper contributes to the literature not only by adding another estimation testing the robustness of previous findings but by exploring new linkages between the energy sector and grain markets.

Studies looking at quantifying the impact on grain prices tend to focus on estimating some measure of losses in farm revenue from increased transportation costs due to changes in a particular market force. These studies generally compare historic average basis of grains to identity times that are characterized by transportation delays or storage constraints and then calculate losses in farm revenue. For example, Usset (2014) studies the effect of rail delays due to large crops by comparing the grain basis in Minnesota from March 2014 to May 2014 to a historical average. That 3-month comparison suggested that lower prices for soybeans, corn and hard red spring wheat crops farmers could have amounted to around 1% of Minnesota's annual crop revenue. In a similar study, Olson (2014) attempts to determine the extent to which increases in railroad freight rates impacted North Dakota farmers from January to April, 2014. Olson accounts for the fact that 2014 was a large crop year in the region and uses monthly average basis values from distinct grain elevators in North Dakota to arrive at a preliminary estimate of USD \$67 million in lost revenue for crops sold in the state between January and April, 2014. Olson calculates an additional USD \$94 million in lost revenue for that year's crop if the rail service disruptions continued.

Other studies directly consider the impact of rail car availability and rail transport costs (such as rail rates, barge and ocean shipping rates and storage costs) on grain prices (Norton, 1995; Wilson and Dahl, 2010-2011). In a 2015 investigation, researchers from the USDA Agricultural Marketing Service (AMS) examine how transportation costs may have resulted in changes to prices received by producers in the Upper Midwest relative to the prices at the ports in the Pacific Northwest and the Gulf of Mexico. The authors conclude that several factors explained the significant challenges for rail shipments in the Upper Midwest in 2013, which persisted into the Fall of 2014, including a record grain harvest in the U.S. and Canada, a particularly harsh winter often requiring rail operators to cut train lengths, short supply of locomotives and crews for rail services, and the increased demand for services from the energy sector. This study shows transportation costs as a significant factor in explaining why local prices in the Upper Midwest may be relatively low compared to nearby futures prices or spot prices at other locations. The preliminary results suggest that rail transportation cost increases for grains, could have depressed local crop prices on average by between USD \$0.01- USD \$0.08 per bushel in 2014.

3. Theory

This paper poses specific questions regarding the impacts of a particular aspect of transportation costs on wheat prices. To derive testable predictions, it is imperative to develop a theoretical framework of market prices for wheat. In developing the following model, I build on the rational expectations model of stock holding behavior (see for example Gustafson, 1958; Williams and Wright, 1991). In this model, I abstract from the underlying forces that generate the so-called convenience yield and simply specify the spot price as function of storage and transportation costs. Considering these costs, I follow the framework presented in Garcia et al. (2015) in which a stationary rational expectations equilibrium exists in the spot market and implies:

$$P_t = \frac{E[P_{t+1}]}{1+r_t} - \delta_t(I_t, Y_t) - \tau_t(Y_t, O_t) \quad (1)$$

where P_t is the spot market price, r_t is the cost of capital, δ_t is the marginal storage cost and is a monotonically increasing function of inventories, I_t , and τ_t denotes transportation costs as a function of yields in the current season and oil production O_t .

For a more general understanding of the economic situation in local markets, it is preferred to study the behavior of basis values rather than spot prices. The basis equals the difference between the spot market price and the futures market price:

$$B_t = P_t - F_t^T \quad (2)$$

where F_t^T is the price of a futures contract in period t for delivery in period T .⁵

Putting (1) and (2) together it is easy to see how the basis relates local drivers of spot prices, such as transportation costs, and national and international supply and demand conditions. According to these equations, remote locations that are far from inland waterways and markets, and where large distances make the cost of trucking commodities sufficiently high, will consistently have a more negative basis. Also, locations with high storage costs (either due to low storage capacity or unusually large crops) will have a weaker basis.

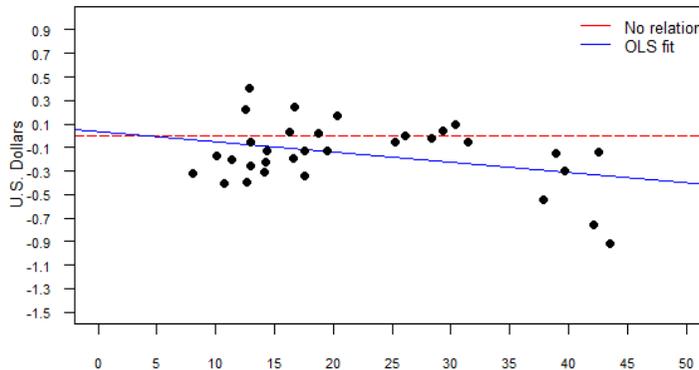
In a context of an energy boom and reduced shipping capacity, this simple but intuitive model predicts that transportation disruptions (which are manifested as increased transportation costs) cause local prices to fall relative to futures prices—that is, locations affected by the energy boom will have a disproportionately weaker (more negative) basis than comparable locations. The impact of transportation disruptions on wheat prices is transmitted through two potential mechanisms. First, because grain processors and exporters face higher shipping costs for the crops they buy, grain elevators may offer farmers lower prices for their crops. Second, if futures prices accurately reflect traders' expectations about future market conditions and are informative about expected transportation disruptions⁶, expectations about track congestion will be reflected in the price for futures contracts. That is, if wheat producers expect current track congestion to remain an issue, they will form expectations for low spot prices in the future and store their crops to sell them for delivery in future dates.

4. Empirical Methods

The three hypothesis posed in this study are the following: (H1) the recent oil boom in the US has had a negative impact on wheat prices; (H2) Midwest farmers have been disproportionately affected by changes in crude oil production and shipment relative to

farmers in the Gulf Coast Region; and (H3) the construction of new pipelines alleviates some of the demand pressure on rail services therefore lowering transportation costs for wheat producers and ameliorating the impact of increased regional oil production and shipment.

The general hypothesis tested in this paper is that increased transportation costs resulting from the increased demand for rail services is an important determinant of wheat basis differentials between regions in the U.S. In fact, a simple visual inspection of the data shows a clear negative linear relation between wheat basis and crude oil nearby futures prices (both measures adjusted for inflation). This is shown in Figure 4.



Source: CBOT and USDA

Figure 4. Oil Nearby futures prices and Wheat Basis (Adjusted for Inflation)

However, as specified in equations (1) and (2) other variables may play a significant and even substantial role in explaining wheat basis differentials. The reduced form equation that will be used to test the model proposed by (1) and (2) is the following:

For region i in year t ,

$$B_{it} = \beta_0 + \beta_1 \delta_{it} + \beta_2 \tau_{it} + v_{it}, \quad (3)$$

where $B_{it} = P_{it} - F_t$ (as in equation 2); δ_{it} represents storage costs, τ_{it} is transportation costs, and v_{it} is an exogenous, random shocks to the system.

The theoretical model suggests estimating an equation for wheat basis with storage and transportation cost variables on the right-hand-side (RHS). However, these variables are not observed directly; therefore, it is necessary to use proxies that absorb their effect so the impact of oil prices can be isolated. Variables that are thought to determine δ_{it} include yields and inventories.⁷ In turn, to specify an estimable form for τ_{it} I consider that multiple factors determine the local demand for rail services and therefore the transportations costs faced by wheat farmers (which in turn are reflected in grain basis). In the context of this paper, the relevant determinants of the demand for rail services are wheat production, wheat storage capacity, oil production, ethanol production, and availability of *feasible* alternative transportation methods—specifically, miles of newly constructed pipelines.⁸

Based on the theory discussed above and previous empirical work in the literature, two equations form the backbone of the analysis presented in this paper: a first-stage equation for transportation costs, and a second-stage equation for wheat basis. In the reduced form of the model, wheat yields, wheat stocks and oil nearby futures prices are included as the

regressors. To simulate a quasi-general-equilibrium analysis, I include ethanol nearby futures prices, total pipeline miles and an interaction term between mileage and oil prices.

I divide the empirical analysis into three sections. First, I estimate the model using national measures to study the impact of track congestion on wheat prices and calculate welfare impacts to farmers nationwide. Then, I use regional data to conduct a comparative study between the Midwest and the gulf regions and assess whether the oil boom and the subsequent competition for transportation in the Upper Midwest accentuates the differences between prices received by wheat producers in the Midwest and farmers in the Gulf Coast region. Finally, I expand the comparative analysis characterized by (4) and (5) adding an interaction term to investigate whether the construction of new regional liquid pipeline networks is linked to regional wheat bases. In estimating the magnitudes of the effects listed above, I use a host of specifications in ordinary least squares, instrumental variables, and two-stage least squares econometric models regressing the wheat nearby basis on oil nearby futures prices. The general reduced-form representation of the equations characterizing the model that is used to examine the three questions posed in this paper is the following:

For region i in year t ,

$$\tau_{it} = \alpha_0 + \alpha_1 Y_{it} + \alpha_2 I_{it} + \alpha_3 Oil_{price_t} + \alpha_4 Ethanol_{price_t} + \alpha_5 Pipeline_{it} + \alpha_6 Boom_{it} + \mu_t + S_i + \nu_{it} \quad (4)$$

$$B_{it} = \gamma_0 + \gamma_1 Y_{it} + \gamma_2 I_{it} + \gamma_3 \widehat{\tau}_{it} + \varepsilon_{it} \quad (5)$$

where Oil_{Price}_t is the current nearby futures price of crude oil; $Ethanol_{Price}_t$ is the current nearby futures price of ethanol; $Pipeline_{it}$ is total miles of liquid pipeline in region i ; $Boom_{it}$ is a vector variable where entries take the value of 1 for years in which region i experienced the oil boom and zero otherwise; μ_t is a time-specific effect; S_i is a region-specific effect; and ν_{it} and ε_{it} are both exogenous, random shocks. Of course, for the national-level analysis the subscript i can be suppressed.

5. Data

For the econometric estimation, I use data obtained from various sources. For the national-level analysis of the impact of increased competition for rail services on wheat basis I use production data from the U.S. Department of Agriculture (USDA) and the National Agricultural Statistics Service (NASS). I construct a wheat nearby basis using price data from the USDA and the Chicago Board of Trade (CBOT). For ethanol and oil futures data I use the first expiration future nearby settlement prices posted by the CBOT and the New York Mercantile Exchange (NYMEX), respectively. Finally, to study the linkage between pipeline construction and wheat basis I use annual data of pipeline mileage from the Pipeline and Hazardous Materials Safety Administration of the US Department of Transportation (PHMSA).

For the comparative study between the Midwest and Gulf Coast regions, I use state-level monthly NASS survey data on wheat price received by farmer, annual census data on yields of winter and spring wheat, and periodic survey data for on-farm and off-farm wheat stocks in addition to futures data from the CBOT and the NYMEX. Also, I use annual data of pipeline mileage by state PHMSA. Notice that even though I am referring to the analysis by PADD as a “regional analysis” I do not actually aggregate the data at the regional level, instead I use state-level data corresponding to the states that comprise each PADD.

Tables 1 through 4 provide information on the datasets and data sources used in the econometric estimations and with the descriptive statistics of the variables used in the econometric regressions at the national level and by regions.

Table 1. Data Sources and Description

Variable Name	Analysis	Description	Unit	Source	Time	Freq.
Wheat Basis	National	Spot P- Nearby P	U.S. dollars per bushel	Created	1969-2014	Daily
Oil Nearby P	National and Regional	First expiration nearby, settlement price for crude oil of density class: Light Sweet-West TX Intermediate-Cushing	U.S. dollars per barrel	NYMEX	1983-2014	Daily
Wheat Spot P	National	Spot Price for #2 Soft Red Wheat in Chicago	U.S. cents per bushel	USDA	1969-2014	Daily
Wheat Nearby P	National and Regional	First expiration future nearby, settlement price	U.S. cents per bushel	CBOT	1969-2014	Daily
Wheat Yields	National	Wheat production in the U.S	Bushel	NASS. Census	1990-2014	Annual
Wheat Stocks	National	U.S. on-farm and off-farm wheat stocks	Bushel	NASS. Survey	1990-2014	Quarterly (Mar, Jun, Sep, Dec)
Ethanol Nearby P	National and Regional	First expiration nearby, settlement price for ethanol	U.S. dollars per gallon	CBOT	2006-2014	Daily
Pipeline Miles	National	Miles of Crude Oil Pipeline	Miles	US DOT PHMSA	2010-2014	Annual
Wheat Basis(i)	Regional	I create this variable from Nearby and Spot(i)	U.S. dollars per bushel	Created	1990-2014	Monthly
Wheat Spot(i)	Regional	Price received by farmer in state(i)	U.S. dollars per bushel	NASS. Survey	1990-2014	Monthly
Wheat Yields(i)	Regional	Winter wheat and/or Spring wheat production in state(i)	Bushel	NASS. Census	1990-2014	Annual
Wheat Stocks(i)	Regional	On-farm and off-farm wheat stocks in state(i)	Bushel	NASS. Survey	1990-2015	Quarterly (Mar, Jun, Sep, Dec)
Pipeline Miles(i)	Regional	Miles of Crude Oil Pipeline in state(i)	Miles	US DOT PHMSA	2010-2014	Annual
Winter Wheat	Regional	This is a Dummy variable taking the value of 1 for positive yields of winter wheat crops and 0 for positive yields of spring wheat crops.	Binary	Created based on NASS, Census data on yields	1990-2014	Monthly

Table 1. Summary Statistics of Variables Used in the Country-Level Analysis

Summary Statistics - National-level Analysis					
Variable	min	med	mean	max	N
Dataset 1					
Wheat Basis	-1.755	-0.068	-0.1	1.272	50
Oil Nearby P	8.423	17.37	24.335	60.988	50
Wheat Yields	3.92E+08	9.31E+08	1.06E+09	2.02E+09	50
Wheat Stocks	3.06E+08	1.35E+09	1.35E+09	2.45E+09	50
Dataset 2					
Wheat Basis	-1.7557	-0.1561	0.1786	1.2723	18
Oil Nearby P	31.39	38.05	39.44	60.99	18
Wheat Yields	4.53E+08	9.52E+08	1.02E+09	1.89E+09	18
Wheat Stocks	3.06E+08	1.35E+09	1.33E+09	2.45E+09	18
Ethanol Nearby P	0.7347	0.9565	1.0001	1.7956	18
Dataset 3					
Wheat Basis	-0.8902	-0.1561	-0.02101	0.9593	10
Oil Nearby P	33.29	40.32	39.96	46.1	10
Wheat Yields	4.53E+08	9.93E+08	1.02E+09	1.58E+09	10
Wheat Stocks	5.90E+08	1.42E+09	1.44E+09	2.45E+09	10
Ethanol Nearby P	0.7347	0.8988	0.9583	1.2639	10
Pipeline Miles	54631	57463	59188	66658	10
Pipeline Miles X Oil Nearby	1818379	2458726	2373525	2938212	10

Table 2. Summary Statistics of Variables Used in the Midwest Analysis

Summary Statistics - Midwest Region (PADD2)*					
Variable	min	med	mean	max	N
Dataset 1					
Wheat Basis	-1.569	-0.079	-0.1001	1.3327	264
Oil Nearby P	7.347	17.531	24.338	65.475	264
Wheat Yields	8277	56415000	92324890	501399998	264
Wheat Stocks	2084000	45045000	73252557	398669998	264
Winter Wheat	0	1	0.8258	1	264
Dataset 2					
Wheat Basis	-1.56988	-0.02533	-0.12856	1.32372	97
Oil Nearby P	22.56	38.72	39.46	65.48	97
Wheat Yields	8277	49140000	81165814	375900001	97
Wheat Stocks	8923000	53953000	73064010	364399999	97
Winter Wheat	0	1	0.7938	1	97
Ethanol Nearby P	0.6476	1.0064	1.0158	1.4856	97
Dataset 3					
Wheat Basis	-0.759	0.0863	0.0593	0.6691	68
Oil Nearby P	29.15	39.08	40.15	47.99	68

Wheat Yields	208315	47285000	78734995	360000000	68
Wheat Stocks	15270000	58371500	88284985	372523999	68
Winter Wheat	0	1	0.7941	1	68
Ethanol Nearby P	0.6476	1.0328	0.9896	1.4856	68
Pipeline Miles	220	1706.6	1775.5	5843.5	68
Pipeline Miles X Oil Nearby	18.91	27.69	26.43	31.69	68

Note: *Excludes Tennessee and Kentucky

Table 3. Summary Statistics of Variables Used in the Gulf Coast Analysis

Summary Statistics - Gulf Coast (PADD3)*					
Variable	min	med	mean	max	N
Dataset 1					
Wheat Basis	-1.17393	-0.07695	-0.09025	0.50903	49
Oil Nearby P	7.347	16.341	24.013	65.475	49
Wheat Yields	140686	50440000	60067464	1.37E+08	49
Wheat Stocks	10000	22221000	40877347	1.58E+08	49
Winter Wheat	0	1	0.9592	1	49
Dataset 2					
Wheat Basis	-1.1739	-0.1112	-0.1058	0.509	18
Oil Nearby P	22.56	37.16	39.38	65.4	18
Wheat Yields	140686	31880000	41435368	1.24E+08	18
Wheat Stocks	10000	16910500	32739556	1.34E+08	18
Winter Wheat	0	1	0.8889	1	18
Ethanol Nearby P	0.731	1.0507	1.0598	1.4856	18
Dataset 3					
Wheat Basis	-0.3061	0.1674	0.163	0.744	11
Oil Nearby P	29.1	40.28	39.27	47.41	11
Wheat Yields	14068	37820000	48155672	1.24E+08	11
Wheat Stocks	30000	29932000	35785455	88982000	11
Winter Wheat	0	1	0.9091	1	11
Ethanol Nearby P	0.7039	0.9861	0.9579	1.159	11
Pipeline Miles	428.5	12719.6	8103.3	17517	11
Pipeline Miles X Oil Nearby	20.74	33.17	29.63	36.75	11

Note: *Includes Data for Texas and Arkansas

6. Results

For each level of aggregation (state-regional and national), equation (5) was estimated with various combinations of variables to proxy for transportation costs. Four basic specifications were explored in each analysis. Each subsequent model added an explanatory variable to the regression, and for each specification, progressively more saturated versions

were explored. Year-specific fixed effects were sometimes used, but, interestingly, they were largely uninformative. State-specific fixed effects were never used for the national or regional analyses due to the limited number of observations. The results that will be presented in this section correspond to those from the preferred specifications. However, I will include in the discussion highlights from the iterative process of model selection. The results corresponding to the main models considered are summarized in Tables 5 through 7.

6.1 H1: the recent oil bonanza in the US negatively impacts on wheat prices

Consistent with the theoretical discussion, in almost every specification of the model, oil price has a negative and statistically significant impact on wheat basis—the exception is the most comprehensive version. In general, the effect is small; the coefficient estimates range from -0.01 to -0.08, indicating that an average USD \$1 increase in oil nearby futures prices is associated with a decrease in the wheat basis of 1 to 8 cents per bushel.

Apart from tackling the determinants of the wheat basis, I was interested in testing if there was a “structural breakpoint” corresponding to the energy boom period. To find out, I pursued a heuristic search for the beginning of the energy boom—that is, I test for significance of before-and-after dummies for the years between 2008 and 2011.⁹ As the results show, there appear to be two possible break points signaling the beginning of the oil boom, one in 2009 and one in 2011. The 2011-Dummy effect is slightly larger than the 2009-Dummy. The 2011 structural breakpoint is likely to be largely related to the shale revolution and the energy boom as indicated in the background section of this paper. The estimates indicate that the wheat basis changed by 45 more cents from 2011 forward, compared to the years before 2011.

In the more parsimonious versions of the model, wheat yields and wheat inventories are sometimes significant. When significant, yields have a negative effect on the basis ($P_t - F_t$) and stocks have a positive effect—in line with theoretical predictions. When ethanol nearby futures prices are included in the regression, many observations are lost due to the fact that the ethanol nearby time series is only available since 2006. In every level of saturation using the ethanol nearby futures prices, the impact of oil nearby futures prices on wheat basis never ceases to be negative and significant. Including the change in pipeline mileage at the national level improves the model substantially (based on measures of fitness). However, the available time series is much shorter for under this specification (the time series begins in 2010 and is only available at the annual frequency).

Finally, to test H3 (that the construction of new pipelines alleviates some of the demand pressure on rail services) with the national data, I include an interaction term (oil nearby futures prices by pipeline mileage). This interaction term will indicate if the effect of oil nearby futures prices on the wheat basis is different under different lengths of pipelines available for moving oil. The expected sign for this term is negative—the impact of oil nearby futures prices is expected to be decreasing as more pipeline infrastructure is in place. Empirically, the term is never significant. Yet, no variable is significant under this specification, probably due to the fact that there are simply not enough degrees of freedom.

6.2 H2: Midwest farmers have been disproportionately affected by changes in crude oil production and shipment relative to farmers in the Gulf Coast

The regressions pertaining to the regional comparative analysis were estimated using a logarithmic transformation of the independent variables. Therefore, the results presented will have a slightly different interpretation than in the National analysis where the regression was on levels. Furthermore, the comprised dataset used for this part of the study does not

contain data on the full set of variables for all the states in PADD2 and PADD3. Hence, although I call the analysis “regional”, this label has to be used with care and the interpretations cannot be generalized for all states in the region.¹⁰

6.2.1 The Midwest Region (PADD2)

In the least saturated specification of the model, oil nearby futures prices do have a negative and significant effect on the basis once the boom period is accounted for. In addition, wheat stocks are always have a positive and significant effect on the basis (the effect is small however, ranging from 0.065 to 0.1). Wheat inventories are always positive and significant determinants of the wheat basis in PADD2 with coefficients ranging from 0.065 to 0.168. Meaning that a 1% increase in inventories is associated with an increase in price per bushel between 0.065 and 0.168 cents. Interestingly, including ethanol nearby futures prices in the regressions seems to improve considerably the explanatory power of the model. The variable is often significant but its sign changes across specifications. A possible explanation for this change of signs is that it may be capturing the impact of other omitted variables.

Introducing the pipeline mileage into the regression improves the fit of the model rather considerably, however, it also leads to some non-innocuous changes. I speculate this is likely to the fact that the number of observations is substantially reduced. Under this specification, oil nearby futures prices stop being significant and exhibit a change in sign; also, effect of ethanol nearby futures prices flips signs, meaning that when pipeline mileage is accounted for, higher ethanol nearby futures prices negatively affect the basis. Finally, including the interaction term to test H3 does not really improve the fit of the model. No variable is significant under this more comprehensive specification, suggesting that there may not be a differential impact of oil nearby futures prices by varying degrees of pipeline extension.

6.2.2 The Gulf Coast (PADD3)

The results for the PADD3 analysis differ from those of PADD2 starkly in some regards. For this region, the oil boom appears to have started in 2009 and not in 2010. Additionally, neither wheat stocks nor ethanol nearby futures prices ever have a significant impact on the basis. Finally, seasonality makes no difference as the winter wheat dummy is never significant and its inclusion does not improve the fit of the model. On the other hand, similar to the results for PADD2, adding ethanol nearby futures prices and total miles of pipeline to the PADD3 regressions adds substantial explanatory power to the model. When the pipeline data is added to the analysis, none of the variables in the regression exhibit significance. Furthermore, the oil nearby variable is sometimes positive and sometimes negative (although never significant). These rather disappointing results are probably due to the drastic reduction in observations. However, the principal result of interest remains unchanged: whenever significant, oil future nearby futures prices continue to have a negative impact on the basis.

Table 4. Summary of Results--Nation-wide Analysis

Nation-wide Analysis							
Dependent Variable: Wheat_Basis							
Regressor	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Oil_Nearby	-0.012* (0.005321)	-0.062* (0.02454)	-0.018** (0.005926)	-0.02** (0.006756)	-0.082* (0.02967)	-0.01* (0.03057)	-0.29 (0.4623)
Wheat_Yields	-7.267E-10 (3.83E-10)	-6.899E-10 (8.466E-10)	-6.891E-10 (3.73E-10)	-4.301E-10 (4.03E-10)	8.225E-10 (1.31E-09)	1.23E-09 (1.07E-09)	1.01E-09 (1.36E-09)
Wheat_Stocks	5.61E-10* (2.77E-10)	5.873E-10 (6.16E-10)	5.358E-10 (2.69E-10)	3.416E-10 (2.92E-10)	-6.737E-10 (9.53E-10)	-1E-09 (7.65E-10)	-8.6E-10 (9.87E-10)
Ethanol_Nearby					-0.166 (0.6762)	-1.093 (0.6148)	-0.95 (0.8051)
Total_Mile						-4.4E-05 (2.75E-05)	-0.00018 (0.00032)
Mileage_Oil Interaction							3.31E-06 (7.96E-06)
D2011			0.455 (0.2355)			0.279 (0.2781)	0.347 (0.3651)
D2009				0.439 (0.2275)	0.61 (0.4258)		
Year-Fixed Effects	NO	YES	NO	NO	YES	YES	YES
R-Sq	0.17	0.74	0.24	0.24	0.52	0.94	0.94
N	50	50	50	50	18	10	10

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Standard errors in parenthesis

Table 5: Summary of Results--Midwest Analysis

Midwest Analysis							
Dependent Variable: Wheat_Basis							
Regressor	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Oil_Nearby	-0.048 (0.037)	-0.052 (0.037)	-0.151*** (0.042)	-0.160*** (0.041)	-0.528* (0.252)	0.172 (0.454)	1.717 (1.288)
Wheat_Yields	-0.021 (0.013)	-0.017 (0.013)	-0.014 (0.012)	-0.009 (0.012)	-0.027 (0.029)	-0.014 (0.027)	-0.016 (0.027)
Wheat_Stocks	0.095*** (0.020)	0.076*** (0.021)	0.086*** (0.020)	0.065*** (0.020)	0.168 ** (0.058)	0.118* (0.050)	0.098 (0.053)
Ethanol_Nearby					0.484 * (0.234)	-0.451* (0.222)	-0.395 (0.225)
Total_Miles						-0.002 (0.040)	0.864 (0.677)
Mileage_Oil Interaction							-5.839 (4.556)
Winter_Wheat		-0.167** (0.054)		-0.180*** (0.051)	-0.276* (0.108)	-0.262** (0.089)	-0.260 (0.088)
D2010			0.285*** (0.062)	0.297*** (0.061)	0.321*** (0.091)	0.375*** (0.105)	0.354 (0.106)
Year-Fixed Effects	NO	NO	NO	NO	NO	NO	NO
R-Sq	0.08	0.11	0.15	0.18	0.33	0.39	0.40
N	264	264	264	264	97	68	68

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

All regressors are logarithmic transformations, the correct interpretation of a regression of the form $Y = B \log(X) + e$ is the following:

A 1% increase in X, is associated with a change of B/100 units of Y.

Standard errors in parenthesis

Table 6: Summary of Results--Gulf Coast Analysis

Gulf Coast Analysis							
Dependent Variable: Wheat_Basis							
Regressor	Coefficient						
Oil_Nearby	-0.020 (0.073)	-0.022 (0.073)	-0.049 (0.079)	-0.163* (0.078)	-0.163* (0.379)	0.703 (0.918)	5.931 (7.804)
Wheat_Yields	0.004 (0.032)	-0.023 (0.072)	0.010 (0.033)	0.014 (0.029)	0.038 (0.043)	0.081 (0.046)	0.082 (0.049)
Wheat_Stocks	0.015 (0.013)	0.019 (0.017)	0.012 (0.013)	0.009 (0.012)	0.025 (0.024)	-0.035 (0.053)	-0.024 (0.059)
Ethanol_Nearby					0.566 (0.463)	1.158 (0.674)	1.296 (0.743)
Total_Miles						0.089 (0.096)	2.446 (3.493)
Mileage_Oil Interaction							-18.502 (27.404)
Winter_Wheat		0.183 (0.441)					
D2011			0.119 (0.1280)				
D2009				0.340** (0.102)	0.427* (0.148)		
Year-Fixed Effects	NO						
R-Sq	0.04	0.50	0.06	0.23	0.56	0.73	0.76
N	49	49	49	49	20	11	11

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

All regressors are logarithmic transformations, the correct interpretation of a regression of the form $Y=B\log(X)+e$ is the following:

A 1% increase in X, is associated with a change of B/100 units of Y.

Standard errors in parenthesis

Under the most parsimonious specification, the impact of oil nearby futures prices on the basis is slightly larger for PADD3 than for PADD2—with the coefficients being -0.163 and -0.151, respectively. This means that a 1% increase in oil prices is associated with a decrease of 0.163 cent per bushel in PADD3 and a 0.151 cent per bushel in PADD2. Given that the average wheat basis in PADD2 and PADD 3 is around -0.12 and -0.106, respectively, this effect roughly translates into a weakening of the basis of 1.2% in the Midwest and of 1.5% in the Gulf Coast. However, if I compare the specifications that include ethanol nearby futures prices, the impact of oil prices on wheat basis is about 4 times larger in the Midwest. According to the estimates from the model including ethanol prices, a 1% increase in oil prices leads to a 0.5 cents decrease in wheat basis in the Midwest—which roughly translates into a 4% increase in the negative basis. Instead, the effect of an equal change in oil prices on the wheat basis in the Gulf Coast is associated with a 0.9% decrease in the basis.

7. Policy Implications

The results presented here are relevant for policymakers concerned with support programs to wheat producers, regulations over the provision of rail services, and the development of alternative methods for transporting oil. If the oil nearby futures prices are a good signal for the increased demand for rail services, my results can either challenge or confirm the theories that have received most attention from the media. For instance, under the most parsimonious specification, I find that the impact of oil nearby futures prices on the basis is very small and actually almost identical for the Midwest and the Gulf Coast regions.¹¹ This result would suggest that the advertised effect of train delays on grain prices in the Upper Midwest is not driven entirely by the increased competition for rail services from the energy sector. Other factors, such as unusually large crops and extreme winter conditions, appear to be important determinants of the apparently disproportionately weak wheat basis in the Midwest.

However, if I compare the specifications that include ethanol nearby futures prices, the impact of oil prices on wheat basis is about four times larger in the Midwest.¹² A result of this magnitude could justify further research on the general equilibrium effects of limited rail shipping services. For example, if the competition for rail services is persistent and the difficulties of expanding rail networks significant, grain producers may turn to trucking services for distribution of their product. In any case, and despite the differences in estimate magnitudes, the principal result of interest remains unchanged between the two regions: whenever significant, oil future nearby futures prices have a negative impact on the basis. Therefore, it could be important to estimate the welfare effects from revenue losses by farmers and the negative externalities from increased truck congestion and train accidents in order to inform whether projects such as the proposed Keystone XL Pipeline had more economic benefits than originally proposed.

Although the relation explored in this paper does not allow me to calculate a back-of-the-envelope estimation of lost revenue from train delays and backlogs, I can do something similar by calculating lost revenue from increases in oil prices (or even from increases in both oil and ethanol prices). The average U.S. wheat production between 2006 and 2014 was 2,127,709,889; therefore, a 1 to 8 cents decrease in the basis roughly translates to an annual decrease in revenue from wheat sales at local markets between a UD\$ 20 and a 170 million.

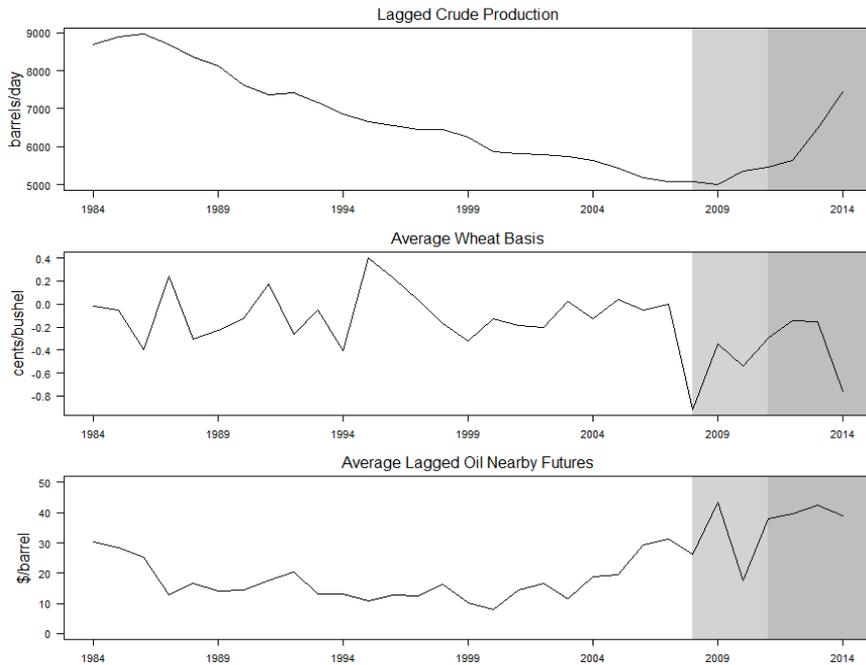
Given the political interest expressed by senators in North Dakota, South Dakota and Minnesota, a similar calculation can be done using state-specific average wheat yields in the

same time period. The average annual increase in oil nearby futures prices between 2006 and 2014 was 13 percent. The most conservative estimated impacts (a 1.2 percent increase in the negative basis after a 1 percent increase in the price of oil nearby futures prices) suggest that each year farmers in ND, SD and MN lost close to USD \$47.8 million, USD \$18.5 million, and USD \$12.5 million in revenues from wheat sales at local markets, respectively.¹³ These numbers are USD \$61.9 million, USD \$159.5 million and USD \$41.5 million when the more inflated estimated impact (a 4 percent increase in the negative basis after a 1 percent increase in the price of oil nearby futures prices) is used in the calculation.¹⁴ Recall that in the North Dakota study by Olson (2014), the preliminary estimate of lost revenue for the 2014 crop due to rail service disruptions was around USD \$171 million (estimated UDS\$ 64 million of lost revenue between January and April, and additional projected USD \$94 million for the remaining of the year). Although the quick computation made here arrives at a much smaller number (between USD \$48 million and USD \$62 million depending on the model of choice), it is worth noticing that Olson estimates lost revenue from all grain products, while I focus only on wheat. This naive comparison seems to suggest the results presented in this paper are consistent with other findings in the literature.

8. Future Research

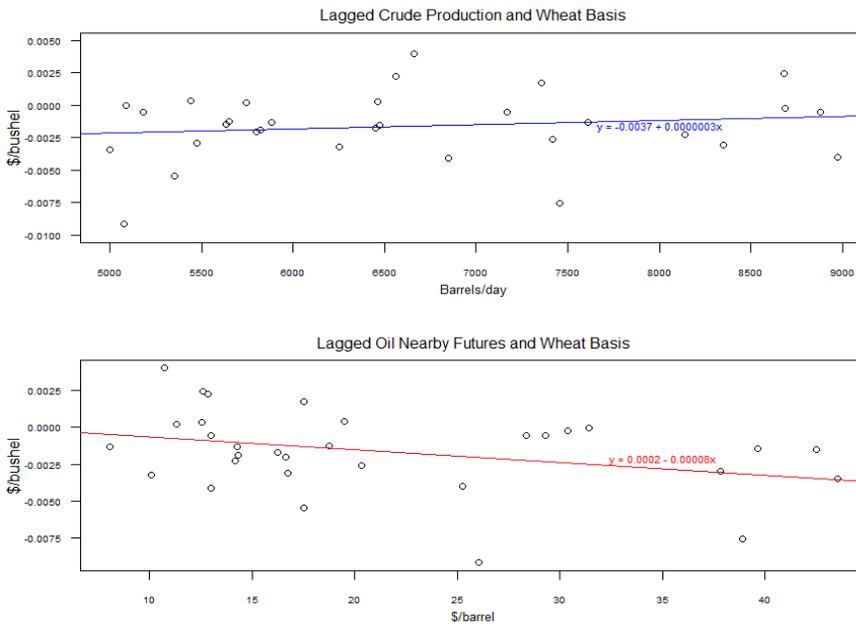
An immediate improvement to the theoretical foundation of the empirical model is to repeat the regressions using lagged oil nearby futures prices in the set of RHS variables. I reran the regressions accordingly and found that all models are consistently worse at fitting the data. However, the coefficients for the oil nearby futures prices are only slightly smaller than those for the models with the contemporaneous prices. A surprising finding is a drastic change in the estimates for the most saturated model. Firstly, there is significance for most variables (although the model's R-sq statistic is still lower than that for the model for which results are reported in this paper). And secondly, the coefficient for oil nearby prices (the variable of interest) is positive rather than negative. It appears prudent to further investigate this issue of model specification.

Another point that became evident throughout the development of this paper, is the apparent importance of including real variables on the RHS. A fairly superficial exploration of this alternative with the national data yields some interesting results suggesting that in future corrections of this paper, using oil shipments data instead of oil nearby futures prices as the main proxy for transportation costs may yield substantially different conclusions. Using lagged crude production instead of lagged or contemporaneous oil prices does not generally improve the fit of the model; in turn, it does consistently change the sign of the estimated coefficients of the oil variable and in many occasions the wheat yields and inventory variables. A visual inspection of the variables makes evident the lack of clear relation between crude oil production and the wheat basis. Instead, oil nearby futures and wheat basis do seem positively related. To illustrate this point, figure 5 compares lagged crude oil production, oil nearby futures prices and the wheat basis, and figure 6 compares the linear relationships between lagged crude oil production and the wheat basis to that between lagged oil nearby futures and wheat basis. As shown in the graphs, the relations are inverse (however, the coefficient for the regression on crude oil production is not statistically significant). Provided that I do have data on volume of oil traded by train and pipeline by regions, I can use these real variables in future regressions to have a better understanding of why these estimates behave so strangely.



Source: EPA, USDA, CBOT

Figure 5. Crude Oil Production, Wheat Basis, and Oil Nearby Futures Prices



Source: EPA, USDA, CBOT

Figure 6. Comparison of Linear Relationship Between Wheat Basis and Lagged Oil Variables

A side objective of this research was to study the impact of new pipeline construction on wheat prices and to assess whether there was a differential impact within different levels of pipeline extension. To test these ideas I complemented the analysis using data on liquid-material pipeline mileage from the PHMSA. Unfortunately, the time series data with pipeline mileage is too short to render the empirical model any confidence. However, this aspect of the study remains open for further investigation. An initial idea is to search in federal archives for maps of pipeline networks in order to construct a measure of pipeline extension and even perhaps a measure of “connectivity”.

9. Conclusion

The objective of this study was to assess whether the energy boom and the subsequent competition for transportation in the Upper Midwest was driving a significant effect on wheat prices nationwide and whether said rail car congestion had a disproportionate effect on wheat prices received by farmers in the Midwest relative to farmers in the Gulf Coast. The analysis was extended to evaluate whether the construction of new pipelines alleviates some of the demand pressure on rail services therefore lowering transportation costs for wheat producers and ameliorating the impact of increased regional oil production and shipment. A rather simple theoretical model of wheat prices was developed to form testable predictions regarding changes in transportation costs in the face of an energy boom. The model predicts that locations affected by the energy boom will have a disproportionately weaker (more negative) basis than comparable locations. For the empirical analysis, I use a host of specifications in ordinary least squares, instrumental variables, and two-stage least squares econometric models regressing the wheat nearby basis on oil nearby futures prices to measure the impact of increased transportation costs on the wheat prices. The reduced-form of the model includes wheat yields, wheat stocks, oil nearby futures prices, ethanol nearby futures prices, total pipeline miles and an interaction term between mileage and oil prices as regressors.

The results from the analysis are consistent with the hypotheses that large crops, limited storage capacity and transportation disruptions (likely caused by increased competition of rail service) are significant determinants of the wheat basis. In general, the results are consistent with the theoretical predictions regarding the impact of other variables included in the study. Furthermore, the results indicate that oil nearby futures prices consistently have a negative and significant effect on wheat basis—both nationally and within regions. The effect of a USD \$1 increase per barrel of oil ranges from 1 to 8 cents per bushel at the national level, from 0.1 to 0.5 cents within the Midwest region, and it is fairly stable at a 0.1 cent decrease in the Gulf Coast region. Although the effects that I find are much lower than those in the existing literature which range from 11 to 18 cents per bushel, it is important to clarify that the literature generally looks at the impact of transportation costs on grain prices. Instead, I instrument for transportation costs with oil nearby futures prices and I focus on one particular crop: wheat.

Given that the average wheat basis between 2006 and 2014 has been USD \$0.17855, a change of 1 to 8 cents constitutes an increase between 5 and 44 percent of the average basis level. Similarly, a change of 0.1 to 0.5 cents within the Midwest would constitute between a 0.8 to a 4 percent increase from the average wheat basis in the region. Conversely, the 0.1 cent change of the wheat basis in the Gulf Coast region roughly translates to a 0.9 percent increase in the (negative) basis. As these numbers indicate, depending on the model used, wheat basis in the Midwest and Gulf Coast region can appear to be equally responsive to changes in oil prices or a case can be made for the Midwest being five times as responsive as the Gulf Coast region to a change in oil prices. Although the relation explored in this

paper does not allow me to perform a back-of-the-envelope calculation of lost revenue from train delays and backlogs, I can do something similar by calculating lost revenue from increases in oil prices (or even from increases in both oil and ethanol prices). For instance, the average U.S. wheat production between 2006 and 2014 was 2,127,709,889; thus, a 1 to 8 cents decrease in the basis roughly translates into an annual decrease in revenue from sales at local markets between a \$20 and a \$170 million.

Provided that oil nearby prices are a good indicator of the state of the energy sector and a strong instrument for the increased demand for rail services¹⁵, the results presented here can either challenge or confirm the theories that have received most attention from the media and are relevant for policymakers concerned with support programs to wheat producers, regulations over the provision of rail services, and the development of alternative methods for transporting oil. Either way, given North Dakota's dominant role as a national wheat producer, it is clear that severe impacts of transportation disruptions on wheat prices will have important implications for the wheat industry as a whole. Therefore reinforcing the timeliness and importance of research on this topic.

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End Notes

¹ These states produced 71% and 64% of the country's wheat in 2014 and 2013, respectively.

² The same is not true for all other grains. Hauling by truck has become increasingly more important than rail. However, rail transportation remains more important than barge.

³ A recent Petroleum Supply Monthly shows an average of 1.7 million barrels per day (b/d) shipped out of the Midwest during the first five months of 2015, of which 638,000 were transported by rail.

⁴ These include the 2015 USDA AMS study "Rail Service in the Upper Midwest: Implications for Agricultural Sectors—Preliminary Analysis of the 2014-2014 Situation" in response to a request by Senators from South Dakota and Minnesota (John Thune and Amy Klobuchar), and the 2014 study by Frayne Olsen at North Dakota State University "Effects of 2013/2014 Rail Transportation Problems on North Dakota Farm Income" in response to a request from North Dakota's Senator (Heidi Heitkamp).

⁵ For the empirical analysis of this research I examine the impacts of transportation congestion on the nearby basis. The nearby basis reflects the difference between the local cash price for delivery at time t and the price for the corresponding futures market contract with the settlement date that is closest to t .

⁶ According to the theory of futures trading, prices in the futures market should converge to spot prices as the date approaches the delivery day. Although there is lack of universal consensus for the theoretical purity of this result, it is backed by intuition and evidence. It is claimed that $E[S_t] \rightarrow F_t^T$ because otherwise some market participants would be making positive economic profits. For example, if spot prices were lower than future prices even as time approached the month of delivery, traders would buy the asset today and store it to make the delivery.

⁷ For the time horizon considered in this analysis, I abstract from farmers' decision to expand in-farm storage capacity and railroad operators' decision to invest in rail network expansion.

⁸ Currently, there exists literature analyzing how energy markets and grain markets are linked through ethanol (see for example Serra and Zilberman, 2013; Tyner, 2010). However, these papers do not consider how these markets may be linked by transportation. It may be that the joint effect of the ethanol and transportation link between energy and grain markets matters differently than the individual effects. A complicating issue for using ethanol and oil prices as proxies is the imminent threat of endogeneity. Oil and ethanol markets are largely influenced by legislation—which is in turn largely influenced by energy lobbies. A tricky aspect of this or future projects will be figuring out how to account for or abstract from these type of institutional factors.

⁹ These dummy variables are constructed so that the corresponding coefficients measure the difference in the average annual wheat basis between years before and after the corresponding breakpoint. For example, for the 2011-Dummy, the indicator variable equal to zero for the 1990-2007 years and one for the 2008-2014 period. The estimated coefficient on the indicator variable from the 2011 breakpoint regression is the average fitted wheat basis for 2011-2014 minus the average fitted wheat basis for 1990-2011. In this case, the estimates indicate that the basis changes by USD \$0.45 more from 2011 forward compared to the years before 2011.

¹⁰ The states conforming PADD2 are ND, SD, MN (for which there have been senatorial requests to study the impact of train delays on grain prices), NE, KS, OK, MO, IA, WI, MI, IL, IN, OH, KY and TS. I do not have full data for KY and TS, thus these two states are left out from the regression. Similarly, for the analysis of PADD3 not all data are available for the conforming states (NM, TX, LA, AR, MS, AL). In fact, data is limited to TX and AR.

¹¹ According to the estimates corresponding to the most parsimonious of the models, a 1% increase in oil prices is associated with a decrease of 0.163 cents per bushel in PADD3 and a 0.151 cent per bushel in PADD2—which roughly translates into a 1.5% and a 1.2% increase in the negative wheat basis, respectively.

¹² According to the estimates from the model including ethanol prices, a 1% increase in oil prices leads to a 0.5 cents decrease in wheat basis in the Midwest—which roughly translates into a 4% decrease in the basis. Instead, the effect of an equal change in oil prices on the wheat basis in the Gulf Coast is associated with a 0.9% decrease in the basis.

¹³ The average annual wheat yields in the states of ND, SD and MN between 2006 and 2014 were 306'706,656 bushels, 118'981,475 bushels, and 79'735,204 bushels, respectively. The computation was made by multiplying 0.156 (15.6% decrease in the basis following a 13% increase in the price of oil) by the average annual wheat yields in each state.

¹⁴ This estimate was attained using a similar calculation as before, but this time multiplying the yield amount by 0.52 (a 52% reduction in the basis following a 13% increase in oil prices).

¹⁵ Crude oil prices, and in particular prices for crude oil futures contracts, are relevant to this study because of their effects on production decisions by the energy sector. If high futures

prices reflect expectations about future profitability of the industry, these prices would provide a decent proxy for anticipating future changes in the energy sector. Expectations of future high prices would encourage investment in new production technologies or exploration activities, boost current crude production, and likely increase current oil inventories. These changes would in turn impact the demand for shipping services in oil producing regions, therefore, affecting competitor consumers of rail transportation services such as wheat farmers.