The Navigation Economic Technologies Program

July 24, 2004

NETS

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Understanding Grain Movements for Demand Estimation

The Columbia-Snake River System in Washington State

US Army Corps of Engineers®

IWR Report 04-NETS-P-03

Navigation Economic Technologies

The purpose of the Navigation Economic Technologies (NETS) research program is to develop a standardized and defensible suite of economic tools for navigation improvement evaluation. NETS addresses specific navigation economic evaluation and modeling issues that have been raised inside and outside the Corps and is responsive to our commitment to develop and use peer-reviewed tools, techniques and procedures as expressed in the Civil Works strategic plan. The new tools and techniques developed by the NETS research program are to be based on 1) reviews of economic theory, 2) current practices across the Corps (and elsewhere), 3) data needs and availability, and 4) peer recommendations.

The NETS research program has two focus points: expansion of the body of knowledge about the economics underlying uses of the waterways; and creation of a toolbox of practical planning models, methods and techniques that can be applied to a variety of situations.

Expanding the Body of Knowledge

NETS will strive to expand the available body of knowledge about core concepts underlying navigation economic models through the development of scientific papers and reports. For example, NETS will explore how the economic benefits of building new navigation projects are affected by market conditions and/or changes in shipper behaviors, particularly decisions to switch to non-water modes of transportation. The results of such studies will help Corps planners determine whether their economic models are based on realistic premises.

Creating a Planning Toolbox

The NETS research program will develop a series of practical tools and techniques that can be used by Corps navigation planners. The centerpiece of these efforts will be a suite of simulation models. The suite will include models for forecasting international and domestic traffic flows and how they may change with project improvements. It will also include a regional traffic routing model that identifies the annual quantities from each origin and the routes used to satisfy the forecasted demand at each destination. Finally, the suite will include a microscopic event model that generates and routes individual shipments through a system from commodity origin to destination to evaluate non-structural and reliability based measures.

This suite of economic models will enable Corps planners across the country to develop consistent, accurate, useful and comparable analyses regarding the likely impact of changes to navigation infrastructure or systems.

NETS research has been accomplished by a team of academicians, contractors and Corps employees in consultation with other Federal agencies, including the US DOT and USDA; and the Corps Planning Centers of Expertise for Inland and Deep Draft Navigation.

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Understanding Grain Movements for Demand Estimation

The Columbia-Snake River System in Washington State

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ABSTRACT

Grain producers and handlers in the State of Washington have been able to benefit from a multimodal transportation network of roads, railroads and the Columbia-Snake river barge system to effectively move large amounts of grain in a timely and economic manner. Changes are occurring in the industry, including changes in the number of firms and houses, mergers and modal competitiveness due to the competitive environment of the grain industry. Additionally, impacts on marketing strategies occur because choices of available transportation modes reflect the decision process of a warehouse or firm manager.

This paper reports on the aggregate study of grain marketing and transportation in the Pacific Northwest to help lay the groundwork for subsequent empirical demand estimation. These subsequent modeling attempts may include both revealed and stated preference analysis in discrete choice demand models. A thorough understanding of the industry and market characteristics should improve empirical estimation efforts and produce more defensible policy analysis.

Results enumerated in the paper, based on a 90% of shipment volume response rate, show that, in the Columbia-River grain situation, one destination absorbs over 90% of the shipments. Modal competition is active with barge having over a 50% market share, down 12-16% from 10 years ago. Multiple car shipments have increased but not drastically. Rates are competitive and quite consistently so over the time period. Finally, seasonality of grain demand is evident but has generally been stable over time.

The revealed preferences from such an aggregate analysis as in this general study suggest that the price elasticity may vary across shipper, time of movement and modal availability. More complete data and analysis are available from the authors.

INTRODUCTION

Wheat and barley are essential commodities produced in Washington. Eastern Washington, one of the major grain producing regions in the United States, has an ideal combination of soils, climate and supporting industries suitable for dry land and irrigated grain production. Whitman County is the largest wheat-producing county in the nation, with 33 million bushels produced in 2002 (USDA-NASS, 2002).

Transportation is the dynamic link between production areas and consumers. The grain marketing system, which evolves in any grain-producing region, is heavily dependent upon and shaped by the transportation network serving that region. The presence of a multi-modal transportation system plays a very important role in the development of on-farm or commercial storage and facilities investment for efficient movement of crops from the field to the consumer's table (1). Changes in the transportation system shape and affect the overall grain merchandising system.

Grain producers and handlers in the State of Washington have been able to benefit from a multimodal transportation network of county and state roads, highways, railroads, and the Columbia-Snake river system to effectively move large amounts of grain in a timely and economic manner. Interruption or shifts in the infrastructure affect producers, marketers and consumers of grain and agricultural products. Environmental policy debates such as river drawdown may drastically alter the grain marketing and transportation system (2 & 3). Current and evolving modal choices generate multiple effects on the Washington grain industry. These effects include changes in the number of firms and houses, turnover rates, and mergers due to the competitive environment of the grain industry. Additionally, impacts on marketing strategies occur due to available choices in transportation modes reflecting the decision process of a warehouse or firm manager.

Modal choices traditionally available to managers are rail, from 1 to 25/26 cars, multiple truck/trailer configurations, barges and the various combinations of these modes. The competitive interaction between and amongst different transportation modes has contributed to the efficient movement of grain to market. The introduction of 110 car loading facilities, shuttle trains, unit trains and continued rail abandonment can be expected to have implications on the decision-process of warehouse managers when deciding how to transport grain.

At the same time, attempts in the literature and by the Army Corps of Engineers to understand and model the demand for transportation, especially for the river navigation component of the system, has proved difficult because of the need for rich data sets and appropriate conceptual shipper responses. Whether stated or revealed preference is utilized, discrete choice models require the full array of shipper choice sets. Attempts to survey and identify the alternatives available to shippers and the choice processes utilized by these shippers has proved difficult and challenging in recent attempts. Adequate specification of the supply and destination markets, the movements to be modeled and the characteristics of alternative modes is a necessary first step to understanding the industry and specifying the appropriate decision framework and structure for the demand function being determined. In this paper aggregate primary data are used to describe specific detail of the industry so that subsequent modeling efforts may be more fully developed and successful. The authors suggest that producing this intimate knowledge of the industry is the first and most critical step to having models that are both accurate and defendable in the policy arena.

The following will sequentially identify the source and coverage of the data, various characteristics of the grain industry of use in demand modeling and also changes over time. Some brief conclusions are then offered as space allows.

DATA GENERATION

This paper provides information on the storage, handling and transportation of wheat (barley, about 15% of the total, was also part of the survey but, due to space limitations, is not included here) produced in the 17 Eastern Washington grain producing counties during a three-year period ending June 30, 2001. These data were collected through a comprehensive survey of grain warehouses licensed through Washington State, during the 2000/2001 licensing period. Fifty of the 52 licensed firms were surveyed, covering 386 of the total 394 individually licensed houses.

Thirty-three (66 %) of the 50 firms surveyed responded with information related to wheat. The responding firms comprised 316 (81.9%) of the 386 houses surveyed. These responses covered 72.5 % of the total licensed grain storage capacity in Washington State. The response rate covered 80.2% of the total individual houses licensed in the state and 81.0% of the total number of houses (390) within the region. It also covered just lightly less than 90% of the volume shipped in the state.

As is shown in Table 1, the response rate within each of the 17 Eastern Washington counties ranged from 6.3% to 100.0% of the total licensed capacity in each county and from 59.2% to 100.0% of the houses within each county.

INDUSTRY FINDINGS

Population Characteristics

Grain storage facilities within the five counties of Whitman, Lincoln, Walla Walla, Adams and Grant represent 78.5% of the total storage capacity in the 15 county Eastern Washington region. Whitman County, with just over 53 million bushels of storage capacity, or 27.5%, has over one and a half times the capacity as the next largest county, Lincoln. Furthermore, Whitman, Lincoln and Walla Walla counties' total capacity exceeds the capacity of the remaining fourteen counties. Whitman and Walla Walla have direct river access while Lincoln and Adams counties do not.

Seasonality of Shipment

Grain is shipped from most houses throughout the course of the year. Average wheat shipments for all houses remained relatively constant from July through February, varying between 23.7% in September-October to 17.1% in January-February. Immediately prior to harvest, the percentage of wheat shipped dropped to 12.3% and 6.6% in March-April and May-June, respectively (Table 3).

Houses with bulk rail access (25 car shipments or higher) ship the largest percentage (27.1%) of their wheat, relative to all groups and all time periods, during September-October. Houses without bulk rail access were most consistent in their pattern of shipments throughout year, a difference of only 16.8% between their heaviest and lightest periods. Overall, shipments were concentrated in periods following harvest, tapering off until immediately prior to harvest. This latter phenomenon shows a tendency for houses to ship wheat from their location to other houses or river facilities in order to free up capacity in anticipation of grain receipts during harvest.

Destination of Washington Wheat

Although wheat is shipped from Eastern Washington houses to a number of destinations, it is predominantly shipped to Columbia River ocean terminals located between Portland, Oregon and Kalama, Washington. Of the wheat shipped from houses in Eastern Washington, 91.5% goes to Columbia River ocean terminals, 0.37% to Puget Sound terminals and 6.2% is shipped to other

houses as shown in Table 4. In-state and out-of-state flourmills receive 1.79% of wheat shipped from Eastern Washington warehouses. The percentage of wheat trans-shipped to other houses is slightly greater for up-country houses and lower with respect to Columbia River ocean terminals. Trans-shipping is movement of grain to another warehouse, from which it is then shipped to its final destination. The other houses receiving this grain are usually river facilities or houses with bulk rail access.

Modal Choices

Grain is shipped from houses to market destinations via rail, truck, and combinations of truck-barge and rail-barge. Warehouse managers were asked to identify percentages of their grain shipped by each of the modes currently available at their house. Information on rail modal shipments was collected according to whether the grain moved using single-car, 3-car, 25/26-car (bulk rail) or 52-car (unit train) shipments.

Truck-barge was the modal choice for 51.10% of wheat produced in Eastern Washington (Table 5). Additionally, 25/26-car rail accounts for 18.51% of wheat shipments from all houses. No respondents indicated grain being moved by anything greater than 25/26-car shipments at the time of the study.

Up-country houses shipped 48.83% of their wheat via truck-barge and 26.29% via bulk rail (Table 5). Houses without bulk rail access shipped over 60% via truck-barge while 13.41% was shipped via truck to other houses. Just over 29% of all houses have access to bulk rail. Those houses using bulk rail shipped over 73% of their grain via their bulk rail loading facilities and 21.93% via truck-barge. Minor amounts of wheat are moved using the remaining available modes.

Single-car and 3-car rail shipments accounted for only 1.63% of wheat shipped from all houses, 0.37% and 1.26% respectively. Rail-barge accounted for over 4% of wheat shipments from houses in Eastern Washington. Trucking wheat to final markets represents only 0.68% of wheat shipped from all houses, with up-country houses trucking the greatest percentage of wheat to its final destination at 1.01%.

As could be expected, the percentage of wheat shipped via bulk rail increases as the percentage of wheat shipped via truck-barge decreases, although a small amount of wheat is still shipped truck-barge even when the percentage of wheat moving bulk rail is over 80%, (Table 6). A very similar pattern exists when comparing the use of bulk rail by a house that heavily ships truck-barge. Houses that ship between 61% and 80% of their wheat via truck-barge still ship 6.74% of their wheat by bulk rail (7). Those grain shippers relying mostly on truck-barge, those shipping more than 80%, ship virtually no wheat (0.15%) via bulk rail.

Truck-barge is the predominant modal choice among houses. Over 83% of all responding houses used truck-barge as a modal choice. The next two most used modal choices were truck only and bulk rail, with approximately 30% of all houses using each mode. The least used modes were rail-barge, single car and three-car rail. Use of these modes ranged between 2.37% and 7.46% of all houses.

TRANSPORTATION RATES

The average truck, barge, and rail rates to the Columbia River ocean terminals for the shipment of wheat and barley are presented in Table 8. Rates to Columbia River ocean terminals are used for comparison since a large volume of wheat grown in Washington moves down the network of dams on the river system.

In general, the closer a county is to the river system, the greater the differential between rail rates for 1-25 cars and 26-109 cars (Table 8). This suggests that truck-barge rates create a downward

pressure on bulk rail rates. Okanogan, Stevens and Spokane counties had the highest 1-25 car rail rates ranging from just below 44 cents per bushel in Okanogan County to just above 37 cents per bushel in Spokane County. Franklin County had the lowest bulk rail rates for wheat, with 28.46 cents per bushel. Franklin County had the lowest combined truck-barge rate at 27.85 cents per bushel for wheat.

Changes Over Time

A previous study had been done in 1994, by these authors, of exactly the same industry and firms (4 & 5). This allowed inspection of any changes that may have occurred over that ten year time frame.

Several overall industry structure and characteristics have experienced significant change between 1993-1994 and 2001-2002 as illustrated in Table 9. The percent change is calculated using the 1993-1994 values as the base. As shown, there was a 36.6% reduction in the total number of firms and a 20.4% reduction in the number of licensed houses. Total storage capacity was 7.4% less in 2001-2002 and the average size of firms and houses increased 46.1% and 16.4% respectively.

The reduction in the number of firms and licensed houses suggests a certain degree of consolidation occurring over the 8-year period. The degree of consolidation is difficult to pinpoint because federally licensed houses within Washington are not included in these figures. Because houses have the option of licensing under the federal or state systems, but not both, the 30 fewer firms may or may not have exited or have been consolidated.

The 20.4% reduction in number of licensed houses is further explained by examining how the size distribution of houses was affected. Table 10 lists the number of houses by size category for both 1993-1994 and 2001-2002. There was almost a 25% reduction in the number of houses having capacities of less than 800,000 bushels. The number of smallest houses (less than 200,000 bushels) was reduced by a third. The number of houses with greater than 800,000 bushels of capacity increased 8.5%. This shift in the size distribution indicates a movement towards utilizing houses with larger capacities, possibly capturing economies of scale within the industry, with obvious geographic implications for transportation needs and utilization. Changes in the destination of grain shipments exhibited some variation over the time period. Over 10% more of the total grain was shipped to Columbia River ocean terminals in 2001-2002, reaching slightly over 87% in 2002. When the transshipment volume is added these destination could well account for almost 95% of the movement.

Shipment of grain by various modal choices demonstrated a shift between modes. Over 16% less grain was being moved via truck-barge in 2001-2002. While there were minor decreases in most other modal choices, the category for other modes showed a 15.05% increase in grain shipments.

CONCLUSIONS

It is apparent that surveys such as this conducted in this study of the grains industry in Washington are capable of producing information that can be useful in both aggregate and discrete choice models. The industry descriptions developed here help structure the discrete choice model investigation so that results are meaningful in the broader context.

For this industry it is evident that seasonality is very consistent over the ten years, which reflects the physical production characteristics, the foreign demand structure and the marketing alternatives available to the shippers. There are periods of varying demand and the shippers

respond to them, while considering the needs of their local producers for storage and handling space and financial timing needs.

The Columbia tidewater terminals have increased over time in importance and are by far the overriding destination, enough so that demand analysis can comfortably ignore the other marginal destination alternatives.

It is also clear that there is active modal competition (an elastic demand for each mode may potentially be found) and the differing attributes of barge and rail transportation are appealing to all the shippers at various points in time. Even those shippers that are predominantly rail shippers often use truck-barge to some extent over the year. While truck-barge decreased 16% over the last ten years, it still moves over 50% of the grain shipped out of the region.

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LIST OF TABLES AND FIGURES

Table 1. Response Rates by Total State Licensed Capacity

County	Licensed Capacity (bu)		Response Rate
	Total	Surveyed	
Garfield	1,610,000	1,610,000	100.0%
Klickitat	998,000	998,000	100.0%
Chelan	506,000	506,000	100.0%
Okanogan	412,000	412,000	100.0%
Yakima	266,000	266,000	100.0%
Kittitas	90,000	90,000	100.0%
Adams	22,051,000	19,331,000	87.7%
Columbia	9,497,000	7,888,000	83.1%
Douglas	6,890,000	5,690,000	82.6%
Stevens	307,000	247,000	80.5%
Whitman	53,139,000	40,566,000	76.3%
Lincoln	33,009,000	24,087,000	73.0%
Walla Walla	23,397,000	17,063,000	72.9%
Grant	19,978,000	12,678,000	63.5%
Spokane	11,440,000	6,534,000	57.1%
Franklin	4,340,000	1,642,000	37.8%
Benton	4,406,000	277,000	6.3%
Total	**186,060,000**	**139,885,000**	**72.5%**

Table 2. 2001/2002 Total Licensed Capacities of the 17 Eastern Washington Grain Producing Counties.

County	Total Licensed Capacity (bu)	Percent of Study Area Capacity	Average Capacity per House (bu)
Whitman	53,139,000	27.53%	462,078
Lincoln	33,009,000	17.10%	507,831
Walla Walla	23,397,000	12.12%	709,000
Adams	22,051,000	11.42%	490,022
Grant	19,978,000	10.35%	407,714
Spokane	11,440,000	5.93%	476,667
Columbia	9,497,000	4.92%	633,133
Douglas	6,890,000	3.57%	574,167
Benton	4,406,000	2.28%	1,101,500
Franklin	4,340,000	2.25%	868,000
Garfield	1,610,000	0.83%	268,333
Klickitat	998,000	0.52%	998,000
Chelan	506,000	0.26%	506,000
Okanogan	412,000	0.21%	412,000
Stevens	307,000	0.16%	102,333
Yakima	266,000	0.14%	88,667
Kittitas	90,000	0.05%	90,000
Total	**186,080,000**	**100.00%**	**-**

Table 3. Annual Wheat Shipments by Time-Period.

Time Period	Percent of Wheat Shipped			
	All	Up-Country[1]	Bulk Rail User	Bulk Rail Non-User
July-August	20.17%	18.01%	15.96%	21.62%
September-October	23.72%	25.19%	27.07%	22.56%
November-December	20.26%	20.46%	19.92%	20.37%
January-February	17.05%	15.77%	16.13%	17.37%
March-April	12.25%	12.95%	12.12%	12.29%
May-June	6.56%	8.31%	8.79%	5.78%
Total Houses Responding	286	273	86	200
Total Volume Shipped (bu)	100,309,851	67,906,805	25,739,836	74,570,015

[1]Excludes river facilities and transshipment means some double reporting occurs.

Table 4. Wheat Shipments by Destination

Destination	Percent of Wheat Shipped			
	All	Up-Country[1]	Bulk Rail User	Bulk Rail Non-User
Columbia River Ocean Terminals: Washington	62.42%	63.98%	56.59%	64.40%
Columbia River Ocean Terminals: Oregon	29.09%	27.30%	37.86%	26.12%
Puget Sound Terminals	0.37%	0.13%	0.68%	0.26%
Trans-Shipment to Other Houses	6.16%	6.42%	0.87%	7.95%
In-State Flour Mills	1.52%	1.67%	3.29%	0.92%
Out-of-State Flour Mills	0.27%	0.29%	0.65%	0.14%
Feedlots	0.03%	0.04%	0.06%	0.03%
Other	0.14%	0.16%	0.00%	0.19%
Total Houses Responding	291	275	86	205
Total Volume Shipped (bu)	101,881,249	92,643,621	25,739,836	76,141,413

[1]Excludes river facilities.

Table 5. Modes Used to Ship Wheat.

Mode	Percent of Wheat Shipped			
	All	Up-Country[1]	Bulk Rail User	Bulk Rail Non-User
Truck to Other Houses	10.68%	15.70%	2.62%	13.41%
Truck to Final Market	0.68%	1.01%	0.20%	0.84%
Truck-Barge	51.10%	48.83%	21.93%	60.96%
Rail-Barge	4.13%	5.73%	1.64%	4.98%
Single-Car-Rail	0.37%	0.54%	0.23%	0.41%
3-Car Rail	1.26%	1.87%	0.14%	1.64%
25/26 Car Rail	18.51%	26.29%	73.24%	-[1]
52-Car Rail	-	-	-	-
Other	13.26%	0.01%	-	17.75%
Total Houses Responding	300	286	88	212
Total Volume Shipped (bu)	136,402,000	115,860,000	51,919,000	84,483,000

[1]Excludes river facilities.
[2] An omission means that mode was not utilized to ship wheat.

Table 6. Percentages of Wheat Shipped via Truck-Barge by Percent of Wheat Shipped via 25/26 Car Rail.

Percent of Wheat Shipped via 25/26 Car Rail	Number of Houses Surveyed	Total Capacity Surveyed	Percent of Wheat Shipped via Truck-Barge
0 - 20	5	4,640,000	86.71%
21 - 40	6	2,183,000	49.18%
41 - 60	19	11,135,000	35.78%
61 - 80	18	7,940,000	25.06%
81 - 100	38	25,019,000	6.25%

Table 7. Percentages of Wheat Shipped via 25/26 Car Rail by Percent of Wheat Shipped via Truck-Barge.

Percent of Wheat Shipped via Truck-Barge	Number of Houses Surveyed	Total Capacity Surveyed	Percent of Wheat Shipped via 25/26 Car Rail
0 - 20	54	31,630,000	65.80%
21 - 40	17	6,066,000	24.64%
41 - 60	41	16,899,000	16.43%
61 - 80	16	5,877,000	6.74%
81 - 100	119	48,487,000	0.15%

Table 8. Wheat Rail and Truck-Barge Rates by County

	Cents per Bushel				
	Wheat[1]				
County	1-25 Car	26-109 Car	110-120 Car	Truck Rate	Barge Rate
Adams	31.73	28.76	24.71	12.39	18.09
Benton	29.90	-[3]	-	12.00	16.59
Chelan	37.21	34.26	-	30.00	16.59
Columbia	-	-	-	9.35	19.26
Douglas	-	-	-	29.19	16.59
Franklin	31.27	28.46	-	10.51	17.34
Grant	37.30	34.37	-	8.25	20.34
Kittitas	30.88	-	-	20.35	16.59
Klickitat	27.94	-	-	-	16.59
Garfield	-	-	-	-	15.87
Lincoln	36.29	33.39	-	20.96	18.09
Okanogan	43.91	40.97	-	-	16.59
Spokane	37.35	34.05	-	17.12	20.34
Stevens	42.91	-	-	39.77	18.09
Walla Walla	30.88	-	-	10.72	17.21
Whitman	35.88	32.94	-	13.68	20.69
Yakima	30.88	-	-	12.00	16.59

[1] Wheat rates are based on 3,400bu per 268,000lb GWOR car.
[2] An omission indicates no rate information was available.
3 The truck-barge combined rate is the competitive rate to the rail system.

Table 9. Number of Firms, Houses and Total and Average Capacities; 1993/1994 and 2001/2002.

	1993/1994	2001/2002	Percent Change
Number of Firms	82	52	-36.6%
Number of Houses	495	394	-20.4%
Total Storage Capacity	224,991,000	208,418,000	-7.4%
Average Capacity per Firm	2,743,793	4,008,038	46.1%
Average Capacity per House	454,527	528,980	16.4%

Table 10. Size Distribution of Houses; 1993/1994 and 2001/2002.

	Number of Houses						
	Licensed Capacity Classification						
Year	Less than 200,000	200,001-400,000	400,001-600,000	600,001-800,000	800,001-1,000,000	Greater than 1,000,001	Total
1993/1994	194	123	81	38	16	43	495
2001/2002	130	104	67	29	19	45	394
Percent Change	**-33.0%**	**-15.4%**	**-17.3%**	**-23.7%**	**18.8%**	**4.7%**	**-20.4%**

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The centerpiece of these efforts will be a suite of simulation models. This suite will include:

- A model for forecasting **international and domestic traffic flows** and how they may be affected by project improvements.
- A **regional traffic routing model** that will identify the annual quantities of commodities coming from various origin points and the routes used to satisfy forecasted demand at each destination.
- A **microscopic event model** that will generate routes for individual shipments from commodity origin to destination in order to evaluate non-structural and reliability measures.

As these models and other tools are finalized they will be available on the NETS web site:

http://www.corpsnets.us/toolbox.cfm

The NETS bookshelf contains the NETS body of knowledge in the form of final reports, models, and policy guidance. Documents are posted as they become available and can be accessed here:

http://www.corpsnets.us/bookshelf.cfm

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