WASHINGTON STATE UNIVERSITY

Economic Contributions of the Wheat Cluster to the Washington Economy

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Executive Summary

The Washington wheat cluster is composed of wheat producers; wheat transportation storage, and handling; and wheat processing. Roughly 2.3 million acres of land are put into wheat production annually in Washington. Over the last 15 years wheat production has averaged about 60 bushels per acre, but there can be significant year-to-year variation. The combination of yield and price volatility results in significant change in the value of Washington wheat production from year to year. In 2014 both wheat yields and prices were down significantly from their 15 year highs. This lead to total 2014 production value being at its lowest level in 5 years, coming in at $714.9 million. This is equal to the 15 year average value, but the average is weighed down by much lower values early in the period. Despite the 2014 outcome, wheat continues to be one of the top agricultural products produced in Washington.

Wheat processing in the state has declined, but the degree of decline is difficult to assess. Due to a limited number of firms and the associated data privacy issues that come with that, most Washington processing data is not disclosed. The Bureau of Labor Statistics (BLS) reports that 7 flour mills exist in Washington, but only two of those are known to be large commercial facilities. The remaining 5 appear to be smaller operations focusing on local or organic flours.

Total wheat cluster contributions to Washington's gross state product (GSP) came in at just under **$550 million dollars**. Wheat production accounted for $461.4 million of the total; transportation, storage, and handling accounted for another $50.4 million; and wheat processing generated an additional $37.5 million. The cluster supports nearly **8,200 jobs** in the state with wheat production; wheat transportation, storage, and handling; and wheat processing each accounting for 6,941, 778, and 448 respectively.

Total Contributions by Type and Industry Component

Industry	GSP* (000)	Jobs
Wheat Production	$461,441	6,941
Wheat Transportation	$50,478	778
Wheat processing	$37,534	448
Total	**$549,453**	**8,168**

*Gross State Product (GSP) and value added are synonymous in this document.

A significant portion of the total cluster contributions accrued in non-cluster industries. The value added in Washington's service sector, other agricultural activities, and wholesale and retail trade were $195.6 million, $119.1 million, and $57.1 million respectively. Of total wheat cluster contributions, 75% were generated in industries not directly involved in wheat production or processing, along with 71% of the employment contributions. As such, Washington's wheat sector is a fundamental contributor to Washington's overall economic vitality.

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Any errors in the document are the sole responsibility of the authors. Questions regarding any aspect of the document may be directed to the authors.

The Wheat Cluster and Its Role in Washington's Export Base

Washington has always had a robust agricultural sector that has historically played a large role in the state's economy. From 2000 to 2014 Washington agricultural exports rose from $1.3 billion to $3.8 billion or roughly 193% in 15 years. While there has been year-to-year variation, Washington wheat has consistently ranked in the top 4 commodities in terms of the state's agricultural export value.

Table 1 presents the ranking of Washington's top 6 agricultural exports, by total value, for the last several years. Note that wheat ranked as the number 1 export as recently as 2011, but slipped to number 4 in 2014. Despite the slip in relative ranking, however, wheat still accounted for over 13 percent of total agricultural export value in 2014 (USDA-ERS, 2015) .

Table 1: Washington Agricultural Exports Ranked by Value

Year	Wheat	Fruits, fresh	Fruits, processed	Other plant products*	Vegetables, processed	Dairy products
2000	1	2	3	4	5	6
2001	1	2	3	4	5	6
2002	1	2	3	4	5	6
2003	2	1	3	4	5	6
2004	1	2	3	4	5	6
2005	3	1	2	4	5	6
2006	3	1	2	4	5	6
2007	1	2	3	4	5	6
2008	1	2	3	4	5	6
2009	4	1	3	2	5	6
2010	3	1	2	4	5	6
2011	1	2	3	4	5	6
2012	3	1	2	4	5	6
2013	2	1	3	4	5	6
2014	4	1	3	2	5	6

*Includes sweeteners and products, other horticulture products, planting seeds, cocoa, coffee, and other processed foods.

Source: USDA Economic Research Service

The wheat cluster in Washington is composed of portions of three distinct industries: wheat production; wheat transportation, shipping, and handling; and wheat processing. A cluster in this sense is a combination of different industries with *distinct* outputs. Sectors, in an economic context, typically refer to one or more industries with a *similar* output or a very broad grouping of industries such as manufacturing or services. A grouping of hydroelectric, coal fired, and wind generation power plants may be referred to as an "energy sector". It would not represent a cluster since all the power plants generate a

similar output, namely electricity. Aircraft manufacturing is the largest economic sector in Washington accounting for about at 10% of total sales.

Direct[1] employment in the Washington wheat cluster accounted for about 2,170 jobs, and $57.6 million dollars in income to Washington state wheat farmers and their employees (see table 7). However, direct impacts only measure a portion of a cluster's overall contribution to the larger economy. Additional economic activity occurs as businesses and individuals in various industries (in our case the wheat cluster) do business with other entities in other sectors of the state economy. These are referred to as indirect effects when they result from business-to-business interactions (e.g., a wheat farm buys power from a local utility), and induced effects when they result from consumer-to-business interactions (e.g., a farm employee spends part of his/her farm generated income at the local movie theatre).

Accounting for both the indirect and induced affects generated by the activities of a specific sector results in what are called multiplier effects – the income earned in the wheat cluster is spent in other sectors and this results in not only the direct economic contribution, but an additional effect that is a multiple of the direct contribution. When wheat is exported money enters the economy via the wheat cluster but eventually spreads to the transportation sector, to the suppliers of inputs to wheat production, and to the other sectors interacting with the wheat cluster. Accounting for the economic activity contributed by an industry or cluster requires identifying not only the direct effects (sales, value added, income, and jobs within the cluster) but the spillover activity that results in other sectors.

Historic Wheat Production and Prices

Despite a small year-over-year increase in Washington wheat acres, total production was down significantly in 2014 compared to 2013. The production decline was the result of a large reduction in per acre wheat yields. For the 15 years preceding 2014 Washington wheat yields averaged about 60 bushels per acre (Table 2), but fell in 2014 to just 48.2 bushels per acre. The yield decline was coupled by the lowest wheat price in four years. As a result the value of Washington wheat production dropped precipitously from $1.2 billion in 2012 to $714.9 million in 2014[2], a 38% decline in just 2 years. Table 2 synthesizes this information, and Figure 1 shows the historic trend of Washington wheat production and prices going back to 2000.

[1] Direct contribution measures represent the portion of an industry, sector, or cluster that is funded by out-of-state buyers. A more lengthy discussion can be found on page 15.

[2] Production value is measured in sales but economic contributions, as will be discussed later, are always measured in terms of gross state product (GSP), or value added.

Table 2: Historic Washington Wheat Data*

Year	Acres harvested (000)	yield	Bushels Produced (000)	Price per bushel	Value Produced (000)
2000	2,420	68.1	164,880	$2.70	$443,369
2001	2,350	55.9	131,350	$3.23	$423,681
2002	2,390	54.3	129,770	$3.83	$496,873
2003	2,345	59.4	139,345	$3.75	$521,163
2004	2,275	63.1	143,500	$3.68	$524,493
2005	2,225	62.6	139,300	$3.32	$456,316
2006	2,225	62.1	138,250	$4.49	$617,865
2007	2,137	58.7	125,342	$7.58	$949,132
2008	2,225	52.7	118,790	$6.26	$745,163
2009	2,225	55.3	123,085	$4.85	$594,267
2010	2,285	64.7	147,890	$6.24	$925,265
2011	2,345	71.6	167,880	$6.80	$1,134,673
2012	2,165	66.6	144,125	$8.06	$1,162,209
2013	2,175	66.9	145,530	$6.97	$1,014,032
2014	2,250	48.2	108,460	$6.59	$714,858

* 2015 Data from NASS suggests that total value of wheat production declined even further in 2015, to $629.1 million.
Source: USDA NASS: Quick Stats

Figure 1: Washington Wheat Production

Source: USDA NASS

Over the 2000-2014 time period acres planted, yields, and thus the production of Washington wheat has remained relatively stable. Gains in the total value of Washington wheat over this timeframe have come from increased farm level prices. Between 2000 and

2014 prices rose about 144%. However, prices in 2013 and 2014 were significantly lower than their 2012 high of $8.06 per bushel.

Defining the Current Wheat Cluster

Defining an industrial Cluster is more of an art than a science. In fact, much of the original cluster theory started with Alfred Marshall in 1890 and a strict technical description of a cluster still does not exist today. However, the notion has gained prominence and much research has been conducted on clusters since the 1980's. The basic idea is that by locating in some proximity to competitors, suppliers, etc., some economies of scale are realized. Farms that locate near each other benefit from being able to utilize the same transportation networks, grain elevators, and a shared pool of skilled labor. All of this holds true with the Washington wheat cluster. For our purposes we classify the wheat cluster as being composed of three industries, or portions of those industries: 1) wheat farming, which we simply call production, 2) wheat transportation, storage, and handling, and 3) flour milling which we call wheat processing.

The interesting thing to note with Washington wheat is that the cluster is largely export oriented and while it provides a significant economic gain to the state, it is not primarily selling to Washington or even U.S. residents the way, for example, a health care cluster might. Indeed, the export orientation of agriculture is one of the primary ways Washington brings new money into the state's economy. Exports in this report are simply wheat and flour that are sold outside the state. We do not differentiate between domestic exports (wheat and flour being sold to other states in the U.S.) and foreign exports (wheat and flour that leave the country).

Wheat Production

Wheat production is characterized by the North American Industry Classification System (NAICS) as 111140 – Wheat farming, field, and seed production. Unfortunately getting a good picture of any industry at this level is difficult as most industrial data sets confine agriculture to the 3-digit, highly aggregated NAICS level 111 – Crop production. Using total sales and regional jobs-to-sales ratios, we estimate that roughly 1,962 jobs[3] are involved in wheat production including direct and multiplier effects (see table 11). If wheat production in Washington follows the standard staffing patterns as the more broadly defined NAICS crop production category, employment and earnings would breakdown as shown in table 3.

[3] Jobs, in this context, simply refer to the volume of people that work in the industry including full and part time employment as well as proprietors.

Table 3: Top Ten Occupations and Wages in Washington Crop Production

Occupation Code	Occupation Title	Percentage of employment	Average hourly earnings
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	49.8%	$11.58
11-9013	Farmers, Ranchers, and Other Agricultural Managers	19.8%	$32.74
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	0.4%	$13.41
45-2091	Agricultural Equipment Operators	4.9%	$16.47
45-1011	First-Line Supervisors of Farming, Fishing, and Forestry Workers	1.4%	$24.55
45-2041	Graders and Sorters, Agricultural Products	2.4%	$11.68
53-3032	Heavy and Tractor-Trailer Truck Drivers	1.9%	$20.29
37-3011	Landscaping and Grounds keeping Workers	0.8%	$13.51
53-7064	Packers and Packagers, Hand	0.4%	$11.51
45-2099	Agricultural Workers, All Other	0.3%	$16.28
Total		**82.1%**	**$17.45**

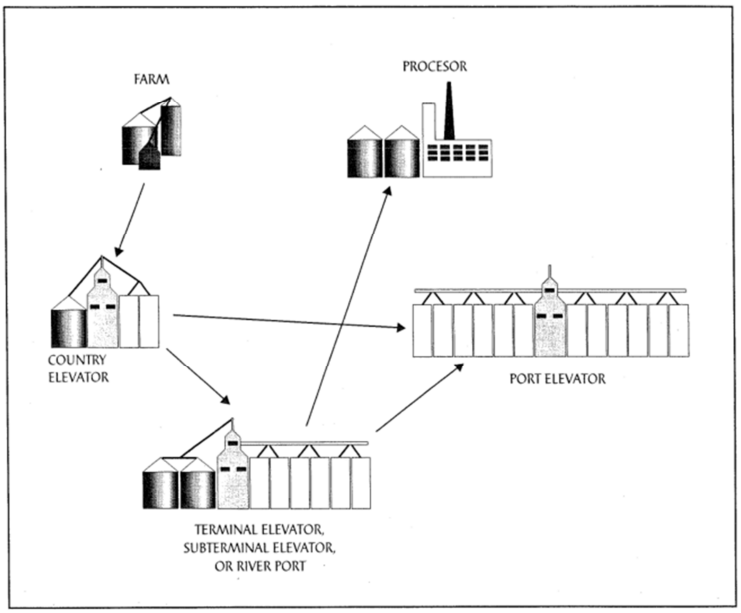
Source: Bureau of Labor Statistics Employment Projections Program

Wheat Transport, storage, and handling

The shipping of wheat can be extremely complex with multiple modes of transportation (e.g., rail, barge, truck) and multiple destinations (eg., processors, county elevators, river ports, etc.). Because of the inherent complexities and to avoid double counting transport activity we simplify our model of grain movement so that all wheat production goes to a county grain elevator from which it then travels to a port or terminal elevator. Terminal elevators will ship to either a processor or port elevator for export. Figure 2 diagrams our assumed model of grain flows.

Table 4 shows the industries included in the transportation, storage, and handling sector of the wheat cluster. It is important to note that this sector of the wheat cluster is part of the forward linkages of the production sector and a backward linkage of the processing sector. However, the transportation costs of exported goods are typically passed on to out-of-state buyers and a margin of their purchase price is directly attributable to the purchase of transportation services. This margin represents the direct contributions of the transportation, storage, and handling component of the cluster.

Figure 2: Washington Wheat Movements



Source: Washington State University Freight Policy Transportation Institute

Table 4: Description of the Transportation, Storage, and Handling Sector

NAICS Code	Industry Description
48211	Rail Transport
483211	Inland Water Freight Transport
4841	General Freight Trucking
4882	Support Activities for Rail Transport
4883	Support Activities for Water Transport
48849	Support Activities for Road Transport
49313	Farm Product Warehousing and Storage

The transportation sector of the wheat cluster is vital to its continued existence and the interactions between transportation and agriculture are clearly symbiotic. However, the production and processing components of the cluster use transportation as an input to their production processes. This is why the direct effects are much smaller for this segment of the cluster and the employment is nearly all captured in the indirect result of the cluster's existence.

Table 5 shows the destination and transportation mode used to move wheat in Washington. This information does not include processed grain (flour) shipments and any in-state shipments must be netted out of the direct effects since those transportation costs would be borne by the in-state mill.

Table 5. Washington Wheat Destinations and Transportation Mode

Destination	Percentage of Wheat	Quantity of Wheat (1000 bu)
Columbia River Ocean Elevators (Portland)	72.40%	97,843
Puget Sound Elevators	4.00%	5,406
Transhipment to Other Houses	12.40%	16,758
In-State Flour Mills	4.00%	5,406
Vancouver, Washington	3.20%	4,325
Other	4.00%	5,406
Total	**100.00%**	**135,142**

Transportation Mode	Percentage of Wheat	Quantity of Wheat (1000 bu)
Truck to Other Houses	14.5%	19,596
Truck to Final Market	2.9%	3,919
Truck - Barge	59.9%	80,950
Single Car Rail	0.5%	676
3 Car Rail	0.9%	1,216
25 or 26 Car Rail	21.0%	28,380
Other	0.3%	405
Total	**100.0%**	**135,142**

Source: Washington State University Freight Policy Transportation Institute

Note that the total volume of bushels transported in 2014 exceeded the number of bushels produced in 2014. This results from international demand exceeding Washington production in 2014 and represents a net reduction in grain inventories carried over from previous years.

Table 6 uses the data above to outline the transportation expenses and generate the total value of wheat transportation in the state. Based on our estimate of exports, (see Appendix B) 87.5% of the value of wheat transportation is being covered by the margin of cluster exports. Of the $40.69 million in wheat transportation that can be seen in the truck, water, and rail sub-total rows below, roughly $35.6 million will be captured as a direct injection of new income to the economy, i.e., roughly $35.6 million in transportation services resulted from exporting Washington wheat.

Table 6. Transportation and Storage Expenditures* ($millions)

Motor Freight Industry	Percentage of Wheat	Avg. Months	Quantity of Wheat (1000 bu)	Dollars Per bu	Dollars Per Month	Total ($millions)
Truck to Other Houses	14.5%	-	19,596	$0.06		$1.18
Truck to Final Market	2.9%	-	3,919	$0.71		$2.78
Truck to Barge	59.9%	-	80,950	$0.16		$12.95
Sub Total Truck Transportation	*77.3%*	*-*	*104,465*	*$0.16*		*$16.91*
Sub Total Water Transportation	*59.90%*	*-*	*80,950*	*$0.19*		*$15.38*
Single Car	0.5%	-	676	$0.49		$0.33
3-Car	0.9%	-	1,216	$0.45		$0.55
25 or 26 Car	21.0%	-	28,380	$0.26		$7.38
Other	0.3%	-	405	$0.35		$0.14
Sub Total Rail Transportation	*22.7%*	*-*	*30,677*	*$0.27*		*$8.40*
Sub Total Transportation	***-***	***-***	***216,092***	***$0.19***	***-***	***$40.69***
Storage		4	24,552		$0.05	$4.91
Handling	100%	-	131,298	$0.05		$6.56
Sub Total Storage and Handling						*$11.48*
Total Transportation, Storage and Handling						**$52.17**

* Figures in this table represent sales figures and should not be confused with value added or income measures.
Source: Washington State University Freight Policy Transportation Institute

Processing

Wheat processing is composed of NAICS 311211 – Flour Milling. According to the IMPLAN data roughly $52 million of the $190 million of flour milling sales went to exports in 2014. Flour milling in the state is well below average concentration levels, accounting for only 128 total jobs in the state, according to IMPLAN. Even at the national level this industry has been in decline, falling roughly 13% in terms of employment from 15,204 in 2000 to 13,199 in 2014[4]. Total employment in Washington is less certain. The small number of firms and data security concerns prevents Washington wheat processing data from being disclosed at the industry level. Employment was reported by the Bureau of Labor Statistics (BLS) in 2003, 2004, and 2014 at 154, 109, and 115 jobs respectively. The number of milling establishments in the state has fluctuated quite a bit as well[5], with 10 in 2003 to a low of 2 in 2007. BLS is currently reporting 7 in the state but it is likely that most of those are organic or specialty grain mills with low milling capacity. Only two commercially sized facilities exist in the state, both in Spokane County. According to the BLS data, milling employment in Washington has fallen slightly more than the U.S. average.

[4] Bureau of Labor Statistics: Quarterly Census of Employment and Wages.
[5] Norman Reed, Columbia magazine, Vol. 22 No. 4

The Washington Wheat Cluster's Economic Contributions

Economic contributions in an economy are often broken down into two primary components; the direct effects and the multiplier effects. In some situations, the multiplier effects are disaggregated further to show how the business and household income and expenditures ripple through the economy differently. Our objective is to simply show how the wheat cluster's export of wheat and flour corresponds to importing new income into the Washington economy. As this new income circulates throughout the state it generates additional rounds of income and spending, all the while supporting employment, until finally those new dollars leak out of the economy for purchases of imported goods and services.

A farmer that sells his grain out-of-state will receive income from the sale of his crop. That income will be used to pay his employees (see table 3), purchase new equipment and additional fuel and fertilizer for next year, perhaps pay for a land lease, and lastly to pay himself. His employees may use their income to pay rent, or purchase new school supplies for their children. Some of the farm and household expenditures will leak out of the economy. For example, new equipment may be imported from Illinois or purchases of household goods from Walmart would see a portion of the profits be returned to Arkansas, etc. The portion of farm and household expenditures that stay in the state would be paying the salaries of the employees at the parts store, retail outlets, grocery stores, etc..

We said in the last paragraph the farmer was selling his grain out-of-state. What about the grain bought or sold within the state? Those transactions do not represent new money entering the state and are recirculating dollars that already existed in the economy. Because local grain is being sold to a local mill it is enhancing cluster activity. However, the contributions of that transaction are captured through the sales of the flour mill. Counting the sale of the wheat to the flour mill, and the sale of flour to an industrial bakery would constitute a double counting of the value of the wheat.

As noted earlier, there are generally three types of economic contributions made by an economic sector to the larger overall economy. The first are the direct effects. These are the effects generated within the sector itself. If a wheat farmer employs a full time laborer that job constitutes a direct effect of the wheat cluster on the larger economy.

Another effect is called the indirect effect. This results from business-to-business transactions. Jobs that exist at the local implement dealer in response to satisfying the business needs of wheat farmers would be included in the indirect effect measure.

The last effect, the induced effect, comes from workers in the sector of interest seeking private goods and services for their personal lives using the income earned from working in the sector. For example, jobs in other sectors that are supported from wheat cluster

workers using their income to go to movies, buy groceries, or purchase a family vehicle constitute induced effects. Induced and indirect effects are often lumped together as multiplier effects – the measurement of economic activity in other sectors that results from the direct activity in the sector being studied.

Direct Effects

There are four ways to measure the effects of an economic sector: through sales of goods and services, income earned, employment supported, and lastly through value added in the economy (commonly referred to as gross state product). The local economy may be at the town, county, state, or even the national level. The analysis presented here measures the contribution of the wheat cluster to the Washington state economy.

The direct effects of the Washington wheat cluster stem from the production and processing industries as well as the portion of transportation, storage, and handling that is paid for by out-of-state wheat buyers. Total direct sales stemming from these portions of the cluster are $625.5 million in wheat exports, $47.1 million in transportation, storage, and handling, and $52.5 million in processed exports. We convert these sales figures into value added, income, and jobs in table 7. It is important to understand that the direct effects do not represent totals for the industries. As stated earlier the total sales value of 2014 wheat production in in the state was $714.9 million. The direct effects represent the value of exports only.[6] Similarly, direct jobs do not represent total employment in the industry but the share of total employment supported by the exports of the cluster.

Table 7: Direct Effects

Industry	Sales (000)	Value Added (000)	Income (000)	Jobs
Wheat Production	$625,500	$97,126	$40,665	1,904
Wheat Transportation	$47,079	$21,427	$14,670	231
Wheat Processing	$52,520	$4,686	$2,221	35
Direct Cluster Effects	**$725,099**	**$123,240**	**$57,555**	**2,170**

Source: IMPLAN 2014 data and author's calculations

Multiplier Effects

The multiplier effects are the additional sales, value added, income, and jobs that stem from the direct effects. Just as the direct effects are the initial "pebble in the pond" the multiplier effects are the additional "ripples" in the economy that stem from the direct shock. It is helpful at this point to see how those ripples spread through the economy. Table 8 shows where wheat producers spend their budgets in the production process.[7] Flour mills,

[6] Because the exact value of exports for wheat were based on estimates, a sensitivity analysis of this variable is conducted and the results may be seen in Appendix B.

[7] To see how budgets are translated to Production functions see Coupal et al. (1995)

transportation, storage and handling, households, and all other industries in the economy have expenditure patterns as well. When the cluster spends money on inputs the suppliers to the cluster also spend money on inputs, etc. The chain reaction of spending, known as multiplier effects, can be seen in the social accounting matrices (SAMs) discussed in Appendix A.

Table 8: Aggregated Annual Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price/Cost	Value/Cost per Acre
Gross Returns				
Wheat	48	bu	$6.59	$317.71
Variable Costs				
Seed:				***$18.54***
Wheat Seed	78	lb	$0.24	$18.54
Fertilizer:				***$82.74***
Nitrogen (dry)	99	lb	$0.66	$65.34
Phosphorous (dry)	17.5	lb	$0.53	$9.28
Potassium (dry)	15	lb	$0.38	$5.63
Sulfur (dry)	10	lb	$0.25	$2.50
Pesticides:				***$77.95***
Roundup	24	oz	$0.20	$4.80
Surfactant	6.4	oz	$0.09	$0.58
Ammonium Sulfate	1.7	lb	$0.22	$0.37
Axial	8.2	oz	$1.05	$8.61
Brox M	12	oz	$0.27	$3.24
Starane	8	oz	$1.73	$13.84
InPlace	5	oz	$0.28	$1.40
Ammonium Sulfate	3.2	oz	$0.07	$0.22
2,4-D	10	oz	$0.34	$3.40
Maverick	0.33	oz	$18.25	$6.02
Discover	3.2	oz	$1.26	$4.03
Osprey	4.75	oz	$4.10	$19.48
Starane+Salvo	22	oz	$0.50	$11.00
Excel 90	3.2	oz	$0.16	$0.51
Brox M	1.6	oz	$0.27	$0.43
Fungicides:				***$13.64***
Quilt	7	oz	$1.43	$10.01
Syltac Sticker	0.5	pt	$7.25	$3.63

Table 8: Aggregated Annual Wheat Enterprise Budget (Cont.)

Item	Quantity Per Acre	Unit	Price/Cost	Value/Cost per Acre
Machinery:				***$49.22***
Fuel	5.80	gal	$3.50	$20.31
Lubricants	1	acre	$2.99	$2.99
Machinery Repairs	1	acre	$9.01	$9.01
Machinery Labor	0.95	hour	$17.80	$16.91
Custom & Consultants:				***$11.59***
Rental Sprayer	1.5	acre	$1.93	$2.89
Custom Aerial	0.5	acre	$9.70	$4.85
Rental Ripper Shooter	1	acre	$2.75	$2.75
Rental Fertilizer Applicator	1	acre	$1.10	$1.10
Other:				***$18.92***
Crop insurance	1	acre	$18.92	$18.92
Overhead				***$8.74***
Operating Interest				***$5.98***
Total Variable Costs				**$287.30**
Variable Costs per Unit				$5.96
Fixed Costs:				
Machinery depreciation				$18.39
Machinery interest				$11.33
Machinery taxes, housing, insurance, licenses				$3.99
Summer Fallow Cost[1]				$43.81
Land Cost				$104.35
Land Taxes				$5.22
Total Fixed Costs				**$187.08**
Fixed Costs per Unit				$3.88
Total Costs per Acre				$474.37
Returns to Risk				**-$156.66**

Source: Washington State University School of Economic Sciences Enterprise Budgets

1. Summer fallow costs are not incurred by all producers in every year

The representative producers' budget above shows that farmers are spending money on inputs such as fertilizer, machinery, labor, etc. It is likely that the farmers are purchasing these inputs from a wholesale or retail outfit. That vendor will have a similar budget, paying the fertilizer manufacturer, a trucking company to ship the fertilizer from the production plant to the store, the stock crew and sales staff, utilities etc. A similar scenario would play out for each of the farmers input purchases. As such the ripple effects stemming from the cluster will affect non-cluster industries.

Table 9 shows the multiplier effects for the cluster and the major industry categories in the state. The multipliers create feedbacks in the cluster that are key to calculating total sales. For example, the direct effects of flour milling result in wages paid to households, the income to the households, in turn, result in increased demand for bread, which increases the demand for flour. Usually the multipliers on the clustered industries are smaller than the direct effects themselves, but the multipliers are what allow us to calculate total contributions.

Table 9: Multiplier Effects

Industry	Sales (000)	Value Added (000)	Income (000)	Jobs
Wheat Production	$19,184	$2,979	$1,247	58
Wheat Transportation	$29,155	$13,466	$8,736	125
Wheat Processing	$439	$39	$19	0
Agriculture	$154,415	$119,065	$104,542	2,708
Forestry	$147	$104	$96	1
Mining	$3,635	$1,228	$448	18
Utilities	$16,335	$7,406	$2,164	17
Construction	$13,972	$6,264	$4,781	79
Processed food	$5,471	$1,026	$626	47
Manufactures	$94,067	$16,836	$6,231	77
Wholesale and retail trade	$85,387	$57,108	$31,136	518
Services	$309,005	$174,141	$79,557	2,214
Miscellaneous	$18,776	$5,123	$3,936	135
Total	**$749,990**	**$404,786**	**$243,519**	**5,998**

Source: IMPLAN 2014 data and author's calculations

Total Contributions

Total contributions represent the sum of the direct and multiplier effects. Though sales are the underlying data used to conduct impact assessments it is not appropriate to use sales as an impact measure. This is because if we were to sum the total sales of every firm in the state's economy, it would greatly exceed the true output of the state. For example, total

2014 sales from all firms in Washington were reported by IMPLAN at over $766 billion dollars. However, Gross state product (GSP), which is the same as value added, was only $428.6 billion in 2014, as reported by IMPLAN. The discrepancy comes largely from the sales measure double counting firms' outputs. If a farmer sells wheat to a processor and the processor sells the flour to a baker, and the baker sells bread to a family, the value of the wheat is effectively counted 3 times. The value added or GSP measure avoids this double counting by only capturing the increased value of the goods at each step in the production process. In order to avoid double counting value added data is used to report industrial contributions.

Table 10 shows the value added contributions of the wheat cluster. The first column in the table shows the major industrial categories. The second shows the direct effects of production; transportation, storage, and handling; and processing exports. The third column shows the multiplier effects resulting from the initial purchases of the cluster, their vendors, and the purchases that stem from households as they spend their income in the state. The fourth and final column shows the total impact resulting from the cluster.

There is a great deal of discussion surrounding the topic of multipliers. The term has been so abused in the political arena that it tends to detract from the actual and original meaning. Nonetheless, there is value in understanding statewide multipliers, if understood correctly and in the context of the models used. To calculate the value added multiplier the total impact, $549.5 million in our case, is divided by the direct effects, $123.2 million. This implies that the new dollar of income generated by the wheat cluster is spent and re-spent in the economy (in our case the state), supporting and sustaining economic activity in every industry it passes through. On average each dollar entering the state through wheat cluster exports is spent and re-spent in the economy 4.46 times before it entirely leaks out of the economy through the purchase of imports.

Table 11 summarizes the total sales, value added, income, and jobs that stem from the cluster's activity. Direct cluster activity amounted to $725.1 million in sales, $123.2 million in value added (GSP), $57.6 million in personal income, and the support of roughly 2,170 jobs. The cluster's presence in the state resulted in total state sales of over $1.4billion, $549.5 million in value added (GSP), $315.7 million in household income, and approximately 8,170 jobs.

Table 10: Value Added Contributions (thousands)

Industry	Direct Effect	Multiplier Effects	Total Effect
Wheat Production	$97,126	$2,979	$100,105
Wheat Transportation	$21,427	$13,466	$34,894
Wheat Processing	$4,686	$39	$4,725
Agriculture	$0	$119,065	$119,065
Forestry	$0	$104	$104
Mining	$0	$1,228	$1,228
Utilities	$0	$7,406	$7,406
Construction	$0	$6,264	$6,264
Processed food	$0	$1,026	$1,026
Manufactures	$0	$16,836	$16,836
Wholesale and retail trade	$0	$57,108	$57,108
Services	$0	$195,568	$195,568
Miscellaneous	$0	$5,123	$5,123
Total	**$123,240**	**$426,213**	**$549,453**

Source: IMPLAN 2014 data and author's calculations

Table 11: Total (Direct and Multiplier) Contributions by Industry and Type

Industry	Sales (000)	Value Added (000)	Income (000)	Jobs
Wheat Production	$644,684	$100,105	$41,912	1,962
Wheat Transportation	$76,234	$34,894	$23,406	356
Wheat Processing	$52,959	$4,725	$2,239	35
Agriculture	$154,415	$119,065	$104,542	2,708
Forestry	$147	$104	$96	1
Mining	$3,635	$1,228	$448	18
Utilities	$16,335	$7,406	$2,164	17
Construction	$13,972	$6,264	$4,781	79
Processed food	$5,471	$1,026	$626	47
Manufactures	$94,067	$16,836	$6,231	77
Wholesale and retail trade	$85,387	$57,108	$31,136	518
Services	$309,005	$195,568	$94,228	2,214
Miscellaneous	$18,776	$5,123	$3,936	135
Total	**$1,475,089**	**$549,453**	**$315,744**	**8,168**

Source: IMPLAN 2014 data and author's calculations

Employment

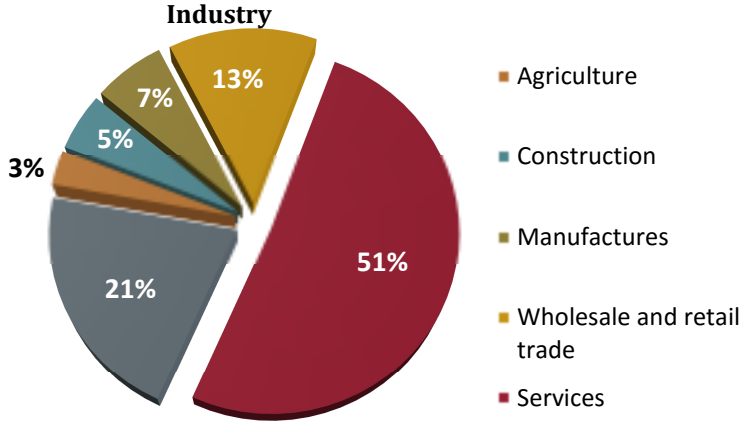
It has become popular to discuss industry employment in terms of *gross jobs*, which would be what is reported by the Bureau of Labor Statistics, and *base jobs*, which credit backward

linked industries to exporters. A barber shop, for example, is not likely exporting the bulk of its services. It serves local residents and circulates a portion of the money that already exists in the economy, but it does not bring new money into the economy. It is because of the exports of other industries that employment in the barber shop can be sustained. The barber shop's employees in this sense are supported by the export industries.

Using this type of framework we can outline the jobs employed in an industry and those supported by that same industry. All industries tend to have both export and resident serving components. An opera house preforms for local residents, but many tourists may attend the opera, and in that sense the opera is exporting (selling to non-residents) its services. An aircraft manufacturer may sell newly produced jetliners abroad, but when residents fly on those planes a portion of their ticket price went to purchase the plane. Thus, even an export oriented firm will have some of its employment serving local residents.

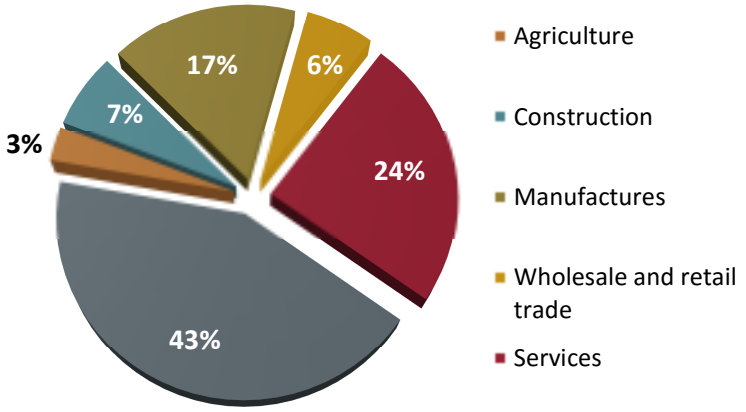
Figures 2 and 3 show the gross and base employment for the major industrial sectors in Washington. The differences in the graphs illustrate the difference between industry employment and industry *supported* employment. A slice of the pie in figure 2 represents the percent of total employment in the economy. The corresponding slice in figure 3 represents the percent of employment supported by the industry.

Figure 2: Gross Washington Employment by Industry



Source: IMPLAN 2014 data and author's calculations

Figure 2: Base Washington Employment by Industry



Source: IMPLAN 2014 data and author's calculations

Table 12 shows the same data as Figures 1 and 2 but gives a break out of the "other" category. One might wonder why the transportation and flour milling sectors are so much larger in terms of gross employment than was seen above. That is simply because the gross employment is showing total employment in the industry not wheat cluster employment only. Transportation for example ships far more than wheat, and would include local truckers and barge operators that don't ship any wheat.

Table 12: Gross vs. Base Employment

Industry	Gross Employment	Base Employment
Wheat Production	1,962	4,731
Transportation and Warehousing*	57,935	40,686
Flour Milling	128	381
Agriculture	123,497	120,502
Forestry	6,904	5,839
Mining	8,780	5,658
Utilities	12,707	8,862
Construction	209,629	272,540
Processed food	50,620	123,287
Manufactures	260,453	677,942
Wholesale and retail trade	537,911	248,825
Services	2,011,194	947,081
Miscellaneous	775,446	325,741
Households	0	714,305
State and Local Government	0	560,783
Total	**4,057,165**	**4,057,165**

*This sector represents all transportation not only wheat cluster transportation.
Source: IMPLAN 2014 data and author's calculations

Conclusions

The wheat cluster in Washington reaches far beyond the borders of the farms and croplands and remains one of the predominate agricultural sectors in the state. In 2014 it attracted roughly $123 million new dollars into the state. That new money was spent and re-spent generating a total of over a half a billion dollars ($549.5 million) in added economic value for the state's economy.

Direct employment in the cluster amounted to over 2,100 jobs, however, once the multiplier effects were included total employment contributions rose to over 8,000, with the agricultural and service sectors seeing the largest shares of employment from the cluster. Wholesale and retail trade grew significantly as well at roughly 500 jobs.

A significant portion of the Washington economy, and the agricultural sector specifically, is dependent on the wheat cluster. Further, these economic benefits are concentrated in Eastern Washington and point to the importance of the wheat cluster in rural Eastern Washington communities.

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Appendix A: A primer on Input-Output Accounts and Social Accounting Matrices

The Basic Input-Output model

Before jumping into the Social Accounting Matrices (SAMs) it will be helpful to discuss a system of accounts embedded in the SAM. The system of accounts known as Input-Output (I-O) represents an economist's version of double-entry book keeping for industries. Figure A.1 below shows a simplified version of an I-O matrix with just a hand full of industries.

Figure A.1: Aggregated form Input-Output Matrix

		Producers as Consumers						**Final Demand**			
		Agric.	Min.	Const.	Manuf.	Services	Other	Households	Investment	Government	Net exports
Producers	Agric.										
	Min.										
	Const.										
	Manuf.										
	Services										
	Other										
Value Added	Labor							Gross Domestic Product			
	Returns to Capital										
	Taxes										

Reading down a column of this table shows you what inputs an industry is buying in order to produce their output. If we look at the Agriculture column, they may buy seed from themselves, fertilizer and farm equipment from the manufacturing sector, and legal and accounting services from the service sector. Payments to their employee are captured in the "Labor" row, they receive the returns to the capital that they own, and they pay taxes to the government. Reading across a row tells us where an industry's income originates. Sticking with agriculture, they sell seed to others in the agricultural sector; their crops may be sold to processing plants in the manufacturing sector, or perhaps directly to consumers. A portion of a household's expenditures will go to buying agricultural goods, and even government may purchase agricultural goods. Lastly, the agricultural industry will sell its output abroad via the "Net exports" column.

Summing all of the labor, capital, and tax payments for all industries gives the sum of all value added and will equal the Gross Domestic Product (GDP) of the region. Similarly summing all of the expenditures of households, government, investment, and net exports

yields the GDP of the region. These two methods of calculating GDP are known as the Income and Expenditure approaches, respectively, and they represent a check for ensuring all accounts balance. It is through the I-O system that we are able to trace the dollars through the economy and calculate multiplier effects.

The Social Accounting Matrix

The social Accounting Matrices (SAMs) are a bit more robust than the I-O tables. SAMs can be extremely detailed, embedding commodity purchases, occupations staffing matrices, detailed government accounts, and even demographic information. The social accounting framework used for this report was derived from the IMPLAN data software and has a structure as follows.

		A	C	F	INST	T(FT)	T(DT)
		1	2	3	4	5	6
A	1		MAKE				
C	2	USE			IUSE	CEXPRT	CEXPRT
F	3	FD				FEXPRT	FEXPRT
INST	4		IMAKE	FS	TRNSFR	IEXPRT	IEXPRT
T(FT)	5		CIMPRT	FIMPRT	IIMPRT	TRNSHP	TRNSHP
T(DT)	6		CIMPRT	FIMPRT	IIMPRT	TRNSHP	TRNSHP

The interpretation of this matrix is slightly different than that of the I-O model. Here the rows and columns match so that the entire matrix is square. In this case A represents the set of industries, C is the set of commodities, F is the set of factors used in production (these are synonymous with the value added components of the I-O table), INST represents institutions such as households, governments, and other non-industry organizations, T(FT) represents foreign trade and T(DT) represents U.S. or domestic trade.

Segments of the SAM that are gray represent regions where there are no transactions. For example, in the SAM industries do not buy from other industries, they buy commodities and this shows up as the “USE” table. Industries also purchase land, labor, capital, and government services. Those purchases are displayed in the “FD” or factor demand segment of the SAM. Industry output is reported in the “MAKE” matrix, though institutions such as government can produce commodities as well. State run power facilities are a good example of institutions producing a commodity. Commodities may also be imported from other parts of the U.S. and from abroad via the CIMPRT tables. Institutions also buy commodities and transfer wealth amongst themselves. Those activities are captured in the “IUSE” and “TRNSFR” tables. Factors available for productive use are supplied by institutions, “FS”, and may be imported in some cases “FIMPRT”. The “FEXPRT” and “IEXPRT” represent factors of production and institutional output that are sold outside of the regional economy.

Appendix B: Sensitivity Analysis

The sensitivity analysis adjusts the percentage of wheat exported. Data constraints on commodity exports at the state level are extremely difficult to overcome and often we need to rely on industry knowledge rather than hard and fast data. It is well known that Washington exports significant portions of its wheat and estimates hover around 85%-90%. For the purposes of our analysis we assumed 87.5% of wheat was exported. We test our results against this figure by adjusting it from a low of roughly 79% to a high of just over 96%. Even though the 87.5% is a fair estimate, after adjusting that figure 10% in either direction the value added contributions are still significant ranging between $495 million to $604 million.

Table B.1: Sensitivity of Value Added from changes in Direct Effects ('000)

Industry	-10%	-5%	Base Case	5%	10%
% of Washington Wheat Exported	78.8%	83.1%	87.5%	91.9%	96.3%
Total Direct Effects	$110,916	$117,078	$123,240	$129,402	$135,564
Total Multiplier Effects	$383,592	$404,902	$426,213	$447,524	$468,834
Total	$494,508	$521,980	$549,453	$576,926	$604,398

Table B.2 shows employment contributions adjusting similarly from a low of 7,351 jobs to 8,985. Even with the swing in employment the significance of the cluster is still clear supporting far more jobs than are directly employed in the cluster.

Table B.2: Sensitivity of Employment from changes in Direct Effects

Industry	-10%	-5%	Base Case	5%	10%
% of Washington Wheat Exported	79%	83%	88%	92%	96%
Total Direct Effects	1,953	2,061	2,170	2,278	2,387
Total Multiplier Effects	5,399	5,698	5,998	6,298	6,598
Total	7,351	7,760	8,168	8,577	8,985