AEM
ASSOCIATION OF
EQUIPMENT MANUFACTURERS

The Economic Footprint of the Agricultural Equipment Industry

Report to the Association of Equipment Manufacturers

Inforum

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Table of Contents

Executive Summary 3
Recent Developments in the Agriculture Machinery and Equipment Industry 7
The Economic Footprint of Agricultural Equipment 12
Occupations within the Agricultural Equipment Industry 20
Regional Agricultural Equipment Manufacturing Clusters 23
The Importance of Agriculture Mechanization 25
References 28
Appendix: Data Sources 29

Tables

Table E-1: Agricultural Machinery and Equipment Supply 5
Table 1: Recent Developments in Agricultural Machinery and Equipment Manufacturing 8
Table 2: Supply of Agricultural Machinery and Equipment, 2011 14
Table 3: U.S. Manufacturing Revenues, 2011 15
Table 4: U.S. Manufacturing Employment, 2011 17
Table 5: U.S. Wholesale Employment, 2011 18
Table 6: Occupations and Wages within the Agricultural Machinery and Equipment Manufacturing Industry, 2011 21
Table 7: Occupations and Wages within the Agricultural Equipment Wholesaling Industry, 2011 22
Table 8: State Ranking, Employment Agricultural Equipment Manufacturing, 2011 24
Table 9: State Ranking, Employment Agricultural Equipment Wholesalers, 2011 24

Figures

Figure 1: Domestic Demand, Output, Exports, and Imports in Agricultural Machinery and Equipment Manufacturing 8
Figure 2: Value of Domestic Manufacturers Shipments and Nominal GDP 9
Figure 3: Relative Export Growth Across Selected Commodities, 2001-2011 9
Figure 4: Relative Growth in Employment for Total Economy, Durable Goods Manufacturing, and Agricultural Equipment Manufacturing 10
Figure 5: Agricultural Prices Relative to the General Price Level 11
Figure 6: Net Farm Income and Agricultural Equipment Investment Spending 11
Figure 7: Indexes for Agricultural and Economy-Wide Labor Productivity Growth in the United States 26

Executive Summary

Over the past century, agricultural production in the United States has increased by more than 500 percent. At the same time, the workforce share of agricultural employment fell from 30 percent to less than 2 percent. That productivity explosion was a key factor in overall U.S. economic growth and development, and agriculture machinery and equipment have been a strong driver behind this progress. Agricultural productivity growth releases labor and land resources for growth in other sectors such as manufacturing, transportation and housing. According to the Agriculture Council of America, in the 1960s one U.S. farmer supplied food for 25.8 persons in the U.S. and in other countries. Today, it estimates, a single U.S. farmer supplies food for 144 people in the U.S. and abroad.[1]

The U.S. agricultural machinery and equipment manufacturing industry has been central to this progress for over a century.[2] Agricultural mechanization has been crucial, allowing for more efficient use of labor, land, energy, and water and enabling farmers to better integrate production processes and manage larger areas of land. Today, new equipment includes electronically-controlled systems which enable precision planning, fertilizer application, and harvesting.

The agricultural equipment industry is not just defined as the factories assembling tractors and harvesters. It also includes a network of researchers and engineers, specialized suppliers, equipment distributors and other service providers, and downstream customers. This cluster of manufacturers, distributors and farmers collaborate and compete with each other for the advancement of U.S. and global food production.

This report describes the many-sided economic impacts of the manufacturing, distribution, and use of agricultural equipment and machinery. The first section considers recent economic developments within the sector, which showed a relatively quicker recovery from recession compared to the rest of the economy. The second section describes the U.S. economic “footprint” of the industry including the economic supply, income, and jobs created by it. Sections three and four look into industry employment in more detail to provide an occupational and regional perspective. The final section aims to illuminate why the most important economic impact of agricultural equipment is its role in supporting sustained productivity growth in agriculture.

[1] Agriculture Council of America: http://www.agday.org/media/factsheet.php

[2] For this exercise, we have defined agricultural equipment manufacturing as NAICS industry 33311 (Agricultural implements) which encompasses both industry 333111 (Agricultural equipment) and 333112 (Lawn and garden equipment). Where available and relevant, we include figures for both industries. However, except where specifically distinguished, we use the term agricultural machinery and equipment manufacture to include both industries. We also consider NAICS sector 42381 (Merchant wholesalers of agricultural equipment) as an important part of the industry cluster.

The conclusions of this study include:

- U.S. domestic sales of agricultural machinery and equipment rose from about $20 billion in 1999 to $38 billion in 2012. Since 1998 and through 2012, U.S. exports of agricultural equipment have grown relatively quickly, more than doubling from about $4 billion to $8.7 billion. In the ten years leading up to 2008, paced by high crop prices and buoyant demand in both domestic and export markets, U.S.-based agricultural equipment manufacturing enjoyed a steady and relatively rapid rise in production. The Great Recession affected the industry, as equipment export revenue contracted by 27 percent in 2009, and domestic revenue fell by 8 percent. In contrast to the general U.S. economy, however, agricultural equipment manufacturing bounced back rather quickly, seeing solid growth in both exports and domestic demand from 2010 onward. Unlike many other industries, employment in the agricultural equipment sectors recovered to pre-recession levels by 2012.

- The strength of agricultural machinery demand over the last 15 years is directly related to the industry's central role in enhancing global farm labor and land productivity growth. Growing middle classes in developing countries are demanding an expanding range of food choices, especially for grain-intensive meat products. This demand is pushing up the prices for food commodities around the world. Higher farm product prices increase the cash flow to farmers worldwide and provides them with both the motive and the means to make new investments in equipment. As the most recent technological advancements to equipment are proving particularly useful for enhancing the labor and land yields for grains, the industry is in a great position to generate more income and jobs within the American economy.

- Table E-1 provides a profile of the agricultural machinery and equipment industry for 2011. Equipment manufacturers generated $15.8 billion in domestic value added (GDP). The economic footprint, however, exceeds that the direct manufacturing sector. It includes downstream distributors and the myriad of activities in the supply chains of both the manufacturers and distributors. The downstream distribution sector (including transportation) produced $12.3 billion of value added. Upstream supply activities for both the agricultural equipment manufacturing and distribution generated roughly another $22.8 billion in domestic value. Taken together, the total value added of these other activities are more than twice the size of the equipment manufacturing industry. The total amount contributed to GDP, at $51.0 billion, is about the same contribution as the entire state of Alaska.

- The jobs associated with the agriculture equipment sector include 78,200 in manufacturing, 117,200 in downstream businesses such as dealers and distributors, and another 181,200 in upstream suppliers. For every agricultural equipment manufacturing job, there are 3.8 other jobs in upstream suppliers or downstream distribution and services. The total of roughly 376,700 jobs within the industry cluster is about the same as the population of Arlington, Texas.

- These jobs are highly paid. The final column of Table E-1 shows that in 2011, the average compensation, including benefits, at agricultural and garden equipment manufacturers is almost $65,700 per job. Compensation at distributors and retailers was about $60,100 per job. Since it includes both high-value manufacturing and business services, the average salary in the agricultural equipment indirect supply chain was almost $72,500 per worker. Overall, the 376,700 workers in the agricultural equipment cluster earned an average of $67,210 per worker, which is 15 percent larger than the economy-wide average wage, which was $58,700.

Table E-1: **Agricultural Machinery and Equipment Supply**
(Millions of Dollars)

	Value Added	Employment (jobs)	Labor Compensation ($ per job)
Total Domestic Associated Supply	50,979	376,708	67,210
Direct Manufacturing	15,836	78,225	65,653
Downstream Direct Services	12,315	117,234	60,142
Indirect Upstream Supply	22,829	181,249	72,453
Manufacturing Multiplier	2.2	3.8	
Total GDP, Employment and Avg Compensation	15,075,000	138,002,000	58,667
Percent share/Compensation multiplier	0.338	0.273	1.15

Sources: U.S. BEA Industry Accounts, U.S. BLS Employment, Hours, and Earnings, U.S. Census International Trade Data, Inforum Estimates

- America benefits greatly from keeping this high-tech sector at home. The jobs within the agricultural equipment manufacturing and distribution sectors span the skill spectrum, and there are ample high-paying middle class occupations. Manufacturing jobs include engineers, assemblers, machinists, mechanics, and technical salespeople. Distribution offers plenty of financial, administrative, and sales positions as well as technicians and mechanics.

- Industries such as equipment manufacturing are often clustered in certain areas. A regional cluster is a geographic concentration of interconnected companies, specialized suppliers, associated service providers, and related institutions in a particular field. For example, almost 30 percent of agricultural equipment manufacturing is consolidated across the three contiguous states of Illinois, Wisconsin, and Iowa. Clusters stay ahead in the global economy through active connections among research, development, and operating assets across small firms, multinationals corporations, universities and government agencies.

- Because it helped produce dramatic gains in both land and labor productivity, the mechanization of agriculture was one of the most important economic developments of the 20th century. To meet the challenge of food supply for the 21st century, agricultural equipment manufacturers and distributors have a full research and development agenda. Working with farm customers and with scientists and engineers in other fields, equipment manufacturers continue to develop innovative and sometimes eye-popping technology. New applications of navigation, computing, information, and sensing technology is driving "precision agriculture," which is greatly improving the management of inputs and the collection of outputs. Information and sensor technologies are driving better tracking and assessment of food sources and conditions. It is easy to envision a greater application of unmanned equipment and new materials that will continue to push agriculture productivity through the next century.

- The contribution of the agricultural machinery and equipment industry does not stop with product technology. Machinery manufacturers were pioneers of modern management and process techniques such as lean manufacturing, six sigma, computer-aided design (CAD), computer-aided manufacturing (CAM), and rapid prototyping. They continue to push the envelope for these technologies, and they will be in the vanguard for 3D manufacturing, materials innovation, and automated design processes. Moreover, the successful application of these advanced production technologies in machinery manufacturing spills over to other sectors, even areas that are seemingly unrelated to manufacturing such as health care and construction.

- Producing more food with less resources has contributed greatly to increases in nutrition, health, and overall living standards across the world. As the global community prepares for a population between 9 and 10 billion by 2050, the importance of sustained agricultural productivity growth will intensify. The convergence of high worldwide food demand, liberalized trade, and rapid technological change provides an important opportunity to enhance American leadership not just in agriculture as a whole, but more specifically in the supporting agriculture equipment cluster. The agricultural equipment industry plays an important role in stimulating economic growth by supporting the agricultural industry, increasing U.S. exports, inventing new and important technology, and creating high-quality jobs. Agriculture policy needs to be determined with this broader perspective in mind.

Recent Developments in the Agriculture Machinery and Equipment Industry

The U.S. agricultural machinery and equipment manufacturing industry is the center of an important "cluster" within the overall economy.[3] An industry cluster is a network of interconnected companies, specialized suppliers, associated service providers, downstream customers, and related institutions in a particular field. Even when they might be competing with each other, these actors are interconnected through their suppliers, customers and employees. Well-performing clusters are characterized by collaboration as well as competition that increases the productivity of the companies and employees within them, which, in turn, contribute to overall economic growth and development. This report describes the many-sided economic impacts of the manufacture, distribution, and use of agricultural equipment and machinery.

The U.S. agricultural machinery industry has shown sustained growth over the past decade and a half, as can be seen by the recent evolution of supply, demand, and foreign trade in the sector since 1998 (Figure 1 and Table 1).[4] Paced by both domestic demand and exports, U.S.-based agricultural machinery and equipment manufacturing output increased from about $20 billion in 1999 to $37 billion in 2012. U.S. manufacturers' export revenue has more than doubled from about $4.0 billion to $8.7 billion. The sustained growth is also evident when we look at the index of agricultural equipment shipments value versus the index of nominal GDP (Figure 2). Revenue almost doubled from 1999 through 2013, while GDP grew by just 75 percent.

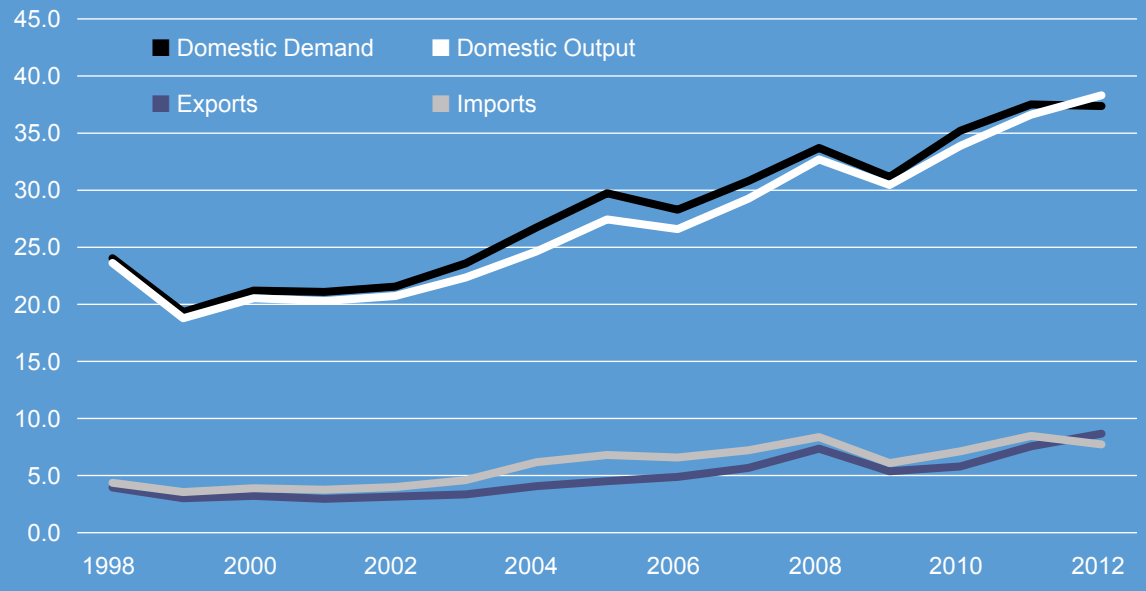
The graph also shows that compared to the general economy, U.S. agricultural equipment manufacturing recovered relatively more quickly and more strongly from the "Great Recession." In 2009, domestic output fell by 8 percent. However, from 2009 to 2013, the value of agricultural equipment shipments expanded by over 31 percent, compared to the overall economy which increased by only 17 percent. While the agricultural equipment industry's share of the total economy is only 0.34 percent, it actually contributed about 1.1 percent (0.03 percentage points of growth) and 2.1 percent (0.04) of total GDP growth in 2010 and 2011, respectively.

Agricultural equipment exports have also punched above their weight over the past decade. Figure 3 shows that from 2001 to 2011, agricultural export value grew by 9.8 percent per year on average. This rate exceeds the growth of exports of construction equipment (8.1 percent), machinery in general (8.4 percent) and total merchandise exports (6.1 percent). Since 1998, U.S. exports of agricultural equipment have more than doubled from about $4.0 billion to $8.7 billion. In 2009, export revenue fell by 27 percent but bounced back with solid growth in 2010 and 2011.

[3] For this exercise, we have defined agricultural equipment manufacturing as NAICS industry 33311 (Agricultural implements) which encompasses both industry 333111 (Agricultural equipment) and 333112 (Lawn and garden equipment). Where available and relevant, we include figures for both industries. However, except where specifically distinguished, we use the term agricultural machinery and equipment manufacture to include both industries. We also consider NAICS sector 42381 (Merchant wholesalers of agricultural equipment) as an important part of the industry cluster.

[4] Domestic supply is the manufacturers' value of production, domestic demand is the sum of supply and imports minus exports.

Figure 1: **Domestic Demand, Output, Exports, and Imports in Agricultural Machinery and Equipment Manufacturing** (Billions of Dollars)



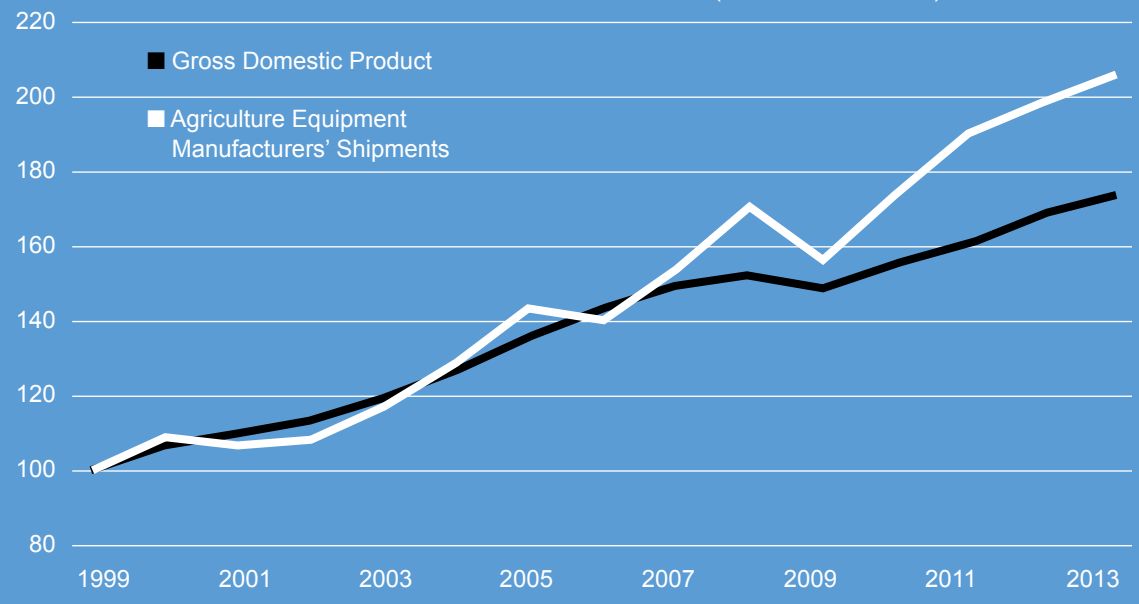
Sources: U.S. BEA Industry Accounts, U.S. Census International Trade Data and Inforum Estimates

Table 1: **Recent Developments in Agricultural Machinery and Equipment Manufacturing**

Billions of Dollars	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Domestic Demand	30.8	33.7	31.2	35.2	37.5	37.4
Exports	5.7	7.4	5.4	5.8	7.6	8.7
Output	29.3	32.7	30.5	33.9	36.6	38.3
Imports	7.2	8.4	6.1	7.1	8.5	7.7
Employment	78.6	83.0	73.9	73.0	78.3	82.8
Percent Change	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Domestic Demand	8.6	8.6	-8.6	13.2	6.9	1.9
Exports	16.1	29.8	-26.9	7.8	30.5	14.6
Output	9.7	10.9	-7.9	11.4	8.5	4.7
Imports	9.7	16.0	-27.3	16.9	19.1	-8.8
Employment	-0.2	5.6	-11.0	-1.1	7.2	5.7

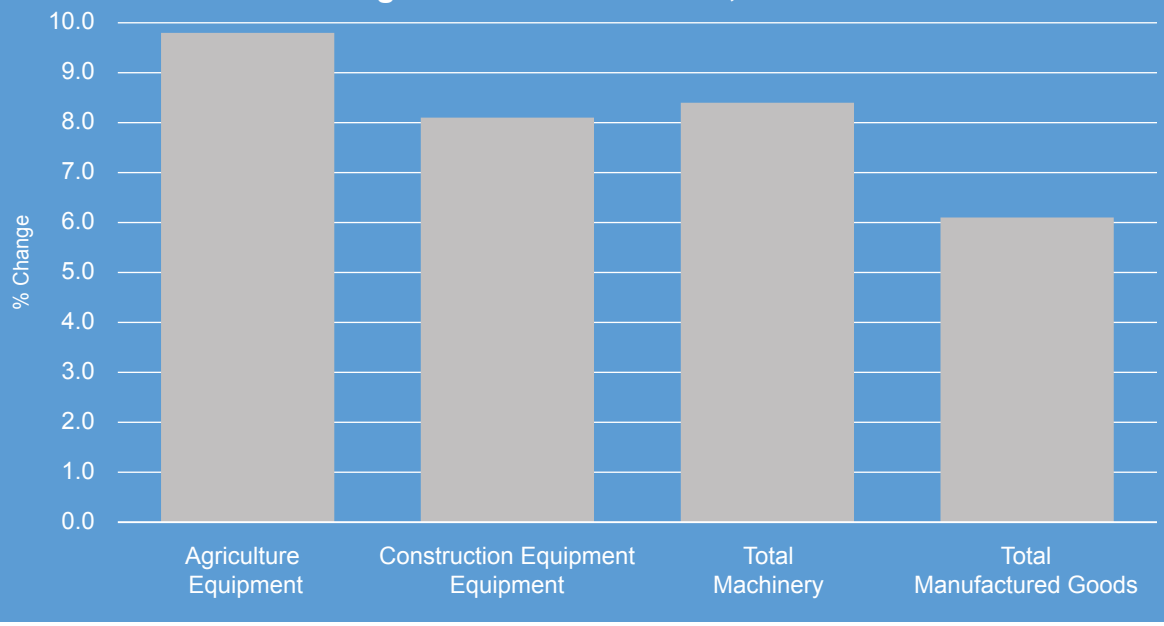
Sources: U.S. BEA Industry Accounts, U.S. BLS Employment, Hours, and Earnings, U.S. Census International Trade Data, Inforum Estimates

Figure 2: **Value of Domestic Manufacturers Shipments and Nominal Gross Domestic Product** (Index 100 in 1999)



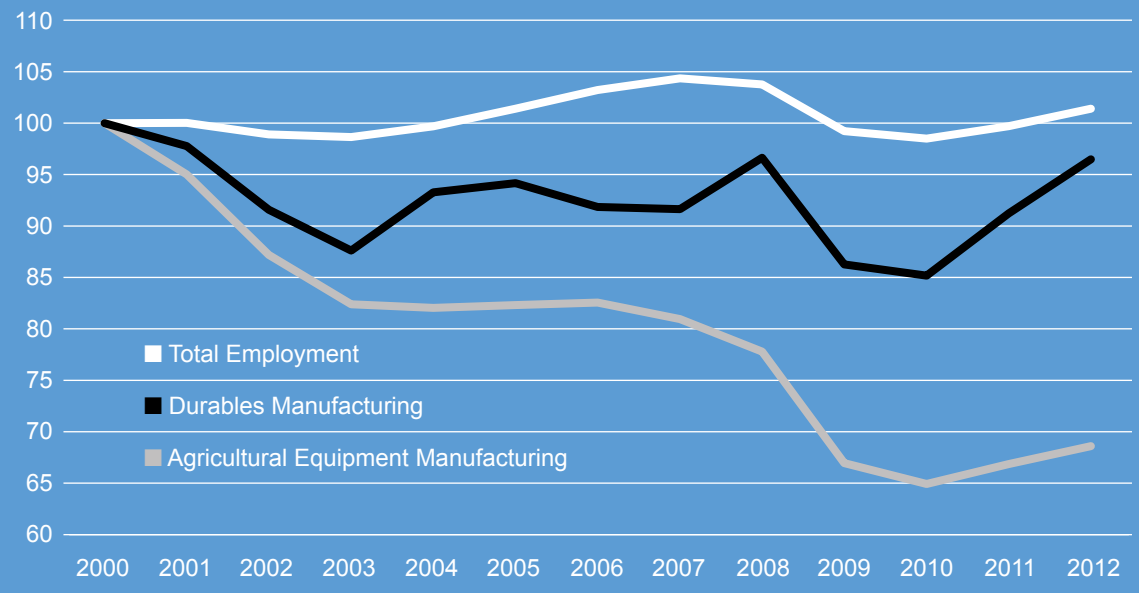
Sources: U.S. Census Bureau, U.S. Bureau of Economic Analysis, Inforum Estimates

Figure 3: **Relative Export Growth Across Selected Commodities Average Annual Growth Rate, 2001-2011**



Sources: U.S. Census International Trade Data, Inforum Estimates

Figure 4: **Relative Growth in Employment for Total Economy, Durable Goods Manufacturing, and Agricultural Equipment Manufacturing** (2000 = 100)



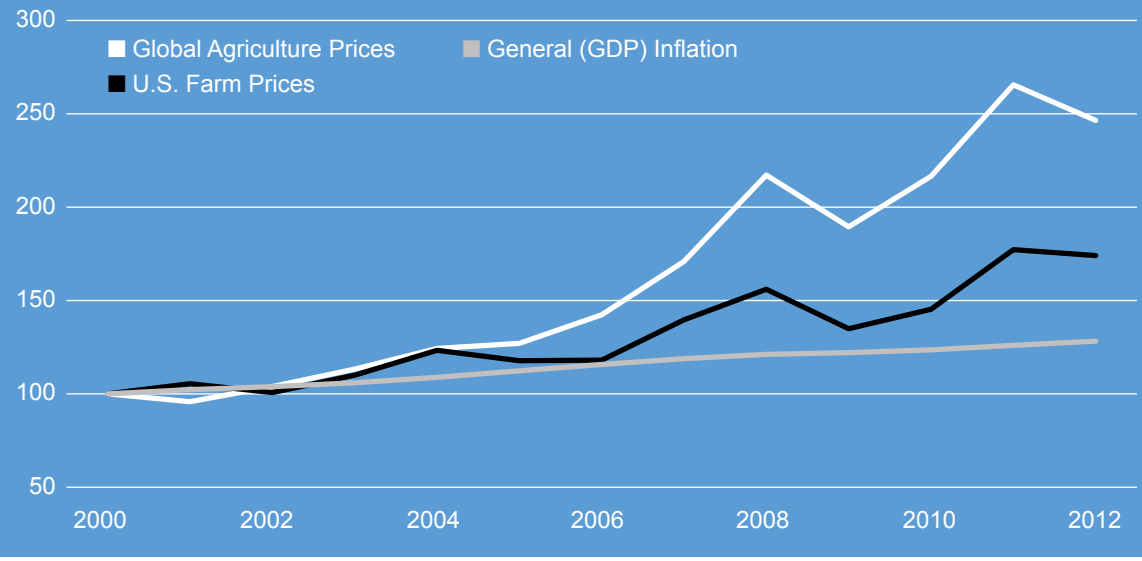
Source: U.S. Bureau of Labor Statistics

Agricultural machinery manufacturing has maintained steady employment since the 1990s. Figure 4 shows indices starting in 2000 for U.S. total employment, durable goods manufacturing employment and agricultural equipment manufacturing employment. Over the 12 years from 2000 through 2012, the economy added almost no jobs. Employment in manufacturing fell by 30 percent over the same period, but agricultural equipment manufacturing employment declined by only 4 percent.

The strength of agricultural equipment demand over the last 15 years is directly related to the global imperative to enhance farm labor and land productivity growth. Growing middle classes in developing countries are demanding an expanding range of food choices, especially for meat products that are very grain-intensive. This demand is pushing up the prices for food commodities around the world. Figure 5 shows indices for U.S. inflation, U.S. agricultural prices received by farmers, and global agricultural commodity prices. Despite substantial volatility, it is clear that the prices for agricultural products have risen about 2 to 3 times faster than general prices.

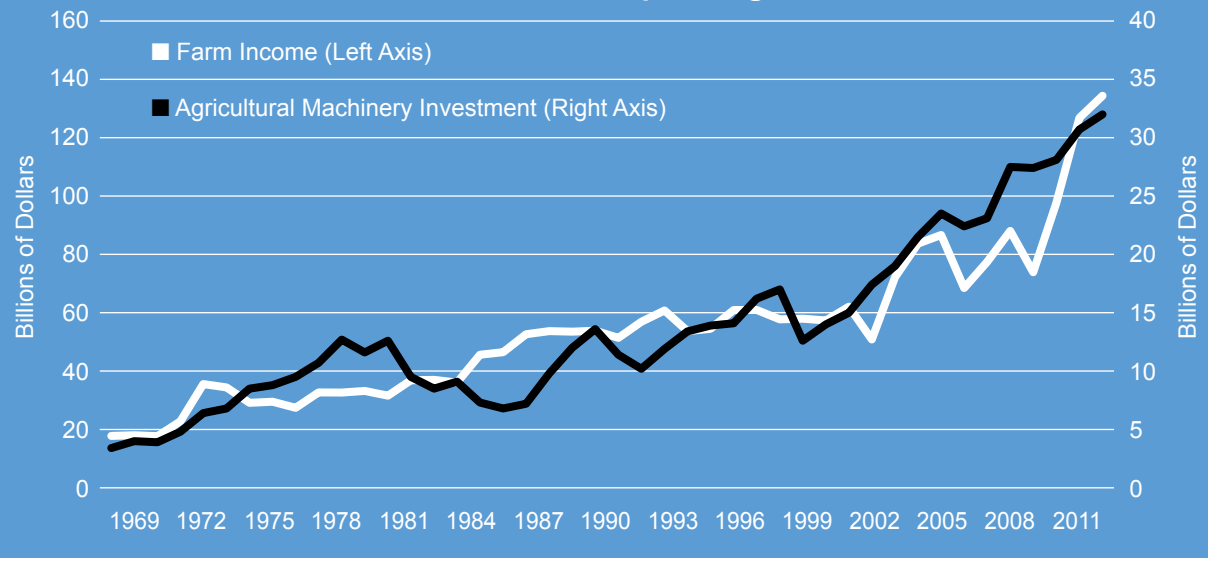
Higher farm product prices increase the cash flow to farmers worldwide and provide them with both the motive and the means to make new investments in equipment. At home, the agriculture sector has enjoyed both strong exports and robust income growth. Figure 6 shows the relationship between changes in U.S. farm income and changes in farm equipment investment. Moreover, and as explained below, the most recent technological advancements to equipment are proving particularly useful for enhancing the land yield for grains.

Figure 5: **Agricultural Prices Relative to the General Price Level**
(2000 = 100)



Sources: World Bank, U.S. Bureau of Economic Analysis

Figure 6: **Net Farm Income and Agricultural Equipment Investment Spending**



Sources: U.S. Bureau of Economic Analysis

The U.S. agricultural equipment industry, therefore, should continue to thrive. Nevertheless, the increase in global food prices over the last decade is a warning to policy makers. Among other issues, it points to the need for better progress on new international trade agreements, especially for agricultural products. A more integrated global market for farm products will respond best to evolving changes to food demand and to short-run bottlenecks and shortfalls to agricultural production. Unfortunately, agricultural trade liberalization is notoriously difficult for several reasons, especially including the rapid changes in trade and technology that might occur from implementation. Gradual but steady progress in international trade will be crucial to accommodate the need for increased food production.

The convergence of high worldwide food demand, liberalized trade, and rapid technological change provides an important opportunity to enhance American leadership not only in agriculture, but also in the supporting agriculture equipment cluster. We will examine below how this cluster plays an important role in stimulating U.S. economic growth, increasing exports, dispersing new technology and creating high-quality jobs. Agriculture policy, therefore, needs to be determined with this broader perspective in mind.

The Economic Footprint of Agricultural Machinery

In this section we will discuss the economic footprint of the agricultural machinery industry. After analyzing the direct manufacturing footprint, we will quickly discover that this only represents a portion of the true economic footprint of the agricultural equipment cluster. If we look downstream from the factory, manufacturers' efforts are complemented with valuable distributor services associated with farm equipment. Such services include sales commissions, leasing, financing, maintenance and repair. Upstream from both the factory and the dealer's lot are dedicated supply chains including energy, utilities, materials manufacturing, custom parts, and business services generating substantial value and employing many workers who make well above-average incomes. Finally, perhaps the most important impact of agricultural machinery is on the farm, where it has helped enable strong productivity growth over the last century.

Table 2 describes the size and structure of agricultural equipment supply including upstream and downstream components of the industry cluster for 2011.[5] For each row of industry detail, we display four concepts: domestic production and imports, value added – which is production minus intermediate inputs of energy, materials, and services – employment and the average annual compensation per employee.[6] The upper part of the table displays the "direct" supply that includes the manufacture of equipment plus the downstream distribution and service activities associated with that equipment. The middle part of the table provides the "indirect" supply associate with upstream suppliers to both manufacturing and to distribution. The lowest lower part shows the total footprint, which is the sum of direct and indirect values.

Industry Revenue Footprint

The first column of the table shows the value of domestic production (gross output) and the imports associated with meeting total demand. Domestic manufacturers realized $36.6 billion of sales in 2011, consisting of $28.6 billion sales of agricultural equipment and $8.0 billion of sales of lawn and garden equipment. Table 3 show this revenue figure within a ranking of all manufacturing industries. Of the 280 manufacturing industries identified by the Bureau of Economic Analysis (BEA), agricultural equipment is ranked 30th by revenues. The size is a bit lower than construction equipment makers ($42 billion), but higher than material handling equipment makers ($28 billion).

However, there is more to this story. Manufacturers' direct revenue does not include substantial value that is added to the price of equipment by downstream businesses such as distributors and dealers. Almost 30 percent of the purchasers' value of an average piece of equipment are transport, wholesale and other distribution charges beyond the factory gate or the import dock. Table 2 identifies these sales. In 2011 $1.6 billion of revenue was earned in transport industries, $12.3 billion by wholesale distributors and $1.2 billion by retailers. Finally, dealers and distributors provided another $4.2 billion in logistical, maintenance, repair, leasing, and finance services to agricultural equipment owners and operators. All told, downstream activities generated another $19.3 billion of business sales, a little more than 50 percent of manufacturers' revenues.

[5] These figures are a synthesis of data from several sources, including the Bureau of Economic Analysis Industry Accounts; Bureau of the Census 2007 Economic Census and 2011 Annual Survey of Manufacturers; and the Bureau of Labor Statistics Employment, Hours, and Earnings. *(See Appendix for a detailed data source description.)*

[6] Compensation includes wages plus benefits and social insurance taxes.

Table 2: **Supply of Agricultural Machinery and Equipment, 2011**
(Millions of Dollars)

	Domestic Production and Imports	Value Added	Employment (jobs)	Labor Compensation ($ per job)
		Direct Supply		
Domestic Manufacturing Total	36,606	15,836	78,225	65,653
Agricultural Equipment Manufacturers	28,563	13,250	59,942	70,284
Lawn & Garden Equipment Manufacturers	8,043	2,585	18,283	50,468
Imports (landed value)	8,477			
Downstream Businesses Total	19,346	12,315	117,234	60,142
Agricultural Equipment Transport Margins	1,643	750	9,070	62,021
Agricultural Equipment Wholesale Margins	12,341	8,049	95,500	63,500
Agricultural Equipment Dealer Services	4,212	2,747		
Lawn and Garden Equipment Retail Margins	1,150	769	12,664	33,474
Total Domestic Direct Supply	55,952	28,150	195,459	62,347
Total Equipment, Parts and Service Demand	64,428			
		Indirect Supply		
Upstream Supply Businesses	47,225	22,829	181,249	72,453
Agriculture, Mining, Utilities & Construct	2,378	1,511	5,915	82,060
Manufacturing	20,896	6,356	52,267	73,479
Wholesale and Retail Trade	3,925	2,566	19,410	68,932
Transport Services	2,427	1,376	14,611	58,452
Financial & Real Estate Services	4,641	2,750	8,709	94,037
Information and Business Services	11,055	7,180	60,219	83,170
Other Services	1,903	1,090	20,118	39,110
		Total Value Added and Employment		
Total Domestic Associated Supply	103,177	50,979	376,708	67,210
Direct Manufacturing	36,606	15,836	78,225	65,653
Downstream Direct Services	19,346	12,315	117,234	60,142
Indirect Upstream Supply	47,225	22,829	181,249	72,453
Manufacturing Multiplier	1.8	2.2	3.8	
Total GDP, Employment and Avg Compensation		15,075,000	138,002,000	58,667
Percent share/Compensation multiplier		0.338	0.273	1.15

Sources: U.S. BEA Industry Accounts, U.S. BLS Employment, Hours, and Earnings, U.S. Census International Trade Data, Inforum Estimates

Table 3: **U.S. Manufacturing Revenues, 2011**
(Millions of dollars)

Rank	Industry	Millions $
1	Petroleum refineries	747,044
2	Motor vehicle parts manufacturing	184,166
3	Light truck and utility vehicle manufacturing	141,353
4	Animal (except poultry) slaughtering, rendering, and processing	130,966
5	Pharmaceutical preparation manufacturing	122,056
6	Iron and steel mills and ferroalloy manufacturing	108,713
7	Other basic organic chemical manufacturing	101,092
8	Aircraft manufacturing	92,537
9	Automobile manufacturing	89,525
10	Plastics material and resin manufacturing	87,603
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23	Construction machinery manufacturing	42,046
-----	----------	---------
29	Fluid milk and butter manufacturing	37,957
30	**Farm and lawn and garden machinery and equipment manufacturing**	**36,606**
31	Machine shops	36,311
-----	----------	---------
47	125 Material handling equipment manufacturing 333920	28,258
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278	Narrow fabric mills and schiffli machine embroidery	1,134
279	Other cut and sew apparel manufacturing	1,070
280	Wood television, radio, and sewing machine cabinet manufacturing	472

Source: BEA Gross Output by Industry Data

The second column of Table 2 shows the value of these sales after deducting intermediate costs for energy, materials, and purchased services. This “value added” includes labor compensation plus all profits, rents, and interest plus net taxes on production, and it is equivalent to the amount of GDP generated by the activity. After intermediate inputs, the agricultural machinery industry produced $15.8 billion of GDP. Domestic activities associated with downstream distribution and other services yielded another $12.3 billion of value added.

This accounting, however, is still not complete. Because equipment makers buy steel, a portion of the value added and employment generated in the steel industry is attributable to the manufacture of agricultural equipment. Electric utilities also contribute indirectly not only by supplying power to equipment manufacturers and distributors but also by supplying power to factories when they are

making steel for agricultural equipment. The value added and employment cited above does not include such "indirect" value added and jobs generated at upstream suppliers of both manufacturing and distribution, including materials manufacturers, energy and utility companies, transportation, and business services.

The upstream production requirements from seven major economic sectors are shown in the first column of the lower part of Table 2. Almost all production sectors – including mining, utilities, and finance – indirectly contribute to equipment manufacture and distribution. Other manufacturing sectors contribute almost $21 billion in output. Information and business services have over $11 billion of sales to the direct activities associated with agricultural equipment.

All told, the total output of direct manufacturing, downstream distribution, and the upstream supply for both is $103.2 billion. While this value suggests an economic footprint much larger than the $36.6 billion that direct equipment manufacturing brings to the table, the figure includes double-counting of intermediate inputs. For example, the steel input in equipment is counted as part of both indirect manufacturing output and the direct output of agricultural equipment.

A more precise picture of the total economic footprint can be obtained by using "industry value added," which is net of intermediate purchases, and thus excludes any double-counting. The second column shows the value added within each sector that is traced to upstream activities of the agricultural equipment supply chain. For example, indirect activities generated $1.5 billion of value added in agriculture, mining, utilities and construction. Manufacturing supplied $6.4 billion of indirect value added. The largest value added contribution, at $7.2 billion, came from information and business services, particularly administrative management and services.

The total value added of indirect production was $22.8 billion. The bottom of Table 2 indicates that adding this amount to the $28.2 billion value added associated with direct production produces an overall economic footprint of $51.0 billion in 2011. Since the nation's Gross Domestic Product (GDP) is the sum of value added across industries, the total value added is an important statistic for measuring the impact of any given industry on the economy. The total value added for the agricultural equipment sector is equal to 0.34 percent of GDP, about the same contribution to GDP as that of the state of Alaska.

It is also interesting to note that the total value added generated by the industry cluster is more than three times the $15.8 billion generated by the original equipment manufacturers. We define a "manufacturing multiplier" as the ratio of downstream and upstream value added to the original manufacturing value added. The computed multiplier shown in Table 2 implies that for every dollar of value added generated by equipment manufacturing, another 2.2 dollars of value added are generated upstream and downstream in the economy.

Industry Employment Footprint

In 2011 U.S. employment reached roughly 138 million, with manufacturing employing 11.7 million workers. Against this backdrop, the employment of the agricultural machinery industry might at first blush not seem significant, but the details in this section and the numbers illustrated in the previous section demonstrate that the industry in fact makes an important economic contribution.

Employment in the agricultural equipment supply chain is shown in the third column of Table 2. Domestic manufacturers of agricultural equipment and lawn and garden equipment employed over 78,000 persons in 2011. Out of 171 U.S. manufacturing industries identified by the Bureau of Labor Statistics, agricultural machinery and equipment manufacturing is ranked 48th in terms of employment (Table 4). With an average annual salary of $ 47,290, total payroll for manufacturing of agricultural equipment comes in at roughly $ 3.7 billion (Table 2). If we take in consideration benefits, the average compensation is $65,650 and the total labor compensation of the industry becomes $ 5.1 billion.

The agricultural equipment industry has a very strong downstream network that supports the manufacturing base, employing 117,200 people. Average compensation at wholesale and retail distributors was about $60,100. The wholesale/dealer distribution alone already contributes roughly 95,500 jobs. In total the downstream jobs represent roughly 1.5 times the manufacturing base.

Table 4: **U.S. Manufacturing Employment, 2011**

Rank	Manufacturing Industry	Thousand Employees
1	Commercial printing, except screen	378.4
2	Medical equipment and supplies	307.7
3	Other plastics products	274.7
4	Machine shops	267.9
5	Aircraft	234.4
-----	----------	---------
47	Breweries	78.3
48	**Farm and lawn and garden machinery and equipment manufacturing**	**78.2**
49	Aircraft engines and engine parts	77.8
-----	----------	---------
169	Audio and video equipment	20.0
170	Tobacco and tobacco products	15.7
171	Breakfast cereal	14.9

Source: BLS Employment, Hours, and Earnings

Table 5: **U.S. Wholesale Employment, 2011**

Rank	Wholesale Industry	Thousand Employees
1	Industrial machinery	283.9
2	General line grocery	226.5
3	Computer and software	221.5
4	Medical equipment	191.0
5	Druggists' goods	186.0
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18	Beer and ale	95.6
19	**Farm and garden equipment**	**95.5**
20	Petroleum	92.6
-----	----------	---------
42	Business to business electronic markets	38.0
43	Other transportation	32.5
44	Packaged frozen food	27.2

Source: BLS Employment, Hours, and Earnings

Table 5 shows that the 95,500 jobs at the equipment distributors level ranked 19th among 44 wholesale industries. Few other manufacturing sectors can claim a spin-off support system as extensive. Even the construction equipment industry, a close peer of agricultural equipment, has a relatively smaller dealer/wholesale distribution network. The agriculture equipment industry's employment levels are just below Beer and Ale wholesale supply and distribution (95,600). However, the sector has larger employment than other wholesale distribution sectors like Petroleum (92,600).

Direct employment in the agricultural equipment industry represents a part of the sector's contribution to the U.S. economy. Manufacturers of agricultural equipment purchase materials and parts such as fluid power equipment, fabricated metal parts, bearings and power transmission equipment, steel, engines, plastics and rubber, and many other manufactured materials. All of these supplier industries have a significant amount of employment.

In 2011, in addition to the 78,200 people directly employed in U.S. farm equipment manufacturing, another 52,300 were indirectly employed in other manufacturing activities to support materials and parts used by the industry. Information and business services employed 60,200 people to supply equipment manufacturing and distribution. Additionally, manufacturers and distributors purchase fuel, electricity, and resources from the agriculture, mining, utilities and construction industries; require parts from wholesale and retail trade; opt in for transportation, financial and real estate services for adding another 68,800 jobs. The total number of upstream jobs adds up to about 181,200, roughly 2.3 times the workers involved in the direct manufacturing. Average compensation for these upstream supply business services was about $72,500.

Overall, the agricultural equipment cluster employed almost 376,700 workers in 2011. The employment figure is almost 5 times the initial direct agricultural equipment manufacturing figures. If we compare the 298,500 downstream and upstream jobs to the roughly 78,200 in direct agricultural equipment manufacturing, we find a manufacturing multiplier for employment of 3.8. That is, for every job devoted to agricultural equipment manufacturing, 3.8 other jobs are maintained in another part of the industry network. To put this in perspective, this is more than half of the total population of the District of Columbia or about the population of Arlington, Texas. This total employment is 0.27 percent of the economy-wide total. Moreover, these jobs are highly paid, with the average compensation of $67,200 per worker, which is 15 percent larger than the economy-wide average of $58,700.

The relatively high value added, employment and compensation multipliers reflect the sophisticated nature of agricultural equipment and the strong linkages of the manufacturers to other parts of the economy. The industry boasts a large and talented distributor and leasing network which provides substantial technical, maintenance and repair services. Similarly, the manufacturing supply chain includes world-class providers of advanced machinery, tooling, materials and electronics. Many of these suppliers are small and innovative firms pioneering advanced manufacturing techniques such as 3D manufacturing. We now turn to a more detailed account of the employment and wages within the sector.

While the economic footprint of the agricultural equipment industry measured in dollars might seem small in comparison to the overall economy, the most important economic contribution of the industry − the impact of equipment on the agriculture itself − is not easily quantified. It is remarkable that the small claim on productive resources can have such a profound impact on not only the economy as a whole, but on the lives of the people who live within them.

Occupations within the Agricultural Equipment Industry

As illustrated above, employment in direct manufacturing and distribution and dealer activities is significant. We examine these jobs more carefully in this section. We showed that at 78,200, agricultural equipment manufacturing employment ranks in the top third, at 48th out of 171 manufacturing industries identified by the Bureau of Labor Statistics. Table 5 showed that the 95,500 jobs at equipment distributors ranked 19th among 44 wholesale industries.

The advantages of retaining these high-tech machinery manufacturing and distribution jobs within the country are substantial. Tables 6 and 7 show the ranges of occupations in agriculture equipment manufacturing and for agricultural equipment wholesale distribution, respectively. They also show the average relative salary (in this case not including benefits). In addition to the technology spillovers to other sectors, the cluster offers ample opportunities for high-paying occupations, including jobs that require high skills but not necessarily a college education.

In 2011, agricultural equipment manufacturing employed 6,800 engineers at an average salary of almost $70,000 each. Roughly half of the jobs in the industry, however, are production jobs such as assemblers, machinists, and welders. On average, these jobs pay almost $40,000 per year plus benefits which is larger than the average for this occupation in manufacturing. The wholesale side of the industry employs almost 100,000 workers, most of those people in sales and services, including mechanics and technicians. On average, the jobs pay between $30,000 and $50,000.

Table 6: Occupations and Wages within the Agricultural Machinery and Equipment Manufacturing Industry, 2011

	Agriculture implement manufacturing		All Manufacturing	
Occupation	Employees	Avg Annual Salary ($)	Employees	Avg Annual Salary ($)
Industry Total	78,225	47,290	11,606,530	46,620
Management Occupations	4,341	112,230	661,530	118,180
Business and Financial Operations Occupations	3,175	64,510	418,960	68,130
Computer and Mathematical Occupations	959	70,520	276,140	87,160
Architecture and Engineering Occupations	6,800	67,950	734,180	76,170
Industrial Engineers	1,466	69,390	147,370	78,120
Mechanical Engineers	2,013	74,750	123,830	79,140
Sales and Related Occupations	2,466	71,070	369,720	62,690
Office and Administrative Support Occupations	7,390	37,560	1,124,020	37,150
Shipping, Receiving, and Traffic Clerks	1,184	33,040	179,690	32,190
Construction and Extraction Occupations	775	48,880	187,050	44,700
Installation, Maintenance, and Repair Occupations	4,200	45,510	576,040	47,010
Industrial Machinery Mechanics	1,847	45,750	163,640	47,770
Production Occupations	43,763	37,290	5,907,010	34,820
First-Line Production and Operating Supervisors	2,592	58,170	406,820	56,830
Assemblers	13,567	34,160	1,157,870	32,142
Machine Programers and Operators	12,824	38,005	990,310	36,348
Machinists	4,258	41,290	294,620	40,580
Metal and Plastic Workers	9,312	37,237	387,720	37,696
Welders	7,386	36,500	206,250	36,020
Other Production Occupations	5,467	34,883	795,890	31,884
Transportation and Material Moving Occupations	3,382	32,890	993,270	30,990
Freight, Stock, and Material Movers	1,629	30,520	267,910	28,190
All Other Occupations	963	51,001	358,610	48,919

Source: Bureau of Labor Statistics, Occupational Employment Statistics (OES), May 2011

Table 7: **Occupations and Wages within the Agricultural Equipment Wholesaling Industry, 2011**

Occupation	Employees	Avg Annual Salary ($)
Industry Total	97,180	41,480
Management Occupations	4,740	102,540
Business and Financial Operations Occupations	1,730	59,440
Computer and Mathematical Occupations	400	53,180
Architecture and Engineering Occupations	210	65,580
Arts, Design, Entertainment and Media Occupations	80	54,590
Building and Grounds Cleaning and Maintenance	900	21,860
Sales and Related Occupations	31,270	45,330
Sales Representatives	15,930	51,333
Office and Administrative Support Occupations	16,140	31,230
Bookkeeping, Accounting, and Auditing Clerks	3,840	33,070
Farming, Fishing, and Forestry Occupations	110	28,030
Construction and Extraction Occupations	260	38,890
Installation, Maintenance, and Repair Occupations	31,860	36,760
Farm Equipment Mechanics and Technicians	21,860	35,350
Production Occupations	2,280	31,360
Transportation and Material Moving Occupations	7,180	29,490
Heavy and Tractor-Trailer Truck Drivers	1,590	35,600

Source: Bureau of Labor Statistics, Occupational Employment Statistics (OES), May 2011

Regional Agricultural Equipment Manufacturing Clusters

Having examined the economic footprint of the agricultural equipment industry's labor force and its occupational distribution, it is interesting to briefly analyze the regional distribution of its employment. From the tables on the next page, it becomes clear that the industry's importance is felt within and across several regions. Table 8 shows the state-level location of agricultural equipment manufacturing jobs and Table 9 displays similar information for agricultural equipment wholesale distribution. These statistics reflect only the direct manufacturing and wholesale jobs. Unfortunately, we do not have data on the regional distribution of upstream indirect jobs which would show that the industry is even more important within these local economies.

In Table 8, the first column provides the number of agriculture equipment manufacturing jobs in the state. The second column indicates each state's share of the national total of agricultural equipment jobs. Iowa's 13,900 jobs is almost 18 percent of all the direct manufacturing jobs. The third column indicates that this accounts for over 1 percent of the total jobs in the state, 6.7 percent of the manufacturing jobs in the state, and 36.2 percent of all the machinery (agricultural, construction, mining, etc.) manufacturing jobs in the state. Table 6 for wholesale distribution is organized similarly.

There are many manufacturing jobs in Iowa, Illinois, and Wisconsin. These are also states with heavy concentrations of motor vehicle and construction machinery manufacturers, activities that require similar technologies and suppliers. In Illinois, the concentration of machinery activities is the center of an important regional cluster that spans several states. The geographic concentration of these industries indicates the interdependence of manufacturing facilities, capital formation, technological advancement and human capital development. It is no coincidence that the region includes world-class science and engineering schools. Indeed, in order to nurture and grow such important industry clusters, private industry needs public policy to continue to foster commercial freedom, suitable infrastructure, basic research and development facilities, and universal high-quality education.

Looking over the figures reported in Table 9, it is not surprising that agricultural equipment wholesalers are distributed across the nation, concentrated in proportion to the nation's mechanized agriculture. Dealers and associated service providers are the face of the entire supply chain to their customers. They are the principal channel of delivering equipment products and services to the farmer, and they are also a vital conduit for information to pass upstream from farmers to manufacturers. Profitable equipment manufacturers adapt their innovation strategy, R&D agendas, and supply-chain capabilities to meet the needs explicitly identified by their customers. Working together, distributors, manufacturers, and upstream suppliers will continue to be a vital source of productivity and competitiveness for the agriculture sector.

Table 8: **State Ranking, Employment Agricultural Equipment Manufacturing, 2011**

Top 10 States, Employment Agricultural Equipment Manufacturing						
Year: 2011				Percent of State		
Rank	State	Employment	Percent of US industry	Total Emp	Mfg Emp	Machinery Mfg Emp
1	Iowa	13,852	17.9%	1.1%	6.7%	36.2%
2	Wisconsin	6,900	8.9%	0.3%	1.6%	11.0%
3	Illinois	6,622	8.5%	0.1%	1.2%	8.4%
4	Nebraska	5,866	7.6%	0.8%	6.3%	62.1%
5	Kansas	5,387	6.9%	0.5%	3.3%	32.1%
6	Minnesota	3,846	5.0%	0.2%	1.3%	12.6%
7	California	3,053	3.9%	0.0%	0.2%	4.3%
8	Texas	2,969	3.8%	0.0%	0.4%	3.1%
9	Georgia	2,788	3.6%	0.1%	0.8%	14.3%
10	Ohio	2,777	3.6%	0.1%	0.4%	3.9%
	Other States	23,469	30.3%			
	Total	**77,529**	**100.0%**	**0.06%**	**0.7%**	**7.3%**

Source: U.S Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table 9: **State Ranking, Employment Agricultural Equipment Wholesalers, 2011**

Top 10 States, Employment Agricultural Equipment Dealer / Wholesale Distribution						
Year: 2011				Percent of State		
Rank	State	Employment	Percent of US industry	Total Emp	Wholesale Emp	Durable Wholesale Emp
1	Illinois	6,759	7.1%	0.1%	2.3%	4.7%
2	Texas	6,021	6.3%	0.1%	1.2%	2.1%
3	Iowa	5,965	6.2%	0.5%	8.9%	19.9%
4	California	5,392	5.6%	0.0%	0.8%	1.7%
5	Minnesota	4,593	4.8%	0.2%	3.6%	7.6%
6	Wisconsin	4,080	4.3%	0.2%	3.6%	6.5%
7	Nebraska	4,030	4.2%	0.5%	9.9%	20.8%
8	Missouri	3,489	3.6%	0.2%	3.0%	6.4%
9	Kansas	3,449	3.6%	0.3%	5.8%	13.0%
10	Ohio	3,358	3.5%	0.1%	1.5%	2.8%
	Other States	48,638	50.8%			
	Total	**95,774**	**100.0%**	**0.07%**	**1.7%**	**3.5%**

Source: U.S Bureau of Labor Statistics, Quarterly Census of Employment and Wages

The Importance of Agriculture Mechanization

Few economies have developed successfully without rapid and sustained agricultural productivity powering overall growth. Agricultural productivity growth is key to overall economic growth, because it releases labor and land resources to support growth in other sectors such as manufacturing, transportation, and housing. In the U.S. from 1910 to 2012, agriculture output increased by over five times. At the same time, the employment share of agriculture fell from 30 percent in 1910 to less than 2 percent now.

Increasing productivity for food production was fundamental to the remarkable development of the economies of North America, Europe, and Japan over the last century. Figure 7 shows an index of U.S. agricultural labor productivity compared to an index of overall private business sector productivity since 1948. Over the past 65 years, labor productivity on the farm grew almost 2.5 times as fast as in the economy as a whole. This progress came from many sources, including new technologies in plant science such as the development of hybrid strains, mechanization, fertilizers and pesticides, and farmer education and outreach.

All of these factors have worked together to provide a thriving and innovative environment for the remarkable enhancement of agriculture productivity. Agricultural equipment, however, played an essential role by substituting directly for labor, land, and time in a myriad of processes including planting, irrigation, weeding, harvesting and processing. Indeed, farm equipment is fundamental to making new plant and chemical technologies possible. For example, hybrid crops do best when planted within a very narrow window within the calendar.[7] The largest planters make this possible by planting up to 75 acres an hour. New crops can also take advantage of precision technologies that allow smaller row spacing which boosts land usage and yields. Planting speed and accuracy continue to increase at impressive rates.[8] Similarly, pest control and harvesting can be accomplished timely and quickly to save crops and raise yields.

This role has been so important that the National Academy of Engineering identified agricultural mechanization as one of the greatest achievements of the 20th century.[9] Motorized equipment such as tractors were introduced in the early 1900s. Subsequent innovations included powered planters, harvesters, reapers, and combines. These advancements produced more efficient use of labor, land, energy, and water and allowed farmers to better integrate production processes and manage larger areas of land. Later in the 20th century, agricultural mechanization included electronically-controlled hydraulics and power systems.

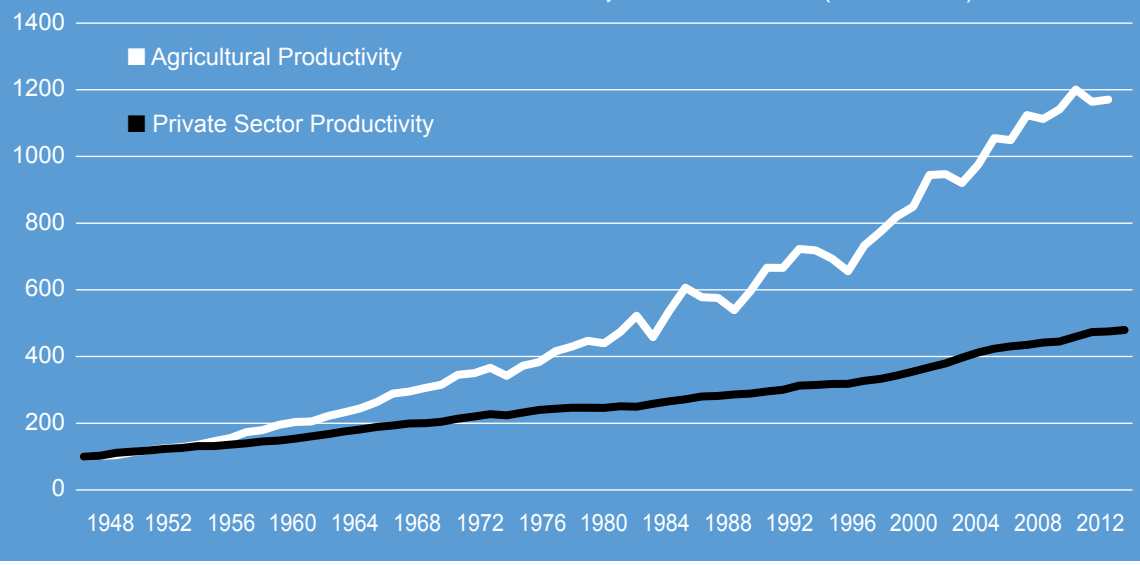
[7] Farnham, Dale, 2001. *"Corn Planting Guide."* Department of Agronomy, Iowa State University.

[8] Potter, Ben, 2014. *"Can You Double Your Planting Speed?"* AgWeb: http://www.agweb.com/article/can_you_double_your_planter_speed_NAA_Ben_Potter/

[9] Constable, George and Bob Somerville, 2003. *A Century of Innovation: Twenty Engineering Achievements that Transformed our Lives*, National Academy of Engineering.

In the 1930s a farmer could harvest an average of 100 bushels of corn by hand in a nine-hour day. Combines produced today can harvest 900 bushels of corn per hour, or 100 bushels of corn in under seven minutes.[10]

Figure 7: **Indexes for Agricultural and Economy-Wide Labor Productivity Growth in the United States, 1948 to 2012** (100 = 1948)



Sources: U.S. Bureau of Labor Statistics, U.S. Department of Agriculture

A recent and interesting paper by economists Richard Steckel and William White, "Engines of Growth: Farm Tractors and Twentieth-Century U.S. Economic Welfare," asks the question: What would be the economic impact of having to farm without the tractor?[11] Steckel and White created a hypothetical scenario which assumed that farmers would have attempted to meet the food production needs of 1954 with the technology of 1909. They found that without the stream of efficiencies and new technologies made possible by mechanization, it would have been impossible for farmers to reach 1954 production without a substantial, and possibly implausible, expansion in the use of labor and land with a consequent large increases in food prices.

This progress continues. For example, in Illinois from 1990 through 2008 corn yields increased by 2.6 bushels, or 30 percent, per year during that period. That equates to an increase of more than 45 bushels in just 18 years. This impressive feat could not have happened without the extensive use of ever-evolving technology and equipment. New input technology in seed, chemicals, and fertilizers are important, but they would be greatly hampered without complementary changes in equipment.

[10] Agriculture Council of America: http://www.agday.org/media/factsheet.php

[11] Richard H. Steckel, William J. White, *"Engines of Growth: Farm Tractors and Twentieth-Century U.S. Economic Welfare."* NBER Working Paper No. 17879 March 2012.

Such productivity growth in producing food must continue. Over the last several years, consumers across the globe have seen food prices rise to record levels. To a large extent, these price increases reflect an improvement in diets for billions of people who are reaching the middle class in emerging nations. As these households increase their intake of meat, the demand for feed grains explodes. Unfortunately, food price pressures greatly exacerbate existing nutritional problems among the poor across the globe and in America as well. Under current projections, the world population is set to reach at least 9 billion persons by 2050. Since most of this increase will occur in developing nations, the pressure of food demand will accelerate. As throughout the past century, continuous and significant agricultural productivity growth is needed to avoid disruptions to economic progress.

Research and development (R&D) in agriculture technology is crucial. Traditionally in the United States, both the public and private sectors have made complementary investments in agriculture R&D. In 2011, the U.S. public sector spent $5 billion, and the private sector invested another $5 billion on research and development in agricultural R&D.[12] Agricultural machinery manufacturers typically spend 2 to 4 percent of their sales on R&D. In 2010, world-wide R&D by farm machinery manufacturers was $2.2 billion, half of which ($1.1 billion) was conducted in the U.S.[13]

This investment is producing some new and remarkable technologies for agricultural production. Today, new applications of navigation, computing, information, and sensing technology is driving "precision agriculture." Precision agriculture utilizes geospatial data techniques to improve the usage of machines that have become "smart" and in so doing reduces waste. On-board Global Navigation Satellite System (GNSS) devices are combined with advanced sensors and automated systems to guide more effective planting, irrigation, fertilization, pest control, and harvesting operations. For example, GNSS provides spatial information on crop yields and moisture content of the soil that can be leveraged by machinery capable of variable-rate applications to deliver optimal amounts of inputs such as fertilizer and water.

The contribution of the agricultural machinery and equipment industry does not stop with product technology. Machinery manufacturers were pioneers in modern process techniques such as lean manufacturing, six sigma, computer-aided design (CAD), computer-aided manufacturing (CAM), and rapid prototyping. They continue to push the envelope for these technologies and will be in the vanguard for 3D manufacturing, materials innovation, and automated design processes. Successful application of these advanced production technologies in machinery manufacturing often spills over to other sectors, even areas that are seemingly unrelated to manufacturing such as health care and construction.

[12] U.S. Department of Agriculture, Economic Research Service based on data from National Science Foundation, USDA's Current Research Information System (CRIS), and various private sector data sources.

[13] National Science Foundation, National Center for Science and Engineering Statistics, and U.S. Census Bureau, Business R&D and Innovation Survey, 2008 Fuglie, et. al., 2011. Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide. ERR-130. U.S. Dept. of Agriculture, Econ. Res. Serv. December.

According to the Agriculture Council of America, in the 1960s one U.S. farmer supplied food for 25.8 persons in the U.S. and in other countries. Today, it estimates, a single U.S. farmer supplies food for 144 people in the U.S. and abroad.[14] As the global community prepares for a population between 9 and 10 billion by 2050, the importance of sustained agricultural productivity growth will intensify. The convergence of high world-wide food demand, liberalized trade, and rapid technological change provides an important opportunity to enhance American leadership not just in agriculture as a whole, but more specifically in the supporting agriculture equipment cluster. The agricultural equipment industry plays an important role in stimulating economic growth by supporting the agricultural industry, increasing U.S. exports, inventing new and important technology, and creating high quality jobs. Agriculture policy needs to be determined with this broader perspective in mind.

[14] Agriculture Council of America: http://www.agday.org/media/factsheet.php

References

Alston, J M, J M Beddow and P G Pardey. "Agricultural Research, Productivity, and Food Prices in the Long Run." Science 325 (September 2009).

Anderson, M A, J M Alston and P G Pardey. "Capital Services in U.S. Agriculture: Concepts, Comparisons, and the Treatment of Interest Rates". Agriculture and Applied." American Journal of Agricultural Economics 93.3 (2011): 718–738.

Constable, George and Bob Somerville. "A Century of Innovation: Twenty Engineering Achievements that Transformed our Lives." 2003.

Farnham, Dale. "Corn Planting Guide." Department of Agronomy, Iowa State University, 2001.

Fuglie, Keith O, et al. "Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide." ERR-130. December 2011.

Fuglie, Keith O, James M MacDonald and Eldon Ball. "Productivity Growth in U.S. Agriculture." EB-9. 2007.

Heisey, Paul, Sun Lin Wang and Keith Fuglie. "Public Agricultural Research Spending and Future U.S. Agricultural Productivity Growth: Scenarios for 2010-2050." EB-17. July 2011.

James, J S, et al. "Structural Changes in U.S. Agricultural Production and Productivity." Choices, The Magazine of Food, Farm and Resource Issues 24.4 (2008).

NIU Center for Governmental Studies. "Industry Cluster Profile: Machinery Manufacturing." 2011.

Pardey, P G, J M Alston and C Chan-Kang. "What Can be Done to Reinvigorate U.S. Agricultural Research?" 2013. <http://www.instepp.umn.edu>.

Pardey, Philip G, Julian M Alston and Connie Chan-Kang. "Public Food and Agricultural Research in the United States: The Rise and Decline of Public Investments, and Policies for Renewal." AGree, April 2013. <http://www.foodandagpolicy.org>.

Potter, Ben. "Can You Double Your Planting Speed?" AgWeb, 2014. <http://www.agweb.com/article/can_you_double_your_planter_speed_NAA_Ben_Potter>.

Reid, John F. "The Impact of Mechanization on Agriculture." The Bridge: Linking Engineering and Society 41.3 (2011).

Ruttan, Vernon W. "Productivity Growth in World Agriculture: Sources and Constraints." Journal of Economic Perspectives 16.4 (2002).

Steckel, Richard H and William J White. "Engines of Growth: Farm Tractors and Twentieth-Century U.S. Economic Welfare." NBER Working Paper No. 17879. March 2012.

Appendix: Data Sources

Concept	Source
Direct Outputs:	
Manufacturing	BEA Gross Output data base 2011
Dealer Services	Economic Census 2007 and County Business Patterns 2011
Trade and transport margins	As above
Imports and Exports	Census Trade data.
Direct Value Added	Economic Census 2007 and BEA GDP by Sector 2011 Inforum LIFT model
Direct Employment:	
Manufacturing	BLS Employment, Hours and Earnings
Wholesalers	BLS Employment, Hours and Earnings
Transport and Trade (ratios)	BEA GDP by Industry 2011, Inforum LIFT model
Indirect Outputs	Computation with LIFT and ILIAD IO Tables for 2011
Indirect Value Added Ratios	BEA GDP by Industry 2011, Inforum LIFT model
Indirect Employment Ratios	BEA GDP by Industry 2011, Inforum LIFT model
Compensation	BEA GDP by Industry 2011, Inforum LIFT model
Occupations and Wages	BLS Occupation and Employment Survey
Employment by State	BLS Quarterly Census of Employment

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