Ohio

Research Office
A State Affiliate of the U.S. Census Bureau

Advanced Manufacturing: Ohio Iron and Steel Industry

January, 2016

ADVANCED MANUFACTURING:
The Ohio Iron and Steel Industry

January 2016

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TABLE OF CONTENTS

Page

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EXECUTIVE SUMMARY

- Ohio ranked second in the nation in raw steel production every year of the last decade, annually pouring between 6.5 and 16.5 million tons; this ranged between 10 and 16 percent of total U.S. output.

- Ohio ranked third in the encompassing iron, steel and ferroalloy products group (NAICS 3311, which includes products made at the mills), second in manufacturing products made from purchased steel (3312), and third in the combination of the two groups – as judged by dollar value-add in the latest Annual Survey of Manufactures by the Census Bureau.

- 13 companies on Fortune magazine's U.S.-1,000 or Global- 500 lists have iron and steel industry establishments in Ohio; three of them – AK Steel, Timken Steel, and Worthington Industries – maintain their world headquarters here.

- ArcelorMittal, the world's largest steel company, is capable of pouring at least 4.6 million tons of raw steel per year in Ohio. It was followed by AK Steel at more than 3.7 million, Republic Steel at nearly 2.6 million, North Star Bluescope at close to 2.2 million and Timken Steel at over 1.5 million. Total capacity in Ohio is at least 16.0 million tons per year.

- 54 counties had at least one iron and steel industry establishment, with the majority in 10 counties: Butler, Cuyahoga, Franklin, Lake, Mahoning, Montgomery, Richland, Stark, Summit and Trumbull; two-thirds of the jobs were found in an overlapping list of eight counties: Butler, Cuyahoga, Defiance, Franklin, Lorain, Richland, Stark and Trumbull.

- AK is the largest industry employer in Ohio with 3,300-plus, followed by ArcelorMittal with over 2,600, Timken with an estimated 1,800-plus, Republic with over 1,600, and Columbus Castings and General Motors with at least 1,100 each.

- 25 companies announced 32 major iron and steel industry investments in Ohio from 2011 through 2014. Planned expenditures surpassed $748 million, with close to 1,700 new jobs anticipated when the projects are completed.

- International investment has become very important, with 15 companies from 11 foreign nations employing well over 6,500 in Ohio making iron, steel, ferroalloy and foundry products; two of them are on Fortune's Global-500 list. ArcelorMittal, Industrias CH SAB de CV (which owns Republic Steel) and Vallourec SA are the largest employers.

- People working in Ohio's iron and steel industry averaged $63,500 in annual pay according to the latest County Business Patterns data (the corresponding national average was $64,100).

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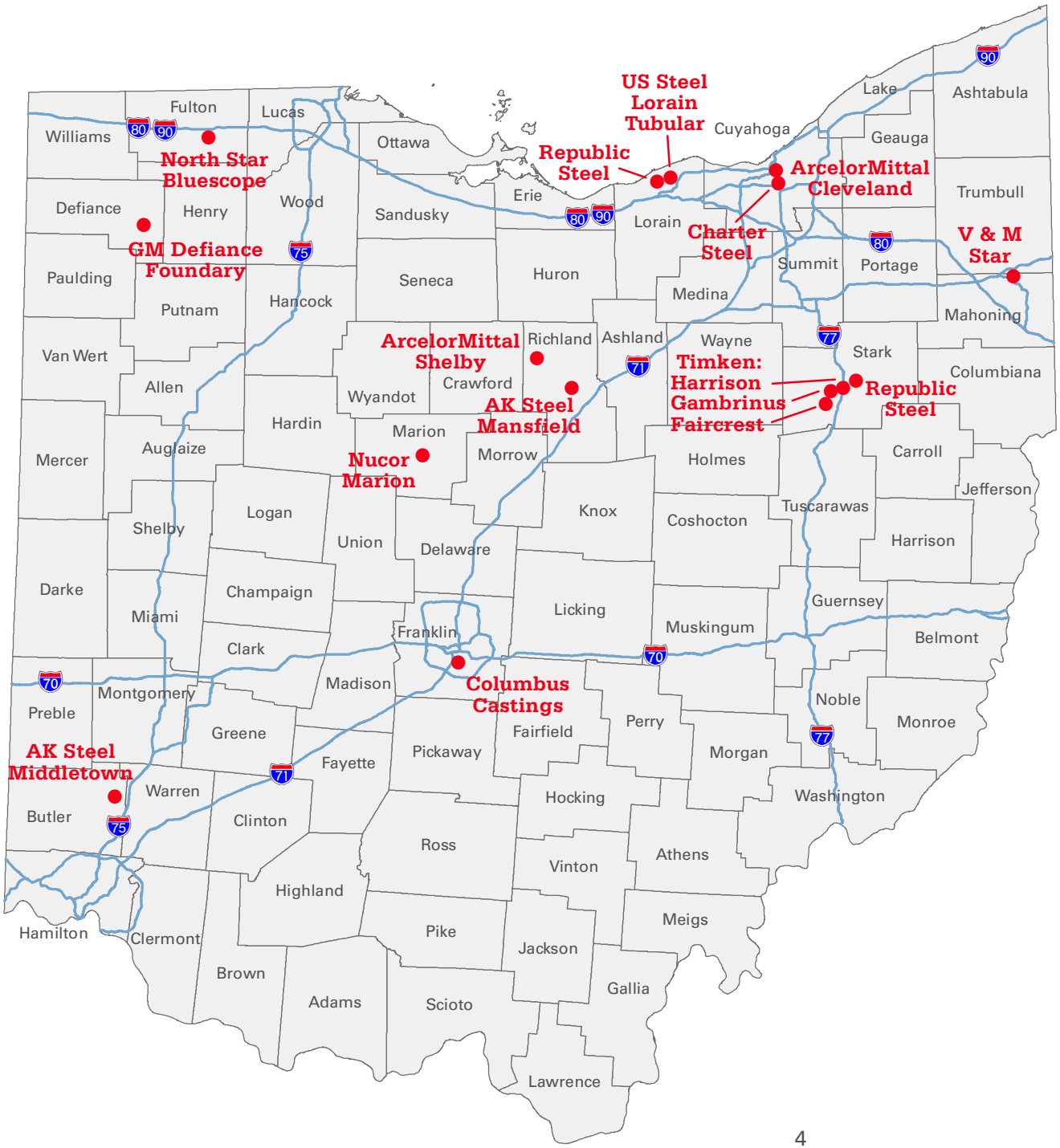
DESCRIPTION OF OHIO'S IRON AND STEEL INDUSTRY



Ohio

Ohio Steel Industry
Notable Establishments*

Key

- Notable Establishment*
- Interstate Highway
- Ohio County

*Major melt facility or establishment believed to employ 500 or more

Sources:
Hoover's Inc., Ohio Development Services Agency, AIM Market Research, company web sites, and news reports

Prepared by:
Office of Research
Ohio Development Services Agency
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NOTABLE IRON AND STEEL INDUSTRY MANUFACTURERS

Thirteen companies on Fortune magazine's U.S.-1,000 or Global-500 lists have iron and steel industry establishments in Ohio. Three of them maintain their world headquarters in Ohio: AK Steel, Timken Steel and Worthington Industries. AK Steel is the largest industry employer in Ohio with 3,300-plus people, followed by ArcelorMittal with well over 2,600, Timken with an estimated 1,800-plus, and Industrias' Republic Steel with well over 1,600. Columbus Castings and General Motors – the two largest foundries – each have at least 1,100. Four more companies employ between 500 and 1,000.[1]

The map above shows the establishment locations employing at least 500 (three Timken sites are counted as one) or that are major furnaces. The list below includes the Fortune companies with at least 25 people at a site as well as other companies employing 500 or more people in Ohio and having at least 25 people at a site. It is organized by NAICS code and includes the city where the site is located. Manufacturing iron and steel products may not be the principal business of some companies on the list, but the sites of such companies are included because the NAICS site codes define them as part of the industry. (Headquarters are included.) See Appendix Table A1 for the complete list organized by company.

Industry Group/Notable[1] Company/Subsidiary or Division	Primary NAICS	City	Jobs at Site[2]
3311			
AK Steel Holding Corp.*/AK Steel Corp./Mansfield Operations[3]	3311	Mansfield	333
AK Steel Holding Corp.*/AK Steel Corp.[3]	3311	Middletown	1,875
Allegheny Technologies, Inc.*/Allegheny Ludlum LLC[3]	3311	Louisville	143
ArcelorMittal SA*/ArcelorMittal Cleveland (east and west sites combined)[4]	3311	Cleveland	1,900
Cargill*-Bluescope (JV)/North Star Bluescope Steel LLC[5]	3311	Delta	345
Carpenter Technology Corp.*/Latrobe Specialty Metals Co.	3311	Wauseon	76
Charter Manufacturing Co., Inc./Charter Steel Division	3311	Cleveland	992
General Electric Co.*/GE Aviation Systems LLC/Morris Technologies	3311	Cincinnati	105
Industrias CH, SAB de CV/Republic Steel, Inc.[5]	3311	Canton	780
Industrias CH, SAB de CV/Republic Steel, Inc.[5]	3311	Canton	110
Nucor Corp.*/Nucor Steel Marion, Inc.[7]	3311	Marion	275
Reliance Steel & Aluminum Co.*/Metals USA Carbon Flat Rolled, Inc.	3311	Wooster	102
TimkenSteel Corp.*/Faircrest, Gambrinus and Harrison Steel Plants combined[3,8]	3311	Canton	1,585
TimkenSteel Corp.*/St. Clair Plant	3311	Eaton	67
United States Steel Corp.*/Lorain Pipe Mill[9]	3311	Lorain	614
Worthington Industries, Inc.*/Dietrich Industries, Inc.	3311	Warren	180

Industry Group/Notable[1] Company/Subsidiary or Division	Primary NAICS	City	Jobs at Site[2]
3312			
AK Steel Holding Corp.*/AK Steel Corp./AK Tube LLC	33121	Walbridge	240
ArcelorMittal SA*/ArcelorMittal Marion[4]	33121	Marion	100
ArcelorMittal SA*/ArcelorMittal Shelby[4]	33121	Shelby	631
Industrias CH, SAB de CV/Republic Steel, Inc.[5]	33121	Lorain	490
Industrias CH, SAB de CV/Republic Steel, Inc.[5]	33121	Massillon	300
Vallourec Star LP[5]	33121	Youngstown	600
AK Steel Holding Corp.*/AK Steel Corp.	331221	Zanesville	143
AK Steel Holding Corp.*/AK Steel Corp./Coshocton Stainless[3]	331221	Coshocton	443
Mitsui & Co., Ltd.*/Steel Technologies LLC[5]	331221	Ottawa	100
Nucor Corp.*/Bright Bar (being acquired from Metalurgica Gerdau)[5,10]	331221	Orville	37
Reliance Steel & Aluminum Co.*/Precision Strip, Inc.[3]	331221	Kenton	66
Worthington Industries, Inc.*/Worthington Steel Co.	331221	Cleveland	175
Leggett & Platt, Inc.*/Solon Specialty Wire Co.	331222	Cleveland	25
33151			
General Motors*[4]	331511	Defiance	1,183
McWane, Inc./Clow Water Systems Co.	331511	Coshocton	400
Westinghouse Air Brake Technologies Corp.*/Standard Car Truck Co., Inc./Sancast, Inc.	331511	Coshocton	50
Constellations Enterprise LLC/Columbus Steel Castings Co.[6]	331513	Columbus	1,100
Worthington Industries, Inc.*/Worthington Steelpac Systems, LLC	331513	Columbus	250
551114			
AK Steel Holding Corp.* (HQ)	551114	West Chester	300
ArcelorMittal SA*/ArcelorMittal USA (DHQ for USA)[4]	551114	Richfield	50
TimkenSteel Corp.* (HQ)[8]	551114	Canton	187
Worthington Industries, Inc.* (HQ)	551114	Worthington	250

Notes: * - A Fortune U.S.-1,000 or Global-500 company; 1 – "Notable" means a company has at least 400 people in Ohio, is on Fortune's U.S.-1,000 or Global-500 list, or is a major melt facility; 2 – All jobs figures should be regarded as approximate; they are thought to be the best available at the time; figures are from Hoover's (2015) unless otherwise noted; sites with less than 25 people have been excluded; 3 – Jobs figure based at least in part on 2013 County Business Patterns; 4 – Jobs figure(s) from company web-site; 5 – Jobs figure from Office of Research (2015a); 6 – Jobs figure from Gearino (2015); 7 – Jobs figure from Jarvis (2015); 8 – Incorporates figures from MacKinnon (2015); 9 – Jobs figure from AP (2015); employees were temporarily laid-off in March; 10 – Information from McCafferty (2015). Sources: Appendix Table A1.

Companies with major raw steel production and processing furnaces also need to be noted regardless of their Fortune status or their employment size. Listed below are such companies, the type of furnace, its location and annual melt capacity in 2013.[2] Total capacity in Ohio is estimated at 16,080,000 tons. Eight companies have 12 high-capacity furnaces; ArcelorMittal was the largest with more than 4.6 million tons, or 28.8 percent of the state total.

			Melt Capacity (Tons/ Year)	
Company/Subsidiary or Division	City	Type of Furnace[1]	Total	Furnace[2]
AK Steel			3,781,000	
AK Steel	Middletown	BOPF		2,899,000
AK Steel	Mansfield	EAF		882,000
ArcelorMittal			4,629,000	
Cleveland East	Cleveland	BOPF		2,535,000
Cleveland West	Cleveland	BOPF		2,094,000
Cargill-Bluescope Steel/North Star Bluescope Steel	Delta	EAF		2,183,000
Charter Steel	Cleveland	EAF		248,000
Industrias CH SAB de CV			2,594,000	
Republic Steel	Canton	EAF		1,394,000
Republic Steel	Lorain	EAF		1,200,000
Nucor	Marion	EAF		397,000
Timken Steel			1,554,000	
Faircrest	Canton	EAF		871,000
Harrison	Canton	EAF		683,000
Vallourec Star	Youngstown	EAF		694,000
Ohio Total:				16,080,000

Notes: 1 - BOPF – basic oxygen process furnace, EAF – electric arc furnace; 2 – Company and news sources may give different numbers (e.g., McCafferty (2013)), but AIM figures are used here for consistency and comparability at one point in time; Warren Steel Holdings was active and had a 441,000 ton capacity at the time, but permanently closed in January, 2016 (O'Brien, 2016). Sources: AIM Market Research (2013), Office of Research (2015b).

Of the 12 major furnaces in Ohio, AK Steel and ArcelorMittal have the three basic oxygen process furnaces (BOPFs,

which are used in the second step of producing steel from iron ore – see the Primer in the Appendix); the combined capacity of the latter is 7,528,000 tons per year, or 46.8 percent of Ohio's current total. Ohio ranked second in total steel production capacity with 12.2 percent of the U.S. total, and third in primary steel production capacity with 14.9 percent of the national BOPF capacity in 2013 (AIM Market Research, 2013; both percentages and ranks include Warren Steel Holdings, which was active at the time).

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GLOBALIZATION AND FOREIGN INVESTMENT IN OHIO

Foreign investment in Ohio is part of the globalization about which industry analysts write, and it has become increasingly important to the industry (see Yucel, 2015a: 25-26; 2015b: 25; 2015c: 25). Fifteen foreign-based companies have 24 subsidiary establishments in Ohio's iron and steel industry; two companies are on Fortune's Global-500 list. All of the companies are listed below, along with the countries where the home office is located, their Ohio subsidiaries, NAICS code(s) and the estimated number of employees here. ArcelorMittal is the largest employer with 2,681 people, followed by Industrias CH, SAB de CV with 1,680. Altogether, the 16 companies employ well over 6,500 in their mills, plants and foundries in Ohio.

Ultimate Foreign Parent	Parent Country	Ohio Subsidiary (no. of sites)	NAICS Code(s)	Total Jobs^
ArcelorMittal SA*	Luxembourg	ArcelorMittal (4)	331: 1, 21, 51	2,681
Bekaert SA	Belgium	Bekaert Corp. (2)	331222	245
Bluescope Steel Ltd. (joint venture with Cargill*)	Australia	North Star Bluescope Steel LLC (1)	3311	345
Caparo Intl. Corp.	United Kingdom	Bull Moose Tube Co. (1)	33121	40
Egon Evertz KG	Germany	Evertz Technology Srvcs. USA, Inc. (1)	33151	30
Eramet SA	France	Eramet Marietta, Inc. (1)	3311	200
GKN plc	United Kingdom	GKN Sinter Metals, Inc. (2)	331222	173
Industrias CH, SAB de CV	Mexico	Republic Steel (4)	331: 1, 21	1,680
Mitsui & Co., Ltd.*	Japan	Steel Technologies, Inc. (1)	331221	100
OAO TMK	Russia	TMK IPSCO (1)	33121	50
ShawCor Ltd.	Canada	ShawCor, Inc. (1)	33121	40
Siemens AG	Germany	Service Guide, Inc. (2)	33151	40
Tata Sons Ltd./Tata Steel Ltd.	India	Thomas Steel Strip Corp. (1)	331221	285
Vallourec SA	France	Vallourec Star (1)	33121	600
Vossloh AG	Germany	Cleveland Track Material, Inc. (1)	33121	50

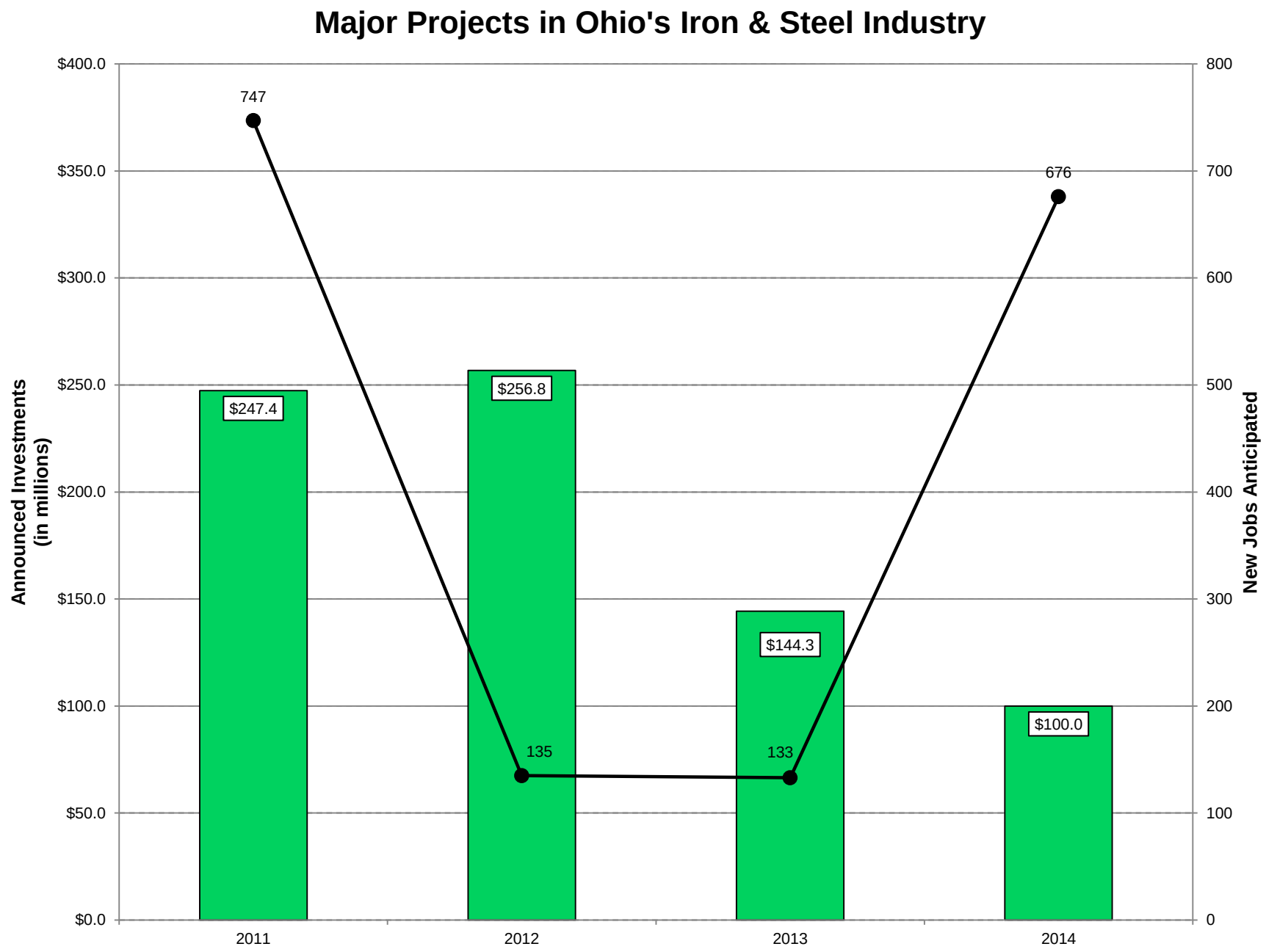
Notes: ^ - "Jobs" figures are thought to be the best available at the time of publication, but their accuracy cannot be guaranteed; * - a Fortune U.S.-1,000 or Global-500 company (privately-held Cargill has sufficient revenue to make Fortune's U.S.-1,000 list); Srvcs. - Services. Sources: Company websites (2015), Fortune (2015), Lexis-Nexis (2015), Office of Research, ODSA (2015a).

The foreign parent companies are headquartered in 11 nations. Three are German, two are British and two are French. Australia, Belgium, Canada, India, Japan, Luxembourg, Mexico and Russia are home to one each. ArcelorMittal and Industrias are the only companies with establishments in more than one specific industry.

A second way to understand the role of foreign investors in Ohio's iron and steel industry is to note their raw steel production capacity. Four companies own five and one-half of the 12 major furnaces in Ohio (assuming Bluescope has one-half

ownership of the furnace in Delta). The combined annual production capacity is 9.0 million tons, or 56.0 percent of the total. Furthermore, ArcelorMittal owns two of the three basic oxygen process furnaces (BOPFs) in Ohio, which amounts to 61.9 percent of primary steel production capacity here. The significant role of foreign investment in Ohio's iron and steel industry in this regard is not atypical; foreign-based steel companies owned an estimated 43.4 percent of all major melt capacity in America and an estimated 50.0 percent of U.S. primary steel production capacity in 2013 (drawn from AIM Market Research, 2013).

Foreign ownership or investment in the U.S. iron and steel industry is only one aspect of globalization. Another has been the establishment of foreign operations by American companies. U.S.-based companies have set-up or acquired overseas operation for various reasons: less regulation, lower labor costs, a desire to expand market share, and/or more rapid growth prospects in emerging economies. This is particularly true of iron and steel producers (Yucel, 2015a: 8, 13), but much less so of foundry companies and producers using purchased steel (Goddard, 2015: 23; Yucel, 2015b: 25; 2015c: 25). Setting up operations in foreign countries also circumvents export barriers.



Source: Office of Research, ODSA

RECENT EXPANSION AND ATTRACTION ANNOUNCEMENTS

Twenty-five companies announced 32 major investments in Ohio's iron and steel industry from 2011 through 2014. Planned expenditures surpassed $748 million, and close to 1,700 new jobs were anticipated when the projects are completed. The chart above shows that the largest aggregate amount of intended investments occurred in 2012, while the greatest number of new jobs was anticipated beginning in 2011.

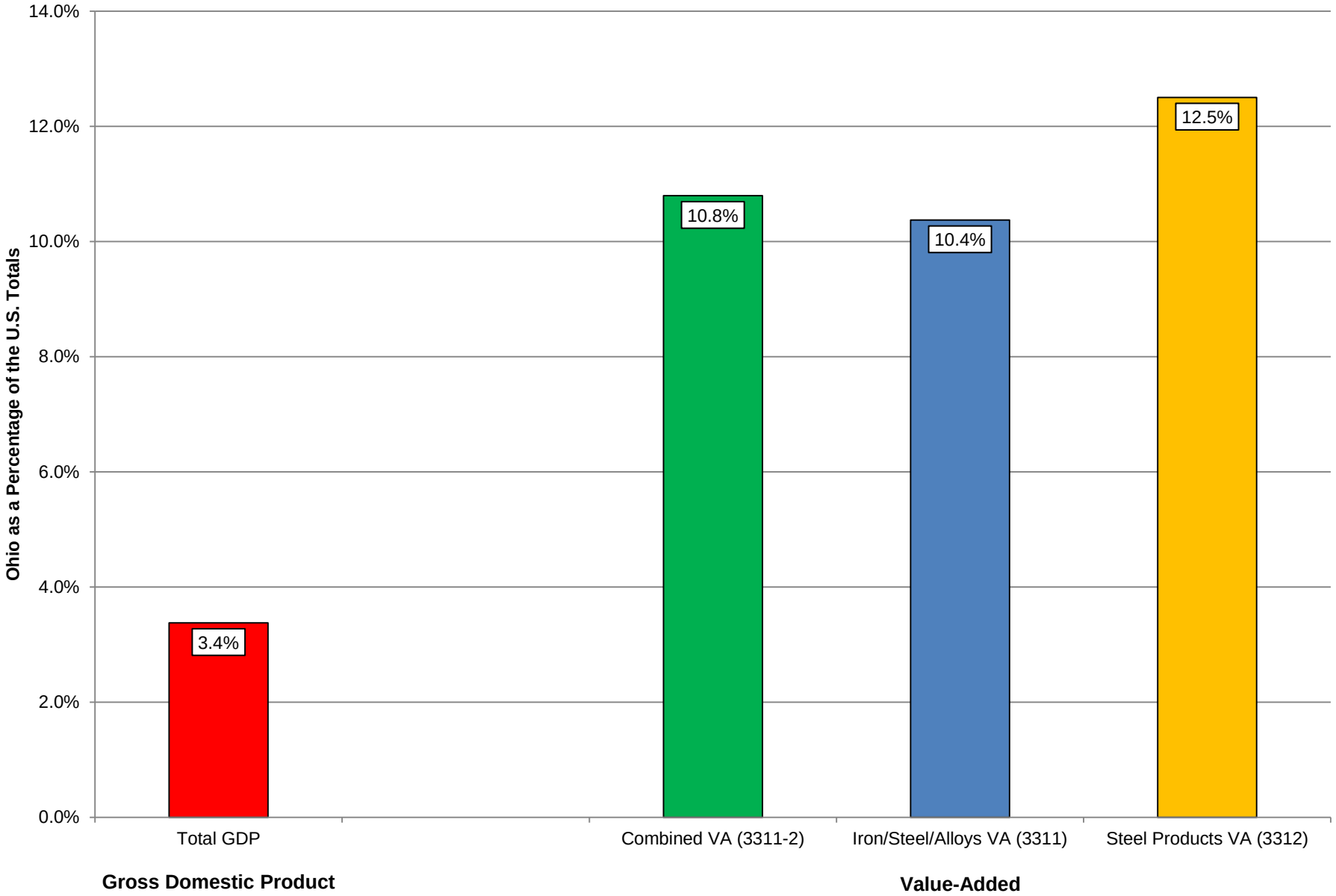
$567.5 million were intended for iron and steel mills and ferroalloy production (NAICS 3311), followed by $148.3 million for manufacturing steel products from purchased steel (3312), and $32.7 million for foundry work (33151). Those figures are 75.8, 19.8 and 4.4 percent of the total. 800 of the new jobs – 47.3 percent – were anticipated in the iron and steel mills and ferroalloys group, with 220-plus – 13.2 percent – for the products from purchased steel group, and almost 670 – 39.5 percent – in the foundries sub-group.

Timken lead all investors with three announcements totaling $302 million, including the single largest announcement of $225 million (from 2012). It was followed by ArcelorMittal with three announcements totaling $120.1 million, Industrias' Republic Steel with $85.2 million, and Vallourec Star with $67.2 million. Columbus Steel Castings anticipated adding the largest number of jobs, a total of 600 over two projects. The Republic project also anticipated adding 449 jobs, while ArcelorMittal's projects anticipated a total of 201 new jobs.

The counts and summary figures are drawn from a list of major investments compiled by the Office of Research (2015b). Companies on the list met at least one of the following criteria: at least $1 million committed for land, building(s) or equipment; at least 20,000 square feet of new space added to a facility; or a minimum of (usually) 50 new jobs. Many major investments are phased-in over two or three years, with employee counts following after project completion. Dollar figures are not comparable with the Census Bureau's capital expenditures data.

See Table A2

The Concentration of the Iron & Steel Industry in Ohio, 2013



Sources: U.S. Bureaus of the Census and Economic Analysis

IRON AND STEEL INDUSTRY CONCENTRATION IN OHIO

DONE FOR NOW

The chart above illustrates the concentration of iron and steel industry groups in Ohio. During 2013, 10.4 percent of the value-added by U.S. iron, steel and ferroalloy producers (NAICS 3311) came from plants in Ohio, while 12.5 percent of steel-products-from-purchased-steel (3312) value-added originated in Ohio. The two groups combined were 10.8 percent of national output (U.S. Bureau of the Census, 2015a).[3] More industry-specific data from the 2012 Census of Manufactures (see Appendix Table 3) show 9.9 percent of ferrous metal foundry (33151) value-added came from Ohio. When combined with iron, steel, ferroalloy and steel-products-purchased-steel output that year, 11.0 percent of total iron and steel industry value-added came from Ohio. By comparison, 3.4 percent of the value of all goods and services provided in America in 2013 originated in Ohio according to the latest gross domestic product (GDP) figures from the U.S. Bureau of Economic Analysis (2015).[4] The greater portions of the former compared with the last indicate the concentration of the industry here.

The following table shows that the summary concentration of the iron and steel industry is broadly based on all specific industries and not reflective of an extraordinary concentration in just one.

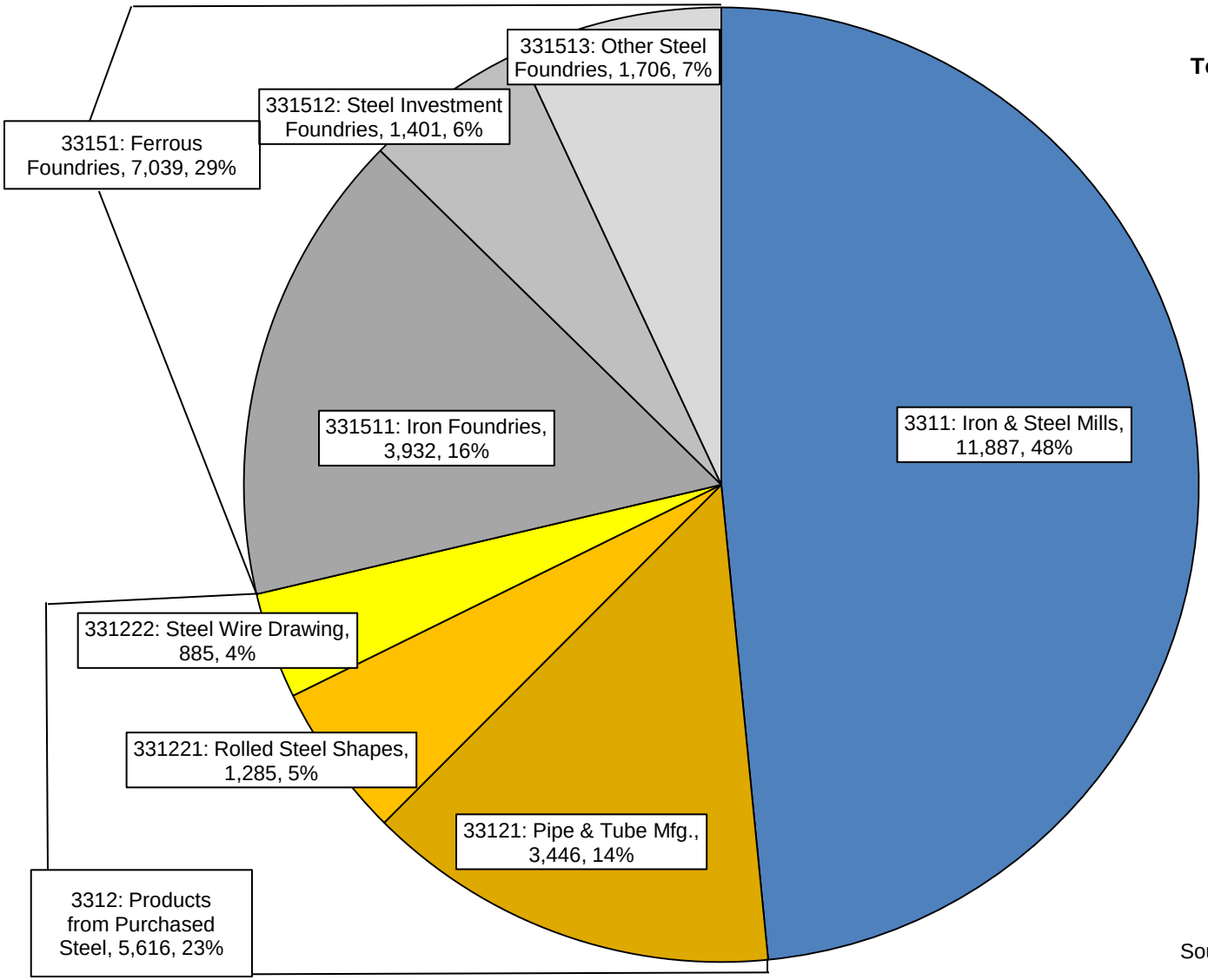
Industry Code and Description	Percent of Value-added in the U.S.	Apparent Rank in the U.S.*
3311: Iron & Steel Mills & Ferroalloys	12.7%	3rd
33121: Iron & Steel Pipes & Tubes from Purchased Steel	16.4%	1st
331221: Rolled Steel Shapes from Purchased Steel	10.2%	1st
331222: Steel Wire Drawing from Purchased Steel	8.1%	2nd
331511: Iron Foundries	7.9%	5th
331512: Steel Investment Foundries	13.7%	2nd
331513: Steel Foundries (except Investment)	10.7%	2nd

Note: * - Not every state with at least one industry establishment can be ranked based on value-added due to confidentiality restraints. Source: U.S. Bureau of the Census (2015c).

Three factors help explain the industry's historical and continuing concentration in Ohio: the raw materials – principally iron ore and coal – are in the area; bulk transportation, whether by water or rail, of both raw materials and products is convenient; and secondary manufacturers using purchased iron and steel (3312 and 33151) prefer to locate near their suppliers (3311), keeping transportation costs low (drawn from Yucel, 2015a: 21).

See Table A3

Employment in Ohio's Iron and Steel Industry
by Specific Industry, 2013



Total: 24,542

Source: U.S. Census Bureau

THE COMPOSITION OF OHIO'S IRON AND STEEL INDUSTRY: EMPLOYMENT

175 establishments employed well over 24,500 people in Ohio's iron and steel industry according to the latest comprehensive data from the U.S. Bureau of the Census (2015b). Close to 11,900 – 48.4 percent – worked in the iron-steel-ferroalloys group (NAICS 3311). (Data gathered prior to implementing the 2012 NAICS show only a minute fraction of the group was in ferroalloy production.)

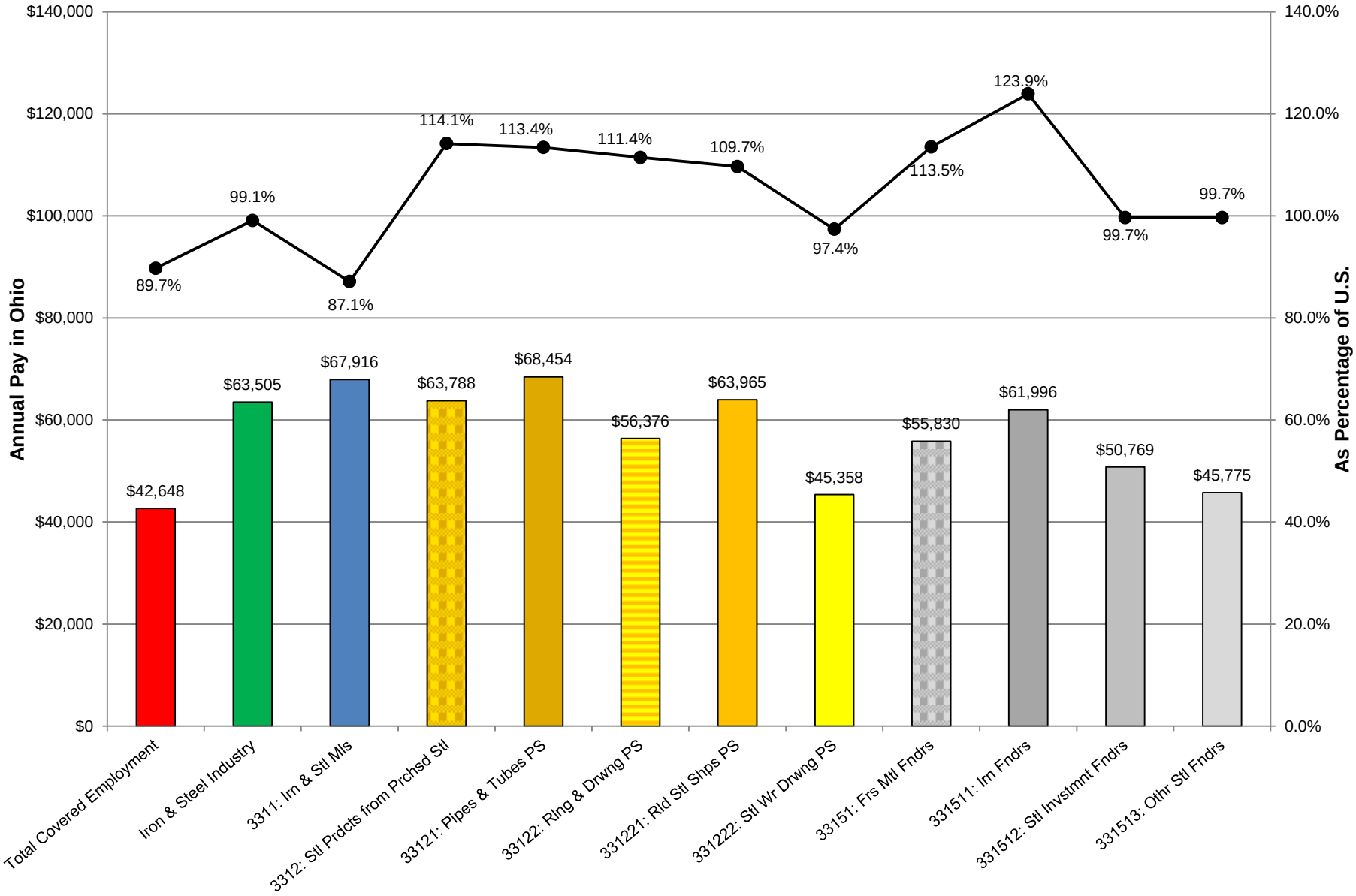
The remaining industry employees were divided between the ferrous metal foundries subgroup (33151) with 7,000-plus – 28.7 percent of the industry – and the products-from-purchased-steel group (3312) with 5,600-plus and 22.9 percent. Iron foundries (331511) were the second largest employers after iron and steel mills with over 3,900 people (the plurality of which were people at GM's Defiance foundry.) The remaining specific industries employed from 885 to 3,400-plus people – 3.6 to 14.0 percent of the industry total.

Overall, 9.1 percent of the iron and steel industry establishments and 11.1 percent of the industry's jobs in America are located in Ohio – concentrated when compared with Ohio's portions of all private non-farm non-railroad establishments and employment – 3.3 and 3.9 percent, respectively. As with value-added in the preceding section, the concentration of industry employment was broadly based, not the result of extreme concentration in one specific industry. Percentages of specific national industry employment in Ohio ranged from 6.1 to 17.0 percent (U.S. Bureau of the Census, 2015b).

See Table A4

Annual Pay in Ohio's Iron and Steel Industry

by Groups and Individual Industries, 2013



Source: U.S. Census Bureau

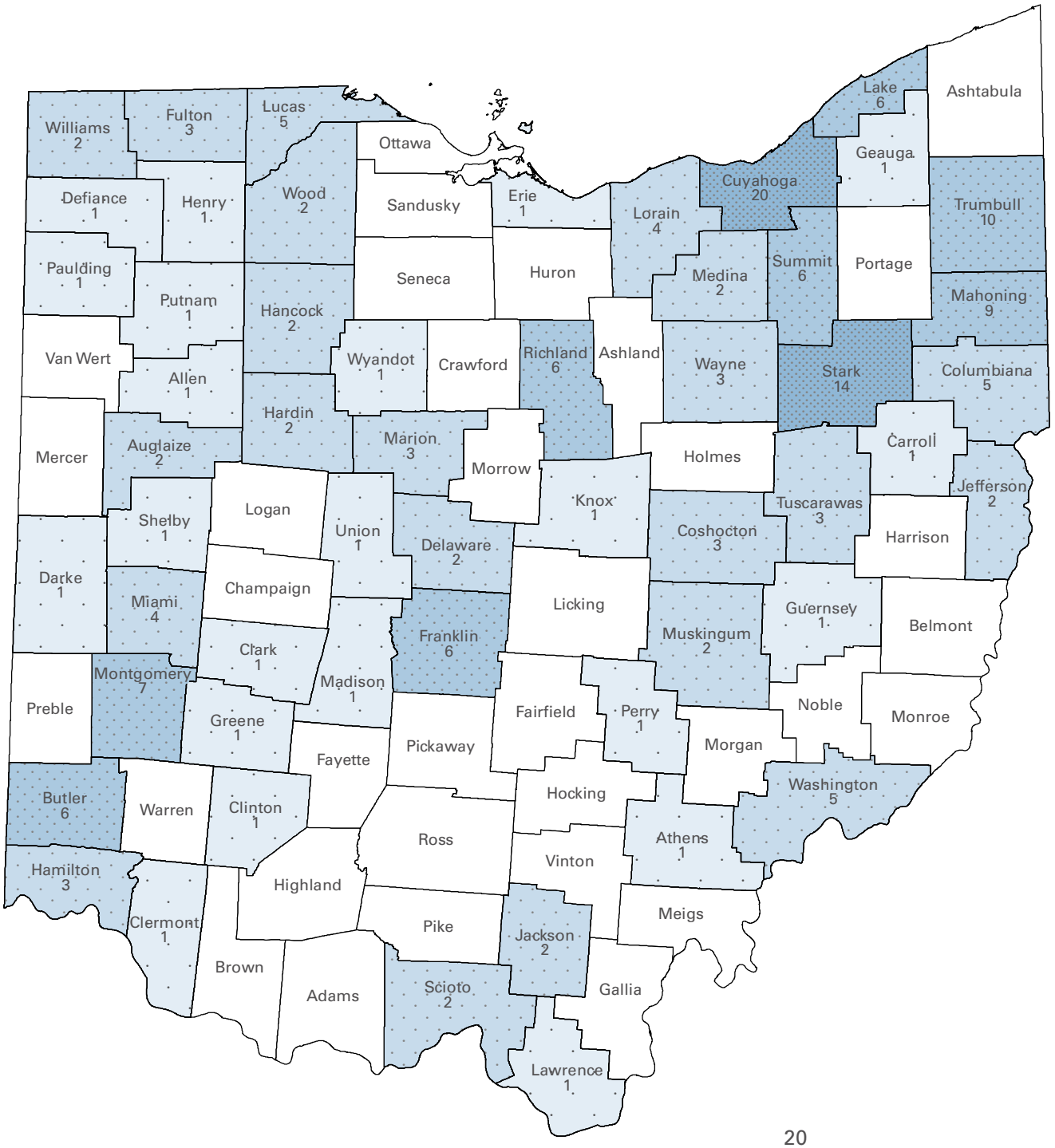
INDUSTRY PAY

The chart above shows that annual pay for all non-farm, non-railroad private sector employees in Ohio averaged more than $42,600 in 2013. People employed in the state's iron and steel industry averaged $63,500, but there is much variation within. Pay was greatest in the iron-steel-ferroalloys group (NAICS 3311, $67,900), followed by the products-from-purchased-steel group (3312, close to $63,800) and ferrous metal foundries (33151, but still more than $55,800).

The chart also illustrates the variation within the latter two groups. The high pay in pipes and tubes made from purchased steel (33121, $68,400-plus) is offset by the lower pay in steel wire drawing from purchased steel (331222, less than $45,400), while pay in rolled steel shapes from purchased steel (331221, $63,600-plus) is slightly above the group average. Similarly, the relatively high pay in iron foundries (331511, nearly $62,000) offsets the lower pay of work in steel foundries (331512 and 3, $50,700-plus and $45,700-plus).

Mean iron and steel industry pay in Ohio was 99.1 percent of the corresponding national average. Again, there is notable variation from one specific industry to the next. Some are close to their corresponding national averages: wire drawing from purchased steel and the steel foundries (97.4 and 99.7 percent, respectively). Others are above the national averages, ranging from 109.7 percent in rolled steel shapes from purchased steel to 123.9 percent at iron foundries. Perhaps surprisingly, the high pay in Ohio's iron-steel-ferroalloys group – $67,900 – is just 87.1 percent of the national average.

See Table A5



Ohio

Ohio Steel Industry

Establishments by County

Statewide: 175

Steel Industry Establishments in County

- 11 - 20
- 6 - 10
- 2 - 5
- 1
- None

Source:
2013 County Business Patterns
U.S. Census Bureau

Prepared by:
Office of Research
Ohio Development Services Agency
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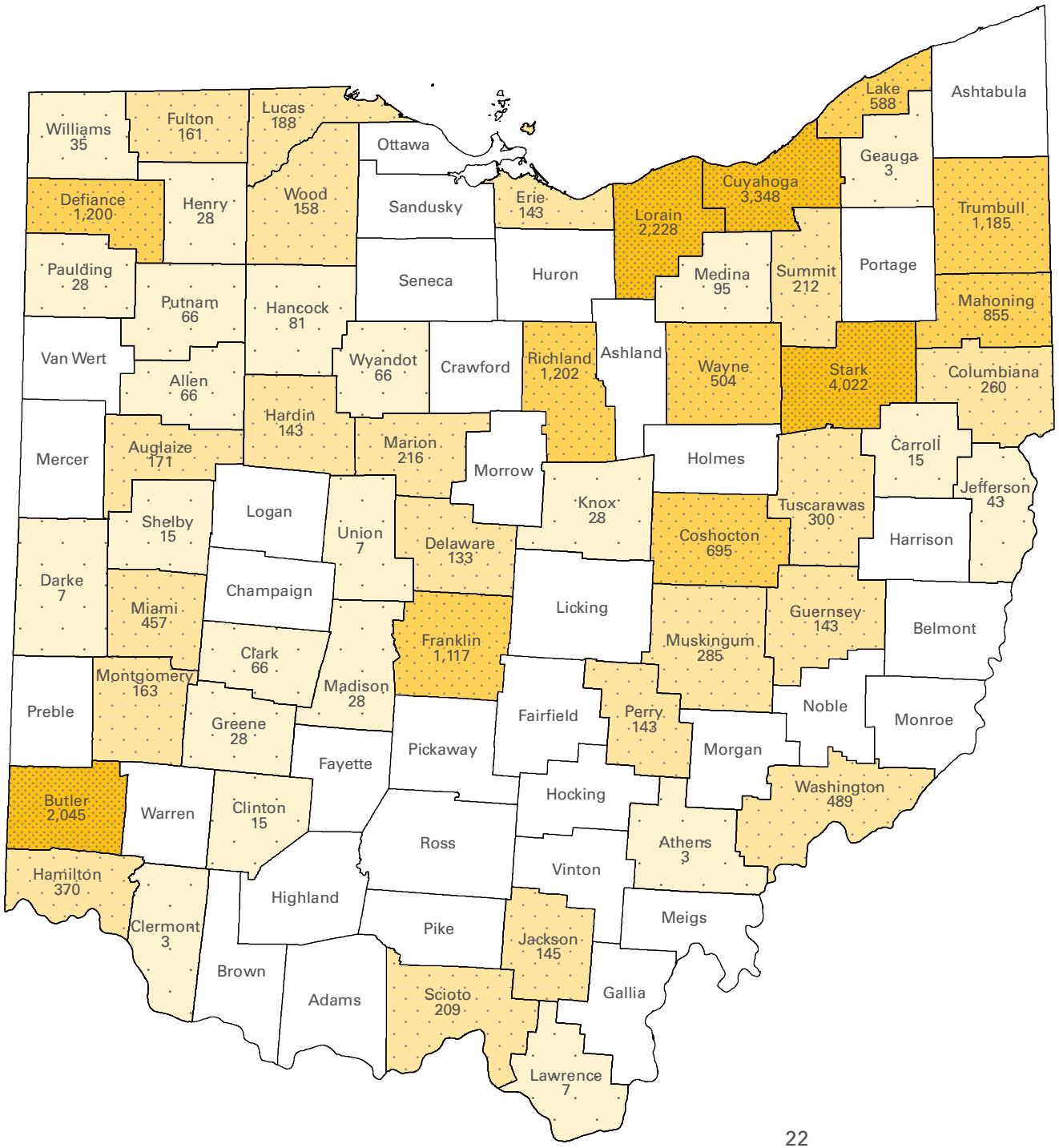
THE DISTRIBUTION OF INDUSTRY ESTABLISHMENTS IN OHIO

The map above illustrates the distribution of the 175 iron and steel industry establishments across Ohio according to the latest County Business Patterns data. Fifty-four counties had at least one industry establishment. However, just over one-half of the establishments were found in 10 counties: Cuyahoga had 20; Stark, 14; Trumbull, 10; Mahoning, nine; Montgomery, seven; and Butler, Franklin, Lake, Richland and Summit, six each. The remaining 44 counties with establishments each had from one to five.

One way to look at the map is to note the clustering of establishments in Northeastern metropolitan areas (MAs) long-noted for iron and steel operations. Canton-Massillon, Cleveland-Elyria, Mansfield and Youngstown-Warren (a total of 10 counties) have 73 establishments, or about two-fifths of the industry total. Indeed, the four MAs still have nine of the 12 major melt facilities in Ohio with 65.9 percent of such capacity, including two of the three basic oxygen process furnaces.[5] (All of the remaining furnaces are electric arc.) Including the Akron MA (two counties) adds six establishments.

Yet more than one-half of the industry facilities are outside of Northeastern Ohio regardless of metropolitan status. Fourteen counties in the Cincinnati, Columbus, Dayton and Toledo MAs combine for 43 establishments, about one-quarter of the state total, and Cincinnati and Toledo each have one major melt facility. (The 12th large-capacity furnace is in Marion.) Franklin and Defiance have the two largest foundries in the state.[6]

See Table A6



Ohio

Ohio Steel Industry

Employment by County*
Statewide: 24,542

Steel Industry Employment in County*

- 2,001 - 4,022
- 501 - 2,000
- 101 - 500
- 1 - 100
- None

*County employment figures shown on this map should be considered estimates

Source:
2013 County Business Patterns
U.S. Census Bureau

Prepared by:
Office of Research
Ohio Development Services Agency
January 2016

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THE DISTRIBUTION OF INDUSTRY EMPLOYMENT IN OHIO

Employment is even more concentrated than the distribution of establishments; eight counties account for two-thirds of the industry jobs in Ohio. Stark topped the list with 4,000, followed by Cuyahoga with 3,300-plus, Lorain with 2,200-plus, and Butler with well over 2,000. Defiance, Franklin, Richland and Trumbull had about 1,100 to 1,200 each. Four more counties had between 500 to 900 industry jobs: Coshocton, Lake, Mahoning and Wayne. Twenty had 100 to 499, and 22 had 1 to 99.[7]

Counties with at least 500 employees often are associated with the facilities of notable industry companies: Butler has AK Steel; Coshocton has AK Steel and the McWane subsidiary Clow Water Systems; Cuyahoga has ArcelorMittal and Charter Steel; Defiance has a General Motors foundry; Franklin has Columbus Steel Castings and Worthington Industries; Lorain has Republic Steel and U.S. Steel; Mahoning has Vallourec; Richland has AK Steel and ArcelorMittal; Stark has Republic Steel and Timken; Trumbull has the Worthington Industries subsidiary Dietrich Industries (and had Privat's Warren Steel Holdings at the time). Lake and Wayne appear to be exceptions in this regard. (The converse exception is Marion County, which has less than 500 employees, but has ArcelorMittal and Nucor.)[8]

See Table A6

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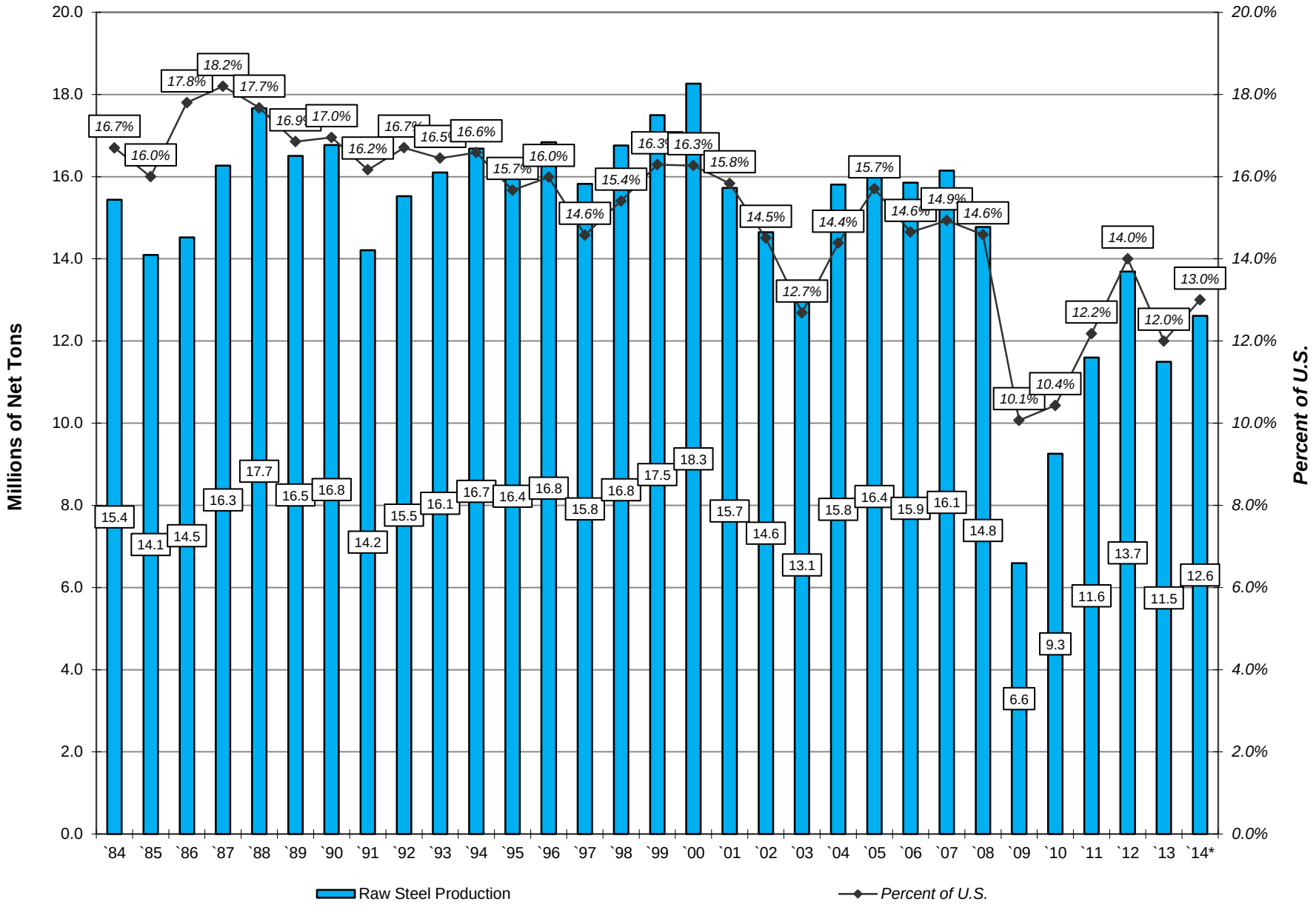
TRENDS

Raw Steel Production in Ohio, 1984-2014



Sources: American Iron and Steel Institute; Hill, et.al.; U.S. Geological Survey

* - Preliminary

RAW STEEL PRODUCTION

Raw steel production is the core of the iron and steel industry, the immediate or proximate starting point for all goods wholly or partially made of steel. The chart above illustrates the cyclical nature of the raw steel production in Ohio, with the relatively low output volumes during 1991, 2003 and 2009 closely corresponding with the depths of national recessions, and the relatively high output volumes during 1990, 2000 and 2007 matching the peaks (or ends) of national economic expansions. The highest and lowest production volumes were 18.3 and 6.6 million net tons in 2000 and 2009, respectively.[9] The 2014 U.S. capacity utilization rate is estimated to be 77.2 percent – relatively low compared to the normal 85 to 90 percent rate, but much better than in the trough of the recession (U.S. Geological Survey, 2015). The rate in Ohio may have been greater.

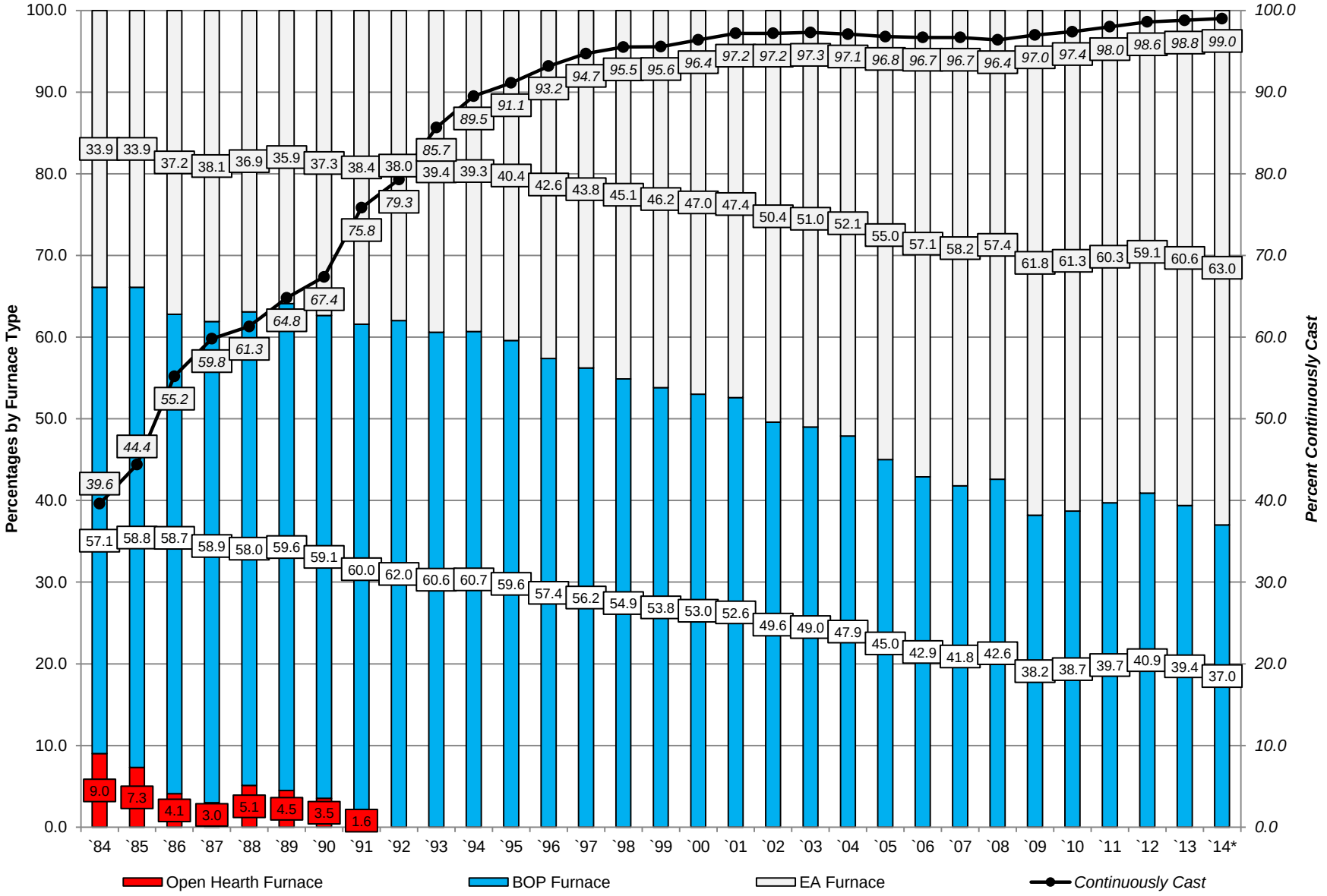
The highly cyclical character of raw steel production reflects the use of relatively large amounts of steel in products with high sale prices: transportation equipment, big appliances and machinery, some fabricated metal products, and non-residential construction projects. These steel-using industries tend to highly cyclical in response to changing consumer demand. When business is good and jobs are plentiful, consumers – individuals, families and organizations – feel confident in purchasing expensive goods. Conversely, consumers cut back or delay expenditures for the same goods during economic hard times, preferring to repair instead of replace (drawn from Levy, 2014, and Corridore, 2014; also see Yucel, 2015a: 16).[10] The earlier part of economic recoveries and expansions generally are led by increasing demand for consumer durables: motor vehicles, appliances and other domestic equipment. By contrast, the demand for capital goods such as those used in non-residential construction, machinery and commercial equipment typically increases after the recovery is well under way and the demand for consumer durables plateaus (Larkin, 2013: O6). Overall, then, steel industry shipments continue through-out an economic expansion.

The chart above also records how the percentage of U.S. raw steel production coming from Ohio seems to have trended lower during the last three decades, although year-to-year variations are readily apparent. Including data from Appendix Table A9, Ohio averaged 16.8 percent of U.S. raw steel production during the 1970s, 16.5 percent during the 1980s, 16.1 percent during the 1990s, but 14.5 percent during the 2000s and 12.4 percent during the first-half of this decade. This may be due to the spread of minimills (which recycle steel) across the country as well as the latter's increasing share of raw steel production. Despite the yearly variations and the slightly lower percentages, Ohio ranked second in raw steel production for every year shown above; 1981 was the last year it ranked third.

Raw steel production methods have shifted over the years with technological advances. The chart on the following page illustrates (1) the demise of open hearth furnaces in favor of more efficient basic oxygen process furnaces (BOPFs) for primary steel production and (2) the growing role of electric arc furnaces (EAFs) for recycling in raw steel production.

U.S. Raw Steel Production, 1984-2014

Percentages by Furnace Type and *Cast*



Sources: American Iron and Steel Institute; U.S. Geological Survey

* - Preliminary

Iron and steel production was a vertically integrated process dominated by large companies for much of the 20th century. The companies owned the materials and equipment used at each step of the primary production process. These included the mines of iron ores, coal and fluxes, the coke ovens, the furnaces, the breakdown mills, and the service and distribution centers (i.e., wholesalers) for steel slitting and sales to end users (Larkin, 2013: O1). 91.6 percent of the raw steel produced in the U.S. during 1960 was made by this primary production process (further described in the Appendices); only 8.4 percent came from mills focused exclusively on recycling scrap (cited by Larkin, 2013: O2 & O3).

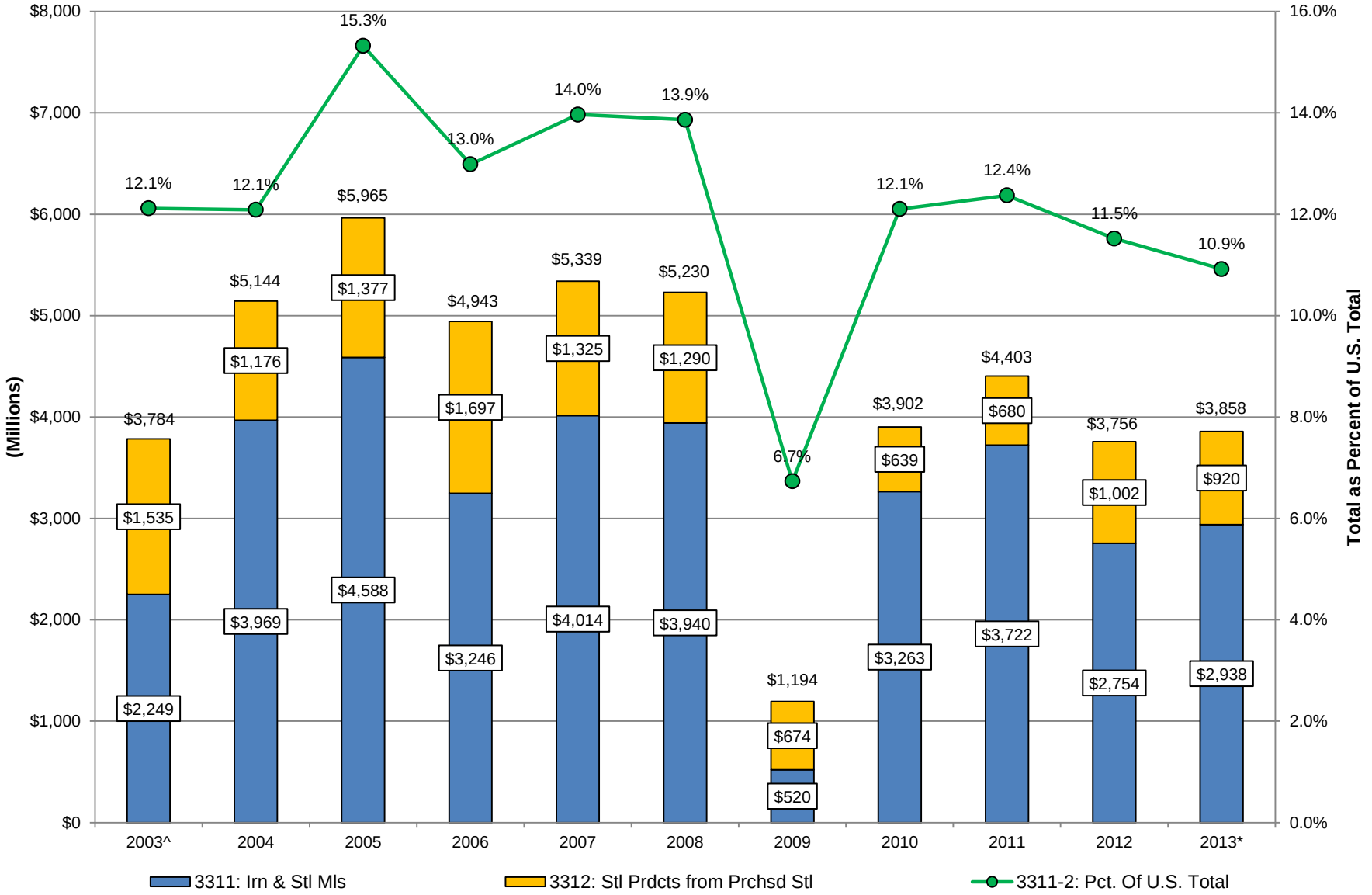
In contrast to primary producers, minimills make steel by recycling ferrous scrap in EAFs. (Some can substitute directly reduced iron when scrap prices are high.) Doing so means that they avoid the costs associated with blast- and BOPFs, coke ovens and equipment to handle raw materials. (Raw materials and the greater energy required for primary steel making are about two-thirds of the costs of primary producers.) Consequently, capital costs for minimills are much lower than for primary producers. Lower capital costs, a leaner management structure, and more flexible, less costly labor arrangements allowed minimills to undercut the prices primary producers would charge for the same products (Larkin, 2013: O1, O3; also Yucel, 2015a: 10, 24-25).[11]

Minimills initially were limited to lower-quality commodity products, but have increased their collective market share as quality improved. One key to their expansion was the development of thin slab and strip casters. These bypassed the need for reducing stands, permitting the direct production of thin slabs and strips from molten raw steel. (North Star Bluescope Steel is an Ohio minimill using such technology.) While primary producers also adopted them, they benefitted minimills more by the reduction of capital needed to compete in markets for higher quality goods such as pipes, plates, strips and sheets. Such items had been the domain of primary producers, but they were forced to abandon markets for specific products. Ultimately, then, it has been interrelated technological advances and reduced costs that enabled minimills to increase their share of domestic raw steel production at the expense of primary producers. Nevertheless, primary producers remain the source for the highest-grade goods (Larkin, 1994, 1995, 2005, 2013).[12]

See Table A7

Value-Added in Ohio's Iron and Steel Products Groups, 2003-2013

(NAICS 3311-2, Standardized on 2009)



Sources: U.S. Bureaus of the Census and Labor Statistics

^ - Estimated; * - Preliminary

PRODUCTION AS MEASURED BY VALUE-ADDED

Value-added (VA) data for the iron-steel-ferroalloys and steel-products-from-purchased-steel groups (NAICS 3311 and 3312) provide a broader picture of industry output in Ohio than raw steel production alone. Figures seen in the chart above have been adjusted with the associated producer price indexes to remove the effects of inflation and deflation to give a better sense of how production *volumes* may have changed.[13] (Unadjusted figures for both groups as well as summary figures combining the two also are shown in Appendix Table A8 along with the producer price index values.) The combined volume fluctuated around $5 billion from 2004 through 2008, peaking above $5.9 billion in 2005. Production fell to less than $1.2 billion at the depths of the recession in 2009, but rebounded in 2010 to $3.9 billion and fluctuated thereafter. Post-recession combined output generally has remained below pre-recession levels.

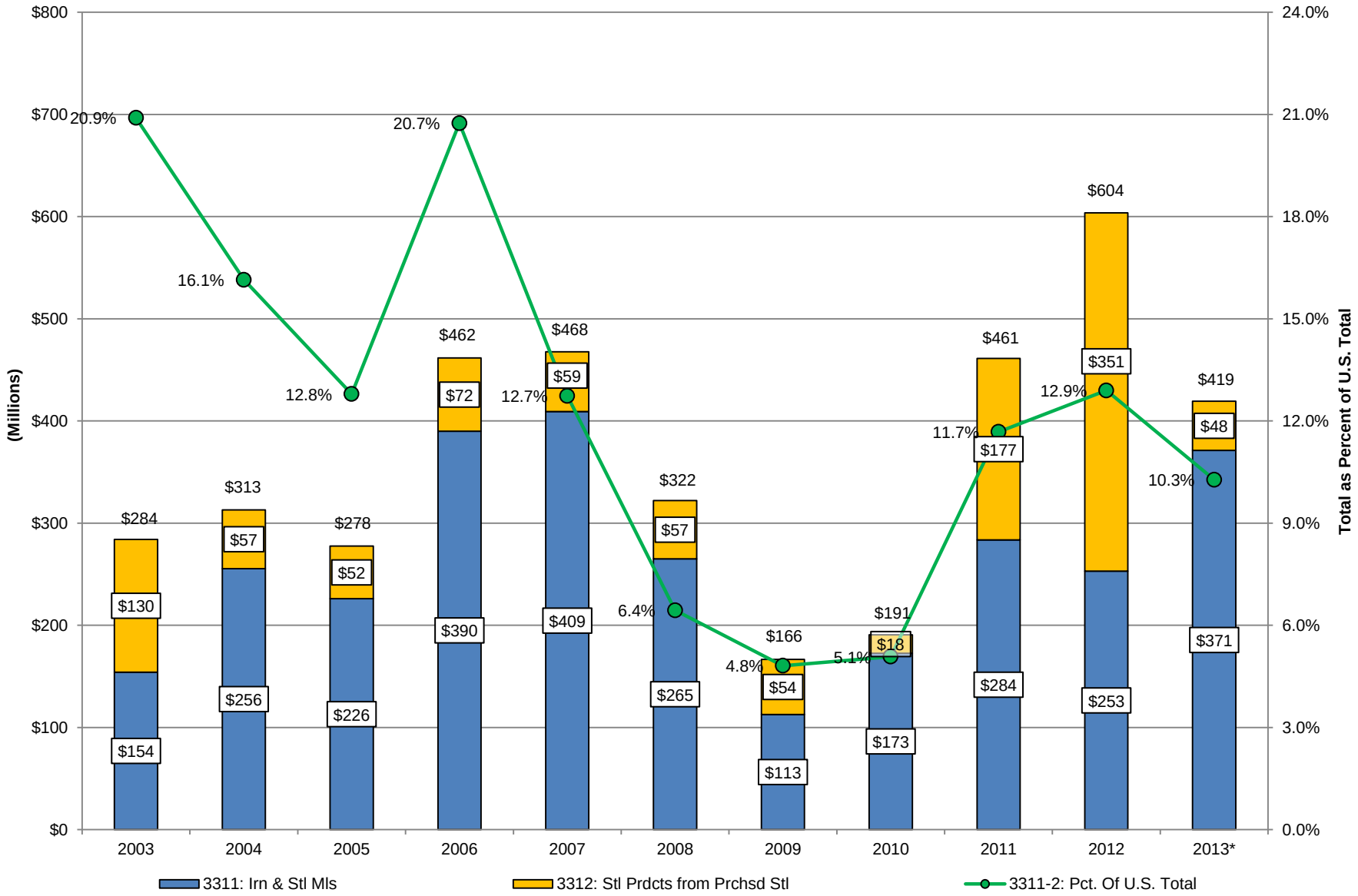
The chart above shows that an average of 74.1 percent of combined output came from the iron-steel-ferroalloys group (NAICS 3311; the VA data include the value of raw steel produced as well as the value of end-use goods *made where the raw steel is produced*). Group output usually varied between $3.2 and $4.6 billion before the recession, was just $520 million in 2009, and varied between $2.7 and $3.8 billion post-recession. (This compares with raw steel production, which ranged from 13.1 to 16.4 million tons during 2003-2008, was 6.6 and 9.3 million tons in 2009 and 2010, and has since fluctuated between 11.5 and 13.7 million tons.)

Output from the products-from-purchased-steel group (3312) averaged 25.9 percent of the combined total. 2009 was the only year when the output exceeded that of the iron-steel-ferroalloys group. Output ranged between $1.1 and $1.7 billion during 2003-2008, was between $600 and $700 million during the recession and two following years, but rose to $1.0 and $0.9 billion in 2012 and 2013. This record of change, when combined with the record of iron-steel-ferroalloys, means both groups are part of the generally lower post-recession levels of combined output.

The chart above also places the combined output of the two groups in a national context: it ranged between 12.1 and 15.3 percent of the corresponding U.S. total before the recession, was 6.7 percent in 2009, and ranged between 10.9 and 12.4 percent post-recession. Additional data in Appendix Table A8 show that VA percentages of iron-steel-ferroalloys from Ohio ranged from 10.3 to 14.6 in 2004-2008, was 3.5 percent in 2009, and ranged from 10.4 to 12.5 thereafter. This contrasts with the percentages of steel-products-from-purchased-steel: 15.7 to 25.6 during 2003-2009 vs. 11.9 to 14.1 thereafter. Consequently, it appears that the post-recession lower portion of combined output mostly reflects the post-recession lower portion of steel-products-from-purchased-steel.

See Table A8

Capital Expenditures in Ohio's Iron and Steel Products Groups, 2003-2013
(NAICS 3311-2, in Current Dollars)



Source: U.S. Census Bureau

* - Preliminary

CAPITAL EXPENDITURES

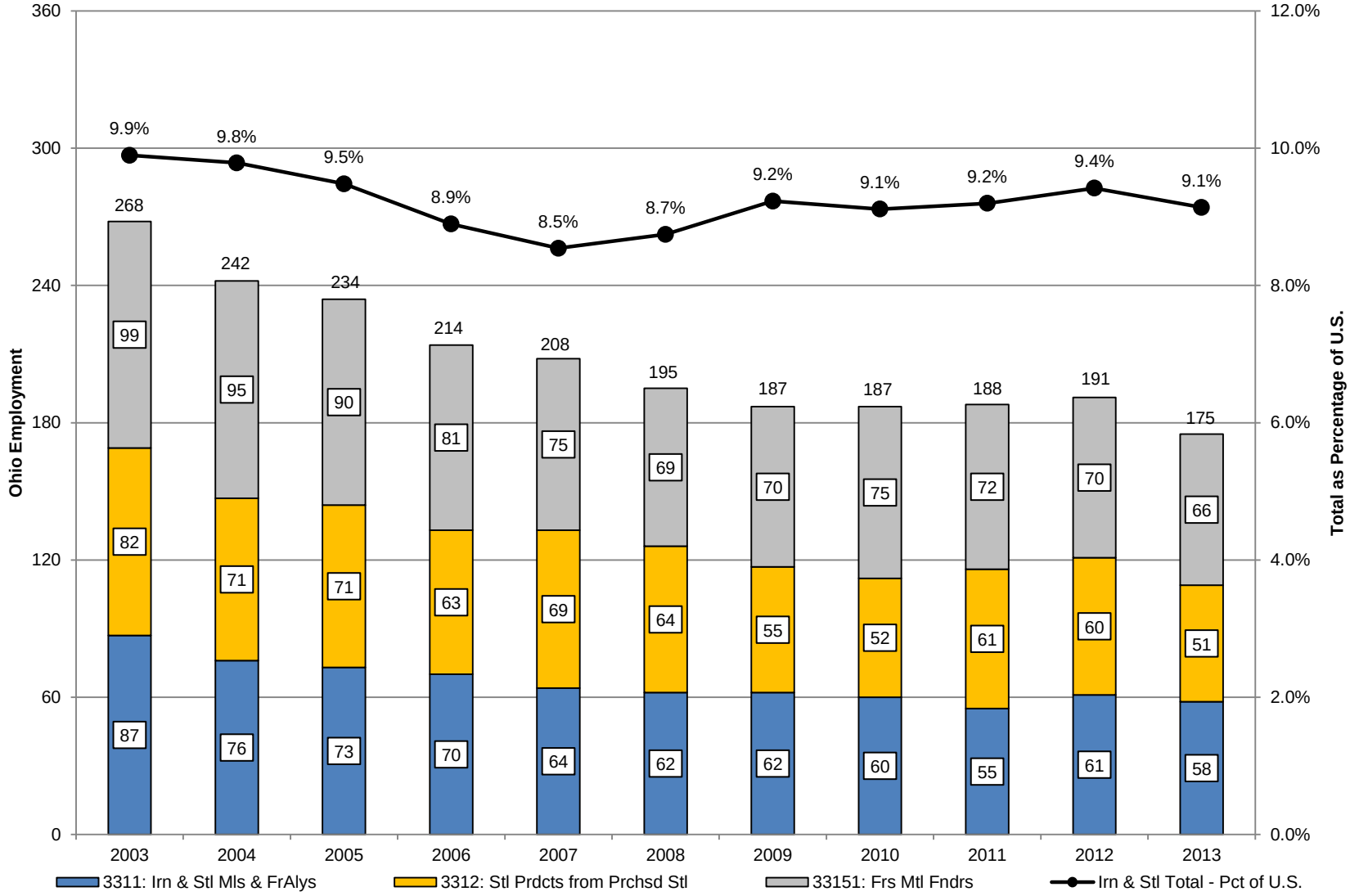
Capital expenditures (CE) are funds spent for buildings and equipment used in manufacturing. The chart above shows combined CE for the iron-steel-ferroalloys and steel-product-from-purchased-steel groups (NAICS 3311 and 3312) have varied widely over the years: from $166 million in 2009 to $604 million in 2012. As percentages of corresponding national totals, they ranged from 4.8 in 2009 to 20.9 in 2003. These variations are evident for each group: from $113 to $409 million by iron-steel-ferroalloy producers, and from $48 to $351 million by manufacturers of steel products from purchased steel. The corresponding percentages of U.S. totals ranged from 3.7 to 17.1 and 3.9 to 30.8 (see Appendix Table A9). While national CE may normally fluctuate over business cycles, CE within one state appear as episodic and hugely variable; hence these great variations in absolute and proportional CE seen above. Seen in this context, long-term averages provide a better understanding of state-level CE. On average, CE for iron-steel-ferroalloy production in Ohio were 9.9 percent of the national total, and steel-products-from-purchased-steel CE were 14.9 percent of the national total. Together, they were 10.9 percent of the combined U.S. total. While annual Census Bureau CE figures for ferrous foundry operations (33151) are unavailable, Goddard reports most have gone into large-scale operations (2015: 28).

Capital intensity (CI) – the ratio of CE to the labor costs – varies by group. CI in iron-steel-ferroalloys is relatively high when compared with the overall average for manufacturing (Yucel, 2015a: 34); costs for primary steelmakers can reach $2,000 per ton of capacity, while those for minimills are about $500 per ton (Larkin, 2013: O1). This amounts to hundreds of millions of dollars for new operations or substantial upgrades of current facilities for whatever reason: efficiently producing steel at competitive prices, meeting environmental regulations, etc. This contrasts with the near-average CI of steel-products-from-purchased-steel (Yucel, 2015b: 30; 2015c: 31), and the below average CI of ferrous foundry operations (Goddard, 2015: 28). The difference is none of the latter secondary producers actually make their source material.

Comparing the national portions of CE and value-added (VA) in Ohio yields further insights into the industry here. As seen in Appendix Tables A8 and A9, 11.4 percent of U.S. VA in the iron-steel-ferroalloys group came from Ohio during 2003-2013, while such mills here received 9.9 percent of CE – a ratio of 1.15 to 1. The corresponding VA::CE ratio for the steel-products-from-purchased-steel group was 1.06 to 1. The combined VA::CE ratio was 1.12 to 1. It appears companies in Ohio generally have generally emphasized production during this time. Any number of factors may help explain this broad conclusion: given the concentration of primary steel production here and that primary steel makers have had larger financial liabilities than minimills, less money may have been available for CE (Larkin, 2013: I4); or it may reflect minimills' growing share of raw steel production; or it may reflect the CE for minimills in more rapidly growing parts of the U.S.; or a greater focus on production automation, inventory and order management, and less on new products (Yucel, 2015a: 34, Yucel, 2015b: 30-31; Goddard, 2015: 28). The list could go on.

See Tables A8 & A9

Establishment Trends in Ohio's Iron and Steel Industry
by Group, 2003-2013



Source: U.S. Census Bureau

ESTABLISHMENTS

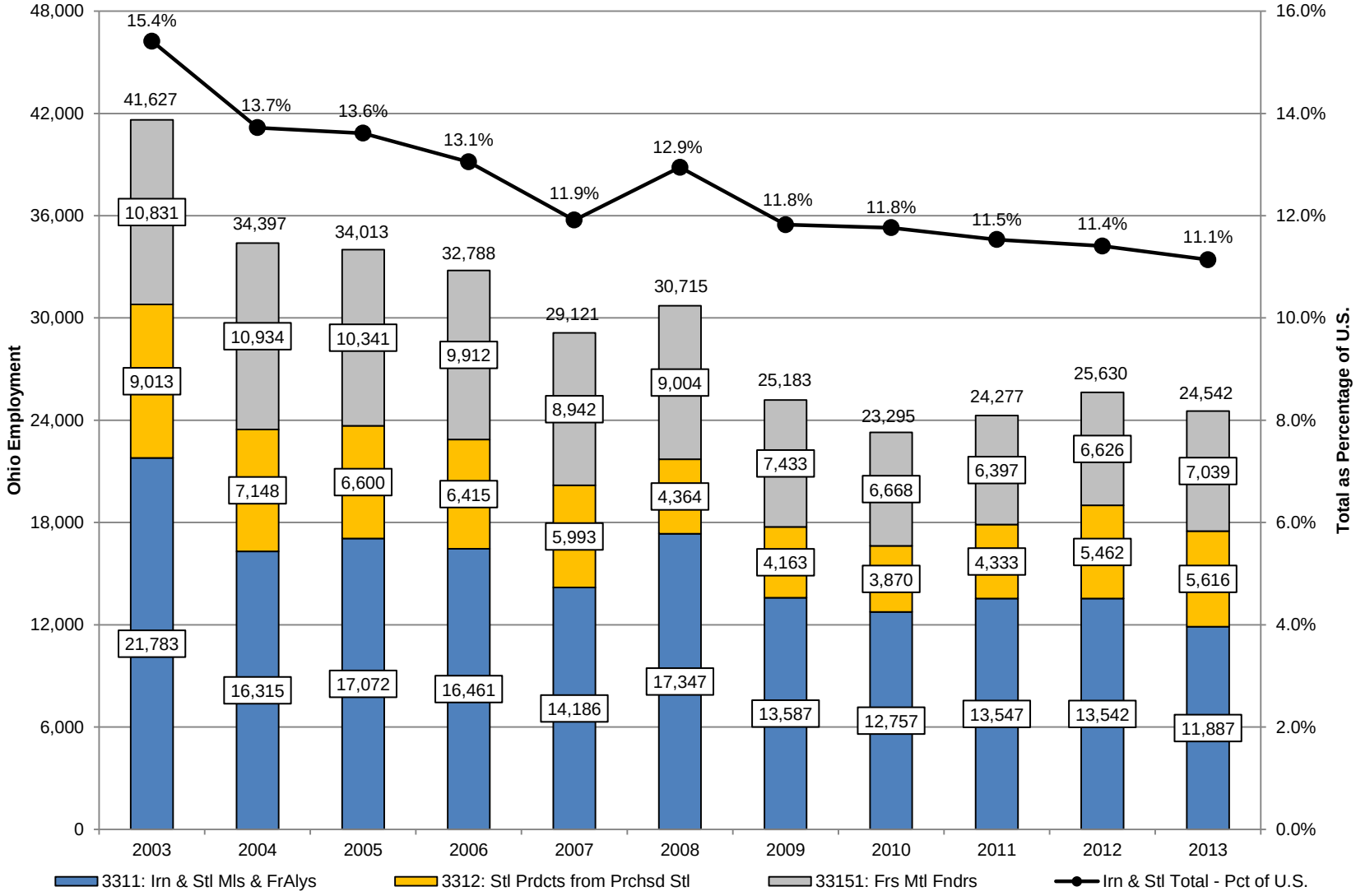
The chart above shows the number iron and steel industry establishments in Ohio fell 34.7 percent from 268 in 2003 to 175 in 2013. Decreasing numbers characterized the three principal industry sectors in nearly equal proportions: 33.3 percent in iron-steel-ferroalloys (NAICS 3311), 37.8 percent in steel products from purchased steel (3312) and 33.3 percent in ferrous metal foundries (33151). Specific industry figures in Appendix Table A10 show more variation. On one hand, the numbers of wire drawing plants (331222) and non-investment steel foundries (331513) fluctuated but showed little or no net change during this time. On the other hand, the number of plants rolling steel shapes (331221) and the number of iron foundries (331511) fell 61.8 and 44.9 percent, respectively.[14]

What happened in Ohio more or less was part of changes seen in America: the number of iron-steel-ferroalloy plants fell 39.0 percent, steel-products-from-purchased-steel plants fell 20.7 percent, and ferrous foundries fell 27.9 percent. The specific industry exception was the 5.0 percent increase iron and steel pipe and tube plants – but, given the fluctuating numbers, this is not indicative of any long-term trend. Overall, total number of U.S. iron and steel industry establishments fell 29.3 percent. Thus, despite the large declines in numbers, the percentage of industry establishments in Ohio merely slipped from 9.9 to 9.1 over the decade.

Analysts have cited a number of factors to explain the declining establishment numbers: market in-roads from imports and by producers of alternative materials; reduced demand for remaining uses; companies leaving the business and the related closure of more labor intensive plants in favor of more modern, more automated facilities; consolidation as companies merge to attain the advantages of greater size (such as administrative efficiency, economies of scale, greater bargaining power in markets, greater product diversity to stabilize income), etc. (Goddard, 2015: 22; Larkin, 2013: O2; Yucel, 2015a: 17, 22, 34-35; 2015c: 12, 24). These factors also affected long-term employment trends.

See Tables A10

Employment Trends in Ohio's Iron and Steel Industry
by Group, 2003-2013



Source: U.S. Census Bureau

EMPLOYMENT

Total employment in Ohio's iron and steel industry fell from 41,600-plus in 2003 to about 23,300 in 2010, a 56.0 percent decline. That otherwise steady decline was interrupted in 2008 as employment rose by about 1,400, but resumed falling in the wake of the Great Recession. Employment rose above 25,600 in 2012 following the expansion of output, but slipped by more than 1,000 jobs in 2013. Analysts state most of the post-recession employment recovery has been [very modest] rehiring at current establishments (Goddard, 2015: 7; Yucel, 2015a: 8; 2015b: 7), while the recent dip reflects the impact of lower worldwide demand for steel and products made from purchased steel (Yucel, 2015a: 8; 2015b: 6). The net change over this decade was a loss of 17,000-plus jobs, a 41.0 percent decline.

The chart above shows that long-term employment losses were seen in all three groups. However, most of the losses occurred in the iron-steel-ferroalloys group (NAICS 3311) – essentially 9,900, a 45.4 percent drop. Nearly 3,800 jobs were lost in foundries (33151) – a 35.0 percent decline, while 3,400 jobs were lost at plants making steel products from purchased steel (3312) – a 37.7 percent decline.

Figures in Appendix Table A11 show two specific exceptions to these broader trends. Employment at non-investment steel foundries (331513) more than doubled over the decade, while employment at steel wire drawing plants (331222) fell and rebounded with little net change.

The changes here were part of roughly similar changes seen across the nation. Data in Appendix Table A11 show net declines of 18.3 percent in iron-steel-ferroalloys employment, an 8.0 percent loss in steel products from purchased steel, and a 24.5 percent drop in foundry jobs. There also was a 21.3 percent gain in non-investment steel foundries. The exception was a 29.3 percent rise in national pipe and tube employment (33121). The less-drastic job losses for the nation as a whole meant that Ohio's portion of American iron and steel industry employment fell from 15.4 to 11.1 percent over the decade.

More current data from the U.S. Bureau of Labor Statistics' Quarterly Census of Employment and Wages show a 2.4 percent increase in industry employment from 2013 to 2014 in Ohio. The 3.9 and 8.6 percent job additions in the steel-products-from-purchased-steel and ferrous foundry groups more than offset the 3.3 percent job loss in the iron-steel-ferroalloys group (2015).[15] However, a number of pipe and tube companies announced temporary plant closures and/or layoffs in 2015 because of weak demand as oil and gas industry drilling was curtailed in the wake of low prices for those resources (AP, 2015; Staff, 2015; Yucel, 2015a: 10; 2015b: 6).

See Table A11

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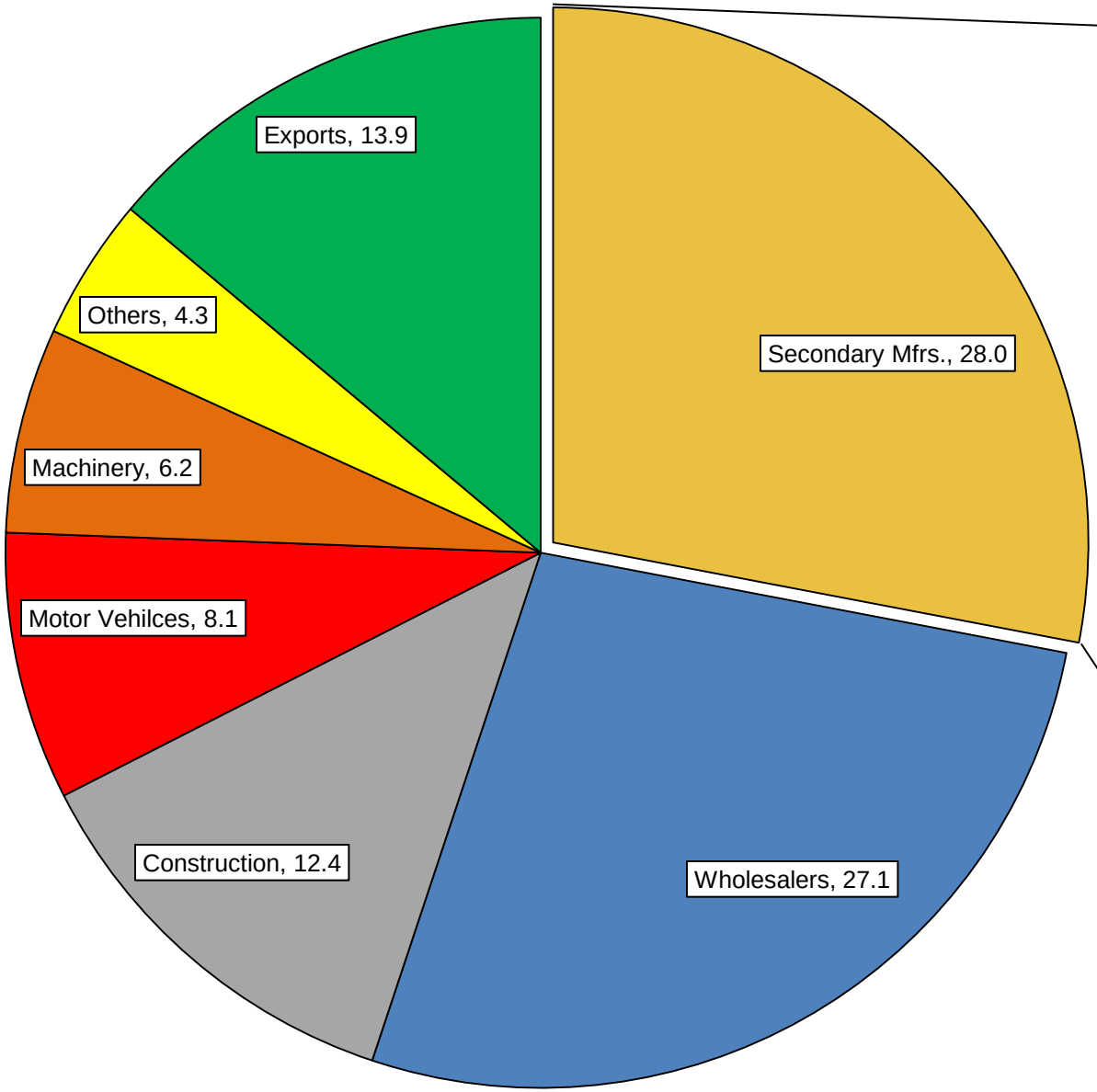
OVERVIEW AND OUTLOOKS

Major Markets for Iron & Steel Mill Products (NAICS 3311)
(Percentage Distribution of Revenue Sources)



Secondary Mfrs. and Their Markets

Pipes & Tubes from Purchased Steel (NAICS 33121)
- utilities (water) - 41.1%,
- energy-related - 34.4%,
- motor vehicles & aerospace - 14.2%,
- others - 10.4%.

Rolled & Drawn Products from Purchased Steel (NAICS 33122)
- motor vehicles - 35.0%,
- wholesalers - 26.7%,
- construction - 8.0%,
- electric power-related - 12.7%,
- exports - 4.1%.

Ferrous Foundries (NAICS 33151)
- machinery - 31.6%,
- transportation equipment - 26.5%,
- pipes/fittings - 14.4%,
- fabricated metal products - 13.8%,
- construction - 7.8%,
- exports - 5.9%.

Sources: Goddard, Yucel

AN OVERVIEW OF THE INDUSTRY

The iron and steel industry thought of as organizations using raw materials and/or scrap to create semi-finished and finished ferrous products for organizations in many other industries – even materials and components used within the industry.[16] As such, different organizations sell somewhat different products in various overlapping markets. The chart above and the following details illustrate the extensive and multifaceted markets for iron and steel industry products. Based on aggregate revenues, the principal markets for iron and steel makers (NAICS 3311) are:

- secondary iron and steel producers using purchased iron and steel (3312 and 33151) – 28.0 percent;
- wholesalers (particularly 4235, also referred to as distribution and service centers) – 27.1 percent;
- construction (23, particularly commercial, industrial and infrastructure) – 12.4 percent;
- the motor vehicle industry (3361-3) – 8.1 percent;
- machinery makers (333) – 6.2 percent;
- all other industries, including other transportation equipment (3364-9) and containers (3324), totaled 4.3 percent;
- 13.9 percent of iron and steel mill products are exported (Yucel, 2015a: 15, 17).

In turn, secondary iron and steel producers make goods for the same and additional markets:

- the principal markets of *pipe and tube manufacturers using purchased steel* (331221) are: utilities (22, especially water transmission, circulation and treatment) and related construction – 41.1 percent, and the extraction (211), refining (324) and transportation (486) of oil and natural gas and derived products – 34.3 percent; other industry markets are motor vehicles, aerospace equipment (3364), chemical processing (325), and food, beverage, paper and pulp processing (parts of 311-2 and 322); exports are a tiny portion of revenues (Yucel, 2015b: 12, 14, 16-18);[17]
- the principal markets for *rolled and drawn products from purchased steel* (331222) are: motor vehicles – 35.0 percent, wholesalers – 26.7 percent, construction – 8.0 percent; other products for electric power generation, transmission and distribution (22) as well as oil and gas extraction, refining and transportation comprise an additional 12.7 percent of the market; exports are 4.1 percent of revenues (Yucel, 2015c: 6, 16-17);
- the principal markets for *ferrous foundries* (33151) are: machinery – 31.6 percent, transportation equipment (336) – 26.5 percent, pipes (331221) and fittings – 14.4 percent, fabricated metal products (332) – 13.8 percent, construction – 7.8 percent; exports are 5.9 percent of revenues (Goddard, 2015: 15-16).

Given the highly cyclical nature of key markets it supplies – oil and natural gas extraction-processing-transportation, non-residential construction, fabricated metal products, machinery, transportation equipment, etc. – most of the iron and steel industry is in turn highly cyclical. While this point was made earlier with regard to iron and steel makers and raw steel production, the chart above extends it to secondary producers (Yucel, 2015b: 31-32; 2015c: 32-33). Even though they

may make similar products for many of the same markets as iron and steel makers do, secondary producers survive because they have the expertise with state-of-the-art technologies to meet customers' exacting specifications more rapidly and efficiently than iron and steelmakers can (Goddard, 2015: 22; Yucel, 2015b: 23; 2015c: 24). These individual market cycles may not be highly correlated with one another, but they ultimately are driven by household consumption.

As organizations providing products – all made from a few key elements – to overlapping markets, domestic iron and steel industry organizations compete not only with one another, but with foreign producers using the same elements as well as other organizations using alternative materials for similar products for the same markets. They also must deal with organizations supplying their inputs and governments regulating their operations and relationships. Changes in these inter-organizational relationships, technologies and markets affect all iron and steel industry organizations to varying degrees.

Perhaps the most significant long-term change has been the reduced demand for iron and steel products, evidenced by the long term downward trend in raw steel production (see Appendix Table A7) in contrast to U.S. population and real economic growth over the decades. A number of related factors are thought to largely explain the change: those reducing the demand for steel, those affecting the rise of minimills, technological advances and the growth of imports.

Changes in the motor vehicle industry exemplify the reduced demand for iron and steel products. Direct shipments to the industry fell 37.1 percent from 23.2 million tons in 1973 to 14.6 million tons in 2012 (Larkin, 2013: O2). Two interrelated factors help explain its reduced demand: (1) the long-term increase in imported motor vehicles displaced sales of U.S.-brand vehicles, and imported vehicles do not use domestically made iron and steel; and (2) companies' efforts to improve fuel efficiency. The easiest way to improve fuel efficiency has been to reduce vehicle weight. To that end, assemblers made vehicles smaller – that choice alone would use less iron and steel – and replaced some iron and steel components with ones made from aluminum, plastics and other materials (also see Goddard, 2015: 22).[18] The long term shift of consumer purchases to light trucks mitigated reduced demand for iron and steelmakers because trucks use more steel (Larkin, 2005); however, high fuel prices reduce light truck sales, dampening the demand for iron and steel products.

Steelmakers – among them ArcelorMittal here in Ohio – responded to demands for reduced weight by developing tougher alloys that weigh less (see Schoenberger, 2013; Yucel, 2015a: 17),[19] and near net shape casting reduced the need for machining parts. Consequently, iron and steel makers regained some of the business lost to manufacturers of alternative materials. (However, recent research and development (R&D) activities – and any subsequent capital expenditures – have focused less on new products and more on improving current product quality and production processes – the latter through automation/computerization for efficiency/productivity and the associated cost reductions and better inventory management. Meeting environmental regulations also has been an R&D goal (Goddard, 2015: 11; Yucel, 2015a: 35-36; 2015b: 11, 30-31; 2015c: 12, 32).) Steel makers also have tried to expand into markets such as residential construction (Yucel, 2015a: 17).

At the same time demand for iron and steel was declining, raw steel production was shifting to minimills as electric arc furnace use expanded and technological advances reduced costs. Foreign producers also gained market share at the expense of domestic producers. Primary steelmakers initially sought to stay competitive by reducing fixed costs; variously selling coal and iron ore assets, selling or shutting coke ovens, and/or spinning-off service and distribution centers.[20] A few even left primary steelmaking to concentrate on specialty steels or purchasing semi-finished products for further processing (i.e., they became secondary producers). In effect, they vertically de-integrated (Larkin, 2007; 2013: O2, O4 & O7). However, these moves left companies to the vicissitudes of the markets. The de-integration strategy met its limits as substantial price increases for raw materials later motivated the remaining companies to vertically re-integrate as part of their efforts to control costs and assure steady supplies.[21] The actions of two companies in Ohio illustrate this: Arcelor-Mittal bought-out other owners of Canada's Wabush Mines (Wire Report, 2007), and AK Steel acquired Solar Fuel for its reserves of low-volatile metallurgical coal and formed a joint venture with Magnetation in iron ore production (Larkin, 2013: O3). On the other hand, high scrap prices reduce minimills' cost advantage and consequently limit the ability of the latter to take market share from the former. (Primary producers are less affected by such high prices because they typically use a 3::1 ratio of pig iron to scrap for steel production (Larkin, 2007: 10).) High scrap prices compelled some minimills to internal sourcing either by purchasing scrap suppliers or by producing directly reduced iron themselves. This vertical integration raises their fixed costs and reduces their cost advantage vis-à-vis primary producers, whom they now more closely resemble as a consequence of these actions (Larkin, 2013: I2-I3, O3-O4). Similarly, consolidations and cost reductions also made domestic steelmakers more competitive with their foreign-based rivals. In addition, foreign-based companies are affected by higher costs for raw materials and transportation (Larkin, 2013: I4). Still, foreign companies remain highly competitive given their advantages and the pressure of global overcapacity (Yucel, 2015a: 24).

Reduced demand from customers, combined with market share gains by minimills and foreign producers, forced a substantial contraction of primary steel production through the closure of inefficient plants, and reduced the number of primary steelmakers through bankruptcies and mergers (Larkin, 2013: O2). It was during bankruptcies that some saw opportunities. One example involving facilities in Ohio illustrates. W.L. Ross formed the International Steel Group (ISG) by purchasing assets of LTV, Bethlehem and Weirton. This became feasible and attractive when the Pension Benefit Guaranty Corp. assumed the pension plans and health care benefits of the liquidating companies.[22] Successor companies also controlled costs by reducing the size of their work forces, including fewer levels of management, and changing work rules and classifications to permit greater flexibility in what people do. Indeed, ISG's management structure resembled that of a minimill, and it operated so efficiently (probably using more modern equipment, too) that it produced 90 percent of what LTV did with only one-fourth of the production workers. ISG subsequently merged with Ispat International NV to form Mittal NV. In turn, the merger of Arcelor and Mittal created the world's largest steel company (Larkin, 2005, 2007).[23]

Such selective asset purchases were part of the international consolidation of the industry. While globalization has been

blamed for the relentless pressure on U.S.-based manufacturers, it also afforded American plants that are part of multi-national companies the opportunity to improve efficiency by learning from co-workers overseas. For example, ArcelorMittal's Burns Harbor, Indiana, plant improved productivity by adopting the best practices of a similar ArcelorMittal plant in Belgium. This included modern equipment and the related automation – particularly computerization – of much of the process (which lead to the improvement of workers' skills), greater flexibility in performing tasks, and a *kaizen*-like attention to the details of process improvement. The steel industry is part of the encompassing trend in American manufacturing: fewer-but-more-highly-skilled workers in more automated factories (Miller, 2012).

Another consequence of consolidation is that U.S. *raw steel production* is now closer to an oligopoly. Three companies – ArcelorMittal, Nucor and U.S. Steel – owned 51.4 percent of U.S. raw steel production capacity in 2013; another four – AK Steel, Gerdau, OAO Severstal and Steel Dynamics – combined for an additional 24.7 percent. (AK, ArcelorMittal, Nucor and U.S. Steel have notable operations in Ohio.) Thirty-six companies owned the remaining 23.9 percent. (The latter included Charter Steel, Industrias' Republic Steel, North Star Bluescope, Timken Steel, Vallourec Star and Warren Steel Holdings – all operating in Ohio at the time.) Furthermore, *primary steel production* became a duopoly given that ArcelorMittal owned 41.1 percent of basic oxygen process furnace capacity and U.S. Steel owned 39.2 percent at the time; AK and Severstal owned the remainder with 10.8 and 9.0 percent, respectively (AIM Market Research, 2013).

Today, competition for the iron and steel industry organizations generally is high even though raw steel production is nearly oligopolistic. This is true for several reasons. Iron and steel makers compete with manufacturers using alternative materials (aluminum, plastics, glass, etc.) for contracts to supply goods to major buyers (i.e., significant revenue sources). Even when steel is chosen, domestic producers compete with imports, which supply a significant portion of domestic consumption (Yucel, 2015a: 24). The same is true for manufacturers using purchased steel. Pipe and tube manufacturers compete with similar producers whose materials are cement, pre-stressed concrete, cast iron (from foundries) or fiberglass-reinforced plastics; manufacturers of rolled and drawn products compete with manufacturers using aluminum, composites, concrete or wood to supply many of the same markets. Again, when steel is chosen, imports have significant shares of these domestic markets (Yucel, 2015b: 11, 24; 2015c: 12, 24).[24] Foreign-based iron and steel industry companies have had various advantages: a high value of the dollar, lower labor costs, more modern equipment, and/or government support have made comparable products less expensive. In addition, U.S. markets have had lower or even no import barriers (Larkin, 2013; Yucel, 2015a: 24).

Like many manufacturing establishments, the iron and steel industry is subject to governmental regulations regarding the environment, zoning, working conditions, and health and safety. These vary by industry sector: environmental regulations for iron and steel production recently have become more stringent while rolling and drawing of purchased steel remains lightly regulated. Conversely, government assistance may be provided in various forms for various industry segments.

While industry production is not subsidized, loans have been provided in times of financial crises. Tariffs on imports are common, but usually remain low if applicable at all. Antidumping penalties are higher and targeted at specific countries, but are subject to review by the World Trade Organization. Quotas have been negotiated occasionally (Yucel, 2015a: 36-37; 2015b: 32-33; 2015c: 33). In addition, federally funded transportation and infrastructure projects require purchases of American-made ferrous foundry products (Goddard, 2015: 30-31). Overall, neither industry analyst assesses these strictures or actions as exceptional when compared with other industries.

While iron and steel industry organizations have long sought these protections as remedies for allegedly unfair trade practices, foreign producers and domestic consumers have argued their cases in response, and the federal government may grant exceptions to the protections (Larkin, 2013). Consumers will buy from anyone who can supply inexpensive steel because it helps them to compete at home and abroad (Miller, 2012); secondary steel producers have been known to import semi-finished steel products for further processing (Larkin, 2007). Indeed, imports often are necessary as apparent steel consumption often exceeds domestic steel production (U.S. Geological Survey, 2015).

Foundries stand apart from the rest of the iron and steel industry in some ways. Some foundries mass produce one or a few items and require large investments to realize economies of scale and stay competitive, and the speed of conveyance is important for efficient production at such establishments. Such foundries typically are divisions of industrial machinery makers or motor vehicle assemblers. Others make one item at a time with little or no movement of the product. Some fall in between the two extremes, making small production runs; here production setups remain flexible and speed is determined by the rate at which molds can be made. Because so much of foundry production is either proprietary for a parent or customized for myriad uses (producers and consumers collaborate on product design in both circumstances), barriers to entry are lower than for the rest of the industry, and the industry remains fragmented despite recent mergers and acquisitions. These factors also help explain why competition within the industry is about average, exports are a small market for foundries, imports an even smaller part of the domestic market (the U.S. has a surplus in the balance of trade in this industry), and why foundries have been relatively unaffected by globalization (Goddard, 2015: 7, 16, 20, 22-23, 29).

THE NEAR AND LONG TERM OUTLOOKS

Many of the trends described in preceding sections are expected to continue at least into the near future. Output of steel mill products is forecast to grow in the near term in response to demands from key end markets: motor vehicles, non-residential construction (as businesses expand to meet consumer demand), and – perhaps – exports (Yucel, 2015a: 8-9, 18). Similarly, near-term output from secondary producers is expected to increase due to demands from manufacturers – particularly motor vehicles – and non-residential construction (variously, power plants, water infrastructure, and oil and gas extraction-processing-transporting) (Yucel, 2015b: 8; 2015c: 10; Goddard, 2015: 8, 11).

Industry growth probably will be slower than average, though, dampened by the growth of iron and steel imports and the increasing use of alternative materials. Import growth is facilitated by the high value of the dollar as well as exacerbated by slowing growth and excess production elsewhere in the world (Goddard, 2015: 8; Yucel, 2015a: 9, 18; 2015b: 7, 9, 11, 18; 2015c: 10, 17). Consequently, U.S. producers likely will seek protective measures from the U.S. government (Yucel, 2015a: 9). Conversely, exports may either grow slowly (Yucel, 2015a: 18) or even decline (Yucel, 2015b: 7, 9, 18; 2015c: 10, 17). Foundry products may be an exception to this broad trend; overall output growth is forecast to be slower than average, but export growth may surpass that of imports (Goddard, 2015: 11, 16). Companies producing alternative materials – variously aluminum, magnesium, plastics or other light-weight materials – may gain market share particularly at the expense of secondary iron and steel producers (Goddard, 2015: 8; Yucel, 2015b: 8-9, 11; 2015c: 9).

Iron and steel companies may pursue varying strategies to deal with the increased competition, depending on their size and position in the industry (Larkin, 2013: H2). Some domestic iron and steel makers may acquire smaller mills, gaining economies of scale by reducing production costs, and further pushing the industry toward oligopoly; others may abandon commodities markets – where competition is based on price – in favor of specialized, higher value-added products (Yucel, 2015a: 5, 9-11). Foundries may adopt a similar strategy of working more closely with their customer to create higher quality products less vulnerable to price competition (Goddard, 2015: 4, 8-9, 11). Secondary producers also may merge to attain economies of scale, increase market share, expand their customer base and range of products, and/or reduce the burden of capital expenditures. Iron and steel companies may acquire secondary producers for the same reasons (and secondary producers may get iron and steel at cost) (Goddard, 2015: 9; Yucel 2015b: 9, 21; Yucel, 2015c: 9-10). Consolidation among secondary producers is not expected to push such production to oligopoly (Yucel, 2015c: 21). It is possible some steel service centers merging with producers as part of the process (Larkin, 2013: O4) extending vertical integration downstream. Larkin (2013: I9) summarizes the forces at work:

> "In sum, as steel industry suppliers become more consolidated, steel companies must either integrate backward or gain greater scale via mergers to avoid being gouged by their suppliers. At the same time, it makes

> sense for steelmakers to consolidate in order to… gain greater bargaining power in negotiating agreements to supply the auto and construction equipment oligopolies. Finally, in view of the global overcapacity that exists in the industry, consolidation aimed at removing uneconomic capacity makes perfect sense."

Regardless of these forces, industry mergers or acquisitions may only occur when conditions are strong and stock prices high (Larkin, 2013: C5). Domestic companies may set up more overseas operations, but no major technical advancements are expected because production processes well established (Goddard, 2015: 8, 11).

Primary producers may compete more effectively with minimills in the flat-rolled market for a number of reasons. Some primary producers have significantly larger pension and health care costs for retirees as well as higher labor costs, but the consolidation, workforce reductions, more flexible rules and cost limits achieved in the last decade mean that such costs will diminish in the future. This plus the vertical integration by minimills and accompanying higher fixed costs reduce the cost structure gap between the two. Consequently minimills may not be in a position to cut prices and take market share from primary producers as they did in the 1980s and 1990s. If minimills do increase their market share, it will be at a slower pace. It remains to be seen how well companies can compete (Larkin, 2013: I3, O2).

Assessing the effects of imports on the domestic industry is more complex. Import levels vary with demand and the value of the dollar, and they can be essential for some domestic companies when demand out-paces domestic production. Global overcapacity might tempt some foreign-based steelmakers to dump their products abroad, but it is highly unlikely that any nation, including one as relatively open as America, will allow any foreign power to flood its markets (drawn from Larkin, 2013: I10). In turn, import restrictions are a motive for foreign-based companies to set up operations here, either by themselves, or in joint ventures with domestic companies (Matthews, 2007b). Such actions could also be part of the expected industry consolidation. Larkin (2005) commented that the international nature of the mergers could mitigate trade disputes; a foreign-based company experiencing a weak home market would be unlikely to ship products to America when such shipments would hurt its American operations. However, further demands on the domestic steel industry for energy efficiency and reduced emissions could increase steel production costs. This would compel some customers to turn to foreign sources with less stringent environmental regulations for lower cost steel. (Larkin, 2013: O7). Consequently the role of imports may continue to be variable and significant but not dominant.

The new factor is the boom in shale gas production. The immediate impact for the Ohio steel industry was seen in increased demand for pipes and tubes for extraction, and added capacity to meet that demand. However, drilling for oil and gas is notoriously cyclical at the local level; drilling in Pennsylvania lasted just three years, and sagged in Ohio with the falling oil and gas prices. Sustaining production requires meeting the demands of drillers in other states and even other countries (Kellehar, 2013). The longer-term indirect effect could be the provision of inexpensive natural gas, which is 30

to 35 percent of the steel industry's fuel as well as refining agent for directly reduced iron. Consequently, fuel costs for the steel industry may be less than otherwise, and directly reduced iron could be less expensive (Grant, 2013; Schoenberger, 2012).

The U.S. Bureau of Labor Statistics (BLS) (2013) expects national output from the iron-steel-ferroalloy group (NAICS 3311) to grow at an average annual rate of 1.0 percent, from 2012 through 2022, slower than 2.6 percent expected for the economy as a whole. However, BLS predicts output from the products-from-purchased-steel group (3312) will grow at an annual average rate of 2.5 percent. This is mostly consistent with Yucel's descriptions of these groups as mature, with limited growth prospects for the next five years (2015a: 5, 13; 2015b: 11; 2015c: 12). Goddard similarly describes ferrous foundries (33151) as a mature industry, with five-year output growth expected to lag the overall economy (2015: 11).

The predicted output growth is not expected to lead to more jobs. Both the U.S. BLS and the Ohio Dept. of Job and Family Services' Labor Market Information division (ODJFS-LMI, 2014) project net employment losses in the iron-steel-ferroalloys and products-from-purchased-steel groups between 2012 and 2022. ODJFS-LMI forecasts job losses at an average annual rate of 1.5 percent for the former and 6.5 percent for the latter. The combined loss rate is 3.7 percent. Fewer than 10,000 employees may remain in each group in Ohio, with combined employment just over 17,000 according to ODJFS-LMI. Neither the U.S. BLS nor LMI have made specific predictions about employment in ferrous foundries; however, Goddard expects national employment to decline slightly over the next five years (2015: 10). In summary, longer-term employment declines in all industry groups are expected due to:

- continuing automation of production processes (Goddard, 2015: 9; Kelleher, 2013; Yucel, 2015b: 9);
- continuing industry consolidation (Goddard, 2015: 10; Yucel, 2015a; 2015b; 2015c); and
- continuing pressure from imports and related cost-cutting measures (Yucel, 2015a: 10, 35).

See Table A12

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APPENDICES

DETAILED TABLES

Table A1: Notable[1] Iron and Steel Manufacturing Companies in Ohio, 2015

Parent/Company/Division	NAICS	City	Jobs Total	Jobs at Site[2]
AK Steel Holding Corp.*			3,334	
AK Steel Holding Corp. (HQ)	551114	West Chester		300
AK Steel Corp.[3]	3311	Middletown		1,875
AK Steel Corp.	331221	Zanesville		143
AK Steel Corp./AK Tube LLC	33121	Walbridge		240
AK Steel Corp./Coshocton Stainless[3]	331221	Coshocton		443
AK Steel Corp./Mansfield Operations[3]	3311	Mansfield		333
Allegheny Technologies, Inc.*/Allegheny Ludlum LLC[3]	3311	Louisville		143
ArcelorMittal SA*[4]			2,681	
ArcelorMittal USA (HQ)	551114	Richfield		50
ArcelorMittal Cleveland (east and west sites combined)	3311	Cleveland		1,900
ArcelorMittal Marion	33121	Marion		100
ArcelorMittal Shelby	33121	Shelby		631
Cargill*-Bluescope (JV)/North Star Bluescope Steel LLC[5]	3311	Delta		345
Carpenter Technology Corp.*/Latrobe Specialty Metals Co.	3311	Wauseon		76
Charter Manufacturing Co., Inc./Charter Steel Division	3311	Cleveland		992
Constellations Enterprise LLC/Columbus Steel Castings Co.[6]	331513	Columbus		1,100
General Electric Co.*/GE Aviation Systems LLC/Morris Technologies	3311	Cincinnati		105
General Motors*[4]	331511	Defiance		1,183
Industrias CH, SAB de CV[5]			1,680	
Republic Steel, Inc.	3311	Canton		780
Republic Steel, Inc.	3311	Canton		110
Republic Steel, Inc.	33121	Lorain		490
Republic Steel, Inc.	33121	Massillon		300
Leggett & Platt, Inc.*/Solon Specialty Wire Co.	331222	Cleveland		25
McWane, Inc./Clow Water Systems Co.	331511	Coshocton		400
Mitsui & Co., Ltd.*/Steel Technologies LLC[5]	331221	Ottawa		100
Nucor Corp.*	3311	Marion	312	
Bright Bar (being acquired from Metalurgica Gerdau)[5,10]	331221	Orrville		37
Nucor Steel Marion, Inc.[7]	3311	Marion		275

Table A1: Notable[1] Iron and Steel Manufacturing Companies in Ohio, 2015

Parent/Company/Division	NAICS	City	Jobs Total	Jobs at Site[2]
Reliance Steel & Aluminum Co.*			168	
Metals USA Carbon Flat Rolled, Inc.	3311	Wooster		102
Precision Strip, Inc.[3]	331221	Kenton		66
TimkenSteel Corp.*			1,839	
TimkenSteel Corp. (HQ)[8]	551114	Canton		187
Faircrest Steel Plant[3,8]				
Gambrinus Steel Plant[3,8]	3311	Canton		1,585
Harrison Steel Plant[3,8]				
St. Clair Plant	3311	Eaton		67
United States Steel Corp.*/Lorain Pipe Mill[9]	3311	Lorain		614
Vallourec Star LP[5]	33121	Youngstown		600
Westinghouse Air Brake Technologies Corp.*/Standard Car Truck Co., Inc./Sancast, Inc.	331511	Coshocton		50
Worthington Industries, Inc.*			855	
Worthington Industries, Inc. (HQ)	551114	Worthington		250
Dietrich Industries, Inc.	3311	Warren		180
Worthington Steel Co.	331221	Cleveland		175
Worthington Steelpac Systems, LLC	331513	Columbus		250

Notes: * - Fortune U.S.-1,000 or Global-500 company; 1 - "Notable" means a company has at least 400 people in Ohio, is on Fortune's U.S.-1,000 or Global-500 list, or is a major melt facility; 2 - All jobs figures should be regarded as approximate; they are thought to be the best available at the time; figures are from Hoover's (2015) unless otherwise noted; sites with less than 25 people have been excluded; 3 - Jobs figure based at least in part on 2013 County Business Patterns; 4 - Jobs figure(s) from company website; 5 - Jobs figure from Office of Research (2015a); 6 - Jobs figure from Gearino (2015); 7 - Jobs figure from Jarvis (2015); 8 - Incorporates figures from McKinnon (2015); 9 - Jobs figure from AP (2015); employees were temporarily laid-off in March; 10 - Information from McCafferty (2015).

Sources: AIM Market Research (2013), AP (2015), Company websites (2015), Fortune (2015), Gearino (2015), Hoover's (2015), Jarvis (2015), McCafferty (2015), McKinnon (2015), Office of Research (2015a), U.S. Bureau of the Census (2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 614-466-2116 (DL, 11/15).

Table A2: Expansion and Attraction Announcements in Ohio's Iron and Steel Industry, 2011-14

Year	Company	Area	NAICS Code	Product	New or Expanded	Announced Investment	Anticipated New Jobs	Space (Sq. Ft.)
2011	ArcelorMittal, Inc.	Cleveland	331111	Steel	Expanded	$36,000,000	156	
2011	Bekaert Corp.	Orrville	331222	Wire products	Expanded	$1,300,000		20,000
2011	Charter Mfg. Co.	Cuyahoga Hgts.	331111	Steel products	Expanded	$37,200,000	17	
2011	Phoenix Tube Co.	Trotwood	33121	Metal tubing	New	$20,000,000	25	100,000
2011	Republic Engineered Products, Inc.	Lorain	331111	Steel	Expanded	$85,200,000	449	
2011	Shelby Welded Tube	Shelby	331111	Welded tubing	Expanded	$1,700,000		51,700
2011	Timken Co. - Faircrest plant	Canton	331111	Steel	Expanded	$35,000,000		
2011	Universal Stainless & Alloy Products	Jackson Twp	331111	Steel products	Expanded	$31,000,000	100	
2011 Subtotals						$247,400,000	747	171,700
2012	Carpenter Technology Corp.	Wauseon	33111	Steel wire	Expanded	$3,000,000		
2012	Long View Steel Corp.	Mansfield	33121	Steel tubing	Expanded	$5,700,000	20	
2012	Metal-Matic, Inc.	Middletown	33121	Steel tubing	New	$8,500,000	80	
2012	Preformed Line Products Co.	Mayfield	331222	Steel wire	Expanded	$6,000,000	25	20,300
2012	Quality Castings	Orrville	331511	Iron castings	Expanded	$4,500,000		
2012	Timken Co. - Faircrest plant	Canton	331111	Steel	Expanded	$225,000,000		90,000
2012	Vallourec (fka V&M Star)	Youngstown	33121	Tubular steel	Expanded	$2,600,000		
2012	Welded Tubes, Inc.	Orwell	33121	Steel tubes	Expanded	$1,500,000	10	
2012 Subtotals						$256,800,000	135	110,300
2013	ArcelorMittal Inc	Cleveland	33111	Steel	Expanded	$55,000,000		
2013	Columbus Steel Castings Co	Columbus	331513	Rail castings	Expanded		50	
2013	GKN Sinter Metals LLC	Gallipolis	33111	Metal products	Expanded	$10,000,000	50	
2013	Heidtman Steel Products Inc	Toledo	331221	Rolled steel	Expanded	$5,700,000	18	
2013	Louis G Freeman Co Inc	Fremont	33111	Steel products	Expanded	$4,200,000	12	
2013	Northlake Steel Corp	Liverpool Twp	33111	Steel products	Expanded	$2,200,000	3	39,000
2013	O S Kelly Corp	Springfield	331511	Foundry - piano parts	Expanded	$1,000,000		24,000
2013	Vallourec Star LP	Youngstown	33121	Steel pipe	Expanded	$65,000,000		
2013	Worthington Industries	Columbus	331221	Steel	Expanded	$1,200,000		
2013 Subtotals						$144,300,000	133	63,000

Table 2: Expansion and Attraction Announcements in Ohio's Iron and Steel Industry, 2011-14

Year	Company	Area	NAICS Code*	Product	New or Expanded	Announced Investment	Anticipated New Jobs	Space (Sq. Ft.)
2014	ArcelorMittal Tubular Products USA LLC	Shelby	3312	Tubular steel	Expanded	$29,100,000	45	
2014	Charter Manufacturing Co	Perry Twp	3311	Steel wire	Expanded			52,000
2014	Columbus Steel Castings Co	Columbus	33151	Steel castings	Expanded	$16,000,000	550	
2014	Harbor Castings, Inc	Cuyahoga Falls	33151	Castings	New	$1,075,000	16	
2014	JMC Steel/Wheatland Tube	Warren	3312	Steel tubing	Expanded	$1,700,000		
2014	Liberty Castings Company LLC	Delaware	33151	Metal castings	Expanded	$10,100,000	52	14,000
2014	Timken Steel Corp	Perry Twp	3311	Steel heat treating	Expanded	$42,000,000	13	
2014 Subtotals						$99,975,000	676	66,000
Grand Totals						$748,475,000	1,691	411,000

Note: * - Beginning with 2014, NAICS codes are less detailed.

Source: Office of Research, ODSA (2012b-2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Table A3: Iron and Steel Industry Concentration in Ohio

Year, Subject & NAICS Codes	Industry Title	From Ohio: Amount (millions)	From Ohio: Distribution in Ohio	U.S. Totals (millions)	Ohio as a Percent of the U.S.
2013 GDP:*	Total	$562,845		$16,665,215	3.4%
331	Primary Metals	$5,655		$63,591	8.9%
2013 Value-Added:					
331*	Primary Metals	$7,976	100.0%	$86,881	9.2%
3311-2	Iron & Steel Industry (Exc. Foundries)	$4,560	57.2%	$42,239	10.8%
3311	Iron & Steel Mills & Ferroalloys	$3,513	44.0%	$33,865	10.4%
3312	Steel Products from Purchased Steel	$1,047	13.1%	$8,374	12.5%
2012 Value-Added:	Primary Metals	$7,998		$85,371	9.4%
3311-2, 33151	Iron & Steel Industry	$5,716	100.0%	$51,732	11.0%
3311	Iron & Steel Mills & Ferroalloys	$3,501	61.2%	$32,409	12.7%
3312	Steel Products from Purchased Steel	$1,196	20.9%	$9,038	13.2%
33121	Iron & Steel Pipes & Tubes	$833	14.6%	$5,088	16.4%
33122	Rolling & Drawing Purchased Steel	$363	6.4%	$3,950	9.2%
331221	Rolled Steel Shapes	$217	3.8%	$2,135	10.2%
331222	Steel Wire Drawing	$146	2.6%	$1,815	8.1%
33151	Ferrous Metal Foundries	$1,019	17.8%	$10,286	9.9%
331511	Iron Foundries	$438	7.7%	$5,552	7.9%
331512	Steel Investment Foundries	$330	5.8%	$2,400	13.7%
331513	Steel Foundries (Exc. Investment)	$251	4.4%	$2,334	10.7%

Notes: * - Gross Domestic Product (GDP) figures are subject revision; due to minor technical differences, state GDP figures are analogous to, but not identical with, national GDP; GDP figures for primary metals are less than value-added (VA) figures because GDP subtracts additional costs included in VA; exc. - except.

Sources: U.S. Bureau of the Census (2015a, 2015c); U.S. Bureau of Economic Analysis (2015).

Table A4: Establishments and Employment in the Iron and Steel Industry, Ohio and U.S., 2013

NAICS Codes	Short Title	Ohio			U.S.			Ohio as a Percent of the U.S.	
		Establishments	Employment	Mean per Establishment	Establishments	Employment	Mean per Establishment	Establishments	Employment
	Total Covered Employment	250,117	4,587,136	18.3	7,488,353	118,266,253	15.8	3.3%	3.9%
3311-2, 51	Iron & Steel Industry	175	24,542	140.2	1,915	220,349	115.1	9.1%	11.1%
3311	Iron & steel mills & ferroalloys	58	11,887	204.9	534	102,778	192.5	10.9%	11.6%
3312	Steel product mfg. from purchased steel	51	5,616	110.1	657	48,221	73.4	7.8%	11.6%
33121	Iron, steel pipe & tube mfg. from purchased steel	20	3,446	172.3	232	26,089	112.5	8.6%	13.2%
33122	Rolling & drawing of purchased steel	31	2,170	70.0	425	22,132	52.1	7.3%	9.8%
331221	Rolled steel shapes	13	1,285	98.8	161	7,559	47.0	8.1%	17.0%
331222	Steel wire drawing	18	885	49.2	264	14,573	55.2	6.8%	6.1%
33151	Ferrous metal foundries	66	7,039	106.7	724	69,350	95.8	9.1%	10.1%
331511	Iron foundries	38	3,932	103.5	398	37,763	94.9	9.5%	10.4%
331512	Steel investment foundries	13	1,401	107.8	119	14,118	118.6	10.9%	9.9%
331513	Steel foundries (exc. investment)	15	1,706	113.7	207	17,469	84.4	7.2%	9.8%

Abbreviations used: exc. - excluding; mfg. - manufacturing.

Source: U.S. Bureau of the Census (2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Table A5: Employment and Pay in the Iron and Steel Industry, Ohio and U.S., 2013

NAICS Codes	Short Title	Ohio Employ-ment	Ohio Annual Pay (000)	Ohio Mean Pay per Worker	U.S. Employ-ment	U.S. Annual Pay (000)	U.S. Mean Pay per Worker	Ohio Means as Percentages of U.S. Means
	Total Covered Employment	4,587,136	$195,630,962	$42,648	118,266,253	$5,621,697,325	$47,534	89.7%
3311-2, 51	Iron & Steel Industry	24,542	$1,558,531	$63,505	220,349	$14,118,724	$64,074	99.1%
3311	Iron & steel mills	11,887	$807,313	$67,916	102,778	$8,013,056	$77,965	87.1%
3312	Steel product mfg. from purchased steel	5,616	$358,231	$63,788	48,221	$2,694,636	$55,881	114.1%
33121	Iron & steel pipes & tubes	3,446	$235,894	$68,454	26,089	$1,574,917	$60,367	113.4%
33122	Rolling & drawing	2,170	$122,337	$56,376	22,132	$1,119,719	$50,593	111.4%
331221	Rolled steel shapes	1,285	$82,195	$63,965	7,559	$440,931	$58,332	109.7%
331222	Steel wire drawing	885	$40,142	$45,358	14,573	$678,788	$46,578	97.4%
33151	Ferrous metal foundries	7,039	$392,987	$55,830	69,350	$3,411,032	$49,186	113.5%
331511	Iron foundries	3,932	$243,767	$61,996	37,763	$1,889,435	$50,034	123.9%
331512	Steel investment foundries	1,401	$71,128	$50,769	14,118	$719,256	$50,946	99.7%
331513	Steel foundries (exc. investment)	1,706	$78,092	$45,775	17,469	$802,341	$45,929	99.7%

Abbreviations used: exc. - excluding; mfg. - manufacturing.

Source: U.S. Bureau of the Census (2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Table A6: Establishments and Employment in Ohio's Iron and Steel Industry, by County, 2013

Area Name	Establishments	Employment*	Area Name	Establishments	Employment*	Area Name	Establishments	Employment*
Ohio	175	24,542	Greene	1	28	Morrow	0	0
			Guernsey	1	143	Muskingum	2	285
Adams	0	0	Hamilton	3	370	Noble	0	0
Allen	1	66	Hancock	2	81	Ottawa	0	0
Ashland	0	0	Hardin	2	143	Paulding	1	28
Ashtabula	0	0	Harrison	0	0	Perry	1	143
Athens	1	3	Henry	1	28	Pickaway	0	0
Auglaize	2	171	Highland	0	0	Pike	0	0
Belmont	0	0	Hocking	0	0	Portage	0	0
Brown	0	0	Holmes	0	0	Preble	0	0
Butler	6	2,045	Huron	0	0	Putnam	1	66
Carroll	1	15	Jackson	2	145	Richland	6	1,202
Champaign	0	0	Jefferson	2	43	Ross	0	0
Clark	1	66	Knox	1	28	Sandusky	0	0
Clermont	1	3	Lake	6	588	Scioto	2	209
Clinton	1	15	Lawrence	1	7	Seneca	0	0
Columbiana	5	260	Licking	0	0	Shelby	1	15
Coshocton	3	695	Logan	0	0	Stark	14	4,022
Crawford	0	0	Lorain	4	2,228	Summit	6	212
Cuyahoga	20	3,348	Lucas	5	188	Trumbull	10	1,185
Darke	1	7	Madison	1	28	Tuscarawas	3	300
Defiance	1	1,200	Mahoning	9	855	Union	1	7
Delaware	2	133	Marion	3	216	Van Wert	0	0
Erie	1	143	Medina	2	95	Vinton	0	0
Fairfield	0	0	Meigs	0	0	Warren	0	0
Fayette	0	0	Mercer	0	0	Washington	5	489
Franklin	6	1,117	Miami	4	457	Wayne	3	504
Fulton	3	161	Monroe	0	0	Williams	2	35
Gallia	0	0	Montgomery	7	163	Wood	2	158
Geauga	1	3	Morgan	0	0	Wyandot	1	66

Note: * - All county employment figures should be considered estimates. The fact that the sum of the county figures, 24,213, is 98.7 percent of the state state total, 24,542, means that the county estimates tend to be slightly low.

Source: U.S. Bureau of the Census (2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 11/15).

Table A7: Raw Steel Production in Ohio and the U.S., 1970-2014 (in thousands of net tons, except ranks and percentages)

	Ohio		U.S.					Ohio		U.S.			
Year	Raw Steel Output	Percent Change from Prior Year	Raw Steel Output	Percent Change from Prior Year	Ohio as Percent of U.S. Output	Ohio's Rank in U.S.	Year	Raw Steel Output	Percent Change from Prior Year	Raw Steel Output	Percent Change from Prior Year	Ohio as Percent of U.S. Output	Ohio's Rank in U.S.
1970	21,684	-10.4%	131,514	-6.9%	16.5%	2	1993	16,101	3.7%	97,877	5.3%	16.5%	2
1971	20,064	-7.5%	120,443	-8.4%	16.7%	2	1994	16,683	3.6%	100,579	2.8%	16.6%	2
1972	23,851	18.9%	133,241	10.6%	17.9%	2	1995	16,444	-1.4%	104,930	4.3%	15.7%	2
1973	26,510	11.1%	150,799	13.2%	17.6%	2	1996	16,837	2.4%	105,309	0.4%	16.0%	2
1974	25,251	-4.7%	145,720	-3.4%	17.3%	2	1997	15,827	-6.0%	108,561	3.1%	14.6%	2
1975	19,620	-22.3%	116,642	-20.0%	16.8%	3	1998	16,758	5.9%	108,752	0.2%	15.4%	2
1976	22,419	14.3%	128,000	9.7%	17.5%	2	1999	17,499	4.4%	107,395	-1.2%	16.3%	2
1977	21,466	-4.3%	125,333	-2.1%	17.1%	3	2000	18,263	4.4%	112,242	4.5%	16.3%	2
1978	21,268	-0.9%	137,031	9.3%	15.5%	3	2001	15,726	-13.9%	99,321	-11.5%	15.8%	2
1979	21,082	-0.9%	136,341	-0.5%	15.5%	3	2002	14,646	-6.9%	100,958	1.6%	14.5%	2
1980	16,100	-23.6%	111,835	-18.0%	14.4%	3	2003	13,100	-10.6%	103,261	2.3%	12.7%	2
1981	18,096	12.4%	120,828	8.0%	15.0%	3	2004	15,807	20.7%	109,879	6.4%	14.4%	2
1982	12,181	-32.7%	74,577	-38.3%	16.3%	2	2005	16,432	4.0%	104,605	-4.8%	15.7%	2
1983	14,586	19.7%	84,615	13.5%	17.2%	2	2006	15,856	-3.5%	108,234	3.5%	14.6%	2
1984	15,438	5.8%	92,528	9.4%	16.7%	2	2007	16,146	1.8%	108,138	-0.1%	14.9%	2
1985	14,094	-8.7%	88,259	-4.6%	16.0%	2	2008	14,778	-8.5%	101,297	-6.3%	14.6%	2
1986	14,522	3.0%	81,606	-7.5%	17.8%	2	2009	6,590	-55.4%	65,460	-35.4%	10.1%	2
1987	16,267	12.0%	89,151	9.2%	18.2%	2	2010	9,257	40.5%	88,731	35.5%	10.4%	2
1988	17,662	8.6%	99,924	12.1%	17.7%	2	2011	11,596	25.3%	95,237	7.3%	12.2%	2
1989	16,506	-6.5%	97,943	-2.0%	16.9%	2	2012	13,688	18.0%	97,774	2.7%	14.0%	2
1990	16,769	1.6%	98,906	1.0%	17.0%	2	2013	11,495	-16.0%	95,790	-2.0%	12.0%	2
1991	14,210	-13.9%	87,896	-10.3%	16.2%	2	2014*	12,610	9.7%	97,002	1.3%	13.0%	2
1992	15,524	-7.4%	92,949	-6.0%	16.7%	2							

Notes: * - preliminary, subject to revision; data after 2011 from the U.S. Geological Survey.

Sources: American Iron and Steel Institute (1974, 1978, 1982, 1987, 1989, 1992, 1996, 1998, 2000, 2002, 2004, 2007), Hill, et.al. (2012), U.S. Geological Survey (2015).

Prepared by: Office Research, Ohio Development Services Agency. Telephone 614/466-2116 (DL, 10/15).

Table A08: Trends in Value-Added for Ohio and the U.S., 2003-2013

Area Name / NAICS: Title	Year 2003^	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*	`03-`13 Averages
In current dollars:												
Ohio: 331(p) - Iron, steel, ferroalloys & products	$2,611	$4,648	$5,824	$5,154	$5,958	$6,935	$1,194	$4,554	$5,779	$4,697	$4,560	$4,719
3311: Iron & steel mills & ferroalloys	$1,631	$3,656	$4,539	$3,549	$4,680	$5,381	$520	$3,864	$4,956	$3,501	$3,513	$3,617
3312: Steel products from purchased steel	$980	$992	$1,284	$1,605	$1,278	$1,554	$674	$689	$822	$1,196	$1,047	$1,102
U.S.: 331(p) - Iron, steel, ferroalloys & products	$22,648	$39,211	$38,521	$41,618	$44,575	$51,517	$17,736	$38,183	$47,387	$41,446	$42,239	$38,644
3311: Iron & steel mills & ferroalloys	$17,600	$32,331	$31,173	$34,367	$37,002	$43,262	$14,715	$31,862	$39,770	$32,409	$33,865	$31,669
3312: Steel products from purchased steel	$5,048	$6,880	$7,348	$7,251	$7,573	$8,255	$3,021	$6,321	$7,616	$9,038	$8,374	$6,975
Ohio as a percentage of U.S. value-added:												
331(p): Iron, steel, ferroalloys & products	11.5%	11.9%	15.1%	12.4%	13.4%	13.5%	6.7%	11.9%	12.2%	11.3%	10.8%	12.2%
3311: Iron & steel mills & ferroalloys	9.3%	11.3%	14.6%	10.3%	12.6%	12.4%	3.5%	12.1%	12.5%	10.8%	10.4%	11.4%
3312: Steel products from purchased steel	19.4%	14.4%	17.5%	22.1%	16.9%	18.8%	22.3%	10.9%	10.8%	13.2%	12.5%	15.8%
For constant dollars, standardized on 2009:												
Producer Price Index for 3311:	100.0	127.0	136.4	150.7	160.8	188.3	137.9	163.3	183.6	175.3	164.8	
Producer Price Index for 3312:	100.0	132.2	146.1	148.2	151.1	188.7	156.6	168.9	189.3	187.0	178.3	
Ohio: 331(p) - Iron, steel, ferroalloys & products	$3,784	$5,144	$5,965	$4,943	$5,339	$5,230	$1,194	$3,902	$4,403	$3,756	$3,858	$4,320
3311: Iron & steel mills & ferroalloys	$2,249	$3,969	$4,588	$3,246	$4,014	$3,940	$520	$3,263	$3,722	$2,754	$2,938	$3,200
3312: Steel products from purchased steel	$1,535	$1,176	$1,377	$1,697	$1,325	$1,290	$674	$639	$680	$1,002	$920	$1,119
U.S.: 331(p) - Iron, steel, ferroalloys & products	$31,228	$42,561	$38,932	$38,073	$38,228	$37,725	$17,736	$32,245	$35,590	$32,604	$35,333	$34,569
3311: Iron & steel mills & ferroalloys	$24,267	$35,094	$31,506	$31,440	$31,733	$31,680	$14,715	$26,907	$29,870	$25,494	$28,328	$28,276
3312: Steel products from purchased steel	$6,960	$7,468	$7,427	$6,633	$6,495	$6,045	$3,021	$5,338	$5,720	$7,109	$7,005	$6,293
Ohio as a percentage of U.S. value-added:												
331(p): Iron, steel, ferroalloys & products	12.1%	12.1%	15.3%	13.0%	14.0%	13.9%	6.7%	12.1%	12.4%	11.5%	10.9%	12.5%
3311: Iron & steel mills & ferroalloys	9.3%	11.3%	14.6%	10.3%	12.6%	12.4%	3.5%	12.1%	12.5%	10.8%	10.4%	11.3%
3312: Steel products from purchased steel	22.0%	15.7%	18.5%	25.6%	20.4%	21.3%	22.3%	12.0%	11.9%	14.1%	13.1%	17.8%

Notes: ^ - Producer price index for December only; * - Preliminary, subject to revision.

Sources: U.S. Bureau of the Census (2005a-2015a, 2013c, 2015c), U.S. Bureau of Labor Statistics (2015).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300 or 614/466-2116 (DL, 10/15).

Table A09: Trends in Capital Expenditures for Ohio and the U.S., 2003-2013 (in millions of current dollars)

	Year											
Area Name / NAICS: Title	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013*	`03-`13 Averages
Ohio: 331(p) - Iron, steel, ferroalloys & products	$284	$313	$278	$462	$468	$322	$166	$191	$461	$604	$419	$397
3311: Iron & steel mills & ferroalloys	$154	$256	$226	$390	$409	$265	$113	$173	$284	$253	$371	$289
3312: Steel products from purchased steel	$130	$57	$52	$72	$59	$57	$54	$18	$177	$351	$48	$107
U.S.: 331(p) - Iron, steel, ferroalloys & products	$1,360	$1,938	$2,170	$2,225	$3,672	$5,002	$3,459	$3,752	$3,948	$4,682	$4,080	$3,629
3311: Iron & steel mills & ferroalloys	$938	$1,490	$1,800	$1,832	$3,220	$4,506	$3,021	$3,289	$2,634	$3,071	$3,302	$2,910
3312: Steel products from purchased steel	$422	$448	$370	$393	$452	$496	$438	$463	$1,314	$1,612	$779	$719
Ohio as a percentage of U.S. capital expenditures:												
331(p): Iron, steel, ferroalloys & products	20.9%	16.1%	12.8%	20.7%	12.7%	6.4%	4.8%	5.1%	11.7%	12.9%	10.3%	10.9%
3311: Iron & steel mills & ferroalloys	16.4%	17.1%	12.6%	21.3%	12.7%	5.9%	3.7%	5.2%	10.8%	8.2%	11.2%	9.9%
3312: Steel products from purchased steel	30.8%	12.8%	13.9%	18.2%	13.0%	11.5%	12.3%	3.9%	13.5%	21.8%	6.2%	14.9%
Ratio: Percentage of Valued-Added in Ohio to to Percentage of Capital Expenditures in Ohio:												
331(p): Iron, steel, ferroalloys & products	0.55	0.73	1.18	0.60	1.05	2.09	1.40	2.35	1.04	0.88	1.05	1.12
3311: Iron & steel mills & ferroalloys	0.56	0.66	1.16	0.49	1.00	2.11	0.95	2.31	1.16	1.31	0.92	1.15
3312: Steel products from purchased steel	0.63	1.13	1.25	1.22	1.30	1.64	1.82	2.82	0.80	0.61	2.03	1.06

Notes: * - Preliminary, subject to revision; p - part.

Sources: U.S. Bureau of the Census (2005a-2015a, 2013c, 2015c).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300 or 614/466-2116 (DL, 10/15).

Table A10: Detailed Iron and Steel Industry Establishment Trends in Ohio and the U.S., 2003-13

NAICS Code	Shorter Industry Title	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Changes: 2003-2013 Number	Percent
Ohio:														
11-92	Total	270,255	271,733	270,968	269,914	270,299	263,761	256,551	253,491	250,476	250,842	250,117	-20,138	-7.5%
31-33	Manufacturing	17,082	16,887	16,617	16,401	16,174	15,941	15,212	14,729	14,526	14,489	14,237	-2,845	-16.7%
3311-2, 51	Iron & steel industry	268	242	234	214	208	195	187	187	188	191	175	-93	-34.7%
3311	Iron & steel mills & ferroalloys	87	76	73	70	64	62	62	60	55	61	58	-29	-33.3%
3312	Steel products from purchased steel	82	71	71	63	69	64	55	52	61	60	51	-31	-37.8%
33121	Iron & steel pipes & tubes	31	27	28	26	27	23	19	17	22	25	20	-11	-35.5%
33122	Rolling & drawing	51	44	43	37	42	41	36	35	39	35	31	-20	-39.2%
331221	Rolled steel shapes	34	31	30	24	24	18	16	15	19	16	13	-21	-61.8%
331222	Steel wire drawing	17	13	13	13	18	23	20	20	20	19	18	1	5.9%
33151	Ferrous metal foundries	99	95	90	81	75	69	70	75	72	70	66	-33	-33.3%
331511	Iron foundries	69	64	62	55	48	39	40	42	41	40	38	-31	-44.9%
331512	Steel investment foundries	15	15	14	13	13	16	16	16	15	15	13	-2	-13.3%
331513	Steel foundries (exc. investment)	15	16	14	13	14	14	14	17	16	15	15	0	0.0%
U.S.:														
11-92	Total	7,254,745	7,387,724	7,499,702	7,601,160	7,705,018	7,601,169	7,433,465	7,396,628	7,354,043	7,431,808	7,488,353	233,608	3.2%
31-33	Manufacturing	341,849	339,083	333,460	331,062	331,355	326,216	308,934	299,982	295,643	297,221	292,094	-49,755	-14.6%
3311-2, 51	Iron & steel industry	2,708	2,473	2,468	2,406	2,435	2,230	2,026	2,052	2,044	2,028	1,915	-793	-29.3%
3311	Iron & steel mills & ferroalloys	876	799	839	827	901	698	588	607	592	562	534	-342	-39.0%
3312	Steel products from purchased steel	828	734	716	698	699	724	645	660	691	723	657	-171	-20.7%
33121	Iron & steel pipes & tubes	221	205	229	240	264	242	201	230	250	262	232	11	5.0%
33122	Rolling & drawing	607	529	487	458	435	482	444	430	441	461	425	-182	-30.0%
331221	Rolled steel shapes	226	181	189	170	183	212	168	161	177	167	161	-65	-28.8%
331222	Steel wire drawing	381	348	298	288	252	270	276	269	264	294	264	-117	-30.7%
33151	Ferrous metal foundries	1,004	940	913	881	835	808	793	785	761	743	724	-280	-27.9%
331511	Iron foundries	623	584	572	527	496	456	443	434	426	407	398	-225	-36.1%
331512	Steel investment foundries	147	135	128	132	128	132	131	131	128	128	119	-28	-19.0%
331513	Steel foundries (exc. investment)	234	221	213	222	211	220	219	220	207	208	207	-27	-11.5%

Note: Exc. - Except.

Source: U.S. Bureau of the Census (2005b-2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Table A11: Detailed Iron and Steel Industry Employment Trends in Ohio and the U.S., 2003-13

NAICS Code	Shorter Industry Title	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Changes: 2003-2013 Number	Changes: 2003-2013 Percent
Ohio:														
11-92	Total (in thousands)	4,770.3	4,762.2	4,762.6	4,825.5	4,782.1	4,728.4	4,460.6	4,352.5	4,432.8	4,548.1	4,587.1	-183.1	-3.8%
31-33	Manufacturing (in thousands)	838.7	814.7	792.8	787.9	761.2	742.8	638.5	599.1	614.0	630.5	632.7	-206.0	-24.6%
3311-2, 51	Iron & steel industry	41,627	34,397	34,013	32,788	29,121	30,715	25,183	23,295	24,277	25,630	24,542	-17,085	-41.0%
3311	Iron & steel mills & ferroalloys	21,783	16,315	17,072	16,461	14,186	17,347	13,587	12,757	13,547	13,542	11,887	-9,896	-45.4%
3312	Steel products from purchased steel	9,013	7,148	6,600	6,415	5,993	4,364	4,163	3,870	4,333	5,462	5,616	-3,397	-37.7%
33121	Iron & steel pipes & tubes	3,837	3,139	3,231	3,183	2,815	2,067	2,031	1,799	2,033	3,495	3,446	-391	-10.2%
33122	Rolling & drawing	5,176	4,009	3,369	3,232	3,178	2,297	2,132	2,071	2,300	1,967	2,170	-3,006	-58.1%
331221	Rolled steel shapes	4,263	3,306	2,903	2,791	2,685	1,488	1,427	1,325	1,493	1,078	1,285	-2,978	-69.9%
331222	Steel wire drawing	913	703	466	441	493	809	705	746	807	889	885	-28	-3.1%
33151	Ferrous metal foundries	10,831	10,934	10,341	9,912	8,942	9,004	7,433	6,668	6,397	6,626	7,039	-3,792	-35.0%
331511	Iron foundries	8,579	8,526	7,827	7,675	6,531	5,330	4,117	3,958	3,706	3,775	3,932	-4,647	-54.2%
331512	Steel investment foundries	1,488	1,725	1,735	1,429	1,472	2,671	2,302	1,731	1,832	1,740	1,401	-87	-5.8%
331513	Steel foundries (exc. investment)	764	683	779	808	939	1,003	1,014	979	859	1,111	1,706	942	123.3%
U.S.:														
11-92	Total (in thousands)	113,398.0	115,074.9	116,317.0	119,917.2	120,604.3	120,903.6	114,509.6	111,970.1	113,426.0	115,938.5	118,266.3	4,868.2	4.3%
31-33	Manufacturing (in thousands)	14,132.0	13,822.0	13,667.3	13,631.7	13,320.2	13,096.2	11,633.0	10,862.8	10,984.4	11,192.0	11,276.4	-2,855.6	-20.2%
3311-2, 51	Iron & steel industry	270,090	250,690	249,853	251,219	244,443	237,244	213,003	198,021	210,486	224,690	220,349	-49,741	-18.4%
3311	Iron & steel mills & ferroalloys	125,871	114,097	109,957	110,790	109,998	109,584	102,212	95,655	100,940	105,309	102,778	-23,093	-18.3%
3312	Steel products from purchased steel	52,401	47,183	46,193	47,069	44,492	43,378	39,868	38,825	41,090	47,669	48,221	-4,180	-8.0%
33121	Iron & steel pipes & tubes	20,181	19,182	20,571	21,543	21,439	18,275	16,753	16,145	17,411	25,592	26,089	5,908	29.3%
33122	Rolling & drawing	32,220	28,001	25,622	25,526	23,053	25,103	23,115	22,680	23,679	22,077	22,132	-10,088	-31.3%
331221	Rolled steel shapes	13,079	10,786	10,322	10,857	9,632	10,458	9,200	9,971	10,457	7,836	7,559	-5,520	-42.2%
331222	Steel wire drawing	19,141	17,215	15,300	14,669	13,421	14,645	13,915	12,709	13,222	14,241	14,573	-4,568	-23.9%
33151	Ferrous metal foundries	91,818	89,410	93,703	93,360	89,953	84,282	70,923	63,541	68,456	71,712	69,350	-22,468	-24.5%
331511	Iron foundries	62,382	59,511	60,892	59,209	55,075	49,276	39,676	36,193	37,872	38,286	37,763	-24,619	-39.5%
331512	Steel investment foundries	15,036	14,794	15,847	16,429	16,777	17,786	15,495	13,474	14,612	15,190	14,118	-918	-6.1%
331513	Steel foundries (exc. investment)	14,400	15,105	16,964	17,722	18,101	17,220	15,752	13,874	15,972	18,236	17,469	3,069	21.3%

Note: Exc. - Except.

Source: U.S. Bureau of the Census (2005b-2015b).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Table A12: Projections for Iron and Steel Industry Employment*, Ohio and the U.S., 2012-22

NAICS Code	Shorter Industry Title	Jobs		Changes: 2012-2022	
		Actual 2012	Projected 2022	Number	Percent
Ohio	Total	5,502,100	5,957,100	455,000	8.3%
31-33	Manufacturing	656,040	635,360	-20,680	-3.2%
331(p)	Iron, steel, ferroalloys & products	17,670	17,020	-650	-3.7%
3311	Iron & steel mills & ferrroalloys	10,020	9,870	-150	-1.5%
3212	Steel products from purchased steel	7,650	7,150	-500	-6.5%
U.S.	Total	134,427,600	149,751,300	15,323,700	11.4%
31-33	Manufacturing	11,918,900	11,369,400	-549,500	-4.6%
331(p)	Iron, steel, ferroalloys & products	153,800	136,100	-17,700	-11.5%
3311	Iron & steel mills & ferrroalloys	93,600	78,700	-14,900	-15.9%
3212	Steel products from purchased steel	60,200	57,400	-2,800	-4.7%

Note: * - Projections have not been made for ferrous metal foundries (NAICS 33151).

Sources: U.S. BLS (2013), ODJFS-LMI (2014).

Prepared by: Office of Research, Ohio Development Services Agency. Telephone 800/848-1300, or 614/466-2116 (DL, 10/15).

Industry Definition and Examples of Products

The nation's industry statistics have been collected under the North American Industry Classification System (NAICS) starting in 1997 (Office of Management and Budget, 1998). Establishments producing goods or services sufficiently alike are classified in the same *industry*, and assigned a six-digit code number. Closely related industries form an *industry group*. The first four digits of the industry code indicate the group to which the industries belong. (A five-digit code defines a *subgroup* when it subsumes more than one six-digit code; otherwise, it defines an industry.) In this report the iron and steel industry is defined as the combination of two groups and a subgroup: *iron and steel mill and ferroalloy manufacturing* (NAICS 3311), *steel product manufacturing from purchased steel* (3312), and *ferrous metal foundries* (33151). Mostly minor changes have been made to the system with each subsequent economic census. The changes had no impact on the industry definition until 2012, when iron and steel vs. ferroalloy production – heretofore two industries – were combined into 331110. The current definitions and examples of specific industry products follow.

3311	Iron & Steel Mills & Ferroalloys.
33111	Iron & Steel Mills & Ferroalloys.
331110	Iron & Steel Mills & Ferroalloys. Activities include the direct reduction of iron ore, producing pig iron, converting pig iron into steel and/or producing elements (ferroalloys) that may be added to molten steel to alter or improve the resulting metal's characteristics. Common ferroalloys include chromium, manganese, molybdenum, nickel, niobium, silicon, titanium, tungsten and vanadium. (See alloy steels in the glossary for further discussion.) Steel products such as bars, pipes, plates, rods, sheets, strips, tubes and wire are included in this industry if they are made where the metal is produced. Likewise, coke ovens may be included if they are integrated with the establishment; otherwise, they are classified elsewhere. Non-ferrous alloy manufacturing is classified elsewhere.
3312	Steel Products from Purchased Steel. Products in this group are not made at establishments where the raw iron or steel is produced.
33121	Iron & Steel Pipes & Tubes from Purchased Steel. Examples include welded, riveted, and seamless pipes and tubes of many sizes and for many purposes and products.
33122	Rolling & Drawing Purchased Steel.
331221	Rolled Steel Shapes. Activities include rolling and drawing shapes such as plates, sheets, strips, rods and bars from purchased steel.
331222	Steel Wire Drawing. Establishments in this industry draw wire from purchased steel. Products include non-insulated wires and ropes, fencing, nails, spikes, staples, tacks and woven steel wire cloth – galvanized or not – if made where the wire is produced; also included are powders, paste and flakes (Yucel, 2015c: 13-14). Similar products made from purchased wire are classified as fabricated metal products (332).

33151 Ferrous Metal Foundries. Establishments in this sub-group purchase and reheat iron or steel, pouring the molten metal into molds of a desired shape to make castings. The casting is removed once the metal has solidified. They may also perform further operations such as cleaning and deburring, but activities such as threading or machining that transform castings into more-finished products may lead to classification outside of the industry. Foundry operations at the same establishment where the raw iron or steel is produced are classified in 331110.

Ferrous castings are used in “virtually all industrial and manufacturing applications” (Goddard, 2015: 14). There are differences between iron and steel castings beyond the defining carbon content (see the Glossary.) Iron products have a lower melting temperature, and shrink less while solidifying, consequently allowing them to be cast into more complex shapes using less energy, less expensive and less specialized equipment. On the other hand, steel castings are easier to weld, and have greater strength, ductility, and wear, heat and corrosion resistance, due in part to their incorporation of alloys (again, see the Glossary). Steel castings are used in bridge and building supports, tools and dies, valves, pumps, compressors and other mechanical components for agricultural, power generation and transportation equipment and sporting goods (Goddard, 2015: 14-15). The choice between iron and steel turns on cost and required performance characteristics. As measured by volume, iron castings are the larger part of this subgroup (Goddard, 2015: 4).

331511 Iron Foundries. Establishments in this industry melt and pour the pig iron or iron alloys they purchased into molds. Analysts still distinguish between gray and ductile iron foundries. Gray iron has a high carbon content; it is used in engine blocks, differential, power-transmission and pump-housings, fire hydrants, lamp-posts, manhole covers, skillets, storm grates and drains, etc., because it can be cast into complex shapes at low cost, withstands high temperatures and pressures, and resists corrosion and wear. However, it is brittle when compared with other iron and steel products. Ductile iron can be stretched, drawn and hammered because its higher magnesium content gives it greater tensile strength; it is used for cam- and crankshafts, pipes, tubes and associated fittings (Goddard, 2015: 13-15).

331512 Steel Investment Foundries. Investment foundries create seamless molds by covering a wax shape with refractory slurry. The wax is melted and drained after the slurry hardens. Highly detailed and consistent castings may be made from such molds. Investment foundry products are used in sporting goods, industrial valves, small arms, turbines and transportation equipment (Goddard, 2015: 14) – the production or assembly of which are classified in other industries.

331513 Steel Foundries (exc. Investment). The difference between investment and non-investment casting is the former destroys the mold used in the casting process and the latter re-uses the mold (Goddard, 2015: 14). Consequently, non-investment castings generally are less expensive than investment castings.

Glossary

Iron and steel terms, presented in approximate order from primary production through foundry work:

Iron ore – rocks or deposits of iron (Fe) compounds. Hematite (Fe_2O_3) is an example.

Directly reduced iron (DRI) – iron ore reduced to the solid metallic state by heating it without melting it. Natural gas usually is the refining agent. 90 to 95 percent iron, it is a substitute for scrap, used when scrap prices are high. Hot briquetted iron (HBI) is DRI in the form of briquettes. Iron carbide (Fe_3C) is another scrap substitute.

Coke – derived by baking coal (petroleum-related material may also be used), it is primarily carbon (C); however, other matter and minerals may still be present. Coke supplies the carbon monoxide (CO) to reduce iron ore in a blast furnace and is a heat source for melting the iron. Coke burns hotter than coal.

Fluxes – substances used to promote the reduction of metals. Examples include, but are not limited to, limestone (primarily calcium carbonate ($CaCO_3$), secondarily magnesium carbonate ($MgCO_3$)), dolomite ($CaMg(CO_3)$), lime (an oxide of calcium) and fluorite (CaF_2).

Blast furnace – a cylindrically shaped furnace lined with refractory bricks and operating at a minimum of $3{,}000^0$F for reducing iron ore to pig iron. Blasting air through the fuel increases the combustion rate for burning-off impurities.

Pig iron – an iron-based product with a carbon content less than 5.0 percent but still greater than 1.7 percent by weight.

Slag – a non-metallic product resulting from the interaction of fluxes and impurities in the smelting and refining of metals. Slag is separated from molten iron and solidified outside the mill. It may eventually be recycled into things such as concrete building blocks.

Basic oxygen process furnace (BOPF) – a pear shaped furnace lined with refractory bricks used in the primary production of steel from molten pig iron and scrap with fluxes and 99 percent pure oxygen (O_2) to reduce carbon, phosphorus (P) and Sulfur (S) to specified levels without introducing nitrogen (N_2) or hydrogen (H_2).

Electric arc furnace (EAF) – a furnace wherein metals are melted by passing an electric current through them. EAFs permit the closely controlled addition of alloying elements as well as being an inexpensive way to recycle steel.

Steel – an iron-based product with a carbon content of 1.7 percent or less by weight.

Raw steel – molten steel before it has been shaped or rolled, including the primary production of steel from iron ore in a BOPF as well as steel produced by recycling in an EAF.

Carbon steel – the world's most common steel; its properties depend on the specific carbon content and microstructure. Steel with carbon content greater than 0.5 percent is high-carbon steel. Alloying elements are insubstantial.

Alloy steels – steels with elements added to alter or improve their properties. Examples include chromium (Cr – at least 10 percent) and nickel (Ni) to produce stainless steel (which resists corrosion), and silicon (Si) to reduce energy loss in electrical steel. Other important elements used to varying degrees in alloy steels are molybdenum (Mo), niobium (Nb), tungsten (W) and vanadium (V) for luster, strength, toughness, wear and/or corrosion resistance.

Continuous casting – pouring molten metal from a ladle through a water-cooled mold for solidification into a particular shape. The process bypasses ingot teeming, stripping, soaking and some preliminary rolling steps thereby saving time, energy and money.

Net or short ton – 2000 pounds; a long ton is a metric ton (1,000 kg.), or about 2,204.6 pounds.

Semi-finished steel – the unrolled basic shapes of billets, blooms and slabs.

- **Billet** – a square or rectangular shape.
- **Bloom** – a square or rectangular shape larger than a billet.
- **Slab** – usually 8-to-10 inches thick, and wider than a bloom. Refinements to continuous casting permitted the direct production of intermediate (4-to-6 inches thick) and thin (1.5-to-2 inches thick) slabs, bypassing the need for reducing stands and thereby saving additional time, energy and money.

Rolling – reducing or changing the cross-sectional area of a work-piece by the compressive forces of rotating rolls. The process is similar to squeezing clothes through the wringers of an old fashion washing machine.

- **Flat rolled** – processed on rolls with smooth faces, as opposed to grooved or cut faces used for structural or shaped products. Common products include sheets, strips and plates.
- **Hot rolled** – processed after it has been reheated, then rolled into coils.
- **Cold rolled** – processed without first reheating the steel. Cold rolling produces a smooth surface and makes the piece easier to machine as well as improving strength, hardness and ductility.

Drawing – pulling steel through a series of plates or dies to produce bars and wires of various gauges.

Finished steel products include, but are not limited to:

- **Structural shapes** – one example is an I-beam rolled and shaped from a bloom.
- **Sheets** – flat rolled from slabs, wider than 12 inches; by volume, the single largest class of products of the industry.
- **Strips** – flat rolled from slabs, less than 12 inches wide, but with a more precise control of thickness.
- **Plates** – flat rolled from slabs, thicker and heavier than sheets; a high-volume class of products primarily used in the construction and heavy machinery industries.
- **Bars** – a high-volume class of products shaped and rolled into various forms from billets. Bars also may be cold-drawn to improve strength, turned, ground and polished to improve surface finish and control size and shape to the requested tolerance level.
- **Wires** – the smallest, thinnest products.

Pipes and tubes – welded products are made by rolling a strip into a loop and welding the edges to seal the gap; seamless products are made by forcing a heated rod or billet through piercers or dies. Seamless products better resist corrosion and pressure; welded products can be longer, cost less and have shorter production times.

Foundries – jobbing foundries are independent establishments producing a limited number of castings from customized molds for their customers; captive foundries are part of vertically integrated companies making large numbers of castings from a few molds to be used in the owner's end products (e.g., motor vehicle engine blocks).

Sand casting – this most common process uses sand as the mold material.
Investment casting – uses the lost wax technique described in the Industry Definition section.
Centrifugal casting – molten metal is forced into the mold by spinning in a centrifuge; also may be used to make pipes and tubes.
Near net shape casting – casting metal in a thin and intricate-but-strong form that eliminates or reduces machining requirements before use or installation of the product.

Some iron and steel producers also engage in subsequent metal processing activities. These include: **annealing** – heating and cooling steel to improve formability and surface durability; **pickling** – removing oxide or mill scale (which can form during hot rolling and annealing) from the surface by immersion in an acidic or alkaline solution in preparation for further processing; and **galvanizing** – coating steel with a layer of zinc (Z) for corrosion resistance; and **slitting** steel – cutting a sheet or strip of steel with rotary knives. These activities are part of the industry *only if performed at establishments where the products are made*; otherwise, they are part of fabricated metals production or the distribution services of wholesale operations (NAICS codes 332 and 4235).

A Primer on Iron and Steel Production Processes

There are two basic types of steel mills: primary producers and minimills. Producing pig iron is the first step of the primary steel making process. Iron ore pellets, limestone and coke are loaded into a blast furnace. The heat melts the ore and the limestone. Two key chemical reactions occur: the carbon from the coke removes the oxygen from the ore, and the limestone removes some impurities. (The result of the latter reaction is called slag, and is removed from the blast furnace.[25]) In the second step, molten pig iron is transferred to a basic oxygen process furnace (BOPF) where contaminants such as phosphorus and sulfur are removed, and carbon, manganese and silicon are either removed or reduced to specified levels. Ferrous scrap, directly reduced iron (DRI), and fluxes may be combined with molten pig iron in this step (Gnidovec, 2003; Larkin, 1994, 1995, 2005; Miller, 1984). About 29 million metric tons of pig iron was produced in the U.S. in 2014, more than 95 percent of which was transferred in molten form to BOPFs at the same site (U.S. Geological Survey, 2015). Current annual production capacities of primary production mills are at least one million net tons, but almost all mills range between two and five million net tons (AIM Market Research, 2013).

By contrast, minimills neither produce pig iron nor use it as a raw material. They typically melt ferrous scrap with fluxes in electric arc furnaces (EAFs).[26] The first EAFs had small capacities – hence the minimill moniker. EAF capacities now range from 20,000 to 4.4 million net tons per year (AIM Market Research, 2013). EAFs dominate production for the slab and flat-rolled markets, but primary steelmaking still produces the highest quality steel (Yucel, 2015a: 35). Both primary producers and minimills use EAFs to create alloy steels (Parker, 1984). Historically, primary producers located mills near their raw materials to minimize transportation costs, but minimills locate near their customers because ferrous scrap is ubiquitous (Larkin, 1994, 1995, 2007; Miller, 1984).

The technology of iron and steel production has changed in additional ways over the decades. BOPFs completely replaced the less efficient open-hearths for primary steel production by 1992 (American Iron and Steel Institute, 1974-2004), yet only 37 percent of the estimated 88 million metric tons of steel produced in the U.S. came from BOPFs in 2014; the other 63 percent came from EAFs (U.S. Geological Survey, 2015). Ingot teeming has almost disappeared as 99 percent of raw steel is continuously cast (U.S. Geological Survey, 2015), now yielding slabs, billets and blooms as little as 1.5 to 2.0 inches thick in a single step. Continuous casting not only created a better product but saved time, energy and money by eliminating breakdown mills and reducing stands (Larkin, 2007: 9-10).

Rolling mill machinery is used to further work such semi-finished steel into finished products: slabs are processed into plates, sheets and strips; billets into bars, rods, and tube rounds; and blooms into structural shapes and rails (Larkin, 1994, 1995, 2007; Miller, 1984). Automation and improved techniques also have been applied to the production of pipes, tubes, wires and castings (Yucel, 2015b, 2015c; Goddard, 2015).

NOTES:

1 "Notable" means a company employing at least 400 in Ohio, or on Fortune's U.S.-1,000 or Global-500 lists, or is a major melt facility in Ohio. Regardless, only sites with at least 25 people are included; company totals reflect only industry employment in Ohio. The complete list organized by company appears in Appendix Table A1.

2 Things change even as data are gathered: Timken's Faircrest capacity was increasing in 2013 (McCafferty, 2013).

3 The 2012 data from Appendix table A3 show the combined output of iron-steel-ferroalloys and steel-product-from-purchased-steel amounts to 82.2 percent of the iron and steel industry total in Ohio.

4 VA and GDP are related measures. The BEA starts with the Census Bureau's VA figures when estimating GDP for manufacturing subsectors such as primary metals (NAICS 331) and subtracts additional costs such as purchased services in deriving the net contribution to GDP. VA data are available for specific industry groups, while GDP data are not. Consequently VA is the best available measure for comparing the relative economic performance of industry groups and geographic areas on an annual basis. More specific data for subgroups and individual industries are found in the quinquennial Census of Manufactures.

5 Canton-Massillon has three – Timken's Faircrest and Harrison sites plus Republic's facility – totaling 2,948,000 tons annually; Cleveland has four – ArcelorMittal's two and one each of Charter Steel and Republic (the last located in Lorain) – totaling 6,077,000 tons; Mansfield has one – AK Steel with 882,000 tons; and Youngstown-Warren has one – Vallourec Star with 694,000 tons. The combined annual capacity of 10,601,000 tons is 65.9 percent of Ohio's current large-site capacity of 16,080,000 tons (drawn from Aim Market Research, 2013). This excludes the mills no longer in operation.

6 AK Steel has basic oxygen process furnace in Middletown, a 2,899,000-ton annual capacity; the North Star Bluescope furnace in Delta (Toledo) has a 2,183,000-ton capacity; Nucor's Marion furnace has a 397,000-ton capacity (Aim Market Research, 2013). Columbus Castings is in Franklin County; General Motors is in Defiance County.

7 Employment figures for all of the counties should be regarded as estimates because the Census Bureau does not disclose precise figures if doing so would violate the confidentiality of respondents. Instead, the Bureau provides a range encompassing the jobs figure. Techniques thought to be fairly accurate on average can generate plausible estimates in these instances. Even when a specific figure is provided by the Bureau, a note describing an error term is often attached.

8 Table A1 lists a notable facility in Fulton County (North Star Bluescope in Delta), but the Census Bureau (2015b) has nothing near the employment level shown in A1. Perhaps the Bureau classifies the establishment differently than this report, or perhaps employees of a temporary service agency (NAICS 56132) work there.

9 Older data in Appendix Table A9 show raw steel production volumes in Ohio during the 1970s surpassing 20 million net tons in most years.

10 Adding to the cyclicality is the perception of price trends. Customers will buy more than they immediately need when they believe prices will go even higher, but only buy what they absolutely need when they believe prices will go lower (Yucel, 2015a: 16).

11 Primary steelmakers also incorporate scrap. That reduces their costs somewhat, but cannot compensate for their greater capital requirements and expenses.

12 Primary producers have concentrated on making higher-value, coated flat-rolled sheet rather than commodity-grade, hot-rolled sheet products. Higher-value goods are not only more profitable, they may be less price-sensitive, which helps cushion the impact of cyclical downturns. However, higher-value items also cost more to make, which still requires companies to control costs to make a profit (Larkin, 2013: H2).

13 Annual data for ferrous metal foundries (NAICS 33151) are not available. The current-dollar figures in A8 were adjusted for inflation by using the U.S. Bureau of Labor Statistics (BLS) (2015) producer price index values for the industry groups with both groups standardized on 2009.

14 Fluctuations in plant numbers – regardless of source – may be more than establishments opening and closing. While some establishments may have gone out of business or been closed as part of a company consolidation, others may have been reclassified when production changed to make or emphasize a different product. Such production changes mean there is no way of knowing for sure exactly what has happened based on aggregate data alone.

15 Most of the statistics used in this report come from the Census Bureau or are derived from its data bases. The use of one source takes advantage of an underlying consistency and uniformity of definitions and coverage across a variety of subjects and geographic levels as well as providing a high degree of accuracy. However, BLS data have the advantage of timeliness even if its coverage differs in varying degrees from the Census Bureau's. Statistics from the two Bureaus may also differ due to differences in how they classify the establishments as well as collection methodologies.

16 In the latter regard, semi-finished products from iron and steel mills (NAICS 3311) are supplies for the steel-products-from-purchased-steel and ferrous foundries groups (3312 and 33151), foundries buy some rolled and drawn products (33122), and some foundry products are used in iron and steel production both at mills and by makers of steel-products-from-purchased-steel (Yucel, 2015a: 14; Yucel, 2015b: 12; Yucel, 2015c: 13; Goddard, 2015: 12).

17 Yucel also states most pipe and tube manufacturers sell products to industrial equipment and plumbing wholesalers who, in turn, sell to customers in many industries; only the larger manufacturers sell directly to end users (2015: 16).

18 The choice between iron and steel vs. alternative materials turns on the consideration of many factors: costs (of the material, the tooling, and the labor to make the product), weight, aerodynamic qualities, production speed, surface finish and paint-ability, ease of recycling, operating temperature, durability and corrosion resistance. Goods made of iron and steel have the advantages over alternative material based on strength, durability (i.e., life expectancy), stability, versatility, ease of recycling, ability to operate in high temperature environments, surface finish and paint-ability, and sometimes cost (Larkin, 2005: Yucel, 2015a: 16; 2015b). Steel can be made corrosion resistant, but it becomes more expensive in the process (Larkin, 2005).

19 ArcelorMittal's particular steel was so tough that the company had to install new rolling and shearing equipment to handle it.

20 Larkin (2005) states that companies divesting their coke ovens did so because they were unwilling to make the financial investments to meet the 1990 Clean Air Act Amendment requirements. Virtually all service and distribution operations have been independent since 2003 – possibly earlier (Larkin, 2013: O4).

21 The rapid emergence of China as the world's largest steelmaking country led to a long-term trend of substantially higher prices for raw materials such as iron ores, coke, coal and ferrous scrap. These eased somewhat during the recent recession, rose with the recovery and increased demand for steel, but paused in 2012. The pause seemed due to slowing demand from the construction sector in China (which reflected a change in government policy). Price trends remain uncertain. On one hand, slower construction growth in China may reduce price pressure on raw materials. On the other hand, population growth and urbanization in Latin America and other Asian nations could increase price pressures (Larkin, 2013: I7).

22 Companies such as LTV and Wheeling-Pittsburgh Steel that had previously entered bankruptcy were not acquired by other steel companies because they retained their liabilities for pension and health care benefits (Larkin, 2005).

Surviving companies are reducing future pension costs by moving to defined-contribution plans and away from defined-benefit plans (Larkin, 2007: 12).

23 Mittal was required by the Justice Department to sell the Sparrows Point facility it had earlier acquired before final approval of its merger with Arcelor (Matthews, 2007a).

24 Just how large a role imports play in meeting domestic demand depends on how calculations are made. On one hand, Yucel states "imports already [are] fulfilling 34.2% of domestic demand" (2015a: 13) for iron and steel products. This is comparable with calculations based on the U.S. Geological Survey (2015) figures where 39 million tons of "imports of iron and steel mill products" amounted to 38.2 percent of the 102 million tons of "apparent steel consumption" for 2014. Yet the same source states "*net import reliance* as a percentage of apparent consumption" was 17 percent (emphasis added). "Apparent steel consumption" is "Defined as steel shipments + imports – exports + adjustments for industry stock changes – semifinished steel product imports," while "net import reliance" is "Defined as imports – exports + adjustments for Government and industry stock changes." Go figure. Yucel (2015c: 12) states 17.0 percent of domestic demand for rolled and drawn products is supplied by imports, but doesn't appear to give a comparable figure for pipe and tube imports.

25 Slag is mostly lime (CaO), silica, and alumina. While it is a byproduct of smelting and refining metals, it becomes an ingredient for other things – mostly road bases and concrete products for road surfaces. It also is spun into mineral wool for insulation, and used in sandblasting, railroad ballast, highway fill, and filters at sewage treatment plants (Gnidovec, 2003).

26 At least some EAF operators have tested DRI, iron carbide and hot briquetted iron as substitutes for expensive scrap (Yucel, 2015a: 35). Slag also is produced in BOPFs and EAFs. Again, it is a byproduct of flux use (Gnidovec, 2003).

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