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Supplementary Materials for

Evaluating the mineral commodity supply risk of the U.S. manufacturing sector

Nedal T. Nassar*, Jamie Brainard, Andrew Gulley, Ross Manley, Grecia Matos, Graham Lederer, Laurence R. Bird, David Pineault, Elisa Alonso, Joseph Gambogi, Steven M. Fortier

*Corresponding author. Email: nnassar@usgs.gov

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Supplementary Materials and Methods

World primary and secondary production and commodity prices

In table S1, descriptions and data sources utilized for world primary and secondary production and prices are provided for each commodity. In most cases, the U.S. Geological Survey's Minerals Yearbooks are utilized as the data source for world production. Because the Minerals Yearbooks include production data over a 5-year interval and because the data are often revised in subsequent editions, the latest Minerals Yearbook reporting data for the pertinent year is utilized in this analysis. For example, data for year 2011 are obtained from the 2015 Minerals Yearbook (the latest yearbook to contain data for year 2011), while data for year 2010 are obtained from the 2014 Minerals Yearbook. Similarly, data for years 2009, 2008, and 2007 are obtained from the 2013, 2012, and 2011 Minerals Yearbooks, respectively. Data for years 2012-2016 are obtained from the 2016 Minerals Yearbook, the latest complete edition as of this writing.

Table S1. Description of data for world primary and secondary production and prices for each commodity (listed alphabetically).

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Alumina	Primary alumina refinery production	Quantities are converted to aluminum content based on the standard stoichiometric ratio (~52.9%)	(*41–46*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. imported alumina, metallurgical grade. Includes cost, insurance and freight.	(*41–46*)
Aluminum	Primary aluminum smelter production	Quantities are reported in aluminum content by the references	(*47–52*)	Secondary aluminum production, post-consumer (old) scrap only	Quantities are reported in aluminum content by the references	(*53*, *54*)	Annual average U.S. market spot price for aluminum ingot	(*47–52*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Antimony	Antimony mine production	Quantities are reported in antimony content, except for Laos for years 2009 and 2010, which are reported in 50% antimony content.	(*55–60*), with additional data for pre-2012 production of Iran (*61*, *62*), Kazakhstan (*63–67*), Laos (*68–70*), and Pakistan (*71*, *72*)	Secondary antimony production from lead-acid battery recycling via secondary lead smelters. Data for year 2007 are not available but are assumed to be the same as those of year 2008	Quantities are reported in antimony content by the reference	(*73*, *74*)	1. New York dealer price for 99.5% to 99.6% antimony metal, including cost, insurance, freight at U.S. ports 2. Oxide 3. Other An average price for each application is calculated based on the consumption combination of these forms.	1. (*55–60*) 2. Based on unit import value of antimony oxide (*75*) 3. Based on unit of antimony ores and concentrates (Sb content) (*75*)
Arsenic	Arsenic trioxide production	Quantities reported in arsenic trioxide are converted to arsenic content based on the standard stochiometric ratio (~75.7%)	(*76–81*)	Not available	Not applicable	Not applicable	1. Annual average arsenic metal landed duty-paid U.S. imports' unit value from China 2. Annual average arsenic trioxide landed duty-paid U.S. imports' unit value from Morocco	(*76–81*)
Barite	Barite primary production	Quantities are converted to barium content based on stochiometric ratio (~58.8%)	(*82–87*), with additional data for Afghanistan (*88*), Armenia (*89–91*), Bosnia & Herzegovina (*92–96*), Chile (*97*), Egypt (*98*, *99*), Nigeria (*100*, *101*), Liberia (*102*), Poland (*103*), Portugal (*104–106*), Saudi Arabia (*107–111*), and Tunisia (*112*)	Not applicable	Not applicable	Not applicable	Annual average unit value of barite sold or used by processors in the United States by application	(*82–87*, *113–115*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Bauxite	Bauxite mine production	Quantities are converted to aluminum content based on Al_2O_3 content of bauxite ore grades reported in (*116*) and the standard stoichiometric ratio (~52.9%). For countries not included by the reference, the Al_2O_3 content of bauxite is assumed to be 41%.	(*41–46*)	Not applicable	Not applicable	Not applicable	Annual average U.S. import unit value of bauxite (free alongside ship)	(*117–123*)
Beryllium	Beryl and bertrandite production	Quantities are converted to beryllium content assuming a 4% of beryl ore. U.S. bertrandite production is reported in the references in beryl ore equivalent, based on an assumed BeO content of 11%	(*124–129*)	Not available	Not applicable	Not applicable	Annual weighted average unit value of U.S. imports of beryllium-copper master alloy, adjusted for beryllium content, which is assumed to be 4%	(*75*)
Bismuth	Primary bismuth refinery production	Quantities are reported in bismuth content in references	(*130–135*)	Aside from an estimate for the United State, no estimates are available for old scrap recycling from other countries	Quantities are reported in bismuth content in references	(*117–123*)	Annual average U.S. dealer price	(*130–135*)
Cadmium	Cadmium refinery production	Quantities are reported in cadmium content by the references	(*136–141*)	Cadmium is recovered from nickel-cadmium batteries, but limited information is available on production levels except for the United States.	Not applicable	Not applicable	Annual average New York dealer price of cadmium metal (99.95% purity) in 5 short-ton lots	(*117–123*)
Cerium	Estimated cerium content of rare earth oxide production	Quantities are converted into cerium content based on the standard stoichiometric ratio (~81.4%)	See the “Rare earth oxide production estimation” section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, cerium oxide, 99.5-99.9% purity	(*142*)
Chromium	Chromite ore production	Quantities are reported in gross weight by the references. The chromic oxide (Cr_2O3) content of the production of each country is	(*143–148*), with data for Finland from (*149*)	Chromium is recycled as a constituent of stainless steel, but country-	Not applicable	Not applicable	Annual weighted average unit value of U.S. imports of chromium (all forms), adjusted for	(*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
		assumed to be as follows: Albania (33%), Australia (43.5%), Finland (25.9%), India (55.9%), Indonesia (54%), Iran (45%), Kazakhstan (51.3%), Kosovo (44%), Madagascar (48%), Oman (50%), Pakistan (52%), Philippines (40%), Russia (38%), South Africa (46% for 44-48% and 42.6% for <44%), Sudan (42%), Turkey (48%), United Arab Emirates (55%), Vietnam (41.4%), and Zimbabwe (55.6%). For certain countries (i.e., Afghanistan, Brazil, China, Greece, and Papua New Guinea), production was reported in chromic oxide content by the original data source and converted by the references into gross weight assuming 44%. This conversion was thus reversed here to obtain chromic oxide content of production for those countries. Quantities are then converted into chromium content based on the standard stoichiometric ratio (~68.4%)		specific data are not readily available			chromium content	
Cobalt mine	Cobalt mine production	Quantities are reported in cobalt content by the references	(*150–155*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. cobalt concentrate exports	(*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Cobalt refinery	Cobalt refinery production	Quantities are reported in cobalt content by the references	(*150–155*)	Secondary recovery of cobalt (non-closed loop). Data are only available for years 2010-2016. Production for prior years is assumed to be the same as those of year 2010.	Quantities are reported in cobalt content by the reference	(*156*)	Annual average U.S. spot price for minimum 99.8% cobalt cathode	(*150–155*)
Copper mine	Copper mine production (concentrates and leaching, electrowon)	Quantities are reported in copper content by the references	(*157–162*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. copper concentrate exports	(*75*)
Copper refinery	Copper primary refinery production, including electrowon	Quantities are reported in copper content by the references	(*157–162*)	Copper secondary refinery production	Quantities are reported in copper content by the references	(*157–162*)	Annual average U.S. producer price for copper cathode	(*117–123*)
Copper smelter	Copper primary smelter production, and production that cannot be differentiated between primary and secondary smelters	Quantities are reported in gross weight, which are typically 99% contained copper or, if production is of matte, reported in copper content	(*157–162*)	Copper secondary smelter production	Quantities are reported in gross weight, which are typically 99% contained copper	(*157–162*)	Annual average unit value of U.S. copper matte imports	(*75*)
Dysprosium	Estimated dysprosium content of rare earth oxide production	Quantities are converted into dysprosium content based on the standard stoichiometric ratio (~87.1%)	See the "Rare earth oxide production estimation" section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, dysprosium oxide, 99.5% purity	(*142*)
Feldspar	Feldspar and nepheline syenite production	Not applicable	(*163–168*)	Not applicable	Not applicable	Not applicable	1. Feldspar, average value, marketable production 2. Nepheline syenite, U.S. average net import unit value	1. (*117–123*) 2. (*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Gallium	Primary (low-grade) production	Quantities are reported in gallium content by the references	(*169*); For years 2007-2011, production quantities are obtained from author of noted reference	Not available; post-consumer scrap recycling is assumed to be negligible (*170*)	Not applicable	Not applicable	Annual average unit value of U.S. gallium imports	(*75*)
Germanium	Primary refinery production	Quantities are reported in germanium content by the references	Canada (*171*), China (*171, 172*), Finland (*149*), Japan (*173*), Russia (*172, 174–178*), and Ukraine (*179–183*) Estimated production data for Belgium and Germany, and more recent Canadian production data, are obtained from personal communication with author of this publication: (*172*)	Secondary production from old scrap data are available only for the United States. Some old and new scrap production of other countries may, however, be included in the primary production data.	Quantities are reported in germanium content by the references	(*117–123*)	1. Annual average germanium metal (≥ 99.99% purity) 2. Annual average price germanium dioxide (≥ 99.99% purity)	(*172*), with original data from Argus Media Group – Argus Metals International
Gold	Gold mine production	Quantities are reported in gold content by the references	(*184–189*)	Fabricated gold old scrap production	Quantities are reported in gold content by the references	(*190*)	Annual average Engelhard quotation for gold	(*184–189*)
Graphite	Natural graphite (flake and amorphous) production	Production is reported as marketable graphite, except for India and Turkey which are reported is run-of-mine. Their quantities are converted to marketable as follows: India (15%), Turkey (5%). Note that marketable grade graphite can have variable fixed-carbon content.	(*191–196*), with revisions based on communication with the author of the references and additional data from Roskill (*197*)	Refractory graphite materials are recycled from various products, but data are not available. High-quality flake graphite is currently not recycled	Not applicable	(*117–123*)	Annual average unit value of U.S. graphite imports	(*75*)
Helium	Helium (both grade-A and crude) extracted from natural gas and withdrawn from storage (i.e., extracted from natural gas in prior years)	Quantities are reported in cubic meters (at 101.325 kilopascals absolute pressure and 15˚C) of contained helium gas	(*117–123, 198–200*)	Helium can and is captured and recycled in some applications, but no18 specific data are available	Not applicable	Not applicable	Average fiscal year price of crude helium sales by the U.S. government, adjusted for helium content	(*201–209*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Indium	Primary indium refinery production	Quantities are reported in indium content by the references	(*210–215*)	Although there is a significant amount of new scrap generated from indium-tin-oxide (ITO), post-consumer (old scrap) is negligible (*170*)	Not applicable	Not applicable	Annual average unit value of U.S. indium imports	(*75*)
Iridium	Iridium mine production	Quantities are reported in iridium content by the references	South Africa (*216–221*); Zimbabwe (*222–227*); Canada's production is estimated based on information from (*228*); Russia's production is estimated based on its exports (*229*) as reported by trade partners, which are allocated to iridium based on unit value	Secondary production data are not available. However, most iridium secondary production is, believed to be closed-loop toll-refined (e.g., chemical catalysts) and would thus excluded from the analysis (*230*).	Not applicable	Not applicable	Engelhard Corp. unfabricated iridium metal	(*117–123*)
Iron ore	Iron ore mine production	Quantities are reported in iron content by the references	(*231–236*), with additional data for years prior to 2012 for Germany (*237*, *238*), Kenya (*239–243*), Nigeria (*100*, *101*), Portugal (*244*), Togo (*245*), and Uganda (*246–250*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. consumption	(*117–123*)
Lanthanum	Estimated lanthanum content of rare earth oxide production	Quantities are converted into lanthanum content based on the standard stoichiometric ratio (~85.3%)	See the "Rare earth oxide production estimation" section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, lanthanum oxide, 99.5-99.9% purity	(*142*)
Lead mine	Lead mine production	Quantities are reported in lead content by the references	(*251–256*), with additional data for Tajikistan (*257*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. lead concentrate exports	(*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Lead refinery	Primary lead refinery production. For certain countries primary and secondary production cannot be differentiated and are thus included in this analysis	Quantities are reported in lead content by the references	(*251–256*)	Secondary lead refinery (old scrap only)	Quantities are reported in lead content by the references	(*251–256*), with additional data for Bosnia & Herzegovina (*92–96*), Ghana (*258*), Lebanon (*259*, *260*), Nigeria (*100*, *101*, *261*), Sri Lanka (*262–264*), and Venezuela (*265–267*)	North American producer price (2007-2012); North American market price (2013-2016)	(*251–256*)
Lithium	Lithium minerals and brine production	Lithium chemicals are converted to their lithium content based on the standard stoichiometric ratio (e.g., Li_2CO_3: 18.8%, LiCl: 16.4%). Lithium hydroxide production is excluded to avoid double-counting. Lithium content for the production of other countries were varied from 2-3% depending on country and year based on recommendation from author of references.	(*268–273*), with revisions provided by author of references	Recycling is estimated to have contributed around 1% of refined lithium production (*274*)	Not applicable	Not applicable	Annual average unit value of U.S. lithium imports, all forms, adjusted for lithium content	(*75*)
Magnesium (metal)	Primary magnesium metal production; For some countries (e.g., Russia), secondary production cannot be differentiated from primary and is thus included	Quantities are reported in magnesium content by the references	(*275–280*)	Aside from old scrap recycling of magnesium metal or otherwise included in the primary production statistics, not are available.	Not applicable	Not applicable	Yearend U.S. Western spot price for magnesium metal	(*117–123*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Manganese	Manganese ore production	Quantities are reported in manganese content by the references, except for a few instances where only gross weight is reported: Egypt (content is assumed to be 30% for year 2007); Morocco (content is assumed to be 53% for years 2007-2011); Sudan (content is assumed to be 29% for years 2007 and 2009), Turkey (content is assumed to be 36% for years 2007-2011)	(*117*, *281–285*), with production of "other" countries delineated based on data for Bulgaria (*286–290*), Burkina Faso (*291–293*), Chile (*97*, *294*, *295*), Côte d'Ivoire (*292*, *293*, *296–299*), Egypt (*98*, *99*, *300–302*), Georgia (*303–307*), Greece (*308*), Hungary (*309–314*), Indonesia (*315–319*), Iran (*61*, *62*, *320–322*), Morocco (*323–327*), Namibia (*328–332*), Oman (*333*), Philippines (*334–338*), Romania (*339–341*), Sudan (*342*, *343*), Thailand (*344–348*), Turkey (*349–353*), Russia (*174–178*), Vietnam (*354–358*), and Zambia (*359–363*)	Manganese is recycled as a constituent of ferrous and nonferrous scrap as well as from steel slag. The recovery of scrap specifically for manganese is, however, negligible. (*117*) It is thus excluded from this analysis.	Not applicable	Not applicable	Annual average unit value of U.S. manganese imports, all forms, adjusted for manganese content	(*75*)
Mica	Mica production (all grades and forms)	Not applicable	(*364–369*), with additional pre-2012 production data for Austria (*370–374*) and Zimbabwe (*223–226*). China's pre-2012 production data are obtained from (*375–379*)	Not applicable	Not applicable	Not applicable	Annual average unit value of mica consumption by end-use as reported by the references	(*364–369*, *380*, *381*)
Molybdenum	Molybdenum mine production and recovery as byproduct of copper mine production	Quantities are reported in molybdenum content by the references	(*382–387*)	Global molybdenum recovered from secondary sources (not differentiated by country) as estimated by the reference for years 2009-2016. For years 2007 and 2008, quantities for year 2009 are utilizes	Quantities are reported in molybdenum content by the reference	(*388*)	Time-weighted average price of molybdenum contained in technical-grade molybdic oxide	(*117–123*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Neodymium	Estimated neodymium content of rare earth oxide production	Quantities are converted into neodymium content based on the standard stoichiometric ratio (~85.7%)	See the "Rare earth oxide production estimation" section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, neodymium oxide, 99.5-99.9% purity	(*142*)
Nickel mine	Nickel mine production	Quantities are reported in nickel content by the references	(*389–394*)	Not applicable	Not applicable	Not applicable	Annual average price of U.S. export of nickel ores and concentrates adjusted for nickel content	(*75*)
Nickel plant	Production of nickel metal (includes cathode and briquets); high-nickel pig iron and ferronickel; nickel chemicals (including powder, salts, and solutions); oxide sinter; and other unspecified plant production	Quantities are reported in nickel content by the references	(*389–394*)	Nickel is recycled as a constituent of stainless steel, but country-specific data are not readily available	Not applicable	Not applicable	Annual average London Metal Exchange nickel price, cash	(*118–123*)
Niobium	Niobium mineral concentrate production	Quantities are reported in niobium content by the references	(*395–400*)	Niobium-containing steels and superalloys were recycled, but data are not available. Recycling of materials specifically for their niobium content was negligible (*117*).	Not applicable	Not applicable	Annual average unit value of U.S. niobium imports, all forms, adjusted for niobium content	(*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Palladium	Palladium mine production	Quantities are reported in palladium content by the references	(*401–406*), with additional data for China (*375*, *376*, *407*)	Refined palladium production from secondary sources including end-of-life automotive catalytic converters, jewelry, and electronics	Quantities are reported in palladium content by the reference	(*407*)	Engelhard Corp. unfabricated palladium metal	(*117–123*)
Phosphate	Phosphate rock production	Quantities, reported in P_2O_5 content, are converted to phosphate content based on the standard stochiometric ratio (~43.6%)	(*408–413*)	None	Not applicable	Not applicable	Annual average price (free-on-board) of marketable phosphate rock (all grades)	(*117–123*)
Platinum	Platinum mine production	Quantities are reported in platinum content by the references	(*401–406*), with additional data for China (*375*, *376*, *407*)	Refined platinum production from secondary sources including end-of-life automotive catalytic converters, jewelry, and electronics	Quantities are reported in platinum content by the reference	(*407*)	Engelhard Corp. unfabricated platinum metal	(*117–123*)
Potash	Marketable potash production	Quantities, reported in K_2O equivalent, are converted to potassium content based on the stochiometric ratio (~83%)	(*414–419*)	None	Not applicable	Not applicable	Annual average unit value of U.S. potash imports, all forms, adjusted for potash content	(*75*)
Praseodymium	Estimated praseodymium content of rare earth oxide production	Quantities are converted into praseodymium content based on the standard stoichiometric ratio (~82.8%)	See the “Rare earth oxide production estimation” section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, praseodymium oxide, 99.5-99.9% purity	(*142*)
Rhenium	Primary rhenium production	Quantities are reported in rhenium content by references	(*420–425*); Data for “Other” countries are not disaggregated due to lack of information	Rhenium is recycled, but country-specific information is not readily available	Not applicable	Not applicable	Annual average price of rhenium metal pellets (99.99% pure)	(*117–123*, *426*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Rhodium	Rhodium mine production	Quantities are reported in rhodium content by references	South Africa (*216–221*); Russia and Canada (*407*); Zimbabwe (*427–432*); United States (*433*)	Refined rhodium production from end-of-life automotive catalytic converters	Quantities are reported in rhodium content by the reference	(*407*)	Engelhard Corp. unfabricated rhodium metal	(*117–123*)
Ruthenium	Ruthenium mine production	Quantities are reported in ruthenium content by references	South Africa (*216–221*); Zimbabwe (*222–227*); Canada's production is estimated based on information from (*228*); Russia's production is estimated based on its exports (*229*) as reported by trade partners, which are allocated to ruthenium based on unit value	Secondary production data are not available. However, most iridium secondary production is, believed to be closed-loop toll-refined (e.g., chemical catalysts) and would thus excluded from the analysis (*230*).	Not applicable	Not applicable	Engelhard Corp. unfabricated ruthenium metal	(*117–123*)
Samarium	Estimated samarium content of rare earth oxide production	Quantities are converted into samarium content based on the standard stoichiometric ratio	See the "Rare earth oxide production estimation" section of this document	Not available	Not applicable	Not applicable	Annual average China free-on-board export price, samarium oxide, 99.5% purity	(*142*)
Selenium	Primary selenium production	Quantities are reported in selenium content by the references	(*434–439*), with additional data for China from (*375*, *440*). Production data of the United States are not available but they, along with any industry stock changes, are assumed to equal U.S. exports	Not available	Not applicable	Not applicable	U.S. spot market price for selenium metal powder, minimum 99.5% purity, in 5-ton lots	(*117–123*)
Silver	Silver mine production	Quantities are reported in silver content by the references	(*441–446*)	Silver recovered from new and old scrap	Quantities are reported in silver content by the references	(*441–446*) for the Unites States; (*447–449*) for all other countries	Engelhard's industrial bullion quotations	(*117–123*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Strontium	Celestite production	Quantities are converted to strontium content using a factor ~43.9% based an assumed $SrSO_4$ grade of 92% and a stochiometric ratio of ~47.7%, except for Iran for which an average grade of 86.5% is assumed (*450*), yielding a strontium content of ~41.3%	(*451–456*)	None	Not applicable	Not applicable	Annual average unit value of U.S. strontium imports, all forms, adjusted for strontium content	(*75*)
Tantalum	Tantalum mineral concentrate production, which does not include tantalum from tin slags	Quantities are reported in tantalum content by the references	(*457*, *458*)	Estimated quantity of tantalum recovered from old scrap are available but not delineated by country	Quantities are reported in tantalum content by the reference	(*11*)	Annual average unit value of U.S. tantalum imports, all forms, adjusted for tantalum content	(*75*)
Tellurium	Tellurium refinery production (for years 2010-2016 only)	Quantities are reported in tellurium content by references	Bulgaria (*286*, *287*), Canada (*459*), China (*440*), Japan and Russia (*434–436*), Peru (*460*), South Africa (*216–218*), Sweden (*461*). Data for other countries (Chile, Germany, India, Indonesia, Kazakhstan, Mexico, Philippines, Peru, Republic of Korea, Spain, and Uzbekistan) are from (*171*) for year 2011 and assumed constant for all other years due to lack of better information.	Not available, but recovery from old scrap is assumed to be very small	Not applicable	(*117–123*)	Annual average tellurium price, 99.95% purity	(*117–123*)
Tin mine	Tin mine production	Quantities are reported in tin content by references	(*462–467*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. tin ores and concentrates exports, adjusted for tin content	(*75*)
Tin smelter	Tin primary smelter production	Quantities are reported in tin content by references	(*462–467*)	Tin secondary smelter production	Quantities are reported in tin content by references	(*462–467*)	Annual average New York dealer/market price	(*117–123*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Titanium metal	Titanium sponge metal production	Quantities are reported in titanium content by references	(*117–123*, *198–200*)	The majority of titanium metal recycled is new scrap (i.e., revert). Specific old scrap statistics are generally not available and are thus excluded from this analysis.	Not applicable	Not applicable	Yearend titanium metal price	(*117–123*)
Titanium mineral concentrate	Titanium mineral production, including ilmenite, leucoxene, rutile, and titaniferous slag	Ilmenite and leucoxene are assumed to be 60% TiO_2; rutile is assumed to be 94% TiO_2; titaniferous slag is assumed to be 85% TiO_2. Titanium content of TiO_2 is calculated based on the standard stoichiometric ratio (60%)	(*468–473*), with additional pre-2011 production data for Turkey (*350–353*)	Not applicable	Not applicable	Not applicable	Annual average unit value of U.S. titanium mineral concentrate imports adjusted for titanium content	(*75*)
Tungsten	Tungsten concentrate production	Quantities are reported in tungsten content by the references	(*474–479*)	Secondary tungsten production. Data are not disaggregated by country.	Quantities are reported in tungsten content by the references	(*480*, *481*)	Annual average U.S. spot price for tungsten concentrate calculated from weekly prices	(*474–479*)
Vanadium	Production of vanadium feedstock from ores and concentrates, steel slags from vanadiferous iron ores, and as a byproduct of uranium	Quantities are reported in vanadium content by the references	(*482–487*), with additional data from (*488*)	Vanadium recovered from spent catalyst, petroleum resides, and fly ash. Due to lack of data for years prior to 2010, secondary production for years 2007-2009 are assumed to be the same as those of year 2010	Quantities are reported in vanadium content by the references	(*488*)	Annual average unit value of U.S. vanadium imports (all forms), adjusted for vanadium content	(*75*)

Commodity	World primary production			World secondary production			Prices	
	Description	Assumed content	References	Description	Assumed content	Reference	Description	References
Yttrium	Estimated yttrium content of rare earth oxide production	Quantities are converted into yttrium content based on the standard stoichiometric ratio (~78.7%)	See the "Rare earth oxide production estimation" section of this document	Not available; post-consumer scrap recycling is assumed to be negligible.	Not applicable	Not applicable	Annual average China free-on-board export price, yttrium oxide, 99.999% purity	(*142*)
Zinc mine	Zinc mine production	Quantities are reported in zinc content of concentrates and direct shipping ores by references	(*489–494*)	Not applicable	Not applicable	Not applicable	Annual weighted-average unit value of U.S. zinc concentrate imports and exports	(*75*)
Zinc smelter	Primary zinc smelter production. In certain cases, primary and secondary smelter production are not differentiated. Undifferentiated production is included as primary production.	Quantities are reported in zinc content by references	(*489–494*)	Zinc secondary smelter production	Quantities are reported in zinc content by references	(*489–494*)	Platts Metals Week annual average price for North American SHG zinc; based on the LME cash price plus premium	(*489–494*)
Zirconium	Zirconium mineral concentrate production	Quantities, which are reported in gross weight by the references gross, are converted to zirconium content as follows: ~73% for Russia (given that it is reported as 98% ZrO_2); ~50% for all other countries (assuming they are reporting production as $ZrSiO_4$).	(*495–500*)	Zirconium is recycled but country-specific are not available	Not applicable	Not applicable	Annual average unit value of U.S. zirconium imports (all forms), adjusted for zirconium content	(*75*)

A full list of references cited in this Supplementary Materials can be found on the following website: https://doi.org/10.5281/zenodo.3595382.

Commodities with data for multiple production stages

For eight commodities (aluminum, cobalt, copper, lead, nickel, tin, titanium, and zinc) production data are available for multiple production stages. For example, production data are available for bauxite mining, alumina refining, and aluminum smelting. To determine which of these sequential production stages poses the greatest risk (i.e., the potential "bottleneck"), the DP, TE, and EV indicator scores are assessed independently for each stage. The stage with the highest indicator scores among the production stages in a given year is then used as the score for that particular commodity for that year.

For aluminum, bauxite mine, alumina refinery, and aluminum smelter production were assessed. For cobalt, mine and refinery production were assessed. For copper, mine, smelter, and refinery production were assessed. For lead, mine and refinery production were assessed. For nickel, mine and plant production were assessed. For tin, mine and smelter production were assessed. For titanium, titanium mineral concentrate and titanium metal production were assessed. For zinc, mine and smelter production were assessed. Descriptions and data sources for each of these process stages are provided in table S1.

For the DP indicator, the stages with the highest scores for the eight commodities were aluminum smelter, cobalt mine, copper smelter, lead mine, nickel plant, tin smelter, titanium metal, and zinc smelter. These stages had the highest DP indicator scores for their respective commodities for all years of the analysis with the following exceptions: tin mine had the higher scores for years 2007 and 2008 and lead refinery had the higher scores for years 2009 and 2010.

For the TE indicator, the stages with the highest scores for the eight commodities were bauxite, cobalt refinery, copper refinery, lead refinery, nickel plant, tin smelter, titanium mineral concentrate, and zinc smelter. These stages had the highest TE indicators scores for their respective commodities for all years of the analysis with no exceptions.

For the EV indicator, the stages with the highest scores for the eight commodities were aluminum smelter, cobalt refinery, copper refinery, lead refinery, nickel plant, tin smelter, titanium mineral concentrate, and zinc smelter. These stages had the highest EV indicators scores for their respective commodities for all years of the analysis with the following exceptions: titanium metal had the higher scores for years 2007, 2011, 2014.

Willingness to Supply Index

The Willingness to Supply Index (WSI) is comprised of three components: Trade Ties (TT), Shared Values (SV), and Military Cooperation (MC). TT refers to the extent of trade that a country has with the United States as is measured as the monetary sum of its imports and exports with the United States in a given year relative to its gross domestic product (GDP)

$$TT_{t,c\leftrightarrow USA}^{raw} = \frac{\sum(I_{t,c\leftarrow USA}, E_{t,c\rightarrow USA})}{GDP_{t,c}} \quad \text{Eq. S1}$$

where for country *c* in year *t*, *I* and *E* are its reported imports and exports of all commodities (i.e., all trade) with the United States in monetary terms and GDP is its gross domestic product in current U.S. dollars. Trade data are obtained from United Nations Comtrade Database (*501*), while GDP data are obtained from the World Bank (*502*) or, if not provided by the World Bank, the International Monetary Fund (*503*). To normalize the raw TT scores, the following equation was utilized

$$TT_{t,c\leftrightarrow USA}^{norm.} = \max\left(1 - \log_{10}\left(100 * \left(TT_{t,c\leftrightarrow USA}^{raw} + 1\%\right)\right), 1\%\right) \quad \text{Eq. S2}$$

Note that this normalization limits TT scores such that a country with a total trade value with the United States greater than or equal to 9% of its GDP yields a score of 1 and no country receives a TT score lower than 0.01.

Shared Values (SV) refers to the extent to which a country shares similar ideological values with the United States. To assess SV, Freedom House's *Freedom in the World (FIW)* reports are utilized (*36*). The reports assess the political rights and civil liberties of over 195 countries and 14 territories through 25 indicators that are aggregated to several subcategories: Electoral Process, Political Pluralism and Participation, Functioning of Government, Political Rights, Freedom of Expression and Belief, Associational and Organizational Rights, Rule of Law, Personal Autonomy and Individual Rights. To determine how 'close' a specific country is to the United States, the Euclidean distance between the country in question, *c*, and the United States is calculated across all FIW subcategories, *s*

$$SV_{t,c\leftrightarrow USA}^{raw} = \sum_{s}\left(Subcategory_{s,t,c} - Subcategory_{s,t,USA}\right)^{\frac{1}{2}} \quad \text{Eq. S3}$$

The raw SV scores are then scaled such that the maximum observed value across all countries and years is given a score of 1.

Military Cooperation (MC) is based on whether or not a country has a current collective defense arrangement with the United States (*504*). This includes countries that are currently part of the North Atlantic Treaty Organization (NATO), the Inter-American Treat of Reciprocal Assistance (Rio Treaty), as well as other bi- and trilateral mutual defense agreements.

Figure S1 displays the results for TT, SV, and WSI, which is calculated as the simple average of these two components less 0.1 for any those that have collective defense arrangement (MC) for each year of the analysis. Lower scores, shaded in green, suggest a greater willingness to supply to the United States. Data limitations precluded the inclusion of all countries. In such cases, WSI was calculated based on the scores of the available component.

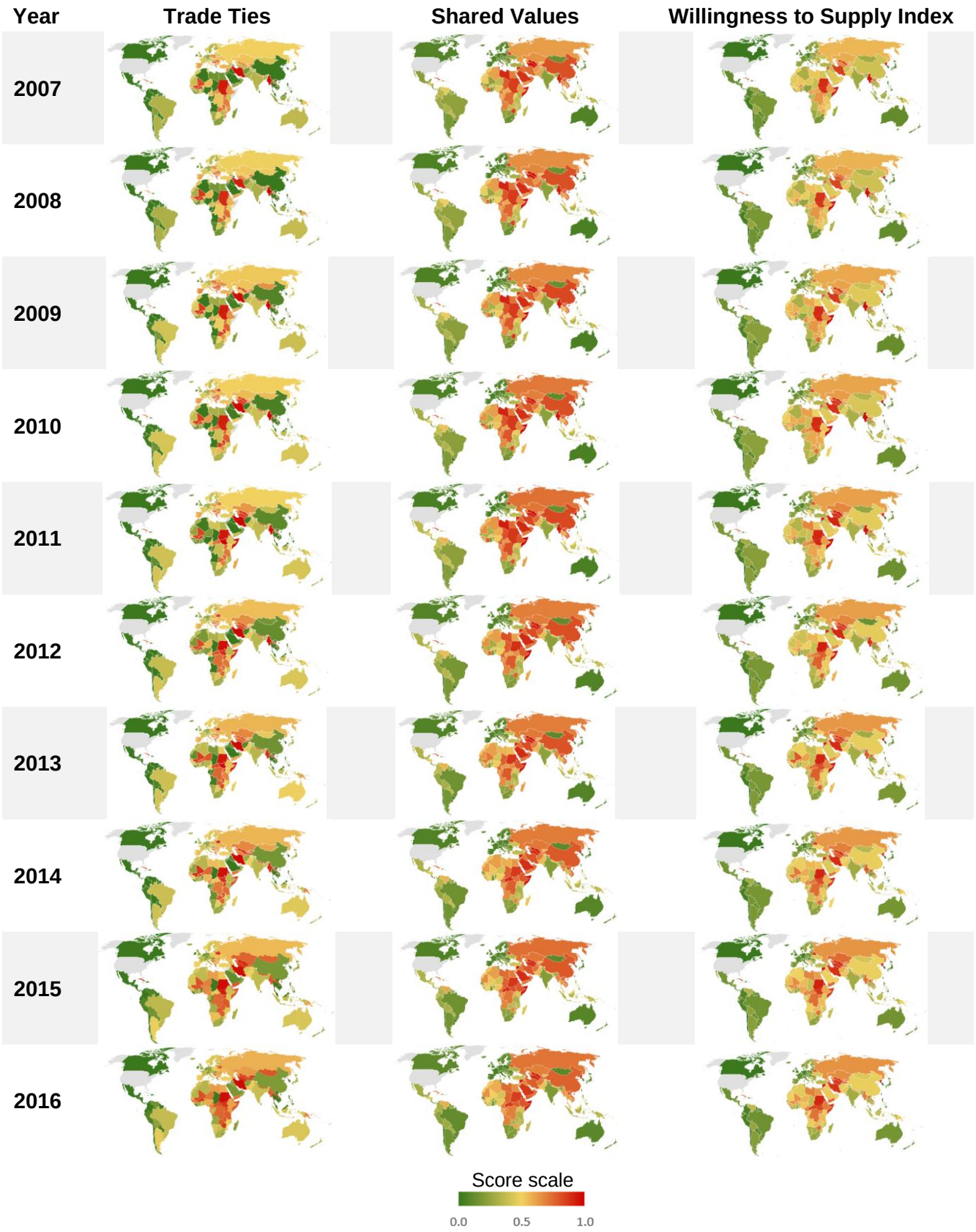


Fig. S1. WSI and constituent components by year.

Net Import Reliance and Apparent Consumption

In table S2, the descriptions and data sources for U.S. primary production, secondary production, imports, exports, and changes in industry and government stocks are identified for each commodity. These variables are used in calculating U.S. “apparent consumption” and U.S. net import reliance. Imports and exports are obtained from U.S. Census Bureau (*75*), unless otherwise noted. Import and export trade codes (Harmonized Tariff Schedule codes, HTS codes) are identified along with the assumed elemental content conversion factors. For certain HTS codes, the trade quantity is reported in two different measurements (e.g., gross vs. contained weight or number of units vs. mass). Where available, the reported contained weight is used in the analysis. For gold, consumption is not calculated using this approach and is instead calculated based on the reported consumption quantities in the following references: (*184–189*). In turn, net import reliance for gold is calculated by taking the difference between domestic production and reported consumption. A similar method is also utilized for the rare earth elements, which is explained in detailed in a later section of this document.

Table S2. Description of data for U.S. apparent consumption calculation by component for each commodity.

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
Alumina	Refinery production of calcined and other alumina (trihydrate, activated, tabular, and other), reported in calcined equivalent	(*41–46*)	Not applicable	Not applicable	2818200000 2818300000	0.529 0.346	2818200000 2818300000	0.529 0.346	U.S. industry stock changes, excluding consumer stocks except those at primary aluminum plants	(*41–46, 505*)
Aluminum	Primary smelter production	(*47–52*)	Secondary aluminum production, old scrap only	(*47–52*)	7601103000 7601106000 7601203000 7601206000 7601209030 7601209045 7601209075 7603100000 7603200000 7604101000 7604103010 7604103050 7604105030 7604105060 7604210000	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	7601100000 7601209030 7601209045 7601209075 7601209500 7603100000 7603200000 7604101000 7604103010 7604103050 7604105030 7604105060 7604210000 7604291000 7604293010	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	U.S. aluminum industry stocks of ingots, semi-fabricated materials, scrap inventory in United States and Canada (original data source is the Aluminum Association, Inc.); London Metal Exchange U.S. warehouses	(*47–52, 506*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
					7604291000 7604293010 7604293050 7604295030 7604295060 7606113030 7606113060 7606116000 7606123030 7606126000	1 1 1 1 1 1 1 1 1 1	7604293050 7604295030 7604295060 7606113030 7606113060 7606116000 7606123030 7606123070 7606126000	1 1 1 1 1 1 1 1 1	(includes alloyed aluminum)	
Antimony	No U.S. mine production; primary smelter production excluded because the net imports of ores and concentrates are included.	Not applicable	Secondary antimony in the form antimonial lead from lead battery recycling via secondary lead smelter production	(*73*, *74*)	2617100000 2620910000 2825800000 8110000000 8110100000 8110200000 8110900000 7801910000	1 1 0.835 1 1 1 1 0.04	2617100000 2620910000 2825800000 8110000000 8110100000 8110200000 8110900000 7801910000	1 1 0.835 1 1 1 1 0.04	No U.S. government stocks or representative industry stock changes are available	Not applicable
Arsenic	No U.S. production	Not applicable	Aside from new scrap from gallium arsenide wafers (which are excluded), there is no information available on U.S. secondary production	Not applicable	2804800000 2811191000 2811291000 2813901000 2851000010 2853000010	1 0.777 0.757 0.607 0.518 0.518	2804800000	1	Not available	Not applicable
Barite	Barite primary production	(*82–87*)	Not applicable	Not available	2511101000 2511105000 2833270000	0.588 0.588 0.588	2511100000 2833270000	0.588 0.588 0.588	Not available	Not applicable
Bauxite	Bauxite mine production	(*41–46*), production data for the United States are withheld by references to avoid disclosing company priority information	Not applicable	Not applicable	2606000030 2606000060 2606000090	Quantities are converted to aluminum content based on Al_2O_3 content of bauxite ore grades reported in (*116*) and the standard stoichiometric ratio (~52.9%). For countries not	2606000030 2606000060 2606000090	Quantities are converted to aluminum content based on Al_2O_3 content of bauxite ore grades reported in (*116*) and the standard stoichiometric ratio (~52.9%). For countries not	U.S. industry stock release, includes all forms of bauxite (dry weight equivalent, converted to aluminum content). For certain years, quantities are withheld by the references to avoid disclosing company	(*117–123*, *198*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
						listed, the Al_2O_3 content of bauxite is assumed to be 41%.		listed, the Al_2O_3 content of bauxite is assumed to be 41%.	proprietary data.	
Beryllium	Bertrandite ore production	(*124–129*)	Not available	Not applicable	2617900030 2825901000 7405006030 7409901030 7409905030 7409909030 8112113000 8112116000 8112120000 8112130000	0.04 0.36 0.04 0.015 0.015 0.015 1 1 1 1	8112113000 8112116000 8112120000 8112130000	1 1 1 1	U.S. industry stock releases and U.S. government national defense stockpile release, including beryl ore, beryllium-copper master alloy, and beryllium metal	(*124–129*, *507–511*)
Bismuth	No U.S. primary bismuth refinery production	(*130–135*)	Estimated secondary production from old scrap	(*117–123*)	2834220000 2834290500 2836930000 2836992000 3823903100 3824903100 3824993100 8106000000	0.431 0.431 0.82 0.82 1 1 1 1	2834220000 2834290500 2836930000 2836992000 8106000000	0.431 0.431 0.82 0.82 1	U.S. consumer stock releases	(*130–135*)
Cadmium	Primary cadmium refinery production	(*136–141*), production data for the United States are withheld by references to avoid disclosing company priority information	Cadmium recovery from end-of-life nickel-cadmium batteries. Production data are withheld by references to avoid disclosing company proprietary data.	(*136–141*)	2825907500 2830300000 2830902000 8107100000 8107200000 8107300000 8107900000	0.875 0.778 0.778 1 1 1 1	2830300000 2830902000 8107100000 8107200000 8107300000 8107900000	0.778 0.778 1 1 1 1	U.S. producer stock releases. Data for years 2011-2016 are not available	(*136–141*)
Chromium	None	Not applicable	Chromium content of stainless-steel scrap recycled	(*143–148*)	2610000020 2610000040 2610000060 2819100000 2819900000 2833230000 2833294000	0.684 0.684 0.684 0.519 0.684 0.171 0.171	2610000000 2819100000 2819900000 2833230000 2833294000 2841300000 2841400000	0.648 0.519 0.684 0.171 0.171 0.349 0.284	U.S. consumer stock releases as well as releases from U.S. National Defense Stockpile, all	(*143–148*, *512–515*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
					2841300000 2841400000 2841500000 2841501000 2849902000 7202410000 7202491000 7202495000 7202495010 7202495090 7202500000 8112206000 8112210000 8112220000 8112290000	0.349 0.284 0.093 0.284 0.867 1 1 1 1 1 1 1 1 1 1	2841500000 2841501000 7202410000 7202490000 7202500000 8112200000 8112210000 8112220000 8112290000	0.093 0.284 1 1 1 1 1 1 1	forms, adjusted for chromium content	
Cobalt mine	Cobalt byproduct mine production	(*150–155*)	Not applicable	Not applicable	2605000000	1	2605000000	1	Because the United State did not refine any cobalt during the time period analysis (*150–155*), additions to stocks are assumed to equal the sum of production and net imports	Not applicable
Cobalt refinery	No U.S. primary refinery production during time period of analysis	(*150–155*)	Secondary cobalt refinery	(*117–123*)	2822000000 2827340000 2827396000 2833291000 2836991000 2915230000 2915293000 8105106000 8105109000 8105203000 8105206000 8105209000	0.72 0.25 0.25 0.27 0.46 0.24 0.24 1 1 1 1 1	2822000000 2827340000 2827396000 2915230000 2915293000 8105100000 8105200000	0.72 0.25 0.25 0.24 0.24 1 1	U.S. government stock releases, as well as releases from industry stocks and London Metal Exchange's U.S. warehouses	(*150–155*, *516*)
Copper mine	Copper concentrate, precipitates, and electrowon	(*157–162*)	Not applicable	Not applicable	2603000010 2607000010 2608000010 2616100010 2616900010 2620196010 2620200010	1 1 1 1 1 1 1	2603000010 2620300000	1 1	Not available	Not applicable

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
					2620210010 2620290010 2620300010 2620906010 2620907010	1 1 1 1 1				
Copper refinery	Copper electrolytic and electrowon refinery production	(*157–162*)	Copper recovered as refined copper and in alloys and other forms from copper-base scrap processed in the United States, old scrap only	(*157–162*, *517–519*)	7403110000 7403120000 7403130000 7403190000 7406100000 7406200000 7407101000 7407101500 7407103000 7407105010 7407105050	1 1 1 1 1 1 1 1 1 1 1	7403110000 7403120000 7403130000 7403190000 7406100000 7406200000 7407100000	1 1 1 1 1 1 1	Stock releases of U.S. refineries wire-rod mills, brass mills, other industry, COMEX, and London Metal Exchange (U.S. warehouses)	(*157–162*, *517*)
Copper smelter	Copper primary smelter production	(*157–162*)	There has been no smelter production from scrap in the United States since October 2001 (*520*)	Not applicable	7401000000 7401100020 7401200000 7402000000	1 1 1 1	7401000010 7401000050 7401100000 7401200000 7402000000	1 1 1 1 1	U.S. stock releases of blister and in-process material	(*157–162*, *517*)
Feldspar	Feldspar (including hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite) production. U.S. nepheline syenite not included because it was not considered marketable as a flux	(*163–168*)	Not applicable	Not applicable	2529100000 2529300010 2529300050	Not applicable	2529100000 2529300000	Not applicable	Not available	Not applicable
Gallium	There was no primary gallium production in the United States during	(*169*)	Aside from new scrap from gallium arsenide wafers (which are excluded), there is no information available	Not applicable	2851000010 2853000010 8112911000 8112921000	0.482 0.482 1 1	Not available	Not applicable	U.S. consumer stock releases, (≥99.99% purity)	(*169*, *521–528*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
	the time period of analysis		on U.S. secondary production							
Germanium	Although there is germanium contained in zinc concentrates mined in the United States, no germanium is recovered from these concentrates in the United States (they are exported for processing)	Not applicable	Germanium refining from old scrap sources only	(*117–123*), for years 2012-2016, production data for the United States are withheld by references to avoid disclosing company priority information	2825600000 8112303000 8112306000 8112309000 8112926000 8112926500 8112991000	For this combined commodity code, germanium content is estimated based on unit value analysis and stochiometric ratio 1 1 1 1 1 1	2825600000 8112300000 8112926100 8112991000	Germanium content is estimated based on unit value analysis and stochiometric ratio for all codes	U.S. government stock releases	(*117–123*, *198*)
Graphite	None	Not applicable	Not available	Not applicable	2504101000 2504105000 2504900000	1 1 1	2504100000 2504900000	1 1	Not available	Not applicable
Helium	Helium (both grade-A and crude) extracted from natural gas and withdrawn from storage (i.e., extracted from natural gas in prior years)	(*117–123*, *198–200*)	Helium used in large-volume application are seldom recycled in the United States	(*117–123*)	2804290010	1	2804290010	1	Releases from U.S. government storage are already included in the production figures	Not applicable
Indium	None	Not applicable	None	Not applicable	8112913000 8112923000	1 1	Not available	Not applicable	Not available	Not applicable
Iridium	Assumed to be negligible	Not applicable	Non-toll refined production assumed to be negligible	Not applicable	7110410010 7110490010 7110410050	1 1 For this combined commodity code, iridium content is estimated based on unit value analysis	7110410000 7110490000	For these combined commodity codes, iridium content is estimated based on unit value analysis	U.S. government stock releases. Reliable data on industry stock releases is not available.	(*401–406*, *529*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
Iron ore	Iron ore mine production	(*231–236*)	Not applicable	Not applicable	2601110030 2601110060 2601110090 2601120030 2601120060 2601120090 2601200000	0.62 0.58 0.6 0.63 0.65 0.62 0.62	2601110030 2601110060 2601110090 2601120030 2601120060 2601120090 2601200000	0.62 0.58 0.6 0.63 0.65 0.62 0.62	U.S. industry stock releases from stocks at mines, plants, and loading docks	(*231–236*, *530*)
Lead mine	Lead mine production	(*251–256*)	Not applicable	Not applicable	2603000020 2607000020 2608000020 2616100020 2616900020 2620196020 2620200020 2620210020 2620290020 2620300020 2620906020 2620907020	1 1 1 1 1 1 1 1 1 1 1 1	2607000020 2620200000 2620290000	1 1 1	Not available. However, given that the last primary smelter closed in yearend 2013, additions to stocks are assumed to equal net imports for years 2014-2016	Not applicable
Lead refinery	Primary lead refinery, domestic ores and base bullion	(*251–256*)	Secondary lead refinery, old scrap only	(*251–256*)	2824100000 2824200000 2824901000 2824902000 2824905000 2836700000 2836994000 7801100000 7801910000 7801993000 7801999050 7804200000	0.928 0.907 0.928 0.907 0.928 0.775 0.775 1 1 1 1 1	2824100000 2824200000 2824900000 2824902000 2824909000 2836700000 2836994000 7801100000 7801910000 7801993000 7801999050 7804200000	0.928 0.907 0.928 0.907 0.928 0.775 0.775 1 1 1 1 1	U.S. stock releases by consumers and secondary smelters	(*251–256*, *531*)
Lithium	Lithium production	(*268–273*), production data for the United States are withheld by references to avoid disclosing company priority information	Not applicable	Not applicable	2825200000 2836910010 2836910050	0.165 0.188 0.188	2825200000 2836910010 2836910050	0.165 0.188 0.188	Not available	Not applicable
Magnesium (metal)	Primary magnesium	(*275–280*), production	Magnesium recovered from magnesium-	(*275–280*, *532–534*)	8104110000 8104190000	1 1	8104110000 8104190000	1 1	Not available	Not applicable

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
	metal production	data for the United States are withheld by references to avoid disclosing company priority information	based and aluminum-based old scrap alloys		8104200000 8104300000 8104900000	1 1 1	8104200000 8104300000 8104900000	1 1 1		
Manganese	None	Not applicable	Not available	Not applicable	2602000040 2602000060 2820100000 2820900000 2841600010 2841600050 2841610000 2841690000 2841690010 2841690090 7202111000 7202115000 7202191000 7202195000 7202300000 8111003000 8111004500 8111004700 8111004900 8111004910 8111004990 8111006000	1 1 0.6 0.775 0.348 0.462 0.348 0.462 0.333 0.462 1 1 1 1 1 1 1 1 1 1 1 1	2602000000 2820100000 2820900000 2841600000 2841610000 2841690000 2841690010 2841690090 7202110000 7202190000 7202300000 8111000000	0.5 0.6 0.775 0.462 0.348 0.462 0.333 0.462 0.79 0.79 1 1	Government, producer and consumer stock releases of manganese ore, ferromanganese, and silicomanganese (all converted to manganese content)	(*117–123*, *198*)
Mica	Scrap and flake mica production, but excludes any low-quality sericite and sheet mica	(*364–369*)	Not applicable	Not applicable	2525100010 2525100020 2525100050 2525200000 2525300000 6814100000 6814900000	1 1 1 1 1 1 1	2525100000 2525200000 2525300000 6814100000 6814900000	1 1 1 1 1	U.S. industry stock releases of mica splittings	(*364–369*)
Molybdenum	Molybdenum mine production and recovery as a byproduct of copper mining	(*382–387*)	Molybdenum is recycled as “a component of catalysts, ferrous scrap, and superalloy scarp.” (*117*) No specific data are,	Not applicable	2613100000 2613900000 2825700000 2841701000 2841705000 3823903400 3824903400	1 1 0.666 1 1 1 1	2613100000 2613900000 2825700000 2841700000 7202700000 8102100000 8102910000	1 1 0.666 1 1 1 1	Stock releases of U.S. consumers, product producers, and concentrate at mines and	(*382–387*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
			however, available. Secondary production is therefore excluded from this analysis.		3824993400 7202700000 8102100000 8102911000 8102915000 8102920000 8102923000 8102926000 8102940000 8102953000 8102956000 8102970000	1 1 1 1 1 1 1 1 1 1 1 1	8102920000 8102940000 8102950000 8102970000	1 1 1 1	plants, where available, as reported by the references	
Nickel mine	Nickel concentrate from Eagle mine in Michigan since 2014 and production as a byproduct from Stillwater operations in Montana	(*118–123*, *198*, *433*, *535*)	Not applicable	Not applicable	2604000040 2620903000 2620993000	1 1 1	2604000040	1	Information on U.S. stock releases was not available. Because all of Eagle mine's nickel production was exported, stock releases were set equal the sum of net imports and production less any production from Stillwater, which was processed domestically	Not applicable
Nickel plant	Minor quantities are produced from byproduct at Stillwater's base metal refinery in Columbus, Montana. All nickel production from the Eagle mine was exported for processing	(*433*, *535*)	Secondary recovery from ferrous and nonferrous scrap (reported in nickel content)	(*118–123*, *198*)	2825400000 2827350000 2833240000 3815110000 7202600000 7501100000 7501200000 7502100000 7503000000 7504000010 7504000050	0.65 0.25 0.22 0.22 1 0.22 0.77 1 0.5 1 1	2825400000 2827350000 2833240000 3815110000 7202600000 7501100000 7501200000 7502100000 7503000000 7504000010 7504000050	0.65 0.25 0.22 0.22 1 0.22 0.77 1 0.5 1 1	Stock releases of U.S. consumers and products, nickel (all forms)	(*118–123*, *198*)
Niobium	There has not been any	(*117*)	Not available	Not applicable	2615903000 2615906030	0.112 0.209	2615903000 2615906030	0.112 0.209	U.S. consumer and U.S.	(*395–400*, *536–539*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
	significant niobium mine production reported since 1959				2825901500 7202930000 7202930010 7202930090 7202934000 7202938000 8112914000 8112924000	0.699 0.65 0.65 0.65 0.65 0.65 1 1	7202930000	0.65	government stock releases	
Palladium	Stillwater and East Boulder mine production. The minor quantities of palladium recovered from Eagle mine in Michigan are excluded due to lack of data	(*433*, *535*)	Palladium content of hypothetically available catalytic converter scrap from obsolete vehicles in the United States are multiplied by the ratio of the palladium content of world catalytic converter scrap refined to theoretically available world catalytic converter scrap using data from reference. Recycling from obsolete jewelry and electronics in the United States is assumed negligible. Analysis excludes toll-refined palladium.	(*407*)	7110210000 7110290000	1 1	7110210000 7110290000	1 1	Not available, assumed to be negligible	Not applicable
Phosphate	Phosphate rock mine production	(*408–413*)	None	None	2510100000 2510200000	0.2 0.2	2510100000 2510200000	0.2 0.2	U.S. producer stock releases	(*117–123*, *198*)
Platinum	Stillwater and East Boulder mine production. The minor quantities of platinum recovered from Eagle mine in Michigan are excluded due to lack of data	(*433*, *535*)	Platinum content of hypothetically available catalytic converter scrap from obsolete vehicles in the United States are multiplied by the ratio of the platinum content of world catalytic converter scrap refined to theoretically available world	(*407*)	7110110000 7110110010 7110110020 7110110050 7110190000 7115100000 7118900020	1 1 1 1 1 1 1	7110110000 7110110010 7110110020 7110110050 7110190000 7115100000 7118900020	1 1 1 1 1 1 1	U.S. government stock releases. Reliable data on industry stock releases are not available.	(*401–406*, *529*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
			catalytic converter scrap using data from reference. Recycling from obsolete jewelry and electronics in the United States is assumed negligible. Analysis excludes toll-refined platinum.							
Potash	Marketable potash production	(*414–419*)	None	Not applicable	2834210000 3104200000 3104300000 3104900000 3104900100	0.39 0.52 0.45 0.12 0.12	2834210000 3104200000 3104300000 3104900000 3104900100	0.39 0.52 0.45 0.12 0.12	Not available	Not applicable
Rhenium	Primary rhenium recovery	(*420–425*)	Not available	Not applicable	2841902000 8112915000 8112925000	0.694 1 1	Not available	Not applicable	Not available	Not applicable
Rhodium	Stillwater and East Boulder rhodium mine production	(*433*, *535*)	Rhodium content of hypothetically available catalytic converter scrap from obsolete vehicles in the United States are multiplied by the ratio of the rhodium content of world catalytic converter scrap refined to theoretically available world catalytic converter scrap using data from reference. Analysis excludes toll-refined rhodium.	(*407*)	7110310000 7110390000	1 1	7110310000 7110390000	1 1	Not available, assumed to be negligible	Not applicable
Ruthenium	Not data available; assumed to be negligible	Not applicable	Non-toll refined production assumed to be negligible	Not applicable	7110410030 7110490050 7110410050	1 1 For this combined commodity code, ruthenium content is estimated based on unit	7110410000 7110490000	For these combined commodity codes, ruthenium content is estimated based on unit value analysis	Not available, assumed to be negligible	Not applicable

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content value analysis	HTS codes	Assumed content	Description	References
Selenium	Production data of the United States are not available but they, along with any industry stock changes, are assumed to equal U.S. exports	(*75*)	Not available, but assumed to be small	Not applicable	2804900000 2811292000	1 0.711	2804900000	1	U.S. industry stock releases are not available but they, along with any U.S. production, are assumed to equal U.S. exports	(*75*)
Silver	Silver mine production	(*441–446*)	Silver secondary production from both old and new scrap	(*441–446*)	2603000040 2607000040 2608000040 2616100040 2620196040 2620200040 2620210040 2620290040 2620300040 2620906040 2620907040 2620907560 2620908060 2620997560 2843210000 2843290000 2843290100 7106100000 7106911010 7106911020 7106915000	1 1 1 1 1 1 1 1 1 1 1 1 1 1 0.635 1 1 1 1 1 1 1	2603000015 2607000025 2608000035 2616100040 2843210000 2843290000 2843290100 7106100000 7106911010 7106911020 7106915000	1 1 1 1 0.635 1 1 1 1 1 1	Stock releases from New York Commodities Exchange–COMEX, U.S. Treasury Department, and U.S. industry, where available	(*117–123*)
Strontium	There has not been any significant quantity of strontium mined in the United States since 1959	(*451–456*)	None	Not applicable	2530908010 2805191000 2805221000 2816200000 2816401000 2834292000 2836920000	0.4388 1 1 0.7 0.7 0.414 0.594	2816200000 2816401000 2836920000	0.7 0.7 0.594	Not available	Not applicable
Tantalum	There has not been any significant quantity of tantalum mined	(*457*, *458*)	No specific data available	Not applicable	2615903000 2615906060 8103103000 8103106030 8103106090	0.262 0.303 1 1 1	2615903000 2615906060 8103103000 8103106030 8103106090	0.262 0.303 1 1 1	No government stockpile releases during time period of analysis; no data	(*117–123*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
	in the United States since 1959				8103200030 8103200090 8103300000 8103900000	1 1 1 1	8103200030 8103200090 8103300000 8103900000	1 1 1 1	available for industry stock releases	
Tellurium	Primary tellurium production	(*117–123*), production data for the United States are withheld by references to avoid disclosing company priority information	Not available, but recovery from old scrap is assumed to be very small	Not applicable	2804500020	Tellurium imports are calculated on the basis of monetary value instead of mass quantity	2804500020	Tellurium exports are calculated on the basis of monetary value instead of mass quantity	Not available	Not applicable
Tin mine	None	Not applicable	Not applicable	Not applicable	2609000000	1	2609000000	1	Given that there has been no U.S. primary tin smelting since 1989, (*117–123*) stock releases are set to equal net exports	(*75*)
Tin smelter	None	(*462–467*)	Secondary tin smelter production, old scrap only	(*462–467*)	2825902000 2827370000 2827392500 2841903000 8001100000 8005002000 8005200000 8007003200	0.788 0.626 0.626 0.485 1 1 1 1	2827370000 2827392500 8001100000 8005002000 8005200000 8007003200	0.626 0.626 1 1 1 1	U.S. government stockpile releases and U.S. consumer and deal stocks releases	(*117–123*, *198*)
Titanium metal	Titanium metal production	(*117–123*, *198–200*), production data for the United States are withheld by references to avoid disclosing company priority information	The majority of titanium metal recycled is new scrap (i.e., revert). Specific old scrap statistics are generally not available and are thus excluded from this analysis.	(*117–123*, *198–200*)	7202910000 8108105010 8108105015 8108105030 8108105045 8108105060 8108105090 8108200010 8108200015 8108200030 8108200045 8108200060 8108200090	0.7 1 1 1 1 1 1 1 1 1 1 1 1	7202910000 8108105010 8108105030 8108105045 8108105060 8108105075 8108200010 8108200030 8108200045 8108200060 8108200090 8108200095 8108300000	0.7 1 1 1 1 1 1 1 1 1 1 1 0.85	U.S. industry stock releases	(*117–123*, *198*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
					8108200091 8108200095 8108300000 8108906010 8108906020	1 1 0.85 1 1	8108906010 8108906020	1 1		
Titanium mineral concentrate	Titanium mineral production	(*468–473*)	Not applicable	Not applicable	2614003000 2614006020 2823000000 2614006040	0.9 0.6 0.599 0.9	2614000000 2823000000	0.6 0.599	Not available	Not applicable
Tungsten	Not available, assumed to be negligible	(*117–123*, *198*)	Secondary tungsten production	(*117–123*, *198*), for certain years, production data for the United States are withheld by references to avoid disclosing company priority information	2611000000 2611003000 2611006000 2620902000 2620992000 2825903000 2827394000 2841800010 2841800020 2841800050 2849903000 2850001000 3823903500 3824903500 3824993500 7202800000 8101100000 8101911000 8101915000 8101920000 8101940000 8101950000 8101970000 8101991000	1 1 1 1 1 0.793 0.464 1 1 1 0.939 0.929 1 1 1 1 1 1 0.95 0.95 0.95 0.95 1 0.95	2611000000 2841800010 2841800040 2849903000 7202800000 8101100000 8101910000 8101920000 8101940000 8101950000 8101970000 8101991000	1 1 1 0.939 1 1 0.7 0.95 0.95 0.95 1 0.95	U.S. government stock releases of tungsten ores and concenters, and tungsten metal powder Producer stock releases including tungsten metal powder and tungsten carbide powder Consumer stock releases including ammonium paratungstate, other tungsten chemicals, ferrotungsten, tungsten metal powder, tungsten carbide powder, and tungsten scrap	(*474–479*, *540*)
Vanadium	Vanadium recovery as a co-product from uraniferous sandstone operations	(*482–487*)	Vanadium recovered from spent catalysts, petroleum residues, and combustion ash	(*488*)	2615906090 2620400030 2620500000 2620907520 2620908020 2620991000 2620997520 2825300010	0.56 0.56 1 1 1 0.56 0.56 1	2615906090 2620500000 2620991000 2825300010 2825300050 7202920000 8112927000	1 1 1 1 1 1 0.56	U.S. industry stock releases of vanadium contained in vanadium oxide, vanadium-aluminum alloy, ferrovanadium,	(*482–487*, *541*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
					2825300050 2827391000 2827491000 2833293000 2841901000 2850002000 3823903600 3824903600 3824993600 7202920000 8112406000 8112927000	1 1 1 1 1 1 1 1 1 1 1 1			vanadium metal, ammonium metavanadate, and other vanadium alloys	
Zinc mine	Production of U.S.	(*489–494*)	Not applicable	Not applicable	2603000030 2607000030 2608000030 2616100030 2616900030 2620110000 2620193000 2620196030 2620200030 2620210030 2620300030 2620906030 2620907030	1 1 1 1 1 1 1 1 1 1 1 1 1	2608000030 2620110000 2620190000	1 1 1	Not available, assumed to be negligible	Not applicable
Zinc smelter	Production of primary U.S. zinc smelters	(*489–494*)	Production of secondary U.S. zinc smelters	(*489–494*)	2817000000 2827360000 2827396500 2830200000 2830201000 2830202000 2830901000 2830901500 2833260000 2833294500 3206200030 3206420000 7901110000 7901121000 7901125000 7902000000 7903100000 7903903000 7903906000 7902000000	0.803 0.479 0.479 0.671 0.671 0.671 0.671 0.671 0.405 0.405 0.36 0.198 1 1 1 1 1 1	2817000000 2827360000 2827396500 2830200000 2830201000 2830202000 2830901000 2830901500 2833260000 2833294500 3206420000 7901110000 7901120000 7902000000 7903100000 7903900000	0.803 0.479 0.479 0.671 0.671 0.671 0.671 1 0.405 0.405 0.198 1 1 1 1 1	Producer and consumer refined zinc stock releases; U.S. government stockpile releases	(*489–494*, *542*)

Commodity	U.S. primary production		U.S. secondary production		U.S. imports		U.S. exports		Stocks changes	
	Description	References	Description	References	HTS codes	Assumed content	HTS codes	Assumed content	Description	References
Zirconium	Production of zirconium mineral concentrates	(*495*–*500*), for year years, production data for the United States are withheld by references to avoid disclosing company priority information	Not available	Not applicable	2615100000 7202991000 8109200000 8109300000 8109900000 2825600000	0.498 0.62 1 1 1 For this combined commodity code, zirconium content is estimated based on unit value analysis and stochiometric ratio	2615100000 7202991000 8109200000 8109300000 8109900000 2825600000	0.498 0.62 1 1 1 For this combined commodity code, zirconium content is estimated based on unit value analysis and stochiometric ratio	Not available	Not available

In addition to the HTS codes outlined in table S2, the following HTS codes and elemental contents (reported in scientific notation) are used to estimate U.S. imports and exports of steel alloy elements.

Table S3. Estimated elemental content of various steel alloys.

HTS code	Al	C	Cr	Cu	Fe	Mg	Mn	Mo	N	Nb	Ni	P	S	Si	Ta	Ti	V	Zr
7204210000	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7204410020	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204410040	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204410060	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204410080	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204490020	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204490040	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204490060	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7204490070	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7205100000		4.05E-02			9.04E-01		3.82E-02					9.32E-04	3.65E-04	1.57E-02				
7205290000	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7206100000	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7206900000	2.20E-05	4.18E-03	8.37E-04	6.95E-04	9.82E-01		7.64E-03	1.87E-04	8.29E-06		2.27E-03	3.44E-04	4.03E-04	1.61E-03				
7207110000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207120010	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207120050	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207190030	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207190090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207200025	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207200045	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207200075	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7207200090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7208101500	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208103000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208106000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208253000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208256000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208260030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208260060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208270030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208270060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208360030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208360060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208370030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208370060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208380015	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208380030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208380090	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208390015	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208390030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208390090	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208403030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208403060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208406060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208510030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208510045	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208510060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208520000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208530000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208540000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7208900000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209150000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209160030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209160060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209160070	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209160091	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209170030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209170060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209170070	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209170091	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209181530	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209181560	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209182520	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209182585	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209186020	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209186090	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209250000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209260000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209270000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				

HTS code	Al	C	Cr	Cu	Fe	Mg	Mn	Mo	N	Nb	Ni	P	S	Si	Ta	Ti	V	Zr
7209280000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7209900000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7210200000					1.00E+00													
7211130000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211140030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211140045	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211140090	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211191500	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211192000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211193000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211194500	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211196000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211197560	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211197590	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7211231500	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211232000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211233000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211234500	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211236030	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211236060	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211236090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211292030	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211292090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211294500	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211296030	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211296080	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7211900000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7212600000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213100000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213913011	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213913015		2.50E-03	3.00E-04	3.00E-04	9.84E-01		9.00E-03	1.00E-04			3.00E-04	2.00E-04	2.00E-04	3.00E-03			1.00E-04	
7213913093	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213990030	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213990060	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7213990090	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7214100000	2.94E-05	3.62E-03	2.09E-03	2.65E-04	9.79E-01		8.23E-03	5.29E-04			2.09E-03	3.93E-04	4.01E-04	3.16E-03				
7214910016	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7214910020	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7214990016	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7214990021	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7214990026	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7214990060	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7215500016	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7215500018	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7215500020	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217101000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217102000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217103000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217104040	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217104045	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217104090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217105030	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217105090	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217106000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7217107000	1.76E-05	1.55E-03	6.41E-04	7.24E-04	9.89E-01		5.26E-03	1.33E-04	6.59E-06		6.82E-04	3.42E-04	4.08E-04	1.58E-03				
7218100000		8.33E-04	1.81E-01	1.63E-03	6.57E-01		1.48E-02	2.12E-02	2.86E-04		1.08E-01	3.88E-04	3.34E-04	1.43E-02				
7218910015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218910060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218990015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218990030	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218990045	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218990060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7218990090	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219110030	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219110060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120002	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120006		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7219120021	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120026	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120051		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7219120056		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7219120066	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120071	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219120081	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219130002	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219130081	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219210020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219210040	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219210060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220005		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				

HTS code	Al	C	Cr	Cu	Fe	Mg	Mn	Mo	N	Nb	Ni	P	S	Si	Ta	Ti	V	Zr
7219220015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220025	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220035	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220040	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220045	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220070	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219220080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219230030	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219230060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219240060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219310010	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219310050	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320025	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320036	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320038	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320044	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320045	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219320060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330005		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7219330020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330025	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330035		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7219330036	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330042	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7219330045	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330070	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219330080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219340020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219340025	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219340030	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7219340035	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219340050	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219350005	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219350015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219350030	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7219350035	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219350050	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219900020	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219900025	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7219900080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220110000	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220121000	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220125000	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220201010	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220201015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220201060	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7220201080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220206005		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7220206010	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220206015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220206060	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7220206080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220207005		2.50E-04	2.09E-01	7.03E-03	4.48E-01		1.91E-02	5.50E-02	1.12E-03		2.50E-01	4.09E-04	2.73E-04	9.27E-03				
7220207010	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220207015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220207060	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7220207080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220208000	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220209030	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220209060	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220900015	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7220900060	3.03E-04	9.23E-05	1.25E-01		8.45E-01		1.09E-02	1.52E-04			6.84E-03	4.00E-04	2.73E-04	8.98E-03		2.19E-04		
7220900080	3.95E-04	1.30E-04	1.81E-01	1.36E-03	6.69E-01		2.18E-02	1.69E-02	6.04E-04	2.41E-04	9.65E-02	4.24E-04	3.01E-04	1.05E-02	1.32E-05	3.95E-04		7.02E-05
7221000005		2.40E-04	2.09E-01	9.93E-03	4.47E-01		2.00E-02	5.20E-02	1.04E-03		2.51E-01	5.45E-04	2.70E-04	9.40E-03				
7221000030	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7221000045	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7221000075	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222110006		2.40E-04	2.09E-01	9.93E-03	4.47E-01		2.00E-02	5.20E-02	1.04E-03		2.51E-01	5.45E-04	2.70E-04	9.40E-03				
7222110057	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222110059		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222110082	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222110084		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222190001	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222190006		2.40E-04	2.09E-01	9.93E-03	4.47E-01		2.00E-02	5.20E-02	1.04E-03		2.51E-01	5.45E-04	2.70E-04	9.40E-03				
7222190052	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222190054		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222200001	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222200006		2.40E-04	2.09E-01	9.93E-03	4.47E-01		2.00E-02	5.20E-02	1.04E-03		2.51E-01	5.45E-04	2.70E-04	9.40E-03				

HTS code	Al	C	Cr	Cu	Fe	Mg	Mn	Mo	N	Nb	Ni	P	S	Si	Ta	Ti	V	Zr
7222200041	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222200043		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222200062	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222200064		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222200067	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222200069		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222200071	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222200073		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222300012		2.40E-04	2.09E-01	9.93E-03	4.47E-01		2.00E-02	5.20E-02	1.04E-03		2.51E-01	5.45E-04	2.70E-04	9.40E-03				
7222300022	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222300024		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222300082	6.27E-04	5.25E-05	1.68E-01	2.07E-03	7.63E-01		1.74E-02	7.16E-03	2.52E-04	1.79E-04	2.84E-02	4.22E-04	7.20E-04	9.41E-03		9.42E-05		
7222300084		5.82E-05	1.92E-01	4.27E-04	6.25E-01		2.02E-02	2.07E-02	4.20E-04	4.79E-04	1.28E-01	5.45E-04	4.10E-04	1.08E-02		3.11E-04		
7222403025	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222403045	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222403065	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222403085	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7222406000	2.92E-04	5.62E-05	1.81E-01	1.20E-03	6.72E-01		1.88E-02	1.45E-02	3.42E-04	3.35E-04	9.90E-02	4.89E-04	5.49E-04	1.01E-02		2.20E-04		
7223001005	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223001016	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223001031	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223001046	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223001061	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223001076	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223005000	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7223009000	2.23E-03	1.68E-03	1.68E-01		7.18E-01		1.56E-02	6.24E-03	4.93E-04		7.72E-02	4.30E-04	2.30E-04	1.06E-02				
7301100000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7301201000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7301205000		1.50E-03	4.00E-02		9.46E-01		3.00E-03	4.50E-03				2.50E-04		5.00E-03				
7302101010		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302101015		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302101025		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302101075		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302105020		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302105060		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302300000		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302400000		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7302909000		6.00E-03			9.77E-01		1.25E-02					5.00E-04	5.00E-04	3.50E-03				
7304110020		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7304110050		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7304110080		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7304191020		2.80E-03			9.78E-01		1.40E-02			1.50E-03		3.00E-04				1.50E-03	1.50E-03	
7304191030		2.80E-03			9.78E-01		1.40E-02			1.50E-03		3.00E-04				1.50E-03	1.50E-03	
7304191045		2.80E-03			9.78E-01		1.40E-02			1.50E-03		3.00E-04				1.50E-03	1.50E-03	
7304191060		2.80E-03			9.78E-01		1.40E-02			1.50E-03		3.00E-04				1.50E-03	1.50E-03	
7304191080		2.80E-03			9.78E-01		1.40E-02			1.50E-03		3.00E-04				1.50E-03	1.50E-03	
7304195020		3.00E-03	4.00E-03	4.00E-03	9.70E-01		1.20E-02	1.50E-03			4.00E-03	5.00E-04	4.50E-04				8.00E-04	
7304195050		3.00E-03	4.00E-03	4.00E-03	9.70E-01		1.20E-02	1.50E-03			4.00E-03	5.00E-04	4.50E-04				8.00E-04	
7304195080		3.00E-03	4.00E-03	4.00E-03	9.70E-01		1.20E-02	1.50E-03			4.00E-03	5.00E-04	4.50E-04				8.00E-04	
7304220030		1.10E-02		2.50E-03	9.68E-01		5.50E-03	1.00E-03			4.00E-03	3.00E-04	2.50E-04	4.00E-03			3.00E-03	
7304220045		1.10E-02		2.50E-03	9.68E-01		5.50E-03	1.00E-03			4.00E-03	3.00E-04	2.50E-04	4.00E-03			3.00E-03	
7304220060		1.10E-02		2.50E-03	9.68E-01		5.50E-03	1.00E-03			4.00E-03	3.00E-04	2.50E-04	4.00E-03			3.00E-03	
7304233000		2.70E-02	2.00E-02		8.97E-01		5.00E-03				4.50E-02			6.00E-03				
7304236030		1.50E-04	1.25E-02		9.69E-01		6.10E-03	6.50E-03				2.50E-04	2.50E-04	5.00E-03				
7304236045		1.50E-04	1.25E-02		9.69E-01		6.10E-03	6.50E-03				2.50E-04	2.50E-04	5.00E-03				
7304243080		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304244010		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304244020		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304246015		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304246030		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304246045		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304246075		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7304291010					1.00E+00							5.00E-04						
7304291020					1.00E+00							5.00E-04						
7304291030					1.00E+00							5.00E-04						
7304291040					1.00E+00							5.00E-04						
7304291050					1.00E+00							5.00E-04						
7304291060					1.00E+00							5.00E-04						
7304292010					1.00E+00							5.00E-04						
7304292020					1.00E+00							5.00E-04						
7304292030					1.00E+00							5.00E-04						
7304292040					1.00E+00							5.00E-04						
7304292050					1.00E+00							5.00E-04						
7304293130		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7304293180		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7304294120		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7304294130		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7304294180		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7304295015		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7304296115		1.50E-03	4.00E-02		9.46E-01		3.00E-03	4.50E-03				2.50E-04		5.00E-03				

HTS code	Al	C	Cr	Cu	Fe	Mg	Mn	Mo	N	Nb	Ni	P	S	Si	Ta	Ti	V	Zr
7304296130		1.50E-03	4.00E-02		9.46E-01		3.00E-03	4.50E-03				2.50E-04		5.00E-03				
7304296145		1.50E-03	4.00E-02		9.46E-01		3.00E-03	4.50E-03				2.50E-04		5.00E-03				
7304313000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7304390008		2.50E-03	4.00E-03	4.00E-03	9.72E-01	9.30E-03		1.50E-03			4.00E-03	3.50E-04	3.50E-04	1.00E-03			8.00E-04	
7304390016		2.50E-03	4.00E-03	4.00E-03	9.72E-01	9.30E-03		1.50E-03			4.00E-03	3.50E-04	3.50E-04	1.00E-03			8.00E-04	
7304390020		2.50E-03	4.00E-03	4.00E-03	9.72E-01	9.30E-03		1.50E-03			4.00E-03	3.50E-04	3.50E-04	1.00E-03			8.00E-04	
7304390028		2.50E-03	4.00E-03	4.00E-03	9.72E-01	9.30E-03		1.50E-03			4.00E-03	3.50E-04	3.50E-04	1.00E-03			8.00E-04	
7304390032		2.50E-03	4.00E-03	4.00E-03	9.72E-01	9.30E-03		1.50E-03			4.00E-03	3.50E-04	3.50E-04	1.00E-03			8.00E-04	
7304413005	1.50E-03	1.00E-03	2.50E-01	7.50E-03	3.88E-01		1.50E-02				3.20E-01	4.50E-04	1.50E-04	1.00E-02		6.00E-03		
7304413015		8.00E-04	1.80E-01		6.20E-01		2.00E-02	3.00E-02	1.00E-03		1.40E-01	4.50E-04	3.00E-04	7.50E-03				
7304413045		3.00E-04	2.30E-01	4.00E-03	4.52E-01		1.50E-02	6.00E-02	2.10E-03		2.30E-01	3.50E-04	2.00E-04	1.00E-02				
7304416005	1.50E-03	1.00E-03	2.50E-01	7.50E-03	3.88E-01		1.50E-02				3.20E-01	4.50E-04	1.50E-04	1.00E-02		6.00E-03		
7304416015		8.00E-04	1.80E-01		6.20E-01		2.00E-02	3.00E-02	1.00E-03		1.40E-01	4.50E-04	3.00E-04	7.50E-03				
7304416045		3.00E-04	2.30E-01	4.00E-03	4.52E-01		1.50E-02	6.00E-02	2.10E-03		2.30E-01	3.50E-04	2.00E-04	1.00E-02				
7304490005	1.50E-03	1.00E-03	2.50E-01	7.50E-03	3.88E-01		1.50E-02				3.20E-01	4.50E-04	1.50E-04	1.00E-02		6.00E-03		
7304490015		8.00E-04	1.80E-01		6.20E-01		2.00E-02	3.00E-02	1.00E-03		1.40E-01	4.50E-04	3.00E-04	7.50E-03				
7304490045		8.00E-04	1.80E-01		6.20E-01		2.00E-02	3.00E-02	1.00E-03		1.40E-01	4.50E-04	3.00E-04	7.50E-03				
7304490060		3.00E-04	2.30E-01	4.00E-03	4.52E-01		1.50E-02	6.00E-02	2.10E-03		2.30E-01	3.50E-04	2.00E-04	1.00E-02				
7304515005		8.00E-04	1.80E-01		6.20E-01		2.00E-02	3.00E-02	1.00E-03		1.40E-01	4.50E-04	3.00E-04	7.50E-03				
7304515015		2.80E-03	1.80E-03		9.87E-01		4.00E-03	1.50E-03				3.50E-04	4.00E-04	2.00E-03				
7304515045		1.50E-03	1.90E-02		9.59E-01		6.00E-03	8.70E-03				2.50E-04	2.50E-04	5.00E-03				
7304515060		1.50E-03	1.90E-02		9.59E-01		6.00E-03	8.70E-03				2.50E-04	2.50E-04	5.00E-03				
7304901000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7304903000		3.30E-03	1.10E-02		9.73E-01		6.00E-03	2.50E-03				3.50E-04	4.00E-04	3.00E-03				
7304905000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7304907000		3.30E-03	1.10E-02		9.73E-01		6.00E-03	2.50E-03				3.50E-04	4.00E-04	3.00E-03				
7305111030		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305111060		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305115000		3.30E-03	1.10E-02		9.73E-01		6.00E-03	2.50E-03				3.50E-04	4.00E-04	3.00E-03				
7305121030		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305121060		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305125000		3.30E-03	1.10E-02		9.73E-01		6.00E-03	2.50E-03				3.50E-04	4.00E-04	3.00E-03				
7305191060		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305195000		3.30E-03	1.10E-02		9.73E-01		6.00E-03	2.50E-03				3.50E-04	4.00E-04	3.00E-03				
7305204000		5.00E-04			9.94E-01		1.00E-03					2.00E-03	1.00E-03	2.00E-03				
7305208000		2.20E-03	1.40E-01	2.00E-03	8.34E-01		1.00E-02				2.00E-03	2.00E-04	1.00E-04	1.00E-02				
7305314000		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305316010		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7305905000		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306110010		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7306110050		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7306191010		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7306191050		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7306195150		1.60E-03			9.76E-01		1.65E-02			5.00E-04		2.00E-04	1.00E-04	4.50E-03		4.00E-04	7.00E-04	
7306214000		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7306218050		8.00E-04	2.00E-01		6.65E-01		2.00E-02		1.00E-03		1.05E-01	4.50E-04	3.00E-04	7.50E-03				
7306291030		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306291090		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306292000		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306294100		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306296010		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306296050		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				
7306298150		3.40E-03	1.50E-03	2.00E-03	9.76E-01		1.25E-02				2.00E-03	2.00E-04	1.50E-04	2.00E-03				

Commodity applications and associated NAICS codes

In table S4, major applications for each commodity are identified and described. The North American Industry Classification System (NAICS) codes associated with each application are also identified. Note that in some cases, the NAICS codes change from year to year. The years for which the NAICS codes are applicable are noted within parentheses. The data sources for demand fractions for each application category are also identified in the table along with any pertinent notes. In certain cases, the data necessary to calculate the Operating Profit of the sector are withheld by the U.S. Census Bureau to avoid disclosing company proprietary information. In these cases, a higher level NAICS code is utilized.

Table S4. Description of applications, associated NAICS codes, and U.S. demand fractions for each commodity.

Commodity	**Application category**	**Application description**	**Associated NAICS codes** (applicable years)	**U.S. demand fraction**	
				Notes	References
Alumina	Primary aluminum production	The primary feed to smelters to produce aluminum	**331312** (2007-2011); **331313** (2012-2016)	Demand fractions are based on domestically produced alumina shipments and imports as noted in the references	(*41–46*, *505*, *543–545*)
	Other	Various uses include abrasives, chemicals, refractories, among others	**327910** (2007-2016); **325188** (2007-2011); **325180** (2012-2016); **327113** (2007-2011); **327110** (2012-2016); **327125** (2007-2011); **327120** (2012-2016)		
Aluminum	Building and construction – Windows, doors, and screens		**332321** (2007, 2012-2016); **33232** (2008-2011)	Demand fractions are based on aluminum shipments by category in the United States and Canada as reported by the reference.	(*546*)
	Building and construction – Awnings, canopies and residential siding		**332322** (2007, 2012-2016); **33232** (2008-2011)		
	Building and construction – Manufactured homes		**321991** (2007-2016); **321992** (2007-2016)		
	Building and construction – Curtain walls, store fronts, and entrances		**332323** (2007, 2012-2016); **33232** (2008-2011)		
	Building and construction – Bridges, streets, and highways		**332312** (2007, 2012-2016); **33231** (2008-2011)		
	Building and construction – Gutters and downspouts		**332114** (2007-2016)		
	Building and construction – Other		**321213** (2007, 2012-2013, 2015-2016); **32121** (2008-2011, 2014); **321214** (2007, 2012-2013; 2015-2016) **321999** (2007-2016); **332311** (2007, 2012-2016); **332911** (2007, 2012-2016); **332912** (2007, 2012-2016); **332913** (2007, 2012-2016); **332919** (2007, 2012-2016); **33291**		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			(2008-2011); **332996** (2007, 2012-2016);		
	Consumer durables – air conditioners, freezers, and refrigerators		**333415** (2007-2016); **335222** (2007-2009); **33522** (2010-2016)		
	Consumer durables – portable appliances		**335211** (2007); **33521** (2008-2011); **335210** (2012-2106)		
	Consumer durables – Cookware and cooking utensils		**332214** (2007); **332211** (2007); **33221** (2008-2011, 2013); **332215** (2012, 2014-2016)		
	Consumer durables – Other		**332999** (2007, 2012-2016); **337121** (2007, 2012-2016); **337122** (2007, 2012-2016); **337124** (2007, 2012-2016); **337125** (2007, 2012-2016); **337127** (2007, 2012-2016); **33712** (2008-2011); **337211** (2007, 2012-2016); **337212** (2007, 2012-2016); **337214** (2007, 2012-2016); **337215** (2007, 2012-2016); **33721** (2008-2011); **337920** (2007-2016); **339920** (2007-2016)		
	Containers and packaging – household and institutional foil		**311340** (2007-2016); **311320** (2007-2011); **311351** (2012-2016); **311330** (2007-2011); **311352** (2012-2016); **311411** (2007, 2012-2016); **31141** (2008-2011); **311412** (2007, 2012-2016); **311423** (2007, 2012-2016); **311812** (2007, 2012-2016); **311813** (2007, 2012-2016); **31181** (2008-2011); **311821** (2007, 2012-2016); **31182** (2008-2011); **311822** (2007); **311824** (2012-2016); **322211** (2007, 2012-2016); **322212** (2007, 2012-2016); **32221** (2008-2011);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			322213 (2007); **322214** (2007); **322215** (2007); **322212** (2012-2016); **322219** (2012-2016); **322221** (2007); **322223** (2007); **322224** (2007); **322225** (2007); **32222** (2008-2011); **322220** (2012-2016); **326111** (2007-2016); **326112** (2007-2016); **327993** (2007-2016)		
	Containers and packaging – metal cans and other semi-rigid food containers		**332431** (2007, 2012-2016); **332439** (2007, 2012-2016); **33243** (2008-2011); **332115** (2007); **332116** (2007); **332119** (2012-2016);		
	Containers and packaging – other containers		**332420** (2007-2016)		
	Electrical – all		**334111** (2007-2016); **334112** (2007-2016); **334113** (2007-2011); **334118** (2012-2016); **334119** (2007); **334210** (2007, 2012-2016); **334220** (2007, 2012-2016); **334290** (2007, 2012-2016); **3342** (2008-2011); **334310** (2007-2016); **334412** (2007-2016); **334413** (2007-2016); **334416** (2007-2016); **334417** (2007-2016); **334418** (2007-2016); **334419** (2007-2016); **334510** (2007-2016); **334511** (2007-2016); **334512** (2007-2016); **334513** (2007-2016); **334514** (2007-2016); **334515** (2007-2016); **334516** (2007-2016); **334517** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			334519 (2007-2016); **335121** (2007, 2012-2016); **335122** (2007, 2012-2016); **335129** (2007, 2012-2016); **33512** (2008-2011); **335313** (2007-2016); **335314** (2007-2016); **335921** (2007, 2012-2016); **335929** (2007, 2012-2016); **33592** (2008-2011); **335931** (2007, 2012-2016); **335932** (2007, 2012-2016); **33593** (2008-2011); **335999** (2007-2016)		
	Machinery & equipment – all		**333111** (2007-2016); **333112** (2007-2016); **333295** (2007); **333298** (2007); **333313** (2007); **33329** (2008-2011); **333242** (2012-2016); **333249** (2012-2016); **333314** (2007-2016); **333315** (2007-2011); **333316** (2012-2016); **333319** (2007); **333318** (2012-2016); **333511** (2007-2016); **333514** (2007-2016); **333515** (2007-2016); **333512** (2007-2011); **333513** (2007-2011); **333516** (2007-2011); **333517** (2012-2016); **333518** (2007-2011); **333519** (2012-2016); **333611** (2007-2016); **333612** (2007-2016); **333613** (2007-2016); **333618** (2007-2016); **333911** (2007-2016); **333912** (2007-2016); **333913** (2007-2016); **333921** (2007, 2012-2016); **333922** (2007, 2012-2016); **333924** (2007, 2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			33392 (2008-2011); **333991** (2007, 2012-2016); **333992** (2007, 2012-2016); **333995** (2007, 2012-2016); **333996** (2007, 2012-2016); **333999** (2007, 2012-2016); **33399** (2008-2011); **333120** (2007-2016)		
	Transportation – trucks and buses (over 10,000 pounds gross vehicle weight)		**336120** (2007-2016)		
	Transportation – passenger cars and light trucks		**336111** (2007-2016); **336112** (2007-2016); **336211** (2007-2016); **336311** (2007); **336312** (2007); **336310** (2012-2016); **36631** (2008-2011); **336322** (2007); **336320** (2012-2016); **33632** (2008-2011); **336330** (2007-2016); **336340** (2007-2016); **336350** (2007-2016); **336360** (2007-2016); **336391** (2007-2011); **336399** (2007-2011); **336390** (2012-2016)		
	Transportation – trailers and semitrailers		**336212** (2007-2016); **336213** (2007-2016); **336214** (2007-2016)		
	Transportation – Other		**336412** (2007-2016); **336413** (2007-2016); **336611** (2007-2016); **336612** (2007-2016); **336991** (2007-2016); **336992** (2007-2016); **336999** (2007-2016)		
	Other – all other not elsewhere specified		**332212** (2007); **332213** (2007); **332216** (2012-2016); **332313** (2007, 2012-2016); **332410** (2007-2016); **332510** (2007-2016); **332710** (2007-2016); **332721** (2007-2016); **332722** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			332991 (2007-2016); **332992** (2007-2016); **332993** (2007-2016); **332994** (2007-2016); **339999** (2007-2016);		
Antimony	Ammunition	Hardener of lead used in ammunition (bullets and shorts), which for the United States are almost exclusively used for small arms (*547*, *548*)	**332992** (2007-2016)	Demand fractions are based on reported U.S. industrial consumption as noted in the references. Data for specific applications are withheld by the references to avoid disclosing company proprietary information. Importantly, reported consumption is notably lower than the calculated apparent consumption.	(*55–60*, *549–551*)
	Ammunition primer	As a friction element and heat-transfer medium in primers for ammunition and explosives (*547*, *548*)	**325920** (2007-2016)		
	Antimonial lead	Primarily used with lead (to make it easier to cast and increases its hardness) plates, connectors, and terminals in lead-acid batteries that are mainly used for vehicles (*547*, *548*)	**335911** (2007-2016); **335912** (2007-2016)		
	Cable covering	Alloyed with lead for sheathing of electrical power and communications cables (*547*, *548*)	**335929** (2007, 2012-2016); **33592** (2008-2011)		
	Ceramics and glass	Fining agents, decolorant, and anti-solarant for transparent glass, mainly for cathode ray tube (CRT) televisions; Opacifiers in ceramics, mainly in lead-free porcelain enamels for cast iron and steel plumbing fixtures; as well as a colorant for pottery and clays (*73*, *547*)	**327211** (2007-2016); **327212** (2007-2016); **327213** (2007-2016); **327215** (2007-2016); **332998** (2007); **33299** (2008-2011); **332999** (2012-2016); **327111** (2007-2011); **327110** (2012-2016); **327124** (2007); **32712** (2008-2011); **327120** (2012-2016)		
	Flame retardants	Flame retardant, typically combined with halogens, for use mainly in various plastics and textiles, but also in pigments, rubber products, adhesives, and paper (*73*, *547*)	**325998** (2007, 2012-2016); **32599N** (2008-2011)		
	Pigments	Pigment for oil-based exterior paints and enamels (no longer used as a white pigment for exterior paints in the United States), anti-solarant for paints, such as yellow paints on school buses, coloring of rubber, and electroconductive pigments for electronic components (*547*)	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325510** (2007-2016)		
	Plastics	Heat stabilizers for common plastics, especially rigid forms of polyvinyl chloride (PVC); polycondensation catalysts in the manufacture of polyethylene terephthalate (PET) (*547*)	**325211** (2007-2016); **325222** (2007); **32522** (2008-2011); **325220** (2012-2016); **325188** (2007-2011); **325180** (2012-2016)		
	Rubbers	Vulcanization of rubber compounds (*73*, *547*)	**325212** (2007-2016)		
	Other	Bearing metals and bearings, castings, sheet and pipe, solder, and type metal (*547*)	**331491** (2007,2012-2016); **33149** (2008-2011); **311492** (2007, 2012-2016)		
Arsenic	Wood preservation and pesticides	Chromated copper arsenide (CCA) preservatives used for pressure treating lumber, as well as used in herbicides and insecticide (*117*)	**321114** (2007, 2012-2016); **32111** (2008-2011);	No detailed U.S. demand fraction data are available. The following demand	

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			325320 (2007-2016)	fraction are assumed for each application category: wood preservation and pesticides 68%; nonferrous alloys 7%; semiconductors 7%; other 18%	
	Nonferrous alloys	Grids in lead-acid storage batteries, hardener for ammunition, as well as an antifriction additive for bearings, lead shot, and clip-on wheel weights (*117*)	**335911** (2007-2016); **332992** (2007-2016); **331491** (2007,2012-2016); **33149** (2008-2011)		
	Semiconductors	High-purity arsenic used in semiconductor applications including gallium-arsenide, germanium-arsenide-selenide, and indium-gallium-arsenide (*117*)	**334413** (2007-2016)		
	Other	Other applications in the glass (fining agent), ceramics (decolorizing), and pharmaceutical industries	**327211** (2007-2016); **327212** (2007-2016); **327213** (2007-2016); **327215** (2007-2016); **325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325412** (2007-2016)		
Barite	Well drilling	Barite used as a weighting agent in fluids for oil and natural gas well drilling (*117*)	**325998** (2007, 2012-2016); **32599** (2008-2011)	Demand fractions are based on crushed and ground barite sold or used by processors in the United States	(*82–87*, *113–115*)
	Other	Various uses as a filler, extender, or weighting agent in paints, plastics, and sealants, adhesives, and rubber (*117*)	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325188** (2007-2011); **325180** (2012-2016); **325212** (2007-2016); **325412** (2007-2016); **327993** (2007-2016); **327999** (2007-2016)		
Bauxite	Alumina production	Primary feed for alumina refineries	**331311** (2007-2011); **331313** (2012-2016)	Demand fractions are based on U.S. consumption by industry	(*41–46*, *505*, *543*, *544*)
	Other	Various applications including abrasives, chemicals, and refractory uses	**325188** (2007-2011); **325180** (2012-2016); **327125** (2007); **32712** (2008-2011); **327120** (2012-2016); **327910** (2007-2016)		
Beryllium	Aerospace and defense	Aircraft structural components (beryllium metal), aircraft landing gear bushings (beryllium alloys), inertial guidance systems (beryllium metal), optical targeting systems (beryllium metal), radar (beryllium oxide), satellite and space telescope mirrors (beryllium metal), connectors in aircraft electronics (beryllium alloys), and heat shields on space vehicles (beryllium metal)	**333314** (2007-2016); **334511** (2007-2016); **336411** (2007-2012); **336413** (2007-2012); **336414** (2007-2012); **336415** (2007-2012); **336419** (2007-2012); **33641** (2013-2016)	Demand fractions are based on sales revenue and value-added sales by market segment for Materion Corporation (formerly known as Brush Engineered	(*552–561*)
	Automotive	Switches, relays, and connectors (beryllium alloys), airbag mechanisms	**335312** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		(beryllium alloys), anti-lock brake systems (beryllium alloys), transmissions (beryllium alloys), electric motors (beryllium alloys), traction control systems (beryllium alloys), fuel injection systems (beryllium alloys), and electronic ignition systems (beryllium oxide)	**335314** (2007-2016); **336312 (**2007); **33631** (2008-2011); **336310** (2012-2016); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016); **336330** (2007-2016); **336340** (2007-2016); **336350** (2007-2016); **336399** (2007-2011); **336390** (2012-2016)	Materials, Inc.)	
	Consumer electronics	Switches, relays, and sensors (beryllium alloys), springs, contacts, and connectors (beryllium alloys), electromagnetic shielding (beryllium alloys), integrated circuit sockets (beryllium alloys), and audio speaker drivers (beryllium metal)	**334111** (2007-2016); **334113** (2007-2011); **334119** (2007-2011); **334118** (2012-2016); **334417** (2007-2016); **334220** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011)		
	Energy	Power generation turbine components (beryllium alloys), oil and gas drill string equipment (beryllium alloys), neutron moderator in nuclear reactors (beryllium metal), X-ray windows on oil and gas exploration sensors (beryllium metal), photovoltaic solar power generation (beryllium oxide)	**333132** (2007, 2012-2016); **33313** (2008-2011); **334516** (2007-2016); **335999** (2007-2016) **325188** (2007-2011); **325180** (2012-2016)		
	Industrial components and other uses	Plastic injection molds and tooling (beryllium alloys), fire sprinkler components (beryllium alloys), resistance welding apparatus (beryllium alloys), non-sparking tools (beryllium alloys)	**332213** (2007); **33221** (2008-2011); **332216** (2012-2016); **333220** (2007-2011); **333249** (2012-2016); **333511** (2007-2016); **333999** (2007, 2012-2016); **33399** (2008-2011); **334290** (2007-2016)		
	Medical	X-ray windows in medical imaging (beryllium metal), catheter wire (beryllium alloys), medical lasers (beryllium oxide), contacts in surgical instruments and pacemaker leads (beryllium alloys)	**334510** (2007-2016); **334517** (2007-2016); **339112** (2007-2016)		
	Telecommunication	Undersea cable repeater housings (beryllium alloys), Global Positioning Systems (beryllium alloys), subsea seismic monitoring systems (beryllium alloys), semiconductor chip packaging for wireless infrastructure (beryllium oxide)	**334220** (2007-2016); **334413** (2007-2016); **334519** (2007-2016); **335929** (2007, 2012-2016); **33592** (2008-2011)		
Bismuth	Chemicals	Bismuth use in various chemicals, cosmetics, paints, and pharmaceuticals	**325188** (2007-2011); **325180** (2012-2016);	Demand fractions are based on U.S.	(*130–135*, *562–564*)

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			325411 (2007-2016); **325412** (2007-2016); **325510** (2007-2016); **325620** (2007-2016)	consumption of bismuth by category as reported by the references.	
	Bismuth alloys	Fusible alloys for fuel tank safety plugs, fire sprinkler triggering fire control system, solders, holders for optical lenses and other articles for machining and grinding	**331491** (2007, 2012-2016); **33149** (2008-2011); **333298** (2007); **33329** (2008-2011); **333249** (2012-2016); **333999** (2007, 2012-2016); **33399** (2008-2011);		
	Metallurgical additive and other uses	Metallurgical additive to aluminum and copper alloys, and steel to improve machinability and to cast iron to improve metal integrity. Other uses include lead-free pipe fittings and fixtures, water meters, rubber vulcanizations, semiconductors and other electronics, ammunition, ceramic glazes, food processing equipment, lubricating greases, etc.	**324191** (2007-2016); **325212** (2007-2016); **327122** (2007-2011); **327120** (2012-2016); **331111** (2007); **33111** (2008-2011); **331110** (2012-2016); **331312** (2007-2011); **331313** (2012-2016); **331511** (2007, 2012-2016); **33151** (2007-2011); **332323** (2007, 2012-2016); **33232** (2008-2011); **332992** (2007-2016); **332996** (2007-2016); **333294** (2007); **33329** (2008-2011); **333241** (2012-2016); **334413** (2007-2016); **334419** (2007-2016); **334514** (2007-2016); **334517** (2007-2016); **335311** (2007-2016); **335313** (2007-2016); **335314** (2007-2016)		
Cadmium	Batteries	Rechargeable (e.g., nickel-cadmium, silver-cadmium, and mercury-cadmium) batteries, which are used to power various industrial applications and consumer electronics (e.g., power tools)	**335911** (2007-2016)	Representative statistics for U.S. demand fractions are not available. All applications are grouped into a single category with a 100% share.	Not applicable
	Coatings and plating	Anticorrosive coatings on iron, steel, brass, and aluminum used in the electronics, automotive, aerospace and military applications, especially in marine and alkaline environments	**332812** (2007, 2012-2016); **332813** (2007, 2012-2016); **33281** (2008-2011)		
	Pigments	Inorganic cadmium sulfide pigments that provide a yellow color	**325131** (2007); **32513** (2008-2011); **325130** (20120-2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Plastic stabilizers	Stabilizer for polyvinylchloride (PVC)	**325211** (2007-2016)		
	Nonferrous alloys	Additive to nonferrous alloys	**331492** (2007, 2012-2016); **33149** (2008-2011)		
	Photovoltaic devices	Cadmium telluride thin-film solar cells	**334413** (2007-2016)		
	Others	Various uses including as catalysts for production of alcohols and esters	**325188** (2007-2011); **325180** (2012-2016)		
Cerium	Batteries	Additive to nickel-metal-hydride (NiMH) battery alloys, which are used to power portable electronics, hybrid electric vehicles, and power tools, among others	**335911** (2007-2016);	See section on rare earth demand and net imports in this document for details	(*565*)
	Catalyst	Catalysts used in automotive catalytic converters, as well as an additive to petroleum catalytic cracking	**324110** (2007-2016); **336399** (2007-2011); **336390** (2012-2016); **325110** (2007-2016)		
	Ceramics	Stabilizing oxide in zirconia ceramics used in a variety of applications including grinding media, cutting tools, and solid oxide fuel cells	**327910** (2007-2016); **333515** (2007-2016)		
	Glass	Additive in glass production for decolorizing and stabilizing	**327212** (2007-2016)		
	Metallurgy	Mischmetal and rare-earth silicide used as an additive to steel and iron, as well as other metallurgical applications including aluminum and magnesium alloys (*565*)	**331111** (2007); **331112** (2007); **33111** (2008-11); **331110** (2012-2016); **336999** (2007-2016); **339999** (2007-2016)		
	Phosphors and pigments	Cerium oxide as an opacified for ceramic tiles, as well as cerium's use in phosphors for light-emitting diodes	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **335110** (2007-2016); **334220** (2007-2016); **334111** (2007-2016); **334119** (2007-2009); **33411** (2008-2011); **334118** (2012-2016); **334210** (2007, 2009-2016); **3342** (2008); **336321** (2007); **3362** (2008-2011); **336320** (2012-2016);		
	Polishing	Polishing powders to create finished surface of glass and electrical components including flat glass, optical glass, liquid crystal displays, silicon wafer surfaces for integrated circuits, glass hard discs, among others (*566*).	**334413** (2007-2016); **339115** (2007-2016)		
	Other	Various uses included food supplement and fertilizer additive, additive to paints and coatings, stabilizer for polyvinyl chloride (PVC), and single crystals for medical imaging (positron emission tomography)	**334511** (2007-2016); **325411** (2007-2016); **325510** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			325211 (2007-2016)		
Chromium	Steels	Additive to steels, mainly stainless steels, to provide hardness and corrosion resistance, especially at elevated temperatures	**331111** (2007); **33111** (2008-2011); **331110** (2012-2016); **331210** (2007-2016); **331512** (2007, 2012-2016); **331513** (2007, 2012-2016); **33151** (2008-2011); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011); **332111** (2007, 2012-2016); **332114** (2007, 2012-2016); **33211** (2008-2011); **332214** (2007); **332215** (2012); **33221** (2008-2011, 2013-2016); **332912** (2007, 2012-2016); **332919** (2007, 2012-2016); **33291** (2008-2011); **332999** (2007, 2012-2016); **33299** (2008-2011)	Demand fractions are based on U.S. consumption of chromium by end-use as reported by the references	(*143–148*, *512–514*)
	Superalloys	Additive to high-performance alloys mainly used in aircraft and land-based turbine engine parts	**331492** (2007, 2012-2016); **33149** (2008-2011); **332117** (2007-2016); **333611** (2007-2016); **336412** (2007-2016)		
	Other	Other uses included metal finishing (e.g., electroplating), abrasives, magnetic storage media, dental alloys, batteries, and chromium chemicals used in pigments, leather tanning, wood preservation, animal feed supplement, and catalysts, among other uses	**311119** (2007-2016); **316110** (2007-2016); **321114** (2007, 2012-2016); **32111** (2008-2011); **325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325188** (2007-2011); **325180** (2012-2016); **327910** (2007-2016); **331314** (2007-2016); **332812** (2007, 2012-2016); **332813** (2007, 2012-2016); **33281** (2008-2011); **334613** (2007-2010, 2012); **33461** (2011, 2013-2016) **335912** (2007-2016); **339114** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			339116 (2007-2016)		
Cobalt mine	Cobalt refining	The United States did not refine cobalt from primary sources during the entire time period of analysis (2007-2016) (*150–155*).	**Not applicable**	Not applicable	Not applicable
Cobalt refinery	Cemented carbides	Cemented carbides used in cutting and drilling tools used by the mining, construction, automotive, and aerospace sectors	**333131** (2007, 2012-2016); **333132** (2007, 2012-2016); **33313** (2008-2011); **333511** (2007-2016); **333514** (2007-2016); **333515** (2007-2016); **332213** (2007); **33221** (2008-2011); **332216** (2012-216)	Demand fractions are based on reported consumption by application. Note that reported consumption totals do not always equal apparent consumption.	(*150–155*)
	Chemical and ceramics	Catalysts used in the chemical industry (e.g., in the synthesis of terephthalic acid and di-methyl terephthalate as precursors for polyester, in the hydroformylation or oxo process for production of aldehydes from alkenes) and the petroleum industry (e.g., desulfurization) (*567*); driers for inks and paints; pigments and decolorizers in glass and ceramics; surface finishing; cathode in rechargeable batteries used in consumer electronics and hybrid and electric vehicles; and other miscellaneous uses	**325199** (2007, 2012-2016); **32519** (2008-2011); **325188** (2007-2011); **325180** (2012-2016); **324110** (2007-2016); **325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325510** (2007-2016); **325910** (2007-2016); **332812** (2007, 2012-2016); **332813** (2007, 2012-2016); **33281** (2008-2011); **335911** (2007-2016);		
	Magnetic alloys	Aluminum-nickel-cobalt, samarium-cobalt, coating on neodymium-iron-boron, as well as soft magnet alloys used in a wide range of applications including hard disk drives, sensors, actuators, and magnetic resonance imaging (*567*).	**334112** (2007-2016); **334510** (2007-2016); **335312** (2007-2016); **334613** (2007-2010, 2012); **33461** (2011, 2013-2016) **332999** (2007, 2012-2016); **33299** (2008-2011)		
	Steels and other alloys	Additive to various steels and other alloys used for wear- and corrosion-resistances and strength (e.g., maraging steel) in chemical manufacturing equipment, medical (e.g., prosthetics) and dental applications	**331111** (2007); **33111** (2008-2011); **331110** (2012-2016); **331512** (2007, 2012-2016); **33151** (2008-2011); **332111** (2007, 2012-2016); **33211** (2008-2011); **332410** (2007-2016); **339113** (2007-2016); **339114** (2007-2016); **339116** (2007-2016)		
	Superalloys	Additive to high-performance alloys mainly used in aircraft and land-	**331492** (2007, 2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		based turbine engine parts	**33149** (2008-2011); **332117** (2007-2016); **333611** (2007-2016); **336412** (2007-2016)		
Copper mine	Copper smelting and refining	Primary feed into copper smelters and refineries	**331** (2007); **33141** (2008-2011); **331410** (2012-2016)	All copper concentrates are assumed to be consumed by copper smelters and refineries	Not applicable
Copper refinery	Building construction	Building wire, plumbing and heating, air conditioning and commercial refrigeration, builders' hardware, and architectural uses (*568*)	**332311** (2007, 2012-2016); **332312** (2007, 2012-2016); **332313** (2007, 2012-2016); **33231** (2008-2011); **332321** (2007, 2012-2016); **332322** (2007, 2012-2016); **332323** (2007, 2012-2016); **33232** (2008-2011); **332510** (2007-2016); **332611** (2007); **332612** (2007); **332613** (2012-2016); **332618** (2007, 2012-2016); **33261** (2008-2011); **332913** (2007, 2012-2016); **332996** (2007-2016); **333411** (2007); **333412** (2007); **333413** (2012-2016); **333414** (2007, 2012-2016); **333415** (2007, 2012-2016); **33341** (2008-2011)	Demand fractions are based on mill products sold to U.S. manufacturers	(*568*)
	Consumer and general products	Appliances, cord sets, military and commercial ordnance, consumer electronics, fasteners and closures, coinage, utensils and cutlery, and other miscellaneous uses (*568*)	**332111** (2007, 2012-2016); **332112** (2007, 2012-2016); **332114** (2007, 2012-2016); **332115** (2007); **221116** (2007); **332117** (2007, 2012-2016); **332119** (2012-2016); **332211** (2007); **332212** (2007); **332213** (2007); **332215** (2012); **332216** (2012); **33221** (2008-2011, 2013-2016); **332710** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			332721 (2007-2016); **332722** (2007-2016); **332811** (2007, 2012-2016); **332812** (2007, 2012-2016); **332813** (2007, 2012-2016); **33281** (2008-2011) **332991** (2007-2016); **332992** (2007-2016); **332993** (2007-2016); **332994** (2007-2016); **332999** (2007-2016); 335211 (2007); 335212 (2007); 335221 (2007); 335222 (2007); 335224 (2007); 335228 (2007); 3352 (2008-2011, 2013-2016); 335210 (2012); 339 (2007-2016)		
	Electrical and electronic products	Power utilities, telecommunication, business electronics, lighting and wiring devices (*568*)	**333611** (2007-2016); **333612** (2007-2016); **333613** (2007-2016); **333618** (2007-2016); **334** (2007-2016); **335110** (2007-2016); **335121** (2007, 2012-2016); **335122** (2007, 2012-2016); **335129** (2007, 2012-2016); **33512** (2008-2016); **335311** (2007-2016); **335312** (2007-2016); **335313** (2007-2016); **335314** (2007-2016); **335921** (2007, 2012-2016); **335929** (2007, 2012-2016); **33592** (2008-2011); **335931** (2007, 2012-2016); **335932** (2007, 2012-2016); **33593** (2008-2011); **335999** (2007-2016)		
	Industrial machinery and equipment	In-plant equipment, industrial valves and fittings, non-electrical instruments, off-highway vehicles, and heat exchangers (*568*)	**332410** (2007-2016); **332420** (2007-2016); **332431** (2007, 2012-2016); **332439** (2007, 2012-2016); **33243** (2008-2011);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			332911 (2007, 2012-2016); **332912** (2007, 2012-2016); **332919** (2007, 2012-2016); **33291** (2008-2011); **333111** (2007-2016); **333112** (2007-2016); **333120** (2007-2016); **333131** (2007, 2012-2016); **333132** (2007, 2012-2016); **33313** (2008-2012); **333210** (2007-2011); **333220** (2007-2011); **333291** (2007); **333292** (2007); **333293** (2007); **333294** (2007); **333295** (2007); **333298** (2007); **33329** (2008-2011); **333241** (20012-2016); **333242** (20012-2016); **333243** (20012-2016); **333244** (20012-2016); **333249** (20012-2016); **333314** (2007, 2012-2016); **333315** (2007); **333319** (2007); **333316** (2012-2016); **333319** (20212-2016); **33331** (2008-2011); **333511** (2007-2016); **333512** (2007-2011); **333513** (2007-2011); **333514** (2007-2016); **333515** (2012-2016); **333516** (2007-2011); **333517** (2012-2016); **333518** (2007-2011); **333519** (2012-2016); **333912** (2007-2016); **333914** (2007-2016); **333921** (2007, 2012-2016); **333922** (2007, 2012-2016); **333923** (2007, 2012-2016); **333924** (2007, 2012-2016); **33392** (2008-2011);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			333991 (2007, 2012-2016); **333992** (2007, 2012-2016); **333993** (2007, 2012-2016); **333994** (2007, 2012-2016); **333995** (2007, 2012-2016); **333996** (2007, 2012-2016); **333997** (2007, 2012-2016); **333999** (2007, 2012-2016); **33399** (2008-2011)		
	Transportation equipment	Automobiles, trucks and buses, railroad, marine, and aircraft and aerospace applications (*568*)	**336** (2007-2016)		
Copper smelter	Copper refining	Primary feed into copper refineries	**331** (2007); **33141** (2008-2011); **331410** (2012-2016)	All copper smelter production is assumed to feed into copper refineries	Not applicable
Dysprosium	Magnets	Additive to neodymium-iron-boron permanent magnets to increase coercivity (resistance to demagnetization)	**335312** (2015, 2016); **334112** (2015, 2016); **333611** (2015, 2016); **336330** (2015, 2016); **334210** (2015, 2016); **336350** (2015, 2016); **333415** (2015, 2016); **336991** (2015, 2016); **333249** (2015, 2016); **334510** (2015, 2016); **333912** (2015, 2016); **333993** (2015, 2016); **335314** (2015, 2016); **33522** (2015, 2016); **336510** (2015, 2016)	See section on rare earth demand and net imports in this document for details	(*565*)
Feldspar	Glass	Glassmaking including container glass, fiberglass, and other glass to improve hardness, durability, and resistance to chemical corrosion (*569*)	**327211** (2007-2016); **327212** (2007-2016); **327213** (2007-2016); **327215** (2007-2016);	Demand fractions are based on estimates of feldspar sold or used by producers in the United States.	(*163–168*, *570–572*)
	Other	Fluxes for ceramics and pottery (electrical insulators, sanitaryware, tableware, and tile), as well as other miscellaneous uses (abrasives, enamel, as well as fillers and extenders for paints, plastics and rubber)	**327111** (2007); **327112** (2007); **327113** (2007); **32711** (2008-2011); **327110** (2012-2016); **327122** (2007); **32712** (2008-2011); **327120** (2012-2016); **327992** (2007-2016); **325510** (2007-2016);		

Commodity	**Application category**	**Application description**	**Associated NAICS codes** (applicable years)	**U.S. demand fraction**	
				Notes	References
			326199 (2007, 2012-2016); **32619** (2008-2011); **326299** (2007, 2012-2016); **32629** (2008-2011)		
Gallium	Optoelectronic deices	Laser diodes and light-emitting diodes; photodetectors and solar cells	**334413** (2007-2016)	Demand fractions are based on U.S. consumption of gallium metal and gallium compounds	(*169*, *521–528*)
	Integrated circuits	Analog and digital integrated circuits			
	Other	Other uses including research and development			
Germanium	Infrared optics	Lenses and windows for infrared optical systems in night-vision equipment, mainly for military use, but also for both commercial and consumer applications (*172*)	**333314** (2007-2016); **334511** (2007-2016); **334513** (2007-2016); **334516** (2007-2016)	Demand fractions are based on estimated U.S. consumption by application	(*118–123*, *198–200*, *573*)
	Fiber optics	Germanium dioxide as a dopant in silica glass for fiber optical fibers used in networks for digital data transmission (*172*)	**335921** (2007, 2012-2016); **33592** (2008-2011)		
	Electronics and solar	Semiconductor and solar photovoltaic applications, especially space applications	**334413** (2007-2016); **334419** (2007-2016)		
	Other	Includes phosphors, metallurgy, chemotherapy, and polymerization catalysts (for polyethylene terephthalate resins)	**335110** (2007-2016); **331** (2007); **33141** (2008-2011); **331410** (2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011); **334517** (2007-2016); **325211** (2007-2016);		
Gold	Jewelry and coins	Fabrication metal and alloying element in jewelry and coins	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)	Demand fractions are based on North American consumption by application as reported by the reference	(*574*)
	Electrical and electronic	Gold used in various electrical and electronic applications to provide electrical conductivity and corrosion resistance	**334412** (2007-2016); **334413** (2007-2016); **334416** (2007-2016); **334417** (2007-2016); **334418** (2007-2016); **334419** (2007-2016); **334519** (2007-2016);		
	Dental	Dental alloys	**339114** (2007-2016); **339116** (2007-2016)		
	Other	Various uses including as a catalyst, in glass making, aerospace for both electronics and lubrication, and medicines and surgical instruments, to name a few	**325188** (2007-2011); **325180** (2012-2016); **325910** (2007-2016); **325412** (2007-2016); **327211** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			327212 (2007-2016); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016); **336414** (2007-2012); **33641** (2013-2016) **339112** (2007-2016)		
Graphite	Brake lining	Used in brake and clutch linings to improve friction coefficient for braking comfort and noise reduction (*575*)	**336340** (2007-2016)	Demand fractions are based on U.S. consumption of natural graphite as reported by the references. Data for certain applications for certain years are withheld to avoid disclosing company proprietary data but included in this analysis.	(*191–196*, *576–578*)
	Carbon products	Mainly used for bearings and carbon brushes	**333613** (2007-2016); **335991** (2007-2016); **332991** (2007-2016)		
	Foundries	Additive to foundry facing sand, as a mound wash lubricant, and as permanent mound material (*197*)	**331511** (2007, 2012-2016); **33151** (2008-2011); **331513** (2007-2016)		
	Lubricants	Various graphite lubricants used for forging metal parts, greases, and other lubrication needs for plant and equipment (*197*); also includes ammunition packings and seed coating (*191*)	**339991** (2007-2016); **332992** (2007-2016); **325320** (2007-2016); **332111** (2007, 2012-2016); **332112** (2007, 2012-2016); **33211** (2008-2011)		
	Powdered metals	Mainly used in the production of powder metal structural parts (*197*)	**332117** (2007-2016); **327992** (2007-2016)		
	Refractories	Additives to refractory materials for high-temperature applications	**327124** (2007); **327125** (2007); **32712** (2008-2011); **327120** (2012-2016)		
	Rubber	Additive to rubbers to improve thermal and/or electrical conductivity of rubbers (*197*)	**326291** (2007, 2012-2016); **326299** (2007, 2012-2016); **32629** (2008-2011)		
	Other	"Includes antiknock gasoline additives and other compounds, batteries, crucibles, drilling mud, electrical and electronic devices, industrial diamond, magnetic tape, mechanical products, nozzles, paints and polishes, pencils, retorts, sleeves, small packages, soldering and welding, steelmaking, stoppers, and other end-use categories" (*191*)	**325998** (2007, 2012-2016); **32599** (2008-2011); **325510** (2007-2016); **327999** (2007-2016); **334613** (2007-2010, 2012) **33416** (2011, 2013-2016); **339942** (2007); **33994** (2008-2011); **339940** (2012-2016); **335911** (2007-2016); **335912** (2007-2016)		

Commodity	**Application category**	**Application description**	**Associated NAICS codes** (applicable years)	**U.S. demand fraction**	
				Notes	References
Helium	Controlled atmospheres	Helium's used in optical fiber manufacturer and semiconductor processing (*579*)	**335921** (2007, 2012-2016); **33592** (2008-2011); **334413** (2007-2016)	Demand fractions are based on estimated helium consumption in the United States by application. For years 2015-2016, the end-use applications noted in the references are somewhat different than those in previous years. To remain consistent throughout the timespan, the data for year 2014 are used instead for years 2015 and 2016.	(*201–209*)
	Cryogenics	Liquid helium-cooled superconducting magnets in magnetic resonance imagining (MRI) machines. Note that a sizeable portion of the helium for this application is likely purchased in this application is by the MRI user (e.g., hospitals and clinics) rather than the manufacturers. Helium cooling of superconducting magnets is also used in the manufacture of single-crystal boules, as well as small- and large-scale laboratory research (e.g., Large Hadron Collider) (*579*)	**334419** (2007-2016); **334510** (2007-2016); **334516** (2007-2016)		
	Leak detection	Helium's use in detecting leaks in science and technology applications (*579*)	**334519** (2007-2016)		
	Purging and pressuring	Liquid helium/liquid oxygen fueled rocket propulsion systems. Note that a sizeable portion of the helium is purchased in this application is by the users of the rocket propulsion systems (e.g., NASA and U.S. Department of Defense) rather than the manufacturers (*579*)	**336415** (2007-2014, 2016); **33641** (2015)		
	Welding	In metal welding, helium is used as a shielding gas to prevent atmospheric contamination (e.g., gas tungsten arc welding) (*579*)	**332312** (2007, 2012-2016); **332313** (2007, 2012-2016); **33231** (2008-2011); **332410** (2007-2016); **332420** (2007-2016)		
	Other	Various other applications including helium's use as a lifting gas (e.g., party and large holiday balloons, weather and research balloons), chromatographic separation in the pharmaceutical and other industries, and breathing mixtures (e.g., Heliox, Trimix, and Heliair) for recreational (e.g., diving) and nonrecreational use (e.g., medical and scientific), to name a few. In many cases the end-users rather than the manufacturers are the purchasers of the helium. (*579*)	**325120** (2007-2016); **325412** (2007-2016); **339920** (2007-2016)		
Indium	Indium-tin-oxide	Transparent, electrically conductive thin-film coating for flat-panel displays, especially liquid crystal displays (LCDs) (*211*)	**334419** (2007-2016)	No representative distribution among applications was available for the United States; all categories were combined in the analysis	Not applicable
	Alloys	Indium-lead solders for inhibiting gold leaching in electronics; indium-silver alloys as a thermal interface in electronics; indium-tin alloys as bonding agents for nonmetallic materials; indium alloys for dental applications (*211*)	**331491** (2007, 2012-2106); **33149** (2008-2011); **339114** (2007-2016); **339116** (2007-2016)		
	Semiconductor and photovoltaic	Indium-phosphide in optoelectronic devices for fiber-optic communication; indium-gallium-selenide (CIGS) thin-film photovoltaic solar cells; indium-gallium-zinc oxide in organic light-emitting diode (OLED) displays and LCDs (*211*)	**334413** (2007-2016)		
Iridium	Chemical	Process catalysts used in the manufacture of acetic acid (Cativa® process), hydrogenation (Crabtree's catalyst), and hydroformylation; as well as the herbicide Metolachlor. Co-catalyst with platinum used in	**325199** (2007, 2012-2016); **32519** (2008-2011); **325320** (2007-2016);	Demand fractions are based on global data due to lack of	(*580–582*)

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		petroleum reforming	**324110** (2007-2016)	data for the United States	
	Electrical & electronics	Crucibles used to grow single crystals (Czochralski process) including lithium tantalite for surface acoustic wave (SAW) noise filters for wireless telecommunications, sapphire for light-emitting diodes (LEDs), yttrium aluminum garnet for solid state lasers, gadolinium gallium garnet for bubble electronic memories, and lutetium oxyorthosilicate and gadolinium oxyorthosilicate as scintillator crystals for medical imagining including positron emission topography (PET) scanners; thermocouples for process control mainly used in the semiconductors and steel industries; and as a phosphorescent emitter material in organic light-emitting diodes (OLEDs)	**334419** (2007-2016); **334513** (2007-2016); **334413** (2007-2016)		
	Electrochemical	Coating for dimensionally stable anodes used in the membrane technology of the chlor-alkali industry (chlorine and sodium hydroxide manufacture) and sodium chlorate production	**325181** (2007-2011); **325180** (2012-2016)		
	Other	Alloying agent with platinum used in electrodes for automotive spark plug tips and aircraft engine igniters; alloying agent with platinum in medical devices such as pacemakers and catheters; alloying agent in platinum jewelry. Other uses, such as iridium's use for cathodic protection and iridium's former use in catalytic converter, are assumed to be relatively minor.	**336322** (2007); **33632** (2008-2011); **336320** (2012-2016); **336412** (2007-2016); **334510** (2007-2016); **339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
Iron ore	Iron and steel	Iron ore consumption in iron and steel plants (blast and steelmaking furnaces)	**331111** (2007); **33111** (2008-2011); **331110** (2012-2016)	Demand fractions are assumed constant at 98% for iron and steel and 2% other uses	(*119*)
	Other	Non-steel uses include "ballast, cement clinker production, coal washing, crushed road base material, fertilizer, heavy media separation, iron oxide pigments, ferrite magnets, oil and gas well drilling, radiation shielding, water treatment, and other specialty applications" (*232*)	**325510** (2007-2016); **324121** (2007-2016); **324199** (2007-2016); **327310** (2007-2016); **327113** (2007-2016); **327110** (2012-2016); **325998** (2007, 2012-2016); **32599** (2008-2011)		
Lanthanum	Batteries	Additive to nickel-metal-hydride (NiMH) battery alloys, which are used to power portable electronics, hybrid electric vehicles, and power tools, among others	**335911** (2007-2016);	See section on rare earth demand and net imports in this document for details	(*565*)
	Catalyst	Catalysts predominantly used in petroleum catalytic cracking, and, to a lesser degree, automotive catalytic converters	**324110** (2007-2016); **336399** (2007-2011); **336390** (2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			325110 (2007-2016)		
	Ceramics	Stabilizing oxide in zirconia ceramics used in a variety of applications in ceramic capacitors and solid oxide fuel cells	**334414** (2007-2011); **334416** (2012-2016);		
	Glass	Mainly used as an additive to improve optical glass properties of small optical lenses mainly for consumer electronics	**327212** (2007-2016); **335921** (2007, 2012-2016); **33592** (2008-2011); **333314** (2007-2016)		
	Metallurgy	Mischmetal and rare-earth silicide used as an additive to steel and iron, as well as other metallurgical applications including aluminum and magnesium alloys (*565*)	**331111** (2007); **331112** (2007); **33111** (2008-11); **331110** (2012-2016); **336999** (2007-2016); **339999** (2007-2016)		
	Phosphors and pigments	Lamp phosphors including fluorescent and LED lamps, as well as display phosphors	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **335110** (2007-2016); **334517** (2007-2016)		
	Polishing	Polishing powders to create finished surface of glass and electrical components including flat glass, optical glass, liquid crystal displays, silicon wafer surfaces for integrated circuits, glass hard discs, among others (*566*)	**334220** (2007-2016); **334413** (2007-2016); **339115** (2007-2016)		
	Other	Various uses included food supplement and fertilizer additive, additive to paints and coatings, stabilizer for polyvinyl chloride (PVC), cement additive, electron microprobes, and magnetic refrigeration (*566*)	**325211** (2007-2016); **325411** (2007-2016); **325510** (2007-2016); **334511** (2007-2016)		
Lead mine	Lead primary refining	Primary feed into lead refineries. Note that primary lead refining was suspended starting year 2014.	**331** (2007); **33141** (2008-2011); **331410** (2012-2013)	All lead concentrate is assumed to be consumed by lead refineries	Not applicable
Lead refinery	Ammunition	Shots and bullets	**332992** (2007-2016)	Demand fractions are based on U.S. consumption of lead by product. In certain cases, data are withheld by references to avoid disclosing company proprietary data but are included in this analysis.	(*251–256*, *531*, *583*, *584*)
	Batteries	Storage lead-acid batteries mainly for starting, lighting, and ignition (SLI) of vehicles. Other uses include non-SLI battery use in nonroad vehicles (e.g., industrial forklifts, airport group equipment, mining equipment, nonroad utility vehicles) as well as stationary sources of power (*585*)	**335911** (2007-2016); **335912** (2007-2016)		
	Brass and bronze	Alloying element	**331421** (2007); **33142** (2008-2011); **331420** (2012-2016)		
	Cable covering	Power and communication cable covering	**335929** (2007, 2012-2016); **33592** (2008-2011)		
	Electronics	Mainly as solders in electronic components	**334** (2007-2016)		
	Glass and ceramics	Leaded glass and lead glazes in ceramics and pottery	**327** (2007, 2016); **3271** (2008-2011, 2013-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			3272 (2008-2011, 2013-2016);		
	Metal cans	Solder used in metal cans and shipping containers	**332431** (2007, 2012-2016); **332439** (2007, 2012-2016); **33243** (2008-2011)		
	Paints, pigments, and chemicals	Use in paints, pigments, and other chemicals	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325510** (2007-2016); **325998** (2007, 2012-2016); **32599** (2008-2011)		
	Petroleum refining	Gasoline additive	**324110** (2007-2016)		
	Printing	Type metal for printing	**333293** (2007); **33329** (2008-2011); **333244** (2012-2016)		
	Storage tanks	Storage tanks, process vessels, and nuclear radiation shielding	**332410** (2007-2016) **332420** (2007-2016)		
	Transportation	Bearing, casting, and terne metal used in motor vehicles and other transportation parts and equipment	**336** (2007-2016)		
	Other	Various uses included bearing and casting metal for electrical and mechanical machinery, caulking, pipes, and sheet lead for building construction, and other miscellaneous uses	**325520** (2007-2016); **331491** (2007, 2012-2016); **33149** (2008-2011); **331522** (2007); **33152** (2008-2011); **331523** (2012-2016); **332999** (2007, 2011-2016); **33299** (2008-2011)		
Lithium	Air treatment	Lithium chemicals (lithium bromide, lithium chloride and lithium hydroxides and oxides) used in absorption chillers, dehumidification and carbon dioxide removal (*274*)	**333413** (2007-2016); **333415** (2007-2016); **335211** (2007); **33521** (2008-2011); **335210** (2012-2016)	Demand fractions for the United States are not available. They are estimated in this analysis based on information provided in the reference	(*274*)
	Batteries	Lithium-ion rechargeable batteries, primary (non-rechargeable) lithium batteries, as well as nickel-metal-hydride rechargeable batteries that use small amounts of lithium (*274*)	**335911** (2007-2016); **335912**(2007-2016)		
	Ceramics and glass	Lithium carbonate and lithium minerals in ceramics (tiles, sanitaryware, tableware, cookware), as well as glaze and enamels; glass-ceramics; and glass, including container glass, fiber glass, and specialty glass (*274*)	**327111** (2007); **327112** (2007); **327113** (2007); **32711** (2008-2011); **327110** (2012-2016); **327122** (2007-2011); **327120** (2012-2016); **327211** (2007-2016); **327212** (2007-2016); **327213** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			327215 (2007-2016)		
	Lubricating greases	Simple and complex lithium lubricating greases used in a variety of applications including industrial, transportation, commercial and household uses (*274*)	**324191** (2007-2016)		
	Metallurgical powders	Lithium metallurgical powders used in continuous casting of steel	**331513** (2007, 2012-2016); **33151** (2011-2015)		
	Polymer production	Butyllithium used as an initiator for the polymerization of synthetic rubbers (e.g., styrene-butadiene rubber and polybutadiene rubber), as well as catalysts for thermoplastics (e.g., styrene block copolymer)	**325211** (2007-2016); **325212** (2007-2016)		
	Other	Various uses including alloys, mainly lithium-aluminum alloys used in commercial and military aircraft and space vehicles; lithium chemicals for organic synthesis in pharmaceuticals, agrochemicals, and flavors and fragrances; lithium carbonate additive to the electrolyte in aluminum smelting; lithium hypochlorite for sanitization; lithium salts in alumina cements and concrete used in construction; alkyd resins used in paints and coatings; lithium niobate and lithium tantalite used in surface acoustic wave filters for telecommunications and consumer electronics (*274*)	**325188** (2007-2011); **325180** (2012-2016); **325199** (2007, 2012-2016); **32519** (2008-2011); **325320** (2007-2016); **325412** (2007-2016); **325998** (2007, 2012-2016); **32599** (2008-2011); **327310** (2007-2016); **331312** (2007-2011); **331313** (2012-2016); **331314** (2007-2016); **334419** (2007-2016)		
Magnesium (metal)	Casting	Cast structural products	**331521** (2007); **331522** (2007); **331523** (2012-2016); **331524** (2007, 2012-2016); **331528** (2007); **331529** (2012-2016); **33152** (2008-2011)	Demand fractions are based on U.S. consumption of primary magnesium by use as reported the references, with adjustments for the uses of secondary magnesium as reported as reported by the same references	(*275–280*, *532–534*)
	Wrought products	Wrought structural products including sheet, plate, and forgings	**331491** (2007, 2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011); **332999** (2007, 2012-2016); **33299** (2008-2011)		
	Aluminum alloys	Magnesium-aluminum alloys used in packaging, transportation and other applications	**331312** (2007-2011); **331313** (2012-2016); **331314** (2007-2016); **331315** (2007-2016); **331316** (2007-2011); **331319** (2007) **33131N** (2008-2011); **331318** (2012-2016)		
	Cathodic protection	Sacrificial magnesium anodes used for cathodic protection	**332813** (2007, 2012-2016); **33281** (2008-2011)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Iron and steel desulfurization	Magnesium used in the desulfurization of iron and steel	**331111** (2007); **33111** (2008-2011); **331110** (2012-2016)		
	Nodular iron	Magnesium additive to nodular iron	**331511** (2007, 2012-2016); **33151** (2008-2011)		
	Reducing agent	Reducing agent for the production of titanium, zirconium, hafnium, uranium, and beryllium	**331** (2007); **33141** (2008-2011); **331410** (2012-2016)		
	Other	Various uses including magnesium chemicals and scavenger, deoxidizer, and powder	**325188** **325180** (2012-2016)		
Manganese	Steel	In steelmaking, manganese is added for desulphurization. It is also added as an alloying element to improve toughness, formability, hardness, and strength. All steels require manganese. This category also includes cast iron.	**331111** (2007); **331112** (2007); **33111** (2008-2011); **331110** (2012-2016); **331210** (2007-2016); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011) **331511** (2007, 2012-2016); **331512** (2007, 2012-2016); **331513** (2007, 2012-2016); **33151** (2008-2011)	Demand fractions are estimated based on information reported on U.S. consumption of manganese metal and manganese ferroalloys reported in the references.	(*281*, *586*)
	Non-ferrous alloys	Additive to non-ferrous alloys, mainly aluminum alloys	**331314** (2007-2016); **331423** (2007); **33142** (2008-2011); **331420** (2012-2016); **331491** (2007, 2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011)		
	Other	Various uses including pigments, primary and storage batteries, and catalysts and other chemical uses.	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325188** (2007-2011) **325180** (2012-2016); **335911** (2007-2016); **335912**(2007-2016)		
Mica	Joint compounds	Ground mica used in joint compounds for “filling and finishing seems and blemishes in gypsum wallboard” (*364*)	**327420** (2007-2016)	Demand fractions are based on ground mica sold or used by producers in the United States by end-use (*364–369*, *380*, *381*). Built-up mica, mica paper, and sheet mica are	(*364–369*, *380*, *381*)
	Paints	Ground mica use as a “pigment extender that also facilitates suspension, reduces chalking, prevents shrinking and shearing of the paint film, increases resistance of the paint film to water penetration and weathering, and brightens the tone of colored pigments. Mica also promotes paint adhesion in aqueous and oleoresinous formulations.” (*364*)	**325131** (2007); **325132** (2007); **32513** (2008-2011); **325130** (2012-2016); **325510** (2007-2016)		
	Plastics	Ground mica used an extender and filler in plastics, especially for automotive parts (*364*)	**325211** (2007-2016); **326121** (2007-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			326122(2007-2016); **326130** (2007-2016); **326199** (2007, 2012-2016); **32619** (2008-2011)	excluded.	
	Well-drilling muds	Ground mica used in well-drilling muds	**325998** (2007); **32599** (2008-2010)		
	Other	Various uses of ground mica including "molded electrical insulation, roofing, rubber, textile and decorative coatings, welding rods" and miscellaneous" (*364*). This category also includes well-drilling mud for years 2011-2016 due to lack of disaggregated data for those years.	**324112** (2007-2016); **325212** (2007-2016); **325520** (2007-2016); **326211** (2007, 2012-2016); **32621** (2008-2011); **326220** (2007-2016); **326291** (2007, 2012-2016); **326299** (2007, 2012-2016); **32629** (2008-2011); **333992** (2007, 2012-2016); **33399** (2008-2011); **32599** (2011); **325998** (2012-2016)		
Molybdenum	Cast iron	Alloying agent in cast iron	**331511** (2007, 2012-2016); **33151** (2008-2011)	Demand fractions are estimated based on U.S consumption of molybdic oxides, ferromolybdenum ammonium and sodium molybdate, molybdenum scrap, and other forms of molybdenum materials (all converted to molybdenum content) by end-use as reported by the references.	(*382–387*, *587–589*)
	Catalysts and other uses	Mainly used as catalysts in the petroleum and petrochemical industries	**325188** (2007-2011); **325180** (2012-2016); **324110** (2007-2016); **325110** (2007-2016)		
	Lubricants	Molybdenum disulfide used in lubrication	**324191** (2007-2016)		
	Mill products	Various mill products made from metallurgical powder	**332117** (2007-2016)		
	Nonferrous alloys	Additive to nonferrous alloys and molybdenum metal	**331491** (2007, 2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011)		
	Pigments	Molybdenum-based pigments to provide stable color formation and inhibit corrosion	**325131** (2007); 32513 (2008-2011); 325130 (2012-2016)		
	Steels	Alloying agent to various steels, including engineering steels, stainless steels, tools steels, and superalloys, to improve strength, wear- and corrosion-resistance, and hardness	**331111** (2007); **331112** (2007); **33111** (2008-2011); **331110** (2012-2016); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011)		
Neodymium	Batteries	Additive to nickel-metal-hydride (NiMH) battery alloys, which are used to power portable electronics, hybrid electric vehicles, and power tools, among others	**335911** (2015, 2016);	See section on rare earth demand and net imports in this document for details	(*565*)
	Catalysts	Catalysts used in automotive catalytic converters and synthetic rubber	**336390** (2015, 2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		synthesis, as well as an additive to petroleum catalytic cracking	**325212** (2015, 2016); **324110** (2015, 2016)		
	Ceramics	Neodymium oxide mainly used in ceramic capacitors	**334416** (2015, 2016)		
	Glass	Neodymium used in tinting glass bottles, neodymium-doped glass used in optic fiber and neodymium fluoride to coat glass for scientific lenses, laser mirrors, etc.	**327212** (2015, 2016); **335921** (2015, 2016)		
	Magnets	Neodymium-iron-boron permanent magnets used in various automotive applications (including drivetrain in electric and hybrid electric vehicles, electric power steering, etc.), consumer electronics (e.g., hard disk drives), off-shore wind turbines, air-conditioners, and many other uses	**335312** (2015, 2016); **334112** (2015, 2016); **333611** (2015, 2016); **336330** (2015, 2016); **334210** (2015, 2016); **336350** (2015, 2016); **333415** (2015, 2016); **336991** (2015, 2016); **333249** (2015, 2016); **334510** (2015, 2016); **333912** (2015, 2016); **333993** (2015, 2016); **335314** (2015, 2016); **33522** (2015, 2016); **336510** (2015, 2016)		
	Metallurgy	Mischmetal used as an additive to steel and iron, as well as other metallurgical applications, especially magnesium alloys (*565*)	**331110** (2015, 2016); **336999** (2015, 2016); **339999** (2015, 2016)		
	Pigments	Neodymium pigment to produce blue to purple color	**325130** (2015, 2016)		
	Polishing	Minor quantities used in cerium-oxide-based polishing powders	**334220** (2015, 2016); **339115** (2015, 2016); **334413** (2015, 2016)		
	Other	Minor quantities used in fiber optic manufacturing	**334511** (2015, 2016)		
Nickel mine	Smelting and refining	Primary feed into base metal smelters and refineries	**311** (2007); **31141** (2008-2011); **311410** (2012-2016)	Single use category	Not applicable
Nickel plant	Cast iron		**331511** (2007, 2012-2016); **33151** (2008-2011)	Demand fraction are based on U.S. nickel consumption by application as reported by the references	(*389–394*, *590–592*)
	Chemicals and chemical uses		**324110** (2007-2016); **325188** (2007-2011); **325180** (2012-2016);		
	Electric, magnet, and expansion alloys		**332999** (2007, 2012-2016); **33299** (2008-2011)		
	Electroplating		**332813** (2007, 2012-2016); **33281** (2008-2011)		
	Nickel-copper alloys		**331423** (2007); **33142** (2008-2011); **331420** (2012-2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Other nickel alloys		**331491** (2007, 2012-2016); **33149** (2008-2011); **331522** (2007); **331523** (2012-2016); **331528** (2007); **331529** (2012-2016); **33152** (2008-2011); **332112** (2007, 2012-2016);		
	Steels (mainly stainless steels)		**331111** (2007); **33111** (2008-2011); **331110** (2012-2016); **331210** (2007-2016); **331512** (2007, 2012-2016); **331513** (2007, 2012-2016); **33151** (2008-2011); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011); **332111** (2007, 2012-2016); **332114** (2007, 2012-2016); **33211** (2008-2011); **332214** (2007); **332215** (2012); **33221** (2008-2011, 2013-2016); **332912** (2007, 2012-2016); **332919** (2007, 2012-2016); **33291** (2008-2011); **332999** (2007, 2012-2016); **33299** (2008-2011)		
	Superalloys		**331492** (2007, 2012-2016); **33149** (2008-2011); **332117** (2007-2016); **333611** (2007-2016); **336412** (2007-2016)		
	Other (mainly batteries)		**335911** (2007-2016); **332812** (2007, 2012-2016); **33281** (2008-2011)		
Niobium	Steels, alloys, and superalloys	Additive to steels, superalloys, and other alloys	**331111** (2007); **331112** (2007); **33111** (2008-2011); **331110** (2012-2016); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011)	All niobium is reported as being used in this application	(*395–400*)
Palladium	Automotive	Catalysts in catalytic converters used to treat vehicle exhaust emissions,	**336399** (2007-2011);	Demand fractions	(*407*)

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		particularly hydrocarbon control in gasoline engines	**336390** (2012-2016)	based on reported fabrication demand for the United States as reported by the reference	
	Chemical	Process catalysts mainly used in the manufacture of hydrogen peroxide, acetaldehyde (Wacker-Hoechst process), purified terephthalic acid (PTA), vinyl acetate monomer (VAM); catchment gauzes to recover Pt and Rh in nitric acid production; as well as fine and specialty chemicals such as vitamins, antibiotics, anti-inflammatory drugs, and dyes.	**325188** (2007-2011); **325180** (2012-2016) **325199** (2007, 2012-2016); **32519** (2008-2011); **325311** (2007-2016); **325412** (2007-2016); **325132** (2007); **32513** (2008-2011); **325130** (2012-2016)		
	Dental & medical	Fabrication metal and alloying agent in dental restorations, such as crowns and bridges	**339114** (2007-2016); **339116** (2007-2016)		
	Electrical & electronics	Conductive paste in multilayer ceramic capacitors (MLCC), now mainly for military and medical applications; conductive tracks in hybrid integrated circuits; and plating of electronic components including lead-frames and connectors	**334414** (2007-2011); **334416** (2012-2016); **334413** (2007-2016); **334412** (2007-2016); **334417** (2007-2016); **334418** (2007-2016); **334419** (2007-2016); **334519** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011)		
	Jewelry	Fabrication metal for palladium jewelry and whiting agent in white gold alloys	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
	Petroleum	Hydrocracking catalysts	**324110** (2007-2016)		
	Other	Catalyst for non-road engine emissions control	**333618** (2007-2016)		
Phosphate	Fertilizer	Wet-process phosphoric acid and superphosphoric acid for fertilizer application	**325311** (2007-2016); **325312** (2007-2016); **325314** (2007-2016)	U.S. demand fractions are assumed to be 95% fertilizer and 10% for use in other applications are noted by the references	(*117–123*)
	Other	Various uses including animal feed supplements, sanitation and surface-active agent manufacturing, and other chemical uses	**311111** (2007-2016); **311119** (2007-2016); **325188** (2007-2011); **325180** (2012-2016); **325611** (2007, 2012-2016); **325612** (2007, 2012-2016); **325613** (2007, 2012-2016); **32561** (2008-2011)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
Platinum	Automotive	Catalysts in catalytic converters used to reduce vehicle exhaust emissions, especially for diesel engines, as well as platinum-tipped electrode for automotive spark plugs and coating for oxygen sensors	**336399** (2007-2011); **336390** (2012-2016); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016)	Demand fractions based on reported fabrication demand for the United States as reported by the reference	(*407*)
	Chemical	Catalysts in the production of specialty silicones; para-xylene; nitric acid and hydrocyanic acid, as well as a variety of bulk and specialty chemicals.	**325212** (2007-2016); **325110** (2007-2016); **325311** (2007-2016); **325199** (2007, 2012-2016); **32519** (2008-2011); **325188** (2007-2011); **325180** (2012-2016)		
	Dental & medical	Alloying agent in dental alloys; biomedical devices including pacemakers, defibrillator; catheters and stents; anticancer drugs (e.g., cisplatin and carboplatin)	**339114** (2007-2016); **339116** (2007-2016); **334510** (2007-2016); **339112** (2007-2016); **339113** (2007-2016); **325412** (2007-2016)		
	Electrical & electronics	Alloy coating for computer hard disk drives; used in varistors, bond wires, capacitors, and contact materials such as switches and relays, electroplated parts such as on printed circuit boards, and electrode coating in fuel cells; as well as thermocouples for process control mainly used in the glass, semiconductors, and steel industries	**334112** (2007-2016); **334412** (2007-2016); **334413** (2007-2016); **334414** (2007-2011); **334416** (2012-2016); **334417** (2007-2016); **334418** (2007-2016); **334419** (2007-2016); **334519** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011); **334513** (2007-2016)		
	Glass	Fabrication metal for glass manufacturing equipment used in the manufacture of technical, optical, fiberglass, and specialty glass including glass for liquid crystal displays (LCDs)	**333298** (2007); **33329N** (2008-2011); **333249** (2012-2016)		
	Jewelry	Fabrication metal and alloying agent in jewelry and decorative applications	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
	Petroleum	Catalysts used in petroleum refinery processes including reforming (i.e., Pt-Re, Pt-Ir, Pt-Sn) and isomerization	**324110** (2007-2016)		
	Other	Turbine blade casting and coating. Other uses such as catalysts for industrial pollution control, coatings for corrosion resistance, and alloys for magnets are assumed to be relatively minor.	**333611** (2007-2016); **336412** (2007-2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
Potash	Fertilizer	Fertilizers (potassium chloride, potassium sulfate, and potassium magnesium sulfate) used in agriculture (*415*)	**325311** (2007-2016); **325312** (2007-2016); **325314** (2007-2016)	U.S. demand fractions are assumed to be 85% fertilizer and 15% for use in other applications are noted by the references	(*117–123*)
	Other	Various chemical and industrial applications including animal feed supplements, secondary aluminum refining, oil-well drilling mud, soap manufacturing, steel heat-treating, pharmaceuticals, catalysts for synthetic rubber manufacturing, beer brewing, and fire extinguishers, to name a few (*415*)	**311111** (2007-2016); **311119** (2007-2016); **312120** (2007-2016); **325188** (2007-2011); **325180** (2012-2016); **325212** (2007-2016); **325412** (2007-2016) **325611** (2007, 2012-2016); **32561** (2008-2011) **325998** (2007, 2012-2016); **32599** (2008-2011); **331314** (2007-2016); **332811** (2007, 2012-2016); **33281** (2008-2011); **339999** (2007-2016)		
Praseodymium	Batteries	Additive to nickel-metal-hydride (NiMH) battery alloys, which are used to power portable electronics, hybrid electric vehicles, and power tools, among others	**335911** (2015, 2016);	See section on rare earth demand and net imports in this document for details	(*565*)
	Ceramics	Additive to cubic zirconia for jewelry	**339910** (2015, 2016)		
	Magnets	Used somewhat interchangeably with neodymium in neodymium-iron-boron permanent magnets used in various automotive applications (including drivetrain in electric and hybrid electric vehicles, electric power steering, etc.), consumer electronics (e.g., hard disk drives), off-shore wind turbines, air-conditioners, and many other uses	**335312** (2015, 2016); **334112** (2015, 2016); **333611** (2015, 2016); **336330** (2015, 2016); **334210** (2015, 2016); **336350** (2015, 2016); **333415** (2015, 2016); **336991** (2015, 2016); **333249** (2015, 2016); **334510** (2015, 2016); **333912** (2015, 2016); **333993** (2015, 2016); **335314** (2015, 2016); **33522** (2015, 2016); **336510** (2015, 2016)		
	Metallurgy	Mischmetal used as an additive to steel and iron, as well as other metallurgical applications, especially magnesium alloys (*565*)	**331110** (2015, 2016); **336999** (2015, 2016); **339999** (2015, 2016)		
	Pigments	Praseodymium pigment for ceramic tiles	**325130** (2015, 2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Polishing	Minor quantities used in cerium-oxide-based polishing powders	**334220** (2015, 2016); **339115** (2015, 2016); **334413** (2015, 2016)		
	Other	Minor quantities used in fiber optic manufacturing	**335921** (2015, 2016)		
Rhenium	High-temperature turbine engine components	Additive to single crystal superalloy used in high-temperature turbine engine components	**331492** (2007, 2012-2016); **33149** (2008-2011); **333611** (2007-2016); **336412** (2007-2016)	Demand fractions are based on estimated consumption of rhenium by application	(*117–123*, *198–200*)
	Catalyst	Bimetallic platinum-rhenium catalyst used in petroleum reforming	**324110** (2007-2016)		
	Other	Mainly other rhenium alloys (e.g., tungsten-rhenium) used in a variety of applications	**331491** (2007, 2012-2016); **33149** (2008-2011)		
Rhodium	Automotive	Catalysts in catalytic converters used to reduce vehicle NO_x emissions	**336399** (2007-2011); **336390** (2012-2016)	Demand fractions are based on reported fabrication demand for the United States by the reference	(*407*)
	Chemical	Process catalysts mainly used in the production of acetic acid (Monsanto process, carbonylation), n-aldehydes (oxo synthesis, hydroformylation), and acetic anhydride (Hoechst/Halcon process), as well as in hydrogenation (Wilkinson's catalyst); and the production of nitric acid and hydrogen cyanide	**325199** (2007, 2012-2016); **32519** (2008-2011); **325311** (2007-2016)		
	Electrical & electronics	Alloying agent in industrial thermocouples; electrical contacts including sliding contacts such as in electric motors, switches and relays such as in process automation, and reed contacts such as in automotive electronics	**334513** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011)		
	Glass	Alloying agent with platinum for fabricated parts used in glass manufacturing equipment, especially technical and specialty glass	**333298** (2007); **33329N** (2008-2011); **333249** (2012-2016)		
	Other	Electroplated parts mainly for decorative purposes, especially jewelry	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
Ruthenium	Chemical	Process catalysts used in the synthesis of ammonia (KBR Advanced Ammonia Process); synthesis of acetic acid (Cativa® process), synthesis of hydrocarbons (Fisher-Tropsch process), synthesis of caprolactam and adipic acid as a feedstock for nylon 6 and nylon 66 (predominantly in China, thus excluded here), hydrogenation, oxidation, and hydrogenolysis reactions.	**325311** (2007-2016); **325199** (2007, 2012-2016); **32519** (2008-2011)	Demand fractions are based on global data due to lack of data for the United States	(*580–582*)
	Electrical & electronics	Resistive component of thick-film pastes used in hybrid integrated circuits and chip resistors, electrode coating in fuel cell stacks; sputtering targets for coating of hard disk drives. Other uses, such as ruthenium used in imageable thick-film paste for plasma display panels, are assumed to be relatively minor especially since the early 2010s.	**334413** (2007-2016); **334112** (2007-2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Electrochemical	Coating for dimensionally stable anodes used in the diaphragm and membrane technology of the chlor-alkali industry (chlorine and sodium hydroxide manufacture) and sodium chlorate production.	**325181** (2007-2011); **325180** (2012-2016)		
	Other	Alloying agent in platinum jewelry; alloying agent in dentistry; alloying agent that provides corrosion-resistance for titanium piping for offshore oil and geothermal production. Other applications such as ruthenium's use in specialty alloys for aerospace and machining applications and corrosion-resistance for shipping vessels and underwater structures are assumed to be relatively minor.	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016); **339114** (2007-2015); **339116** (2007-2016); **331491** (2007, 2012-2106); **33149** (2008-2011)		
Samarium	Magnets	Samarium cobalt (SmCo) permanent magnets used in servo-motors, medical devices, consumer electronics, and other uses	**335312** (2015, 2016); **334510** (2015, 2016); **334111** (2015, 2016); **334511** (2015, 2016); **339999** (2015, 2016)	See section on rare earth demand and net imports in this document for details	(*565*)
Selenium	Agriculture and biological	Additive to fertilizer, soils, and animal feed as a micronutrient, dietary supplement, and as a fungicide to control dandruff and dermatitis (*593*)	**311119** (2007-2016); **325311** (2007-2016); **325312** (2007-2016); **325314** (2007-2016); **325411** (2007-2016); **325412** (2007-2016);	Demand fractions are based on global estimates by the reference (for all years) with the exception of electrolytic manganese, which is assumed to not be an application in the United States. Fractions are thus renormalized without this application category	(*593*)
	Electrical	Photoreceptors in photocopiers and laser printers, infrared detectors, solar photovoltaics (copper-indium-gallium-diselenide), rectifiers, x-ray receptors (*593*)	**333315** (2007-2011); **333316** (2012-2016); **334119** (2007-2009); **33341** (2010, 2011); **334118** (2012-2016); **334413** (2007-2016); **334517** (2007-2016)		
	Glass	Decolorizing container and other silica glass, provides red color art glass, and reduces solar heat for architectural glass (*593*)	**327211** (2007-2016); **327212** (2007-2016); **327213** (2007-2016); **327215** (2007-2016)		
	Metallurgy	Microalloying additive to improve machinability of stainless steel, carbon steel, and copper (*594*)	**331** (2007); **33111** (2008-2011); **331110** (2012-2016); **33142** (2008-2011); **331410** (2012-2016) **33142** (2008-2011); **331420** (2012-2016);		
	Pigments	Cadmium sulfoselenide pigments in plastics, ceramics, glazes and paints (*593*)	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016)		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
	Other	Catalysts for selective oxidation, plating solutions, steel bluing, and blasting caps (*593*)	**325188** (2007-2011); **325180** (2012-2016); **325920** (2007-2016); **325612** (2007, 2012-2016); **32561** (2008-2011); 332813 (2007, 2012-2016); 33281 (2008-2011)		
Silver	Brazing alloys and solder	Silver-containing brazes and solders to produce electrically conductive and corrosion-resistant joints used in a variety of applications ranging from air-conditioners and refrigerators to automobiles and aircraft (*595*)	**325998** (2007, 2012-2016); **32599** (2008-2011)	Demand fractions are based on U.S. consumption of silver (including scrap) by end-use as reported by the references. For years 2007-2011, solar photovoltaics are included in the "other" category	(*447–449*)
	Catalysts	Catalysts mainly for use in ethylene oxide production	**325199** (2007, 2012-2016); **32519** (2008-2011)		
	Electrical and electronics	Virtually all electronic devices utilize silver for its superior electrical conductivity. This category also includes silver used in batteries.	**334** (2007-2016); **335** (2007-2016); **336321** (2007); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016)		
	Jewelry, silverware, coins and medals	Various jewelry, silverware, coins, and medals	**339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33911** (2008-2011); **339910** (2012-2016)		
	Photography	Photographic film and paper	**325992** (2007, 2012-2016); **32599** (2008-2011)		
	Solar Photovoltaic	Conductive paste for silicon solar photovoltaics	**334413** (2007-2016)		
	Other	Various uses including antimicrobial bandages, dental amalgam, pharmaceuticals, high-performance spark plugs, water treatment, to name a few	**339113** (2007-2016); **339114** (2007-2016); **339116** (2007-2016); **325412** (2007-2016); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016); **325612** (2007, 2012-2016); **32561** (2008-2011); **332813** (2007, 2012-2016); **33281** (2008-2011); **325188** (2007-2011); **325180** (2012-2016); **332999** (2007, 2012-2016); **33299** (2008-2011); **331491** (2007, 2012-2016); **33149** (2008-2011);		
Strontium	Drilling fluids	Celestite as an additive in drilling muds, which is an alternative to barite	**325998** (2007, 2012-2016);	Demand fractions	(*451*)

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		(*451*)	**32599** (2008-2011)	are based on information provided in the reference and further discussion with the authors of the reference	
	Electrolytic production of zinc	Strontium carbonate added to reduce the "lead content of the electrolyte and of the zinc deposited on the cathode" (*451*)	**331** (2007); **33141** (2008-2011); **331410** (2012-2016)		
	Ferrite ceramic magnets	Ferrite ceramic magnets used in small direct current motors for automobiles windshield wipers, loudspeakers, and other electronic equipment (*451*)	**327112** (2007, 2008, 2010, 2011) **32711** (2009); **326110** (2012-2016); **334310** (2007-2016); **336322** (2007) **33632** (2008-2011); **336320** (2012-2016)		
	Master alloys	Strontium metal added to aluminum alloys, to improve strength and ductility, for use in the automotive applications (*451*)	**331314** (2007-2016); **331319** (2007); **33131** (2008-2011); **331318** (2012-2016); **332510** (2007-2016); **333924** (2007, 2012-2016); **33392** (2011-2015); **336211** (2007-2016)		
	Pigments and fillers	Strontium used in pigments, paints, and phosphors (*451*)	**325510** (2007-2016); **334290** (2007-2016); **339950** (2007-2016); **325131** (2007, 2012-2016); **32513** (2008-2011); **335110** (2007-2016)		
	Pyrotechnics and signals	Strontium nitrate used in flares, fireworks, and traces in ammunition (*451*)	**325998** (2007, 2012-2016); **32599** (2008-2011)		
	Other	Various uses including medical applications (e.g., strontium-89 for treatment of bone cancer), toothpastes, frits in ceramic glazes, glass modified to improve optical properties, fiberglass, laboratory and pharmaceutical glass, substrate in semiconductors, wireless devices and memory chips, and analytical chemistry laboratory use (*451*)	**325412** (2007-2016); **325611** (2007, 2012-2016); **32561** (2008-2011); **327122** (2007-2011); **327120** (2012-2016) **327215** (2007-2016); **327212** (2007-2016); **334413** (2007-2016); **333314** (2007-2016); **334419** (2007-2016); **334516** (2007-2016)		
Tantalum	Alloy additive	Additive to certain nickel- and cobalt-based superalloys mainly use in aircraft engine and land-based gas turbines	**331492** (2007, 2012-2016); **33149** (2008-2011); **332117** (2007-2016); **333611** (2007-2016); **336412** (2007-2016)	Demand fractions are based on global consumption of tantalum by application as reported by the references. Data	(*596*, *597*)
	Capacitors	Capacitor-grade tantalum powder and tantalum wire for electronic capacitors used in consumer electronics (e.g., cellular phones, computers,	**333315** (2007-2011); **333316** (2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		cameras, televisions), medical devices (e.g., pacemakers and hearing aids), automotive electronics (e.g., airbag activation, engine management modules, etc.), and other electronic equipment (cellular phone base stations, power rectifiers, etc.) (*11*)	**334111** (2007, 2012-2016); **334112** (2007, 2012-2016); **344113** (2007); **334118** (2012-2016); **334119** (2007); **333411** (2008-2011); **334210** (2007, 2009-2016); **334220** (2007, 2009-2016); **334290** (2007, 2009-2016); **3342** (2008); **334310** (2007-2016); **334416** (2007-2016); **334510** (2007-2016); **334511** (2007-2016); **334512** (2007-2016); **334513** (2007-2016); **334514** (2007-2016); **334515** (2007-2016); **334516** (2007-2016); **334517** (2007-2016); **334519** (2007-2016); **336322** (2007); **33632** (2008-2011); **336320** (2012-2016)	specific for the United States for the years of analysis are not available.	
	Cemented carbides	Cemented carbides used in cutting and drilling tools used by the mining, construction, automotive, and aerospace sectors	**333131** (2007, 2012-2016); **333132** (2007, 2012-2016); **33313** (2008-2011); **333511** (2007-2016); **333514** (2007-2016); **333515** (2007-2016); **332213** (2007); **33221** (2008-2011); **332216** (2012-216)		
	Chemicals	Various chemicals including tantalum oxide used in optical lenses and lithium tantalate for surface acoustic wave (SAW) filters (*11*)	**333314** (2007-2016); **334419** (2007-2016); **325188** (2007-2011); **325180** (2012-2016)		
	Mill products	Chemical processing equipment (e.g., heat exchangers, valves, process vessels, cladding, etc.), medical applications (e.g., prosthetics, sutures, stents, etc.), and nuclear waste containers (*11*)	**332410** (2007-2016); **332420** (2007-2016); **332313** (2007, 2012-2016); **33231** (2008-2011); **332911** (2007, 2012-2016); **33291** (2008-2011); **333298** (2007); **33329** (2008-2011); **333249** (2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			339113 (2007-2016)		
	Sputtering targets	Sputtering targets used in semiconductors, magnetic storage media, and flat panel displays (*11*)	**334413** (2007-2016); **334613** (2007, 2012); **33461** (2008-2011, 2013-2016); **334419** (2007-2016)		
Tellurium	Electronics	High purity tellurium in cadmium-telluride thin-film photovoltaic cells; bismuth telluride and antimony telluride in thermoelectric devices (Pelteir effect) used as coolers; and infra-red detectors (*594*)	**334413** (2010-2016); **334419** (2010-2016); **334511** (2010-2016)	Demand fractions are based on a global estimate provided in the reference. This estimate is used for all years of the analysis due to lack of better data.	(*117*)
	Metallurgy	Additive to various alloys to improve fatigue strength (lead alloys), improve machinability (copper alloys), machining characteristics (steel alloys), and as a carbide content stabilizer and to improve chill response (certain cast irons) (*594*)	**33111** (2010, 2011); **331110** (2012-2016); **33149** (2010,2011) **331491** (2012-2016); **331492** (2012-2016); **33151** (2010, 2011); **331511** (2012-2016);		
	Rubber	Vulcanizing agent and accelerator for rubber production and catalyst for synthetic fiber production (*117*)	**325212** (2010-2016); **325188** (2010, 2011); **325180** (2012-2016); **32522** (2010, 2011); **325220** (2012-2016)		
	Other	Various uses including pigments for glass and ceramics (*117*)	**32513** (2010, 2011); **325130** (2012-2016)		
Tin mine	Primary tin smelter production	The has not been any primary tin smelting in the United States since 1989	**Not applicable**	Not applicable	Not applicable

Commodity	**Application category**	**Application description**	**Associated NAICS codes** (applicable years)	**U.S. demand fraction**	
				Notes	References
Tin smelter	Alloys	Various tin alloys, including copper-based alloys (e.g., bronze) used in plumbing and heating applications, machinery and engine bearings, fittings, castings, and stampings; tin-plated copper wire, high-impact alloys for aircraft landing gear; additive to cast iron for engine blocks, etc. (*598*)	**325910** (2007-2016); **331421** (2007); **331422** (2007); **331423** (2007); **33142** (2008-2011); **331420** (2012-2016); **331491** (2007, 2012-2016); **33149** (2008-2011); **331511** (2007-2016); **331522** (2007); **331523** (2012-2016); **331525** (2007); **331528** (2007); **331529** (2012-2016); **33152** (2008-2011); **332911** (2007, 2012-2016); **332912** (2007, 2012-2016); **332913** (2007, 2012-2016); **332919** (2007, 2012-2016); **33291** (2008-2011); **332999** (2007, 2012-2016); **33299** (2008-2011); **336312** (2007); **33631** (2008-2011); **336310** (2012-2016); **336413** (2007-2016)	Demand fractions are based U.S. consumption of tin by finished product form as reported by the references. Note that some data are withheld by the references to avoid disclosing priority company data but are used in this analysis.	(*462–467*, *599–601*)
	Chemicals	Tin-based chemicals used in the production and curing of polyvinyl chloride, polyurethane, biocides (for anti-fouling paint; e.g., tributyltin), perfume and soap stabilizer, toothpaste additive, and catalysts (*598*)	**325211** (2007-2016); **325188** (2007-2011); **325180** (2012-2016) **325199** (2007, 2012-2016); **32519** (2008-2011); **325611** (2007, 2012-2016); **32561** (2008-2011); **325620** (2007-2016)		
	Tinplate	Tinplate mainly used for cans and containers	**332431** (2007, 2012-2016); **332439** (2007, 2012-2016); **33243** (2008-2011)		
	Solders	Tin solder mainly used in electronic devices for making connections on circuit boards. Tin solder is also used in automotive applications (e.g., radiators, air conditioners, and automotive electronic components) (*598*)	**325998** (2007, 2012-2016); **32599** (2008-2011); **334417** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011); **336391** (2007-2011); **336399** (2007-2011); **336390** (2012-2016); **336322** (2007);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			33632 (2008-2011); **336320** (2012-2016)		
	Other	Various uses including float glass industry (Pilkington process), tin tetrachloride to improve abrasive resistance to glass bottles, jewelry, lead-acid batteries, dental amalgam, ammunition, etc. (*598*)	**327211** (2007-2016); **327213** (2007-2016); **335911** (2007-2016); **332992** (2007-2016); **339114** (2007-2016); **339116** (2007-2016); **339911** (2007); **339912** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
Titanium metal	Aerospace	Titanium metal and alloys used for its strength-to-weight ratio and corrosion resistance in variety of aerospace applications (e.g., airframes, aircraft engines, satellites, helicopters, missiles, etc.)	**336411** (2007, 2012); **336412** (2007, 2012); **336413** (2007, 2012); **336414** (2007, 2012); **336415** (2007, 2012); **336419** (2007, 2012); **33641** (2008-2011, 2013-2016)	Demand fractions are based on estimated consumption of titanium metal by application in the United States as reported by the references	(*118–123*, *198–200*, *573*)
	Other	Other titanium metal applications include armor, automotive exhaust systems, chemical processing (e.g., chlor-alkali), food processing equipment, heat transfer equipment, oil and gas industry (mainly offshore), pulp and paper industry, marine hardware, medical implants and dental alloys, nuclear fuel and waste containers, power generation, sporting goods, and other miscellaneous uses (*117*, *469*)	**325181** (2007-2011); **325180** (2012-2016); **332410** (2007-2016); **332420** (2007-2016); **333132** (2007, 2012-2016); **33313** (2008-2011); **333611** (2007-2016); **333291** (2007); **333294** (2007); **33329** (2008-2011); **333241** (2012-2016); **333243** (2012-2016); **336312** (2007); **33631** (2008-2011); **336310** (2012-2016); **336992** (2007-2016); **339920** (2007-2016); **339112** (2007-2016); **339113** (2007-2016); **339114** (2007-2016); **339116** (2007-2016)		
Titanium mineral concentrate	Pigments for paint, varnish, and lacquer		**325131** (2007); **32513** (2008-2011); **325130** (2012-2016);	Demand fractions are based on U.S. consumption of	(*468–473*, *602–604*)

Commodity	**Application category**	**Application description**	**Associated NAICS codes** (applicable years)	**U.S. demand fraction**	
				Notes	References
			325510 (2007-2016); **332812** (2007, 2012-2016); **33281** (2008-2011); **339942** (2007); **33994** (2008-2011); **339940** (2012-2016);	titanium concentrate for pigments and miscellaneous uses and then by the distribution of titanium pigment shipments by industry	
	Pigments for paper		**322121** (2007, 2012-2016); **32212** (2008-2011); **322130** (2007-2016)		
	Pigments for plastic and rubber		**325211** (2007-2016); **325212** (2007-2016)		
	Pigments for other uses (e.g., agricultural, building materials, catalysts, ceramics, coated fabrics and textiles, floor coverings, food, and printing ink)		**311340** (2007-2016); **313320** (2007-2016); **325188** (2007-2011); **325180** (2012-2016); **325910** (2007-2016); **327111** (2007-2011); **327110** (2012-2016); **327122** (2007-2011); **327120** (2012-2016)		
	Other uses including welding-rod coatings and fluxes, carbides, chemicals, glass fiber, and titanium metal and alloys		**331** (2007); **33141** (2008-2011); **331410** (2012-2016); **33149** (2008-2011); **331491** (2012-2016); **325998** (2007, 2012-2016); **32599** (2008-2011); **333992** (2007, 2012-2016); **33399** (2008-2011); **332111** (2007, 2012-2016); **332112** (2007, 2012-2016); **33211** (2008-2011)		
Tungsten	Cemented carbides	Cemented carbides used in cutting and drilling tools used by the mining, construction, automotive, and aerospace sectors	**333131** (2007, 2012-2016); **333132** (2007, 2012-2016); **33313** (2008-2011); **333511** (2007-2016); **333514** (2007-2016); **333515** (2007-2016); **332213** (2007); **33221** (2008-2011); **332216** (2012-216)	Demand fractions are based on tungsten consumptions by first-use as reported by the references. Data for years 20	(*480*)
	Steel and alloys	Tungsten used in various steels (mainly tool steels), as well as nickel-based superalloys and other alloys	**331111** (2007); **331112** (2007); **33111** (2008-2011); **331110** (2012-2016);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			331491 (2007, 2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011)		
	Mill products	Tungsten mill products produced via powder metallurgy for use mainly in lamps (e.g., incandescent lamps) and various other applications including electrical and electronic applications (mainly as electrical contacts) (*480*)	**335110** (2007-2016); **335931** (2007, 2012-2016); **33593** (2008-2011)		
	Chemical and other	Tungsten used as catalysts, dyes and pigments, tungsten hexafluoride gas in the production of semiconductor circuits and circuit boards, and various other uses	**325188** (2007-2011); **325180** (2012-2016); **325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **334413** (2007-2016);		
Vanadium	Aluminum alloys	Vanadium-aluminum master alloys used to provide titanium-alloys the required strength for use in the aerospace industry	**331312** (2007-2011); **331313** (2012-2016); **331314** (2007-2016)	Demand fractions are based on reported demand for the United States by the reference. Note that some data are withheld by the references to avoid disclosing priority company data but are used in this analysis. Also note that reported consumption is notably less than apparent consumption	(*482–487*, *541*, *605*, *606*)
	Cast iron	Addition of vanadium to cast iron to improve its wear resistance and mechanical properties	**331511** (2007, 2012-2016); **33151** (2008-2011)		
	Steel alloys	Alloying agent in various steels to provide additional strength, toughness, malleability and weldability. These steels are used in numerous applications including but not limited to line pipes, structural applications (e.g., high-rise buildings), transportation applications (e.g., automobiles, aerospace, and rail), machinery and equipment, containers, to name a few.	**331112** (2007); **33111** (2008-2011); **331110** (2012-2016); **331210** (2007-2016); **331221** (2007, 2012-2016); **33122** (2008-2011)		
	Other alloys	Other vanadium alloys including magnetic alloys, welding alloys, and superalloys. Vanadium-bearing superalloys (e.g., IN-100, H53, C-276) are used in a number of applications including aerospace engines and marine gas turbine engines (*488*)	**331491** (2007, 2012-2016); **331492** (2007, 2012-2016); **33149** (2008-2011)		
	Other	Other applications include catalysts (for the production of various chemicals including maleic anhydride, phthalic anhydride, synthetic rubber, and sulfuric acid, as well as the scrubbing of fluid catalytic cracking flue gases), dyes and pigments, medicines and pharmaceuticals, and other chemical applications (*488*)	**324110** (2007-2011); **325188** (2007-2011); **325180** (2012-2016); **325192** (2007); **32519** (2008-2011); **325194** (2012-2016); **325211** (2007-2016); **325212** (2007-2016); **325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **325411** (2007-2016); **325412** (2007-2016);		
Yttrium	Advanced ceramics	Additive to zirconia crystal to form yttria-stabilized zirconia, as well as an additive silicon aluminum oxynitrides, silicon nitride, and aluminum	**327910** (2007-2016); **327123** (2007-2011);	See section on rare earth demand and	(*565*)

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
		nitride, which are used in various applications including structural ceramics, ceramic cutting tools, fiber optic connectors, oxygen sensors, thermal barrier coating for aircraft and power generation turbines, bio-ceramics, and solid oxide fuel cells (*565*)	**327120** (2012-2016); **336412** (2007-2016); **333611** (2007-2016); **333618** (2007-2016); **335921** (2007, 2012-2016); **33592** (2008-2011); **333515** (2007-2016); **334519** (2007-2016); **327113** (2007-2011); **327110** (2012-2016); **339113** (2007-2016); **334413** (2007-2016)	net imports in this document for details	
	Glass	Dopant in glass for specialty applications (*565*)	**335921** (2007, 2012-2016); **33592** (2008-2011)		
	Phosphors and pigments	Yttrium-hosted phosphors for lighting (fluorescent and light-emitting diode lamps), displays (cathode ray tubes, plasma display panels, and field-emission display), x-rays, and other phosphors; as well as small amounts for color-staining pigments (*565*)	**325131** (2007); **32513** (2008-2011); **325130** (2012-2016); **335110** (2007-2016); **334220** (2007-2016); **334111** (2007-2009, 2012-2016); **334119** (2007-2009); **33411** (2010, 2011); **334118** (2012-2016); **334210** (2007, 2009-2016); **3342** (2008); **336321** (2007); **3362** (2008-2011); **336320** (2012-2016); **334517** (2007-2016)		
	Other	Solid state laser crystals including neodymium-doped yttrium-aluminum-garnet (YAG) crystal. Yttrium is also used in magnesium alloys, but demand data are not available. (*565*)	**334511** (2007-2016)		
Zinc mine	Zinc smelting	Smelting of zinc concentrates	**331** (2007); **33141** (2008-2011); **331410** (2012-2016)	In this analysis it is assumed that all zinc concentrates are provided to primary smelters	Not applicable
Zinc smelter	Galvanizing	Galvanizing of steel (either directly by steel mills or steel fabricators) for protection from corrosion. Galvanized steel is used extensively in the automotive and construction industries. (*489*, *607*)	**331111** (2007); **33111** (2008-2011); **331110** (20012-2016); **331112** (2007); **331210** (2007-2016); **331221** (2007, 2012-2016); **331222** (2007, 2012-2016); **33122** (2008-2011);	Demand fractions are estimated based on the remainder of apparent consumption after subtracting the quantities for the other applications	Not applicable

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			332812 (2007, 2012-2016); **33281** (2008-2011)	noted below	
	Zinc-base alloys	Zinc-base alloys mainly used in die-cast parts for various applications including automotive parts, as well as hardware, home appliances, medical instruments, office equipment, power tools. (*489*)	**331491** (2007, 2012-2016); **331522** (2007); **33152** (2008-2011); **331523** (2012-2016); **332510** (2007-2016)	Demand fractions estimated are based on net imports of casting grade zinc relative to apparent consumption after adjustments for net import reliance	(*75*)
	Brass and bronze	Brasses and bronzes that are fabricated into wires, rods, bars, and tubes for various applications. (*607*)	**331421** (2007); **331422** (2007); **33142** (2008-2011); **331420** (2012-2016)	Demand fractions are based on reported consumption of zinc by copper industry	(*568*)
	Other	Other applications include various zinc chemicals, zinc semi-manufactures, and miscellaneous uses. Zinc chemicals include zinc oxides, zinc carbonate, zinc sulfate, zinc sulfide, zinc chloride, zinc borate, zinc selenite, and nanoform zinc compounds. These zinc compounds are used in agriculture and animal husbandry, food and pharmaceutical industries, plastics, paper, and textile industries, ceramics and glass industries, electronics industry (varistors), rubber vulcanization for tires, and in pigments. Zinc semi-manufacturers are fabricated zinc products mainly as rolled zinc, which is used in architectural applications and coinage, as well as wire and rod used in galvanic anode in zinc batteries (*489*, *607*, *608*)	**325131** (2007); **325132** (2007); **32513** (2008-2011); **325130** (2012-2016); **325510** (2007-2016); **325181** (2007-2011); **325180** (2012-2016); **325412** (2007-2016); **325212** (2007-2016); **332999** (2007, 2012-2016) **33299N** (2008-2011); **335911** (2007-2016); **335912** (2007-2016); **331524** (2007, 2012-2016); **331529** (2012-2016)	Demand fractions are estimated based on net imports of zinc oxides, zinc sulfates, zinc sulfides, zinc chlorides, zinc yellow, zinc dusts, and zinc powders and flakes relative to apparent consumption after adjustments for net import reliance	(*75*)
Zirconium	Ceramics (traditional)	Zircon and zirconium silicates as opacifiers in traditional ceramics (i.e., whiteware for sanitaryware, tableware, electrical porcelain, enamel, etc.) and ceramic glazes (*609*)	**327111** (2007); **327112** (2007); **327113** (2007); **32711** (2008-2011); **327110** (2012-2016)	Demand fractions are based on estimates and forecasts for zircon consumption by category for North America as reported by the reference	(*609*)
	Chemicals	Zirconium chemicals and high-purity zirconia for pigments, paints, inks, metal coatings, antiperspirants, leather tanning, textiles, oil and gas industry, catalysts (as stabilizer in three-way automotive catalytic converters), and cubic zirconia for jewelry and decorative glass (*609*)	**313312** (2007); **31331** (2008-2011); **313310** (2012-2016); **316110** (2007-2016); **325181** (2007-2011); **325180** (2012-2016); **325131** (2007);		

Commodity	Application category	Application description	Associated NAICS codes (applicable years)	U.S. demand fraction	
				Notes	References
			32513 (2008-2011); **325130** (2012-2016); **325510** (2007-2016); **325910** (2007-2016); **325620** (2007-2016); **332812** (2007, 2012-2016); **33281** (2008-2011); **336399** (2007-2011); **336390** (2012-2016); **339911** (2007); **339913** (2007); **339914** (2007); **33991** (2008-2011); **339910** (2012-2016)		
	Foundry sands	Zircon foundry sands used in metal casting	**333511** (2007-2016); **331511** (2007, 2012-2016); **331512** (2007, 2012-2016); **331513** (2007, 2012-2016); **33151** (2008-2011); **331521** (2007); **331522** (2007); **331523** (2012-2016); **331524** (2007, 2012-2016); **331525** (2007); **331528** (2007); **331529** (2012-2016); **33152** (2008-2011)		
	Refractories	Zircon-based refractories used as linings for furnaces, kilns, incinerators, reactors and crucibles mainly in the production of iron and steel, cement, and glass (*609*)	**331111** (2007); **331112** (2007); **33111** (2008-2011); **331110** (2012-2016); **327125** (2007); **32712** (2008-2011); **327120** (2012-2016); **333298** (2007); **33329N** (2008-2011); **333249** (2012-2016)		
	Other	Variety of uses including abrasives, cathode ray tube (CRT) glass for televisions and computer monitors, other specialty glass, zirconium sponge and alloys in nuclear energy, industrial process plants, and photographic flash bulbs, and solid oxide fuel cells (*609*)	**327211** (2007-2016); **327212** (2007-2016); **327910** (2007-2016); **332410** (2007-2016); **334413** (2007-2016); **335110** (2007-2016);		

Rare earth elements

Rare earth oxide production estimation

The following method was utilized to estimate global rare earth oxide (REO) production by element for each producing country. Total REO production data were obtained from the U.S. Geological Survey's Minerals Yearbooks (*610–615*). Because Chinese production quantities reported in the U.S. Geological Survey's Minerals Yearbooks represent only official production quotas, the quantity of illegal production had to be incorporated. However, because it is believed that some of the legal production in China came from illegal production, summing both quantities would result in a certain amount of double-counting. Estimates for both legal and illegal production were thus obtained from Roskill (*566*), which accounted for these issues.

Because the distribution of individual rare earth elements varies considerably by location, it was necessary to disaggregate Chinese production by province. The quantities for China's legal production were disaggregated by province based on province-level export quotas (*565*, *616*, *617*). For illegal production, Roskill (*566*) provides estimates by region (Northern region: Inner Mongolia and Shandong provinces; Central region: Sichuan province; and Southern region: Yunnan, Guangxi, Guangdong, Jiangxi, and Fujian provinces). Illegal production estimates for Inner Mongolia and Shandong provinces in the Northern region were disaggregated among these two provinces based on their legal production quota (*565*, *616*, *617*). For the Southern region, Roskill notes that illegal production is predominately in the remote regions of western Yunnan and Guangxi provinces, although Guangdong, Jiangxi, and Fujian provinces also have significant illegal production (*566*). Due to lack of better information, the Southern region's estimated illegal production was thus allocated as follows: 33.3% Yunnan, 33.3% Guangxi, and the remaining 33.3% distributed proportionally among Guangdong, Jiangxi, and Fujian based on their legal production quotas.

The total REO production by country (and by province for China) were then allocated to individual rare earth element oxides using the distributions for each country noted in table S5 and for Chinese province noted in table S6.

For Malaysia, the proportion that was produced by monazite and xenotime were obtained from the British Geological Survey (*173*). For the Chinese province of Jiangxi, the average of the four distributions noted in table S5 is utilized in this analysis. No representative REO distribution was found for Yunnan province. The distribution for Xinfeng in Jiangxi province, which is noted as having a similar "rich europium and middle yttrium" distribution (*618*), was utilized instead.

Table S5. Rare earth oxide distribution (in percent of total) for various world regions.

REO	**Australia** Mt. Weld, Central Lanthanide Deposit (monazite)	**Brazil** Eastern coast (monazite)	**India** Manavalakurichi, Tamil Nadu (monazite)	**Malaysia** Perak (monazite)	**Malaysia** Perak (xenotime)	**Russia** Lovozero complex (loparite)	**Thailand** (monazite)[a]	**United States** Mountain Pass, California (bastnäsite)[b]	**Vietnam**
Y_2O_3	0.76	1.40	0.45	2	61	1.25	-	0.12	0.55
La_2O_3	23.88	24.00	22	23	1.24	25	22.4	34.0	33.7
CeO_2	47.55	47.00	46	46.2	3.13	50.5	45.5	48.8	48.7
Pr_6O_{11}	5.16	4.50	5.5	4.6	0.493	5	5.1	4.2	3.59
Nd_2O_3	18.13	18.50	20	19.7	1.59	15	17.6	11.7	11.3
Sm_2O_3	2.44	3.00	2.5	3.2	1.14	0.65	2.3	0.79	1.07
Eu_2O_3	0.53	0.1	0.015	0.1	0.12	0.09	--	0.13	0.24
Gd_2O_3	1.09	1.00	1.2	0.8	3.47	0.55	1.2	0.21	0.54
Tb_4O_7	0.09	0.1	0.06	--	0.906	--	--	*0.014*	0.06
Dy_2O_3	0.25	0.4	0.18	--	8.32	0.55	2.2	*0.027*	0.12
Ho_2O_3	0.03	trace	0.02	--	1.98	0.7	--	*0.004*	0.02
Er_2O_3	0.06	0.1	0.01	--	6.43	0.8	--	*0.003*	0.09
Tm_2O_3	0.01	trace	--	--	1.12	0.1	--	*0.001*	--
Yb_2O_3	0.03	0.02	--	--	6.77	0.2	--	*0.001*	0.02
Lu_2O_3	--	Not	--	--	0.988	0.15	--	*0.0001*	--
References	(*619*)	(*620*)	(*621*)	(*622*) cited in (*623*)	(*624*)	(*625*) cited in (*626*)	(*627*)	(*628*)	(*629*)

Table S6. Rare earth oxide distribution (in percent of total) for various regions in China.

				Southern China (ion-adsorption type) deposits							
REO	Bayan Obo, Inner Mongolia[c]	Mianning Sichuan	Weishan, Shandong	Longnan, Jiangxi[d]	Xunwu, Jiangxi	Xinfeng, Jiangxi	Shanghang, Fujian	Pingyuan, Guangdong[e]	Jianghua, Hunan	Dingnan, Jiangxi[f]	Guangxi
Y_2O_3	0.5	0.91	0.76	64.9	10.07	24.26	25.64	10.3	47.4	11.7	29
La_2O_3	23	31.49	35.46	2.18	38	27.56	27.32	27.2	16.03	16.8	24.07
CeO_2	50	47.69	47.76	<1.09	3.5	3.23	2.02	4.9	0.32	42.3	0.6
Pr_6O_{11}	6.2	4.11	3.95	1.08	7.41	5.62	5.78	7	4.4	3.7	5.56
Nd_2O_3	18.5	12.96	10.9	3.47	30.18	17.55	19.82	29.5	10.35	14.3	19.81
Sm_2O_3	0.8	1.47	0.79	2.34	5.32	4.54	4.19	5.4	2.43	2.9	4.38
Eu_2O_3	0.2	0.26	0.13	<0.37	0.51	0.93	0.87	0.58	0.1	0.5	0.72
Gd_2O_3	0.7	0.66	0.53	5.69	4.21	5.96	4.23	3.9	3.96	2.5	4.35
Tb_4O_7	0.1	0.08	0.14	1.13	0.46	0.68	0.74	0.7	0.97	0.4	0.62
Dy_2O_3	0.1	0.22		7.48	1.77	3.71	3.77	2.6	6.24	2.1	4.06
Ho_2O_3	--	0.04		1.6	0.27	0.74	0.42	0.52	1.2	0.4	0.77
Er_2O_3	--	0.06		4.26	0.88	2.48	2.32	0.91	3.52	1.1	2.59
Tm_2O_3	--	0.02		0.6	0.13	0.27	0.39	0.14	0.56	0.2	0.39
Yb_2O_3	--	0.05	0.03	3.34	0.62	1.13	1	0.71	2.38	1	2.66
Lu_2O_3	--			0.47	0.13	0.21	0.37	0.12	0.38	0.1	0.45
References	(*630*)	(*631*)								(*632*)	(*618*)

[a] Percentages are based on the averages of the ranges provided in the reference

[b] The percentages for the oxides of Tb, Dy, Ho, Er, Tm, Yb, and Lu are reported as totaling 0.05%. This sum is disaggregated in this analysis among the individual rare earth oxides based on information noted in (*624*).

[c] Percentages refer to rare earth ore concentrate

[d] The percentages for CeO_2 and Eu_2O_3, noted as <1.09 and <0.37, respectively, are assumed to equal 1.09 and 0.37, respectively, in the production allocation calculation.

[e] Although monazite and xenotime deposits exist in Guangdong province, this analysis assumes that all of Guangdong's production pertains to ion-adsorption deposits

[f] Percentages are approximated based on the average distribution of five samples in ion-adsorption ores (1130S3-7) noted in the reference. Percentages have been converted from rare-earth element content to their oxide equivalent for consistency of display.

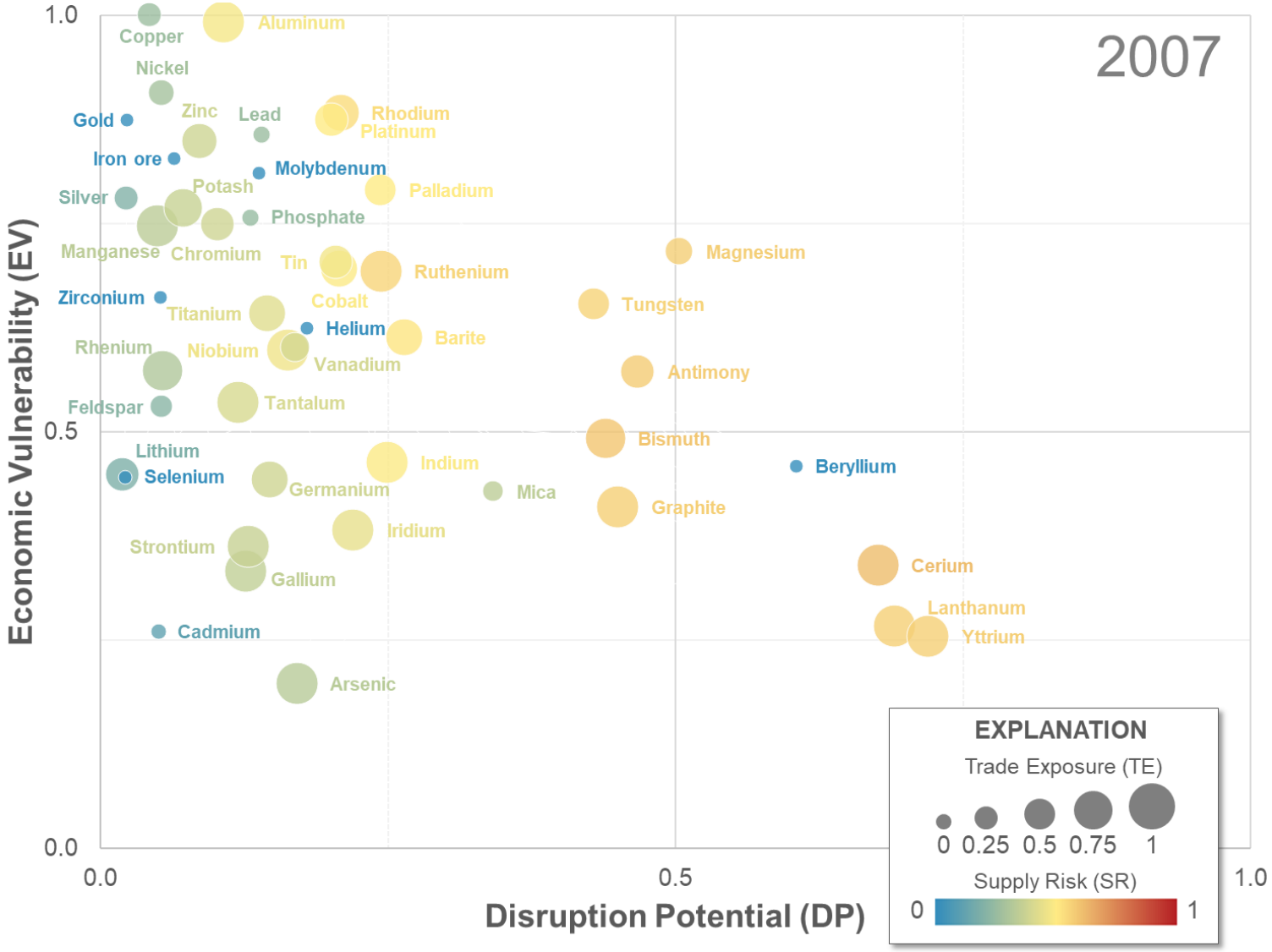
Rare earth demand and net imports

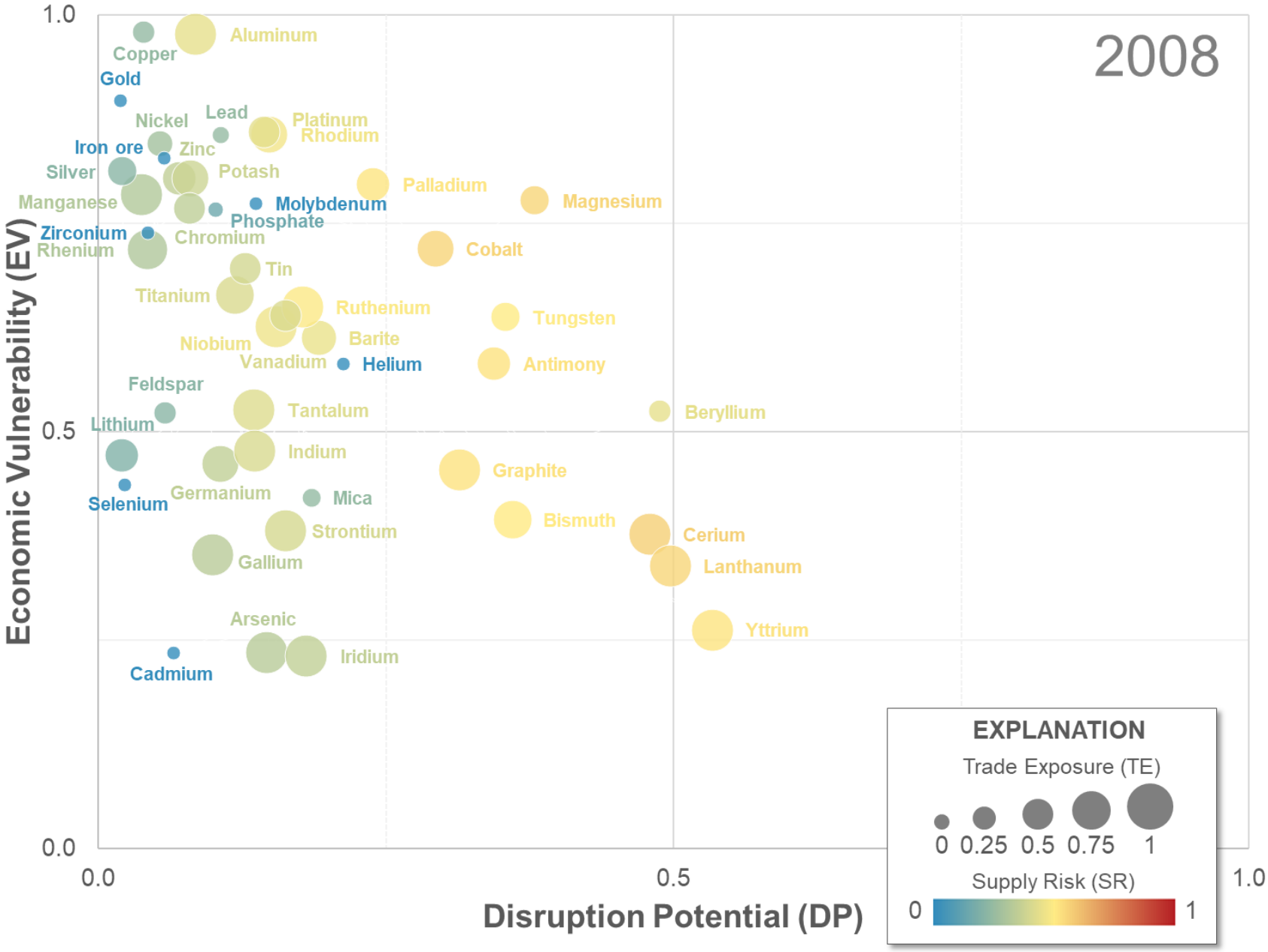
Estimates of U.S. demand for the rare earths by individual element and by application are derived using information and data from Roskill (*565*). Roskill reports total rare earth consumption (not separated for individual elements) by application and region, including the United States. Separately, Roskill also reports global consumption (not separated by country or region) by individual rare earth element and application. To obtain consumption by individual rare earth element by application for the United States the combination of these two separate data sets was required. To accomplish this task, it was assumed that the rare earth element consumption contribution for each application, and for each year, on a global basis was applicable to the consumption of the United States. For example, Roskill notes a specific contribution of lanthanum, cerium, and neodymium in rare earth catalyst consumption on a global basis for the years in questions. This ratio of lanthanum, cerium, and neodymium in global rare earth catalysts was applied to the separate dataset which provides the U.S. share of rare earth catalysts consumption to obtain an estimate of U.S. consumption of lanthanum, cerium, and neodymium that is specific for catalysts. This estimation technique was used for the following applications: catalysts, polishing powders, nickel-metal hydride (NiMH) batteries, metallurgy, glass additives, ceramics, phosphors and pigments, and other miscellaneous applications.

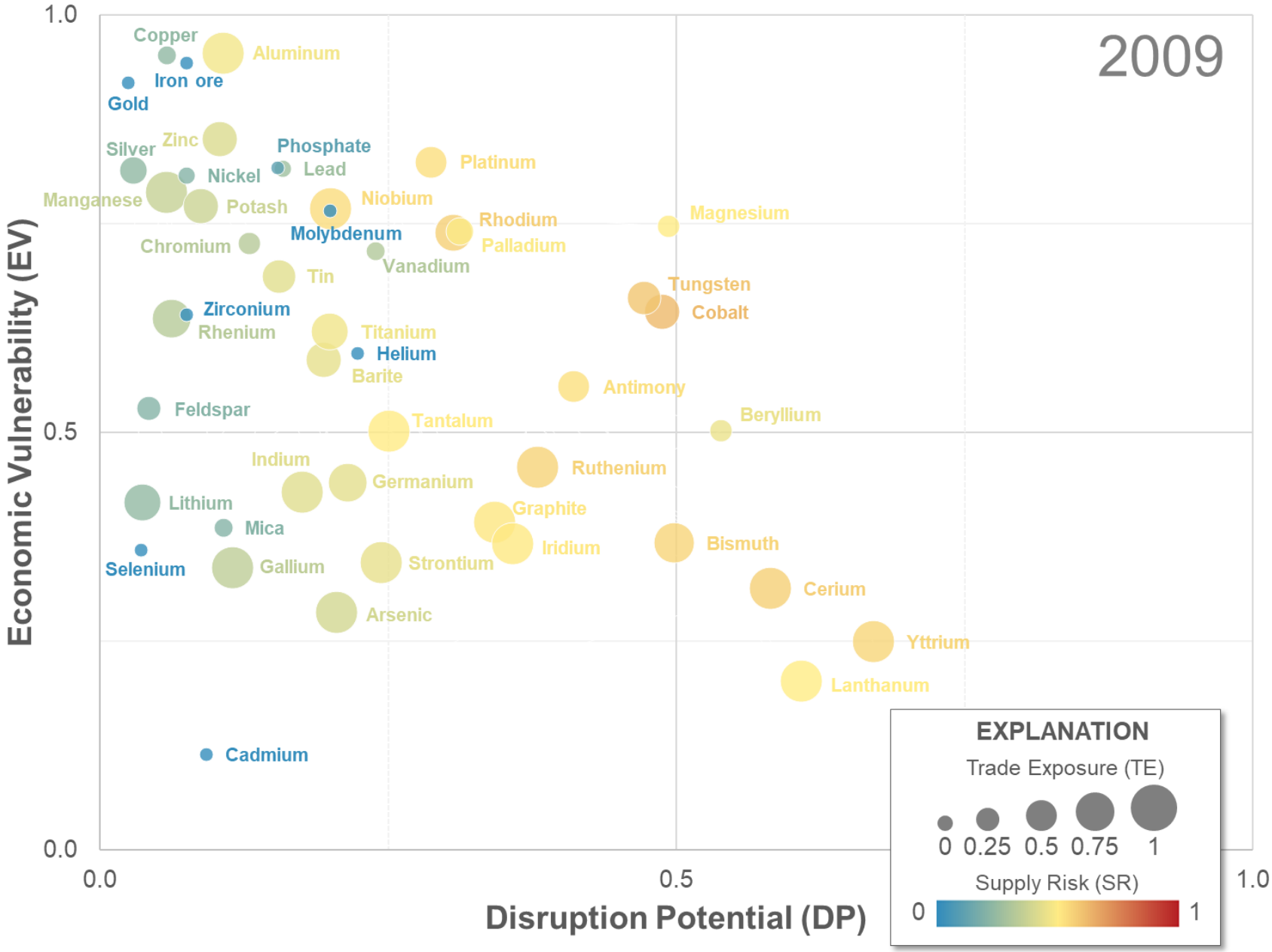
In addition to the small amount of rare earth consumption for the U.S. production of magnet alloys reported by Roskill (*565*), which are assumed to be solely for samarium contained in samarium cobalt (SmCo) magnets, net imports of permanent magnets and of articles intended to become permanent magnets after magnetization are included using the following trade codes: 8505110070 (NdFeB) and 8505110050 (SmCo). These net imports were quantified on a momentary basis and then distributed among neodymium, praseodymium, dysprosium, samarium based on their assumed mass distribution (83% neodymium, 14% praseodymium, 3% dysprosium for NdFeB and 28% Sm, 72% Co for SmCo) and the prices of these commodities for the years in question. Note these trade codes only became available beginning in mid-2014 and are thus only included in this analysis for years 2015 and 2016.

The TE indicator for the rare earths was, in turn, calculated by subtracting domestic production as described in the previous section of this document from total demand for each rare earth element. This method thus assumes negligible domestic stock changes.

Results by year




2008
Economic Vulnerability (EV)
Disruption Potential (DP)
1.0
0.5
0.0
0.0
0.5
1.0
Aluminum
Copper
Gold
Nickel
Lead
Platinum
Rhodium
Iron ore
Zinc
Silver
Potash
Palladium
Magnesium
Manganese
Molybdenum
Phosphate
Zirconium
Chromium
Rhenium
Cobalt
Tin
Titanium
Ruthenium
Tungsten
Niobium
Barite
Vanadium
Helium
Antimony
Feldspar
Tantalum
Beryllium
Lithium
Indium
Graphite
Selenium
Germanium
Mica
Bismuth
Strontium
Cerium
Gallium
Lanthanum
Arsenic
Yttrium
Iridium
Cadmium
EXPLANATION
Trade Exposure (TE)
0 0.25 0.5 0.75 1
Supply Risk (SR)
0
1


2009
Economic Vulnerability (EV)
Disruption Potential (DP)
1.0
0.5
0.0
0.0
0.5
1.0
Copper
Aluminum
Iron ore
Gold
Silver
Zinc
Phosphate
Lead
Platinum
Nickel
Manganese
Potash
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Molybdenum
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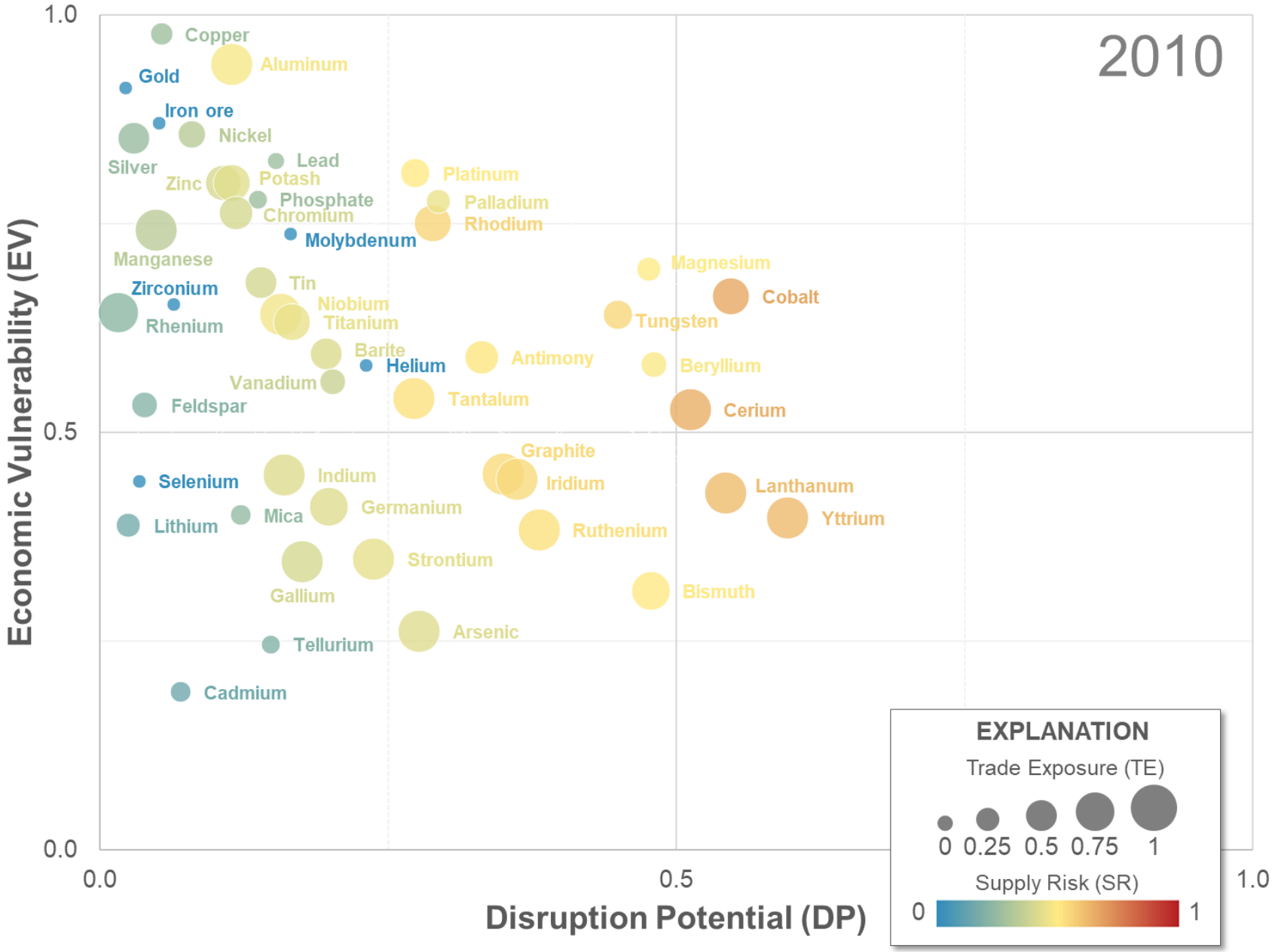
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Disruption Potential (DP)
1.0
0.5
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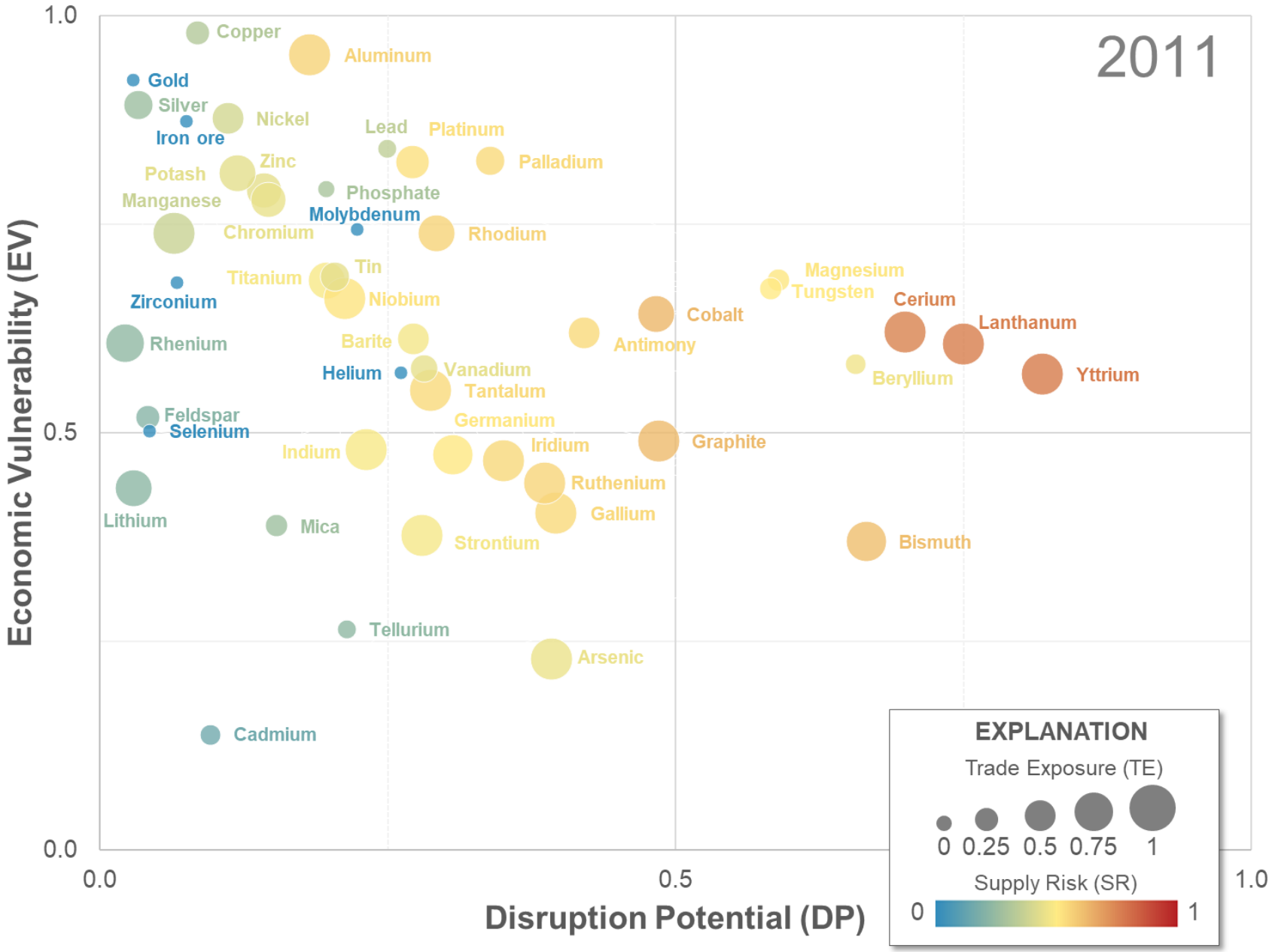
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Supply Risk (SR)
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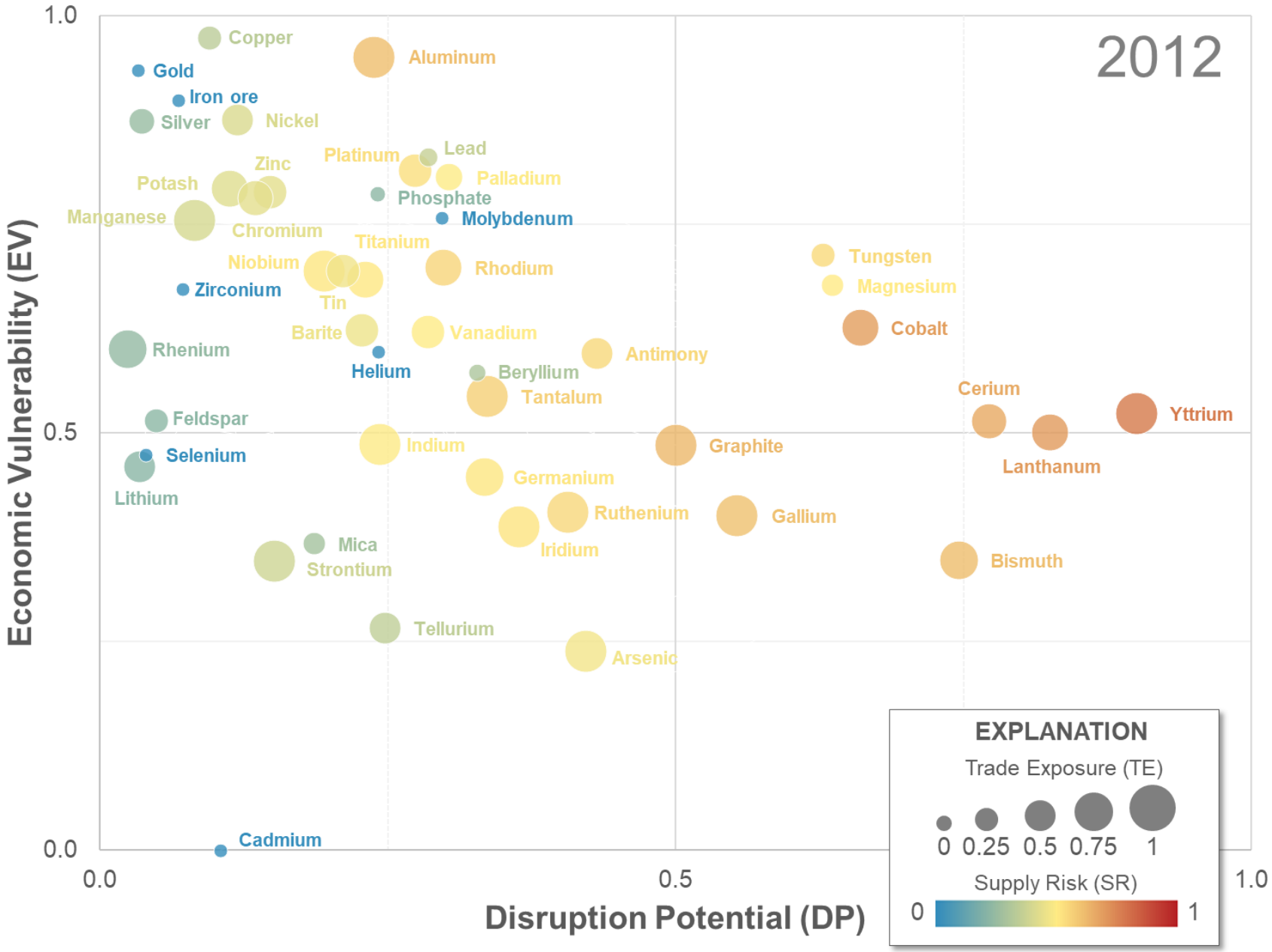
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Economic Vulnerability (EV)
Disruption Potential (DP)
1.0
0.5
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1.0
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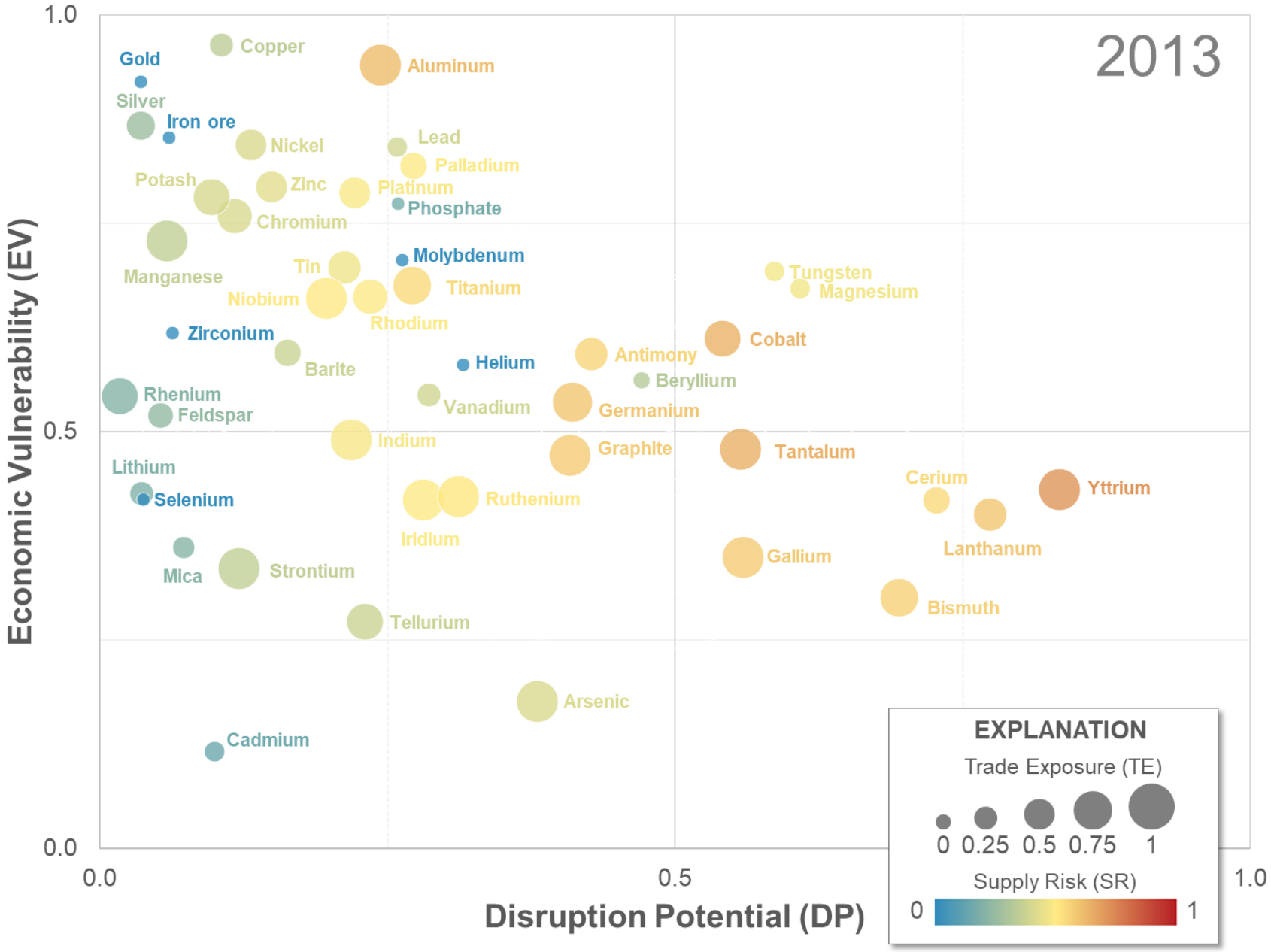
EXPLANATION
Trade Exposure (TE)
0 0.25 0.5 0.75 1
Supply Risk (SR)
0
1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Disruption Potential (DP)
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0.5
0.0
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1.0
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EXPLANATION
Trade Exposure (TE)
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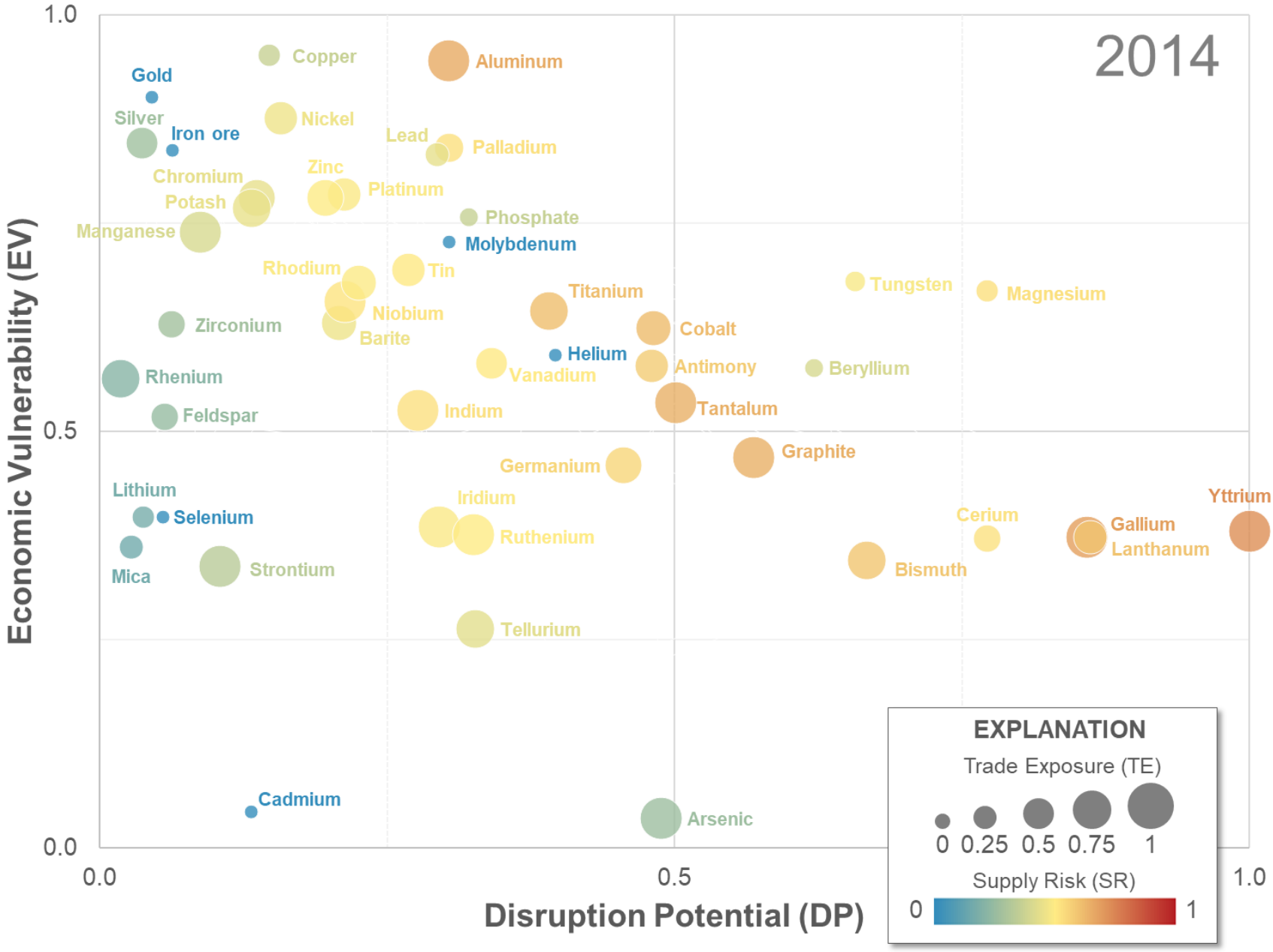
Supply Risk (SR)
0
1


2014
Economic Vulnerability (EV)
Disruption Potential (DP)
1.0
0.5
0.0
0.0
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1.0
Copper
Aluminum
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Iron ore
Nickel
Lead
Palladium
Zinc
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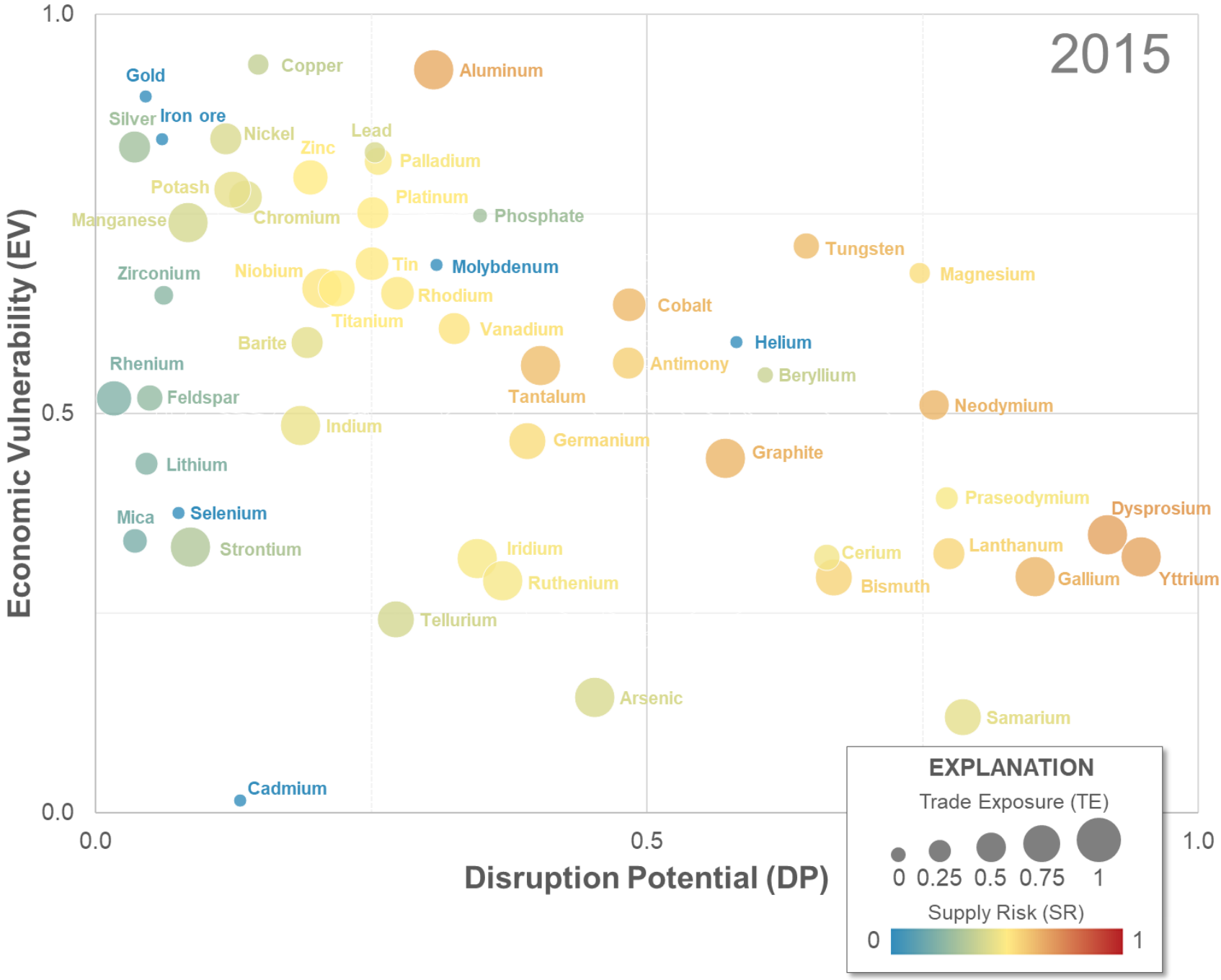

Fig. S2. SR, DP, EV, and TE scores for years 2007–2015.

Hierarchical cluster analyses

A hierarchical cluster analysis was performed for year 2016 on all commodities based on the Euclidean distance across the three individual indicators (Supply Distribution, Economic Vulnerability, and Trade Exposure) and Ward's minimum variance method (*633*, *634*). The "within groups sum of squares" was used as guidance to determine that there were 7 clusters. The results are displayed in the following figures.

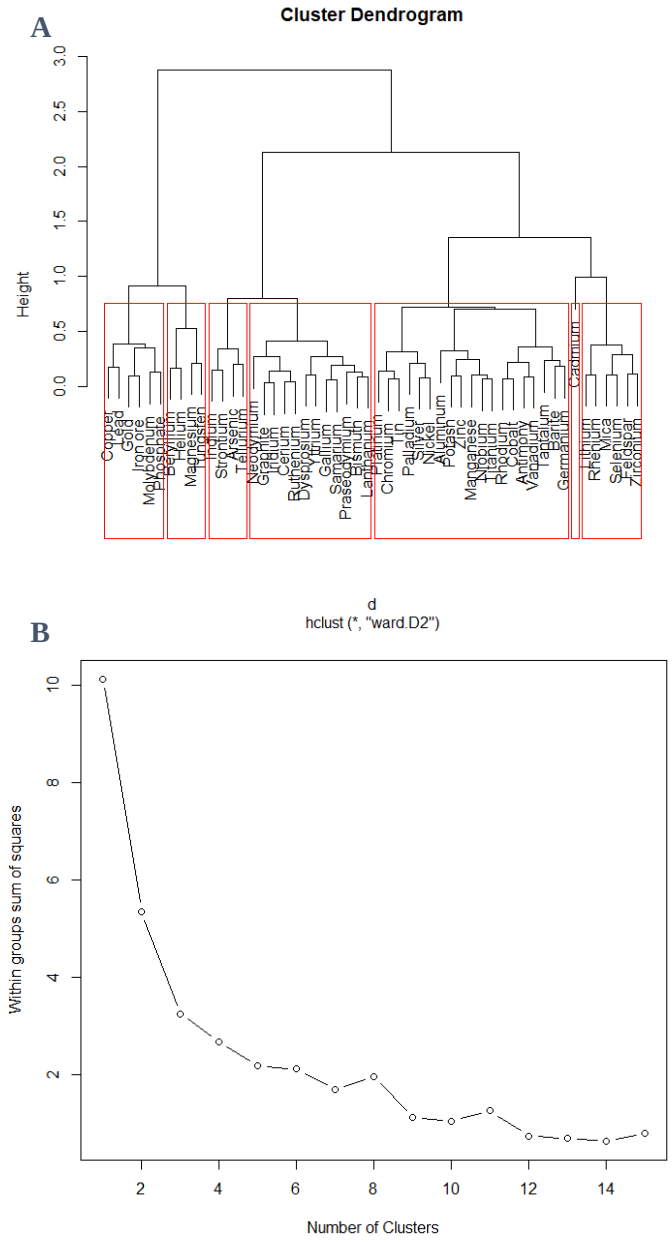

Fig. S3. Hierarchical cluster analysis dendrogram (A) and within groups sum of squares (B) for year 2016 based on the Euclidean distance across the three indicators.

A second hierarchical cluster analysis was performed on the average overall Supply Risk for all years (2007-2016) using the same method. The results for that analysis are presented in the figures below.

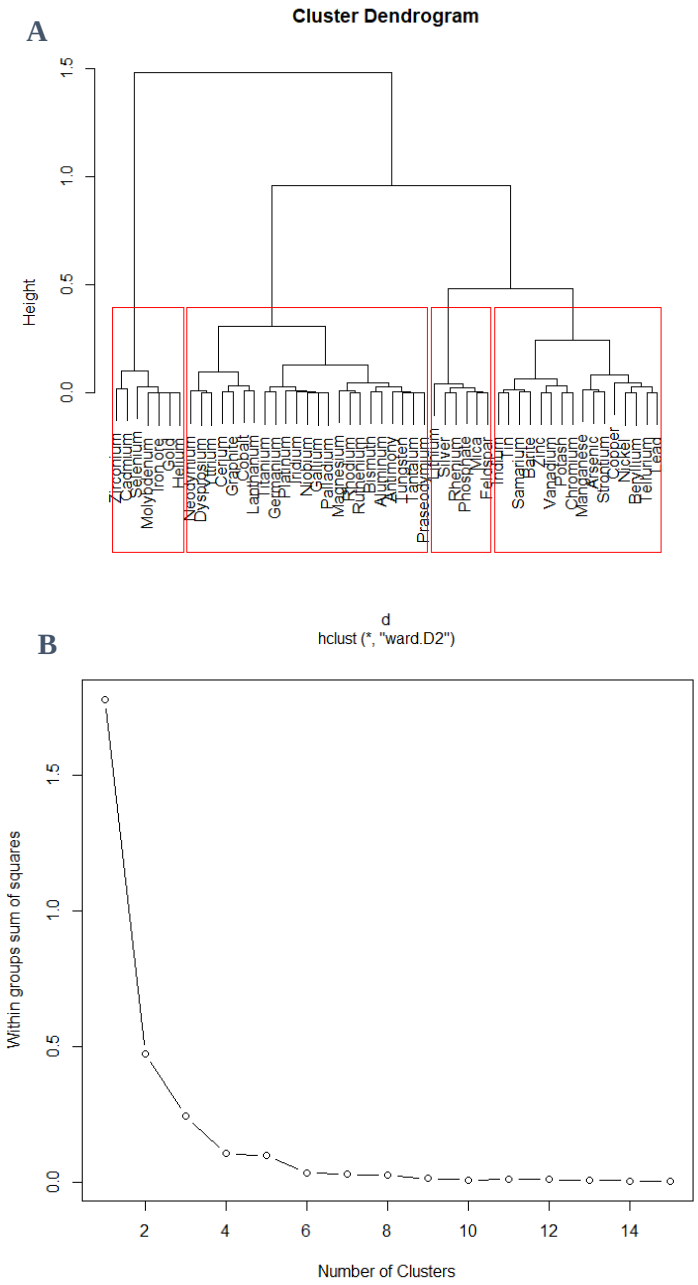

Fig. S4. Hierarchical cluster analysis dendrogram (A) and within groups sum of squares (B) based on the Euclidean distance of the 2007-2016 average SR scores.