Introducing Domestic Requirements Tables for 1997–2015

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ON FEBRUARY 17, 2017, the Bureau of Economic Analysis (BEA) released domestic requirements tables for the first time. The new estimates cover the period 1997–2015 and will be updated annually along with the full suite of BEA products based on the supply-use framework.[1] These tables show the amount of domestic intermediate inputs required, both directly and indirectly, in order for industries to supply goods and services to final demand.[2] Domestic requirements tables provide unique insights into domestic supply chains and the structural linkages among domestic industries.

In addition to providing insights into the domestic economy, the new domestic requirements tables can be contrasted with the total requirements tables already published by BEA in order to highlight the extent to which industries are reliant on global supply chains. One way to summarize a supply chain with requirements tables is through backward linkages. Backward linkages include the value of all intermediate inputs in a supply chain and are estimated by summing up a column of a requirements table.[3] Differences in backward linkages between the total requirements tables and the domestic requirements tables estimate the portion of goods and services in an industry's supply chain that are produced abroad.

Based on this measure, in 1997, the industry most reliant on global supply chains for its intermediate inputs was petroleum and coal products manufacturing followed by motor vehicles, bodies, trailers, and parts manufacturing. By 2015, motor vehicles, bodies, trailer, and parts manufacturing had become the most reliant industry followed by primary metals manufacturing, while petroleum and coal products manufacturing had dropped to the fifth most reliant industry.

Between 1997 and 2015, six different manufacturing industries were among the top three most reliant on global supply chains for their intermediate inputs. Generally, goods industries—especially manufacturing industries—relied more than services industries on global supply chains for their intermediate inputs, while service industries were less reliant on international supply chains. Within services, transportation industries were generally the most reliant on global supply chains. In 1997, the two services industries that most relied on global supply chains for their inputs were water transportation and pipeline transportation. By 2015, water transportation had dropped to second most reliant, and air transportation moved to the top position. Table 1 illustrates the top three industries that are the most reliant on global supply chains for

1. These products include supply and use tables, both before and after redefinitions; make tables; direct and total requirements matrices; and import matrices.
2. Domestic requirements tables are similar to the total requirements tables published by BEA. While domestic requirements tables reflect only domestically produced intermediate inputs, total requirements tables include both imported and domestically produced intermediate inputs.
3. Backward linkages include both the value of all intermediate inputs in a supply chain as well as the value of the final goods or services produced.

Table 1. Ranking of Industries Most Reliant on Global Supply Chains for Their Inputs

	First	Second	Third
1997	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Other transportation equipment
1998	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Other transportation equipment
1999	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Computer and electronic products
2000	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Computer and electronic products
2001	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Computer and electronic products
2002	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Other transportation equipment
2003	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Apparel and leather and allied products
2004	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2005	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2006	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2007	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2008	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2009	Motor vehicles, bodies and trailers, and parts	Petroleum and coal products	Primary metals
2010	Petroleum and coal products	Motor vehicles, bodies and trailers, and parts	Primary metals
2011	Motor vehicles, bodies and trailers, and parts	Petroleum and coal products	Primary metals
2012	Motor vehicles, bodies and trailers, and parts	Petroleum and coal products	Primary metals
2013	Motor vehicles, bodies and trailers, and parts	Primary metals	Petroleum and coal products
2014	Motor vehicles, bodies and trailers, and parts	Primary metals	Petroleum and coal products
2015	Motor vehicles, bodies and trailers, and parts	Primary metals	Other transportation equipment

their intermediate inputs in 1997–2015, and table 2 illustrates the top three services industries.

Differences in backward linkages between total requirements tables and domestic requirements tables highlight the steady increase in the interconnected nature of the global economy. Chart 1 graphs these differences for the 1997–2015 period for major sectors in the economy. Nearly all sectors follow a similar pattern. The period from 1997–2000 is marked by an increase in reliance on foreign supply chains for inputs followed by a downturn in 2001 with the 2002–2008 period showing even larger increases in reliance on global supply chains and surpassing the 2000 peak. Most sectors show a sharp decline in 2009 followed by a quick recovery in 2010 that claws back much of 2009's retrenchment. The 2011–2015 period shows a flat or slightly decreasing trend. Considering the 1997–2015 period as a whole, most industries saw a slight increase in reliance on foreign supply chains for their intermediate inputs.

Looking at specific sectors, manufacturing as a whole is the most reliant on global supply chains and was the sector most affected by the 2009 downturn. Agriculture, forestry, fishing and hunting was generally the sector that was second most reliant on foreign supply chains for intermediate inputs, though at times it was surpassed by transportation and warehousing or construction. With the exception of transportation and warehousing, service sectors were the least reliant on global supply chains for their intermediate inputs.

Domestic requirements tables

Three main tables are being added as a part of this expansion of BEA's products. These include the commodity-by-commodity domestic requirements table, the industry-by-industry domestic requirements table, and the industry-by-commodity domestic requirements table. Like the corresponding total requirements tables, the new domestic requirements tables are available at the sector level (roughly a two-digit NAICS classification) and the summary level (roughly a three-digit 2007 NAICS classification) for all years. Tables at the detailed level (roughly a four-digit 2007 NAICS classification) are also available for 2007.

These new estimates will be incorporated into the standard suite of products released periodically by BEA's industry accounts. As part of its annual update, the industry accounts will release an updated and extended time series. In addition, more detailed estimates at roughly a four-digit NAICS classification will

Chart 1. Difference in Backward Linkage Between Total and Domestic Requriements by Major Sector

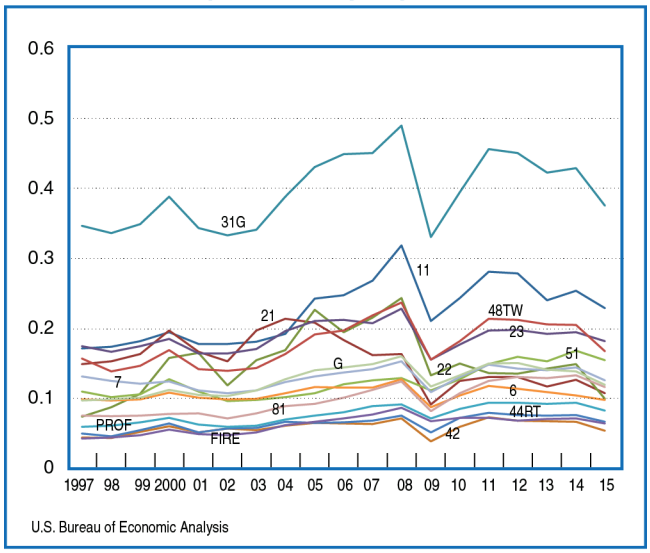

Table 2. Ranking of Services Industries Most Reliant on Global Supply Chains for Their Inputs

	First	Second	Third
1997	Water transportation	Pipeline transportation	Air transportation
1998	Water transportation	Air transportation	Pipeline transportation
1999	Water transportation	Air transportation	Pipeline transportation
2000	Air transportation	Water transportation	Pipeline transportation
2001	Air transportation	Water transportation	Utilities
2002	Water transportation	Air transportation	Truck transportation
2003	Water transportation	Air transportation	Pipeline transportation
2004	Water transportation	Air transportation	Pipeline transportation
2005	Air transportation	Water transportation	Pipeline transportation
2006	Air transportation	Water transportation	Pipeline transportation
2007	Air transportation	Water transportation	Pipeline transportation
2008	Air transportation	Water transportation	Truck transportation
2009	Air transportation	Insurance carriers and related activities	Water transportation
2010	Air transportation	Water transportation	Insurance carriers and related activities
2011	Air transportation	Water transportation	Truck transportation
2012	Air transportation	Water transportation	Waste management and remediation
2013	Air transportation	Water transportation	Waste management and remediation
2014	Air transportation	Water transportation	Waste management and remediation
2015	Air transportation	Water transportation	Waste management and remediation

be released for 2012 as part of the upcoming benchmark release scheduled for the fall of 2018.

The requirements tables are best understood if considered by column. Each column represents the value of all domestic production required in order to supply end-users with one dollar of output.[4] The required production includes both the dollar supplied to end-users as well as the entire supply chain in order to produce that dollar of output. It is common to break down the supply chain portion into two subcomponents: the intermediate inputs directly used in producing that dollar of output, and the intermediate inputs indirectly used, corresponding to the remainder of the supply-chain.

Each column of a commodity-by-commodity domestic requirements table shows the production, broken down by commodity necessary to supply end users with a dollar of a given commodity.[5] Table 3 shows the commodity-by-commodity domestic requirements for the agriculture, forestry, fishing, and hunting commodity in 2015 (see also table 4). The total for the column is 2.019, meaning that in order to supply an end-user with one dollar of agriculture, forestry, fishing, and hunting commodity, on average, the economy produced 2.019 dollars of gross output. This 2.019 is decomposed into the dollar supplied to end users as well as an additional 1.019 dollars of intermediate inputs required to produce that dollar of output. The 1.019 dollars of inputs include 0.306 dollar of agriculture, forestry, fishing, and hunting inputs, 0.266 dollar of manufacturing inputs, and an additional 0.447 dollar of other inputs. Note that these inputs include both the inputs directly purchased to produce the commodity as well as the remaining inputs in the supply chain.

Table 3. Commodity-by-Commodity Domestic Requirements for Agriculture, Forestry, Fishing, and Hunting, 2015

Input-output code		Commodity inputs required to produce a dollar of commodity 11
11	Agriculture, forestry, fishing, and hunting	1.3064095
21	Mining	0.0185741
22	Utilities	0.0196578
23	Construction	0.0130009
31G	Manufacturing	0.2668854
42	Wholesale trade	0.0983996
44RT	Retail trade	0.0027572
48TW	Transportation and warehousing	0.0659758
51	Information	0.0102523
FIRE	Finance, insurance, real estate, rental, and leasing	0.1133102
PROF	Professional and business services	0.0833931
6	Educational services, health care, and social assistance	0.0020719
7	Arts, entertainment, recreation, accommodation, and food services	0.0075720
81	Other services, except government	0.0079202
G	Government	0.0025498
Used	Scrap, used and secondhand goods	0.0006788
Other	Noncomparable imports and rest–of–the–world adjustment	0.0000000
Total commodity output requirements		**2.0194085**

The reason the dollar value of intermediate inputs in the supply chain exceeds the dollar value provided to the end-users is related to the measurement of gross output. Gross output of any product embeds the value of the inputs used in producing that product. Hence, when gross output is added vertically along a supply chain, as was done in summing up the column of a requirements table, the value of intermediate inputs to production can be double-counted.

The industry-by-industry and industry-by-commodity domestic requirements, like the commodity-by-commodity domestic requirements, relate the domestic production required to supply end-users with one dollar of output. A column in the industry-by-industry domestic requirements table shows the domestic production decomposed by industry that is necessary to supply an end-user with a dollar of industry output. Similarly, a column in the industry-by-commodity domestic requirements table shows the domestic production decomposed by industry that is necessary to supply an end-user with a dollar of commodity output.

Methodology and uses

The estimates presented in this article are an accounting decomposition of supply chains. This decomposition has the same theoretical underpinnings as BEA's

Other Tables

In conjunction with the three domestic requirements tables, two additional tables will also be released: the domestic direct requirements table and the market share table. Both of these tables will be produced at the same level of detail and follow the same publication schedule as the domestic requirements tables.

The domestic direct requirements table shows the domestically sourced inputs directly purchased by various industries divided by total output for the industry. The domestic direct requirements table is used as an input to the calculation of the domestic requirements tables.

The market share table shows each industry's share of production of each commodity. The market share table is an input to the calculation of both the domestic requirements and total requirements tables. For more information on these two tables, see the section "Mathematical Derivation of Domestic Requirements."

4. Total requirements tables have a similar interpretation. Each column represents the total value of global production required in order for domestic industries to supply end-users with one dollar of output.

5. The term commodity is used to mean any good or service produced.

currently published total requirements tables. Both sets of estimates are mathematical descriptions of production which relate inputs to output. The main assumptions underlying the calculation of these tables are

- Constant returns to scale.
- No substitution of inputs to production is possible.
- No production process produces more than one type of output.
- Hybrid technology assumption that combines both the industry technology and commodity technology assumption.[6]

The new domestic total requirements estimates are best viewed as representing an average technological relation between inputs and output for a given reference year. Viewing the estimates in this ex-post way, the above assumptions are not overly restrictive because they help simplify the accounting decomposition of supply chains to average relations. Requirements are also commonly used for predictive purposes, not for accounting purposes; the canonical modeling example being to use requirements for impact analysis.[7] When using requirements for predictive purposes, however, caution is necessary, especially if applied to a hypothetical economy with very different levels of output from the actual economy. In this scenario, the assumptions of constant returns to scale and no substitution of inputs can be restrictive because they do not allow for any optimizing behavior on the part of firms in regards to production processes.[8]

Mathematical derivation of domestic requirements tables

The domestic requirements estimates are prepared in four broad steps. The first step is to calculate domestic intermediate inputs based on the use table and imports matrix. The second step is to compute the domestic direct requirements matrix based on the intermediate input section of the domestic use table. The third step is to compute the market share matrix based on the make table. The fourth step is to combine the domestic direct requirements matrix and the market share matrix to create the three types of domestic requirements tables.[9]

Given
q: Vector of commodity output.
g: Vector of after redefinitions industry output.
U: Intermediate inputs portion of the after redefinitions Use table (commodity-by-industry).
V: Make table after redefinitions (industry-by-commodity).
W: Intermediate inputs portion of the Import matrix (commodity-by-industry).
I: Identity matrix
^: A symbol that, when placed over a vector, indicates a square matrix in which the elements of the vector appear on the main diagonal and zeros elsewhere.

$\acute{U}$: Domestic intermediate inputs, are computed as

$$\acute{U} = U - W$$

E: Domestic direct requirements matrix in which entries in each column show the amount of a commodity used by an industry per dollar of output of that industry is computed as

$$E = \acute{U}\hat{g}^{-1}$$

D: Market share matrix in which show the share of industry production of particular commodities is computed as

$$D = V\hat{q}^{-1}$$

The commodity-by-commodity domestic requirements table is computed as

$$(I - ED)^{-1}$$

The industry-by-industry domestic requirements is computed as

$$(I - DE)^{-1}$$

The industry-by-commodity domestic requirements table is computed as

$$E(I - ED)^{-1}$$

Looking ahead

BEA's industry accounts are also developing trade in value added (TiVA) statistics that expand the domestic requirements featured in this article by allowing a decomposition of supply chains into domestic value-added and foreign value-added components. This ongoing TiVA work at BEA is being done in conjunction with related efforts by the Organisation for

6. For a full discussion of various technology assumptions, see, Jiemin Guo, Ann M. Lawson, and Mark A. Planting, "From Make-Use to Symmetric I-O Tables: An Assessment of Alternative Technology Assumptions."
7. For an example of how to use requirements in modeling, see, Mary L. Streitwieser, "A Primer on BEA's Industry Accounts."
8. When using these estimates for predictive purposes, it is common to further assume that there are no capacity constraints.
9. For a discussion on computing requirements tables, see Karen J. Horowitz and Mark A. Planting, "Concepts and Methods of the U.S. Input-Output Accounts."

Economic Co-operation and Development (OECD), the World Trade Organization (WTO), Asia Pacific Economic Cooperation (APEC), and the North America Regional TiVA Initiative.

Requirements Variants

Requirements are a tool for mathematically describing supply chains. Just as there are multiple ways of describing a supply-chain, there are multiple types of requirements tables. This box describes a few of these different variants. In this case, the variants are differentiated based on three parameters: the scope of measurement of the supply chain, the valuation of the supply chain, and the inclusion of demand-side effects. Some of the more common variants are included below, but the list is by no means exhaustive.

Scope. Requirements can estimate the entire supply chain, inclusive of the foreign parts of the supply-chain, or focus exclusively on the domestic component of the supply chain. Requirements that estimate the entire supply chain are called total requirements while requirements that focus only on the domestic component are called domestic requirements.

Valuation. The supply chain, whether domestic or total, can be valued in terms of gross output, value added (or the income generated from production), or employment.

Gross output is measured as the value of goods and services produced in a given year valued at producers' prices (the price received by the industry, including sales and excise taxes). Gross output reflects both the value of the inputs used in production as well as the income accrued from production. Because the value of gross output reflects the value of its inputs, summing requirements along a vertically integrated supply chain leads to double-counting. Gross output requirements decompose the supply-chain into the dollars spent on various inputs.

Income requirements measure production in value added terms. Value added is the additional value generated by the capital and labor utilized in the production process and can be measured as the difference between gross output produced and intermediate inputs used in the production process. Income requirements are usually computed only for domestic requirements tables and decompose the supply-chain into the income accruing to each producer.

Employment requirements are measured in terms of labor employed in production. Labor is commonly measured either as persons engaged in production or as full-time equivalent labor. Employment requirements, like income requirements, are usually computed only for domestic requirements tables. In addition, they are usually computed only for industry-based tables (industry-by-industry and industry-by-commodity tables). Employment requirements decompose the supply chain into the labor employed by each producer.

Demand-side effects. Requirements tables also differ between tables that capture only supply effects and tables that capture supply and demand effects. Requirements that capture only supply effects are called type I multipliers, while type II multipliers include both supply and demand effects. The values in type II requirements embed the type I requirements and include the induced demand resulting from wages earned along the length of the supply chain.

The requirements featured in this article are national-level type I domestic gross output requirements. BEA's existing requirements tables are national-level type I total gross output requirements. In addition, regional type I and type II domestic requirements for gross output, income, and employment are available through BEA's Regional Input-Output Modeling (RIMS II) System.

Table 4. Commodity-by-Commodity Domestic Requirements, After Redefinitions, 2015

[In producers' prices]

	Commodities/Commodities	11	21	22	23	31G	42	44RT	48TW	51	FIRE	PROF	6	7	81	G	Used	Other
Input-output code		Agriculture, forestry, fishing, and hunting	Mining	Utilities	Construc-tion	Manufactur-ing	Wholesale trade	Retail trade	Transpor-tation and ware-housing	Information	Finance, insurance, real estate, rental, and leasing	Professional and business services	Educational services, health care, and social assistance	Arts, entertain-ment, recreation, accommo-dation, and food services	Other services, except government	Government	Scrap, used and secondhand goods	Noncom-parable imports and rest-of the world adjustment
11	Agriculture, forestry, fishing, and hunting	1.3064095	0.0052094	0.0039108	0.0152602	0.0730274	0.0023435	0.0036486	0.0096571	0.0049585	0.0019729	0.0044093	0.0058216	0.0106849	0.0052595	0.0073117	0.0333313	0.0073144
21	Mining	0.0185741	1.0726045	0.0721387	0.0189053	0.0484965	0.0021604	0.0029916	0.0091751	0.0041083	0.0038962	0.0036199	0.0055877	0.0078265	0.0049899	0.0105242	0.0247836	0.0104743
22	Utilities	0.0196578	0.0085315	1.0100277	0.0069636	0.0157795	0.0055060	0.0109130	0.0113817	0.0070212	0.0193032	0.0066161	0.0141318	0.0144968	0.0094162	0.0115183	0.0126808	0.0115195
23	Construction	0.0130009	0.0136767	0.0171639	1.0033318	0.0063702	0.0039950	0.0066177	0.0110698	0.0056974	0.0301592	0.0045434	0.0086629	0.0074047	0.0091628	0.0250936	0.0149080	0.0251000
31G	Manufacturing	0.2668854	0.0888939	0.0687320	0.2586756	1.3836590	0.0405155	0.0500958	0.1766679	0.0892868	0.0330721	0.0620831	0.1023933	0.1563157	0.0889494	0.1260393	0.2218879	0.1260857
42	Wholesale trade	0.0983996	0.0231650	0.0195236	0.0582406	0.0814218	1.0302827	0.0248012	0.0480570	0.0317466	0.0098506	0.0160784	0.0265134	0.0332424	0.0225621	0.0242228	0.0461828	0.0242266
44RT	Retail trade	0.0027572	0.0018911	0.0024145	0.0649587	0.0043887	0.0012630	1.0051420	0.0070727	0.0015962	0.0038366	0.0017948	0.0021187	0.0077672	0.0101903	0.0025148	0.0032520	0.0025149
48TW	Transportation and warehousing	0.0659758	0.0331787	0.0558423	0.0369840	0.0535742	0.0490684	0.0638426	1.1511675	0.0256443	0.0131227	0.0235339	0.0225851	0.0278767	0.0177008	0.0303442	0.0387698	0.0303235
51	Information	0.0102523	0.0065510	0.0145957	0.0132753	0.0151987	0.0201911	0.0265527	0.0171368	1.1964424	0.0223224	0.0430260	0.0257506	0.0231251	0.0212349	0.0347632	0.0267821	0.0347795
FIRE	Finance, insurance, real estate, rental, and leasing	0.1133102	0.0521567	0.0535820	0.0683922	0.0590828	0.0980178	0.1546171	0.1325231	0.1006488	1.2087355	0.1215259	0.1752318	0.1382445	0.1711783	0.0625484	0.0693723	0.0625556
PROF	Professional and business services	0.0833931	0.0866406	0.0919897	0.1048500	0.1527591	0.1654368	0.1702286	0.1337577	0.1727755	0.1353518	1.2145791	0.1661284	0.1908728	0.1068636	0.1260738	0.1485399	0.1261014
6	Educational services, health care, and social assistance	0.0020719	0.0001557	0.0035335	0.0007421	0.0004600	0.0010820	0.0079076	0.0010021	0.0012182	0.0003861	0.0006385	1.0125216	0.0022349	0.0036157	0.0136968	0.0066948	0.0137051
7	Arts, entertainment, recreation, accommodation, and food services	0.0075720	0.0050390	0.0112874	0.0076501	0.0109264	0.0110164	0.0111776	0.0103489	0.0369997	0.0159270	0.0269704	0.0209893	1.0317237	0.0107926	0.0163475	0.0155999	0.0163516
81	Other services, except government	0.0079202	0.0031594	0.0054464	0.0085825	0.0078879	0.0136249	0.0123262	0.0098468	0.0148885	0.0097826	0.0136682	0.0184646	0.0148175	1.0124932	0.0112584	0.0102467	0.0112631
G	Government	0.0025498	0.0011283	0.0028563	0.0019373	0.0031925	0.0071876	0.0064352	0.0181804	0.0033790	0.0042088	0.0039089	0.0044270	0.0073033	0.0035132	1.0041366	0.0037802	0.0041377
Used	Scrap, used and secondhand goods	0.0006788	0.0002753	0.0008393	0.0014451	0.0026247	0.0004632	0.0005215	0.0038799	0.0005002	0.0002949	0.0004435	0.0007078	0.0005937	0.0182806	0.0005103	1.0013500	0.0005100
Other	Noncomparable imports and rest–of–the–world adjustment	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000	1.0000000
Total commodity output requirements		**2.0194085**	**1.4022568**	**1.4338836**	**1.6701944**	**1.9188493**	**1.4521542**	**1.5578191**	**1.7509244**	**1.6969116**	**1.5122227**	**1.5474395**	**1.6120358**	**1.6745304**	**1.5162031**	**1.5069039**	**1.6781622**	**1.5069628**

NOTE. Detail may not add to total because of rounding.