Revisiting Leontief's Paradox

Abstract

According to the popular Heckscher-Ohlin model of international trade, a country is expected to export (import) those products whose production requires the intensive use of the factor of production in relative abundance (scarcity). Leontief (1953) using input-output data of the US economy for the year 1947 found that the US, an overwhelmingly capital-abundant country, exported labour-intensive products and imported capital-intensive ones. Clearly, the results contradicted the predictions of the Heckscher-Ohlin model and they were characterized as "Leontief's paradox". A number of explanations for the so-called paradox were offered and this paper briefly, but critically, evaluates these explanations as it examines whether or not the Leontief's results persist in the case of the US economy during the period 1998-2012.

Key Words: Leontief's Paradox, international trade, US economy, factor content

Jel Classification: F10, F11, F14, F16 and J31

1. Introduction

According to Heckscher-Ohlin (hereafter H-O) model, a country will export those goods that they use intensively the abundant and therefore, the relative cheap factor of production while it will import goods that use its scarce factor. Leontief (1953) tested empirically the H-O model for the US economy, an unquestionably capital-abundant country, and to his surprise, the results suggested that the US exports labour-intensive products and imports capital-intensive ones. Leontief in vain sought to provide credible explanations for these contradictory and, at the same time, disturbing for the H-O model results, soon, however, he realized that the problem was not the results, but the premises of the H-O model. By contrast, neoclassical economists spent a great deal of time and effort explaining such upsetting empirical results that persisted over the years and they were repeated in many countries and instead of questioning the fundamental premises of the H-O model, they characterized the results as "Leontief Paradox" which gradually became an integral part of the international trade theory. In addition, the Leontief paradox led many of the neoclassical economists either to relax some of the assumptions of the H-O model or to advance altogether new trade theories based on monopolistic competition and intra-industry trade.

In the present paper, we revisit the Leontief's paradox and test whether it holds true in the face of recent input-output data for the US economy spanning the period 1998-2012. The remainder of the paper is organized as follows: Section 2 reviews the core propositions of Leontief's Paradox and briefly but critically evaluates the pertinent literature. Section 3 presents the methodology with the aid of which the capital and labour content of the US exports and imports are estimated. Section 4 discusses the empirical results. Finally, Section 5 makes some concluding remarks.

2. The Leontief Paradox in the Literature

According to neoclassical theory of value, relative prices reflect relative scarcities of factors of production; hence, a country would be able to produce relatively cheaper the goods that use intensively its abundant factor of production and by trading with one another to realize economies of scale and therefore to increase both their production and consumption possibilities; thereby, rendering international trade and specialization beneficial to all countries involved (Krugman, *et al.,* 2011, p. 24). At

different stages, these hypotheses, which comprise the H-O model, have been supplemented by additional assumptions such as the introduction of non-reproducible factors of production *i.e.,* land and the homothetic tastes (Vanek, 1963) or the factor price equalization theorem (Samuelson, 1948).[1] In our presentation, we employ the H-O model in its original terms according to which all trading countries employ the same technology.

Leontief (1953) in his investigation utilized input-output data at 50x50 industry detail of the US economy for the year 1947. Furthermore, he divided the industries into two major categories, capital-intensive and labour-intensive and proceeded with the estimation of the capital and labour content of imported and exported goods expressed in millions of US dollars. The results showed that the US, a capital abundant country, exported on average labour-intensive products and imported capital-intensive ones. Leontief was rather sympathetic to the premises of H-O model and sought to reconcile his empirical results with the predictions of the H-O model by claiming that the efficiency of the US workers was approximately three-times higher than that of the respective foreign ones.[2] And in so doing he essentially treated the US as a labour instead of a capital abundant country (Leontief, 1953, p. 344).[3] The higher efficiency hypothesis of the US workers was tested by Kreinin (1965) and the results showed that, under the same conditions of work, the US labour is at most 25 percent more efficient than that of abroad, thereby rendering Leontief's hypothesis unrealistic at least.

Among the first who objected Leontief's findings was Swerling (1953) who claimed that the year 1947 was by no means typical for the US economy which was still under the shock of World War II.[4] In addition, he argued that the estimations of capital and labour intensities were fraught with problems caused by not considering the capital-labour ratios of the countries from which the US economy imports.

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[1] This is the reason why sometimes Vanek's name is appended to the H-O (the H-O-V model) and some other times to Samuelson's name (the H-O-S model).

[2] Given the same capital-labour ratio, Leontief attributed the superior efficiency of US labour to differences in entrepreneurship, working conditions and, in general, the economic culture of the US economy.

[3] Leontief (1956) repeated his test for the same year at a higher (192x192) industry detail and derived results similar to his first study.

[4] The War-shock does not change the expected outcome because one could argue that the War weakened Leontief's results. In any case, the War as a "cause" of the so-called paradox was more a speculation rather than an explanation.

Ellsworth (1954) argued that the paradoxical findings arise because the estimated factor content of imports in the Leontief kind of empirical studies are rather import replacements. More specifically, given that the US is a capital-abundant and labour-scarce country, it is possible that the imported products to be capital-intensive domestically, but labour intensive abroad rendering thus the Leontief studies inappropriate to estimate the true factor content of imports. These results have been characterised as factor-intensity reversals and they are not to be confused with those derived in the famous capital theory controversies in the 1960s. The latter, as is well known, have shown that a change in the distributive variables may lead to changes in relative prices and the subsequent revaluation of capital may change the characterization of an industry from capital to a labour-intensive or vice versa. The implications of the capital theory controversies in the neoclassical theory of international trade have been shown mainly by Steedman and Metcalfe (1977) and Steedman (1979). More specifically, Steedman and Metcalfe (1977) argued that in the case of non-produced factors of production (i.e., land and labour) there are no reversals in factor intensities and the H-O model still maintains its sway. But the same does not necessarily hold true in the presence of produced factors of production (heterogeneous capital) and labour, where factors intensity may change theoretically, at least, more than once. In such a case, the neoclassical trade model is misspecified for it is impossible to determine factor intensities and factor endowments in any logically consistent way (Steedman, 1979). The empirical research has further shown that factor intensity reversals are not only theoretically possible, but they are observed in actual economies, albeit the frequency of their occurrence is rather low (e.g., Leontief, 1985; Han and Schefold, 2006; Tsoulfidis and Mariolis, 2007).

On the other hand, Pasinetti (1981, pp. 187-188) challenged Leontief's empirical findings by arguing that there is no paradox at all for the reason that the capital-labour ratio, an index of mechanisation, was mistakenly taken as an index of capital intensity. According to Pasinetti, the proper index of capital intensity would be the capital-output ratio. Clearly, Pasinetti (1981) contended that the US is a more mechanised economy than the rest of the world and this is reflected in the capital-labour ratio, but there is no evidence whatsoever for the US capital-output ratio, that is, Pasinetti's proper index of capital intensity will be higher, on an average, than that of the rest of the world.

Another criticism in Leontief's findings is rooted in the demand side of the market. According to this criticism, US consumers prefer qualitatively better products which, is speculated, are capital-intensive. It is important to point out that the H-O's model fundamental assumption of similar consumer preferences internationally does not rule out differences in consumption patterns across countries.[5] The rationale is that as income rises people tend to spend proportionally less on food consumption (labour-intensive commodities) and more on qualitatively superior and therefore, capital-intensive commodities (Engel's law). Since, the per capita income of the USA is amongst the highest in the world, the rising spending on qualitatively superior, and therefore, capital-intensive commodities by the US citizens is speculated that led to a rising relative price of capital, despite the capital abundance character of the US economy. Such a change in the price of capital relative to consumption goods might explain the unexpected trade patterns found in Leontief's and other similarly-motivated studies. On further examination, however, such a twist in factor intensities due to the change in spending pattern towards capital-intensive goods by the US citizens is not certain at all. It has been argued that qualitatively superior goods are more likely to be labour-intensive rather than capital-intensive. The idea is that the latter are usually machine-made produced massively in large-scale factories. In any case, the alleged difference in spending patterns in the USA might be an interesting hypothesis to test empirically; however, there is no enough intuition behind it and some of the very early pioneering empirical studies on this issue did not lend support to such a hypothesis (Houthakker, 1957).

Buchanan (1955) questioned Leontief's data by arguing that capital's lifetime may differ in various industries; for instance, two capital goods which are used to produce the same value of output (the first with a lifetime span of, say, four years and the second with ten years), although are treated as if they are the same in Leontief's hypothesis, they are not since the first capital good is more capital-intensive. Buchanan's critique is justified, but it is unlikely that improved estimates of capital stock would overturn Leontief's results. Diad (1956) and Vanek (1963) challenged Leontief's findings by arguing that they would have been different had Leontief accounted for natural resources. Vanek (1963) found that products imported to the US

[5] This hypothesis appears to contradict Samuelson's factor-price equalization theorem because people (unlike capital) are not freely mobile between countries. On closer examination, however, the international differences in consumption patterns might be explained, if besides wages we include the income from profits spent on consumer goods.

were primary-input intensive which leads to an overestimation of the use of capital to the extent that the latter is difficult to be separated from natural resources. Consequently, by restricting the economy's endowments only to capital and labour and by not accounting for oil and other natural resources, Leontief's method fails to fully capture the real dimension of product's input component. That is, if we consider natural resources as a factor of production, then the US might import natural resources-intensive goods (the relatively scarce factor of production) and might export capital and labour-intensive goods (the abundant factors of production relative to natural resources).[6] It is important to note that the inclusion of natural resources together with the ranking of factors intensity in the face of more than two factors of production remain challenging issues.

Baldwin (1971) argued that the introduction of human capital in the discussion weakens the Paradox although it does not eliminate it completely. Stern and Maskus (1981) tested the US trade patterns using natural resources, industry shipments and an index for human capital.[7] Their results confirmed the Leontief paradox for the year 1958, but not for the year 1972; the reason is that in the meanwhile the "US may have become more abundant in physical capital relative to human capital between 1958 and 1972". On the other hand, Stern and Maskus (1981, p. 223) identified a significant negative impact of unskilled labour on their estimates of factor content which, in their opinion, reflect the fact that export industries rely relatively more on the abundant factor of human capital. Their argument is that the US is endowed with more human capital, because of its expenditures on education and health which are embodied in US labour. Thus, the US exports are human-capital-intensive and in a two-factor model appear to be labour-intensive. The trouble with this argument is that the notion of human capital can be hardly thought as a proper primary factor of production (Tsaliki, 2008).

Leamer (1980) examined trade patterns for many countries and factors of production and goods and argued that it is not exactly right to test the H-O model by simply comparing the factor content of an economy's exports and imports. Furthermore, Leamer defined the factor abundance (or scarcity) of a country by the

[6] The trouble with such explanation is that although the US oil-fields are not as rich as those in the Middle-East and some other oil-producing countries, it is hard to accept that the US is poor in natural resources or innovations that may create natural resources such as for instance the production of oil or gas through the shale fracking technique.

[7] They used an index which captures the skilled and unskilled labour. Their index is constructed using the discounted industry-wage differential following Branson and Monoyios (1977).

capital-labour ratio in net exports depending on whether this ratio exceeds (or falls short) of the capital-labour ratio in domestic consumption. As a consequence, Leontief's data, according to Leamer (1980, pp. 495-496) show that for the year 1947 the USA's net exports were more capital-intensive than the consumption expenditures of the same year suggesting that the US economy was in effect more capital than labour-abundant. Clearly, Leamer redefined the problem and the issues contained in the original Leontief's study.

Wolff (2004) working in the spirit of Leontief's initial study found that the "paradoxical results" continue to hold true for the benchmark input-output data of the US economy spanning the period 1947 to 1996. However, he argued that with the passage of time the paradox gets weaker and by projecting his findings into the future, he speculated the possible removal of the paradox in the US economy. Our article inspired by the same approach addresses the issue starting from where Wolff's study ended using more recent input-output data, and in so doing it provides an answer to the question of whether or not Leontief's paradox is strengthened or weakened with the passage of time. Table 1 below summarizes the findings of various studies testing the Leontief's Paradox for a number of countries and years.

Table 1: Summary of studies

Author	Year	Country or countries	Confirmation of Leontief's Paradox
Leontief	1953, 1956	USA	yes
Stolper and Roskamp	1959	East Germany	no
Wahl	1961	Canada	yes
Bharadwaj	1962	India	yes
Baldwin	1971,1979	USA	yes
Hirsch	1979	28 countries	no
Leamer	1980	USA	no
Tatemoto and Ichimura	1959	Japan	yes
Stern & Maskus	1981	USA	1958, yes; 1972, no
Tsao	1980	USA, Taiwan	yes
Bowen, Leamer and Sveikauskas	1987	USA and 27 countries	Reject the H-O-V
Duchin	1990	USA	yes
Trefler	1993, 1995	33 different countries	yes
Davis et al.	1997	Japanese regions	no
Hakura	2001	Various countries	no
Davies & Weinstein	2001	10 OECD countries and the rest of the world aggregated	yes
Wolff	2004	USA	yes

3. Methodology and Data

In our study, instead of assuming *a priori* that the US economy is a capital-abundant country, we used data on capital stock and employment[8] in the effort to compare the US capital-labour ratio relative to that of other countries. The idea is that if the US capital-labour ratio is above the world average, then according to the H-O model, the US should export capital-intensive products and import labour-intensive ones; if the converse holds true, then the Leontief's paradox is ascertained.

We estimate the world capital intensity per decade spanning the period 1950-2010. In Table 2, we display the summary results for the top 15 countries for which data on net capital stock and employment are available. The last row of Table 2 reports the world's average capital-labour ratio in million of US dollars of 2005. Our estimates confirm that the US is an overwhelmingly capital-abundant country as this is indicated by the results displayed in Table 2.

Table 2: Countries with capital-labour ratio higher than the world's average in 2005 USD

1950-1959		1960-1969		1970-1979		1980-1989		1990-1999		2000-2009	
Country	Capital-labour ratio	Country	Capital-labour ratio	Country	Capital-labour ratio	Country	Capital-labour ratio	Country	Capital-labour ratio	Country	Capital-labour ratio
USA	**116451.47**	LUX	158358.92	QAT	773537	QAT	403900.67	BRN	311600.03	QAT	406855.34
AUS	111944.32	USA	**148749.01**	SAU	210723.18	BRN	315390.36	QAT	295968.35	BRN	316142.01
LUX	108319.54	AUS	131294.79	BHR	207889.3	BHR	230062.52	LUX	245901.43	SGP	294474.79
ISL	60733.59	ISL	88502.73	LUX	189784.89	SAU	229957.16	ITA	242034.83	ITA	277143.69
BEL	58973.53	NOR	81792.44	USA	**178340.39**	LUX	228017.8	BHR	241827.45	LUX	271913.97
CAN	54809.04	NLD	80113.97	KWT	173761.52	LBN	210770.57	FIN	223787.52	BHR	269397.14
CHE	54745.04	CHE	78370.71	AUS	146001.11	USA	**197899.18**	USA	**220534.25**	JPN	261584.86
ARG	53263.57	BEL	77946.32	NLD	133655.17	ITA	187947.08	SAU	210428.43	USA	**260018.69**
NOR	52654.17	ARG	73988.33	ITA	132197.93	AUS	180469	FRA	209758.71	HKG	252502.25
VEN	52412.37	FRA	73489.96	ISL	125826.58	FRA	171434.41	AUS	207089.89	FIN	244962.94
NLD	52390.94	DNK	71524.49	FRA	125429.3	NLD	169875.98	BEL	206198.53	BEL	244637.26
ECU	48669.74	ITA	71214.99	NOR	122030.96	KWT	166087.09	AUT	204365.77	AUS	240491.33
GBR	47822.89	CAN	71056.69	CHE	117991.27	GAB	163739.62	JPN	204019.3	KWT	239563.72
DNK	47605.6	VEN	70846.97	BEL	116258.72	NOR	163593.94	NOR	200924.4	NOR	236947.88
NZL	45688	CYP	70101.83	DNK	115046.83	BEL	161064.83	SGP	197981.43	AUT	236299.92
World Average	**42149.23**		**35932.96**		**59488.65**		**61733.02**		**68017.72**		**82061.88**

Source: Authors' calculation

[8] Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2013), "The Next Generation of the Penn World Table" available at www.ggdc.net/pwt

Having established on the basis of available data that the US is a capital-abundant economy we test the predictions of the H-O model using input-output data from the Bureau of Economic Analysis.[9] Since our analysis will be intertemporal we deflate our vectors and matrices in terms of the base year 2005 (Dietzenbacher and Temurshoev, 2012, p. 2, see the Appendix for details). Total capital requirements are estimated by the ratio of net capital stock per unit of output for each industry. Employment requirements are obtained by dividing the total labour hours in millions that individuals contribute to the production of each industry by its corresponding real gross output.

Thus, the direct and indirect capital and labour requirements for exports, L_x, and imports, L_m, we work as follows:

$$L_x = \frac{\mathbf{k}[\mathbf{I}-\mathbf{A}]^{-1}\mathbf{x}}{\mathbf{l}[\mathbf{I}-\mathbf{A}]^{-1}\mathbf{x}} \qquad \text{and} \qquad L_m = \frac{\mathbf{k}[\mathbf{I}-\mathbf{A}]^{-1}\mathbf{m}}{\mathbf{l}[\mathbf{I}-\mathbf{A}]^{-1}\mathbf{m}}$$

Where $\mathbf{x}$ is the column vector of export shares by industry; $\mathbf{m}$ is the column vector of imports shares by industry; $\mathbf{I}$ is the identity matrix; $[\mathbf{I}-\mathbf{A}]^{-1}$ is the Leontief inverse; $\mathbf{k}$ is the row vector of net capital stock coefficients per unit of output; and $\mathbf{l}$ is the row vector of direct employment coefficients. Hence, in our treatment of capital, we restrict ourselves to the marginalist view according to which the intermediate goods or what is the same thing circulating capital is excluded from the definition of capital proper for reasons of double counting. The proper treatment of capital goods though should include all the produced means of production, that is fixed capital along with the stock of materials used up in production (or circulating capital). Thus, the numerators of the above fractions indicate the fixed capital content of exports and imports, whereas the denominators indicate the respective labour content of exports and imports. In so doing, we in effect create an economy with two primary factors of production producing two composite commodities, one designed to capture the factor content of exports and the other that of imports. Consequently, the hypotheses of H-O model can be subjected to what we think a fair empirical test.

4. Results and their Evaluation

Tables 3 and 4 present the structure of US exports and imports expressed by industry shares estimated at current prices for selected top industries over the examined period.

[9] See the Appendix for the source of data and methods of estimations.

We observe that some industries display a significant decrease in their export shares over the years. For example, the share of computer and electronic products (industry 13) was rising reaching its peak 16.40% in 2000, and then declined steadily reaching the level of 6.83% in 2012; however, its status as one of the top exporting industries remained intact. The petroleum and coal products (industry 24) whose share in total exports was less than 1% in the first two years of our study, and over the years, it kept rising reaching the level of 6.5%, in 2012. Table 3 reveals that the US exports are mainly technology goods (in parentheses the ranking of each industry). There is a constant contribution of high and medium-high technology exports such as machinery (industry 12), whose share in 2005 was 8.10%; transport equipment (industry 16) whose share in total exports attained its maximum at 8.33% in 1998 while some industries such as for example the motor vehicles bodies and trailers and parts (industry 15) whose share in the total exports declined from 7.75% in 1998 to 5.71% in 2012. The computer and electronic products industry (13) displays a decline over the entire period while the petroleum and coal products (industry 15) increased markedly in the post-2007 years. The last row of Table 3 presents the correlation coefficient of the sectoral exports of each year relative to the last year of our study. We observe that the correlation coefficient remains high above 85%, with small variability (standard deviation of 4.98% and a coefficient of variation 5.41%) suggesting moderate changes in the structure of the US exports over the entire period of our study.

Table 3: Percentage composition of US exports (current prices)*

	Industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
25	**Chemical products**	7.25% (5)	7.18% (6)	7.64% (4)	7.83% (4)	8.34% (3)	8.94% (2)	9.80% (2)	9.62% (2)	9.42% (2)	9.45% (1)	9.66% (1)	9.28% (2)	9.45% (1)	9.45% (1)	9.33% (1)
27	**Wholesale trade**	9.11% (2)	8.85% (2)	9.15% (2)	8.77% (2)	8.70% (2)	8.40% (3)	8.55% (3)	8.61% (3)	8.84% (3)	8.78% (3)	9.38% (2)	9.29% (1)	9.24% (2)	9.24% (2)	8.78% (2)
12	**Machinery**	8.05% (4)	7.67% (4)	8.42% (3)	8.03% (3)	7.68% (5)	7.25% (5)	8.06% (4)	8.10% (4)	8.07% (4)	8.01% (4)	7.88% (3)	6.97% (4)	7.19% (3)	7.19% (3)	7.20% (3)
13	**Computer and electronic products**	14.40% (1)	15.14% (1)	16.40% (1)	14.49% (1)	12.74% (1)	11.82% (1)	11.36% (1)	10.50% (1)	9.90% (1)	9.02% (2)	7.88% (4)	7.24% (3)	6.32% (5)	6.32% (5)	6.81% (4)
24	**Petroleum and coal products**	0.93% (25)	0.95% (2)5	1.25% (23)	1.22% (24)	1.19% (24)	1.38% (21)	1.60% (19)	2.10% (14)	2.60% (10)	2.96% (10)	4.70% (9)	3.60% (10)	6.34% (4)	6.34% (4)	6.50% (5)
16	**Other transportation equipment**	8.33% (3)	7.77% (3)	6.39% (6)	7.36% (5)	7.02% (6)	6.37% (6)	5.89% (7)	6.32% (6)	6.85% (6)	6.83% (5)	6.10% (5)	6.74% (5)	5.36% (7)	5.36% (7)	5.93% (6)
15	**Motor vehicles. bodies and trailers. and parts**	7.15% (6)	7.24% (5)	7.20% (5)	7.22% (6)	7.79% (4)	7.60% (4)	7.21% (5)	6.96% (5)	6.92% (5)	6.80% (6)	6.03% (6)	4.68% (8)	5.71% (6)	5.71% (6)	5.78% (7)
50	**Management of companies and enterprises**	2.97% (9)	3.37% (9)	3.50% (8)	3.98% (8)	4.40% (8)	4.43% (8)	4.36% (8)	4.01% (8)	4.44% (8)	5.07% (8)	4.82% (8)	5.67% (6)	5.02% (9)	5.02% (9)	4.19% (8)
	Correlation with 2012 export composition	86%	85%	85%	87%	90%	91%	92%	93%	95%	96%	98%	96%	99%	99%	100%

* *Note:* Authors' calculations see Appendix, Table A-2. (in parenthesis the ranking of industries)

Table 4 presents the percentage composition of US imports by major industries. The import share of computer and electronic products industry (13) ranked high and remained fairly constant around 14%. The oil and gas extraction industry (3) starts with a fairly high share in the total imports 4.79% and reaches its maximum 18.51% in 2008 and then falls to 13.82% in the last year of our analysis. One could speculate that this fall was because of the recession of 2008; but also by the import substitution due to technological change in this particular industry. Other important industries are motor vehicles bodies trailers and parts (industry 15); apparel leather and allied products (industry 21); petroleum and coal products (industry 24). The last row of Table 4 presents the correlation coefficient of the sectoral imports to the total volume of imports which shows a remarkable stability of the composition of the US imports over the period of our investigation. Over the years, the correlation coefficient remains high (98.7%) with small variability (standard deviation 4.09% and coefficient of variation 4.29%), suggesting that there have not been any dramatic changes in the structure of the US imports during the period under investigation.

Table 4: Percentage composition of US imports (current prices)*

No	industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
3	Oil and gas extraction	4.79% (7)	5.89% (6)	8.52% (3)	8.37% (5)	7.46% (5)	9.22% (3)	10.52 % (3)	12.6 7% (2)	13.19 % (2)	13.52 % (1)	18.51 % (1)	12.91 % (2)	15.48 % (1)	15.48 % (1)	13.82 % (1)
13	Computer and electronic products	17.48 % (1)	18.60 % (1)	18.21 % (1)	16.32 % (1)	15.22 % (1)	14.31% (2)	14.19 % (1)	13.7 9% (1)	13.40 % (1)	13.05 % (2)	12.55 % (2)	13.89 % (1)	12.57 % (2)	12.57 % (2)	12.34 % (2)
15	Motor vehicles. bodies and trailers. and parts	13.83 % (2)	15.85 % (2)	14.19 % (2)	15.18 % (2)	15.04 % (2)	14.34% (1)	13.17 % (2)	12.1 0% (3)	11.93 % (3)	11.05 % (3)	9.81% (3)	8.43% (4)	9.76% (3)	9.76% (3)	11.13 % (3)
25	Chemical products	7.13% (4)	7.51% (4)	7.23% (5)	8.44% 4	8.26% 3	8.62% (4)	8.23 % (4)	8.38 % (4)	8.36% (4)	8.42% (4)	9.28% (4)	9.72% (3)	9.00% (4)	9.00% (4)	8.55% (4)
21	Apparel and leather and allied products	8.65% (3)	8.54% (3)	7.90% (4)	8.69% 3	7.98% (4)	7.80% (5)	7.15 % (5)	6.78 % (5)	6.39% (5)	6.09% (5)	5.83% (5)	6.40% (5)	5.85% (5)	5.85% (5)	6.07% (5)
12	Machinery	7.10% (5)	6.84% (5)	6.14% (6)	6.17% (6)	5.40% (6)	5.56% (6)	5.78 % (6)	5.89 % (6)	5.91% (6)	5.70% (6)	5.75% (6)	5.08% (6)	5.66% (6)	5.66% (6)	5.97% (6)
24	Petroleum and coal products	1.15% 23	1.38% 22	2.07% (13)	2.25% (13)	1.84% (13)	2.20% 12	2.70 % 11	3.73 % (8)	3.66% (9)	4.17% (8)	4.76% (7)	3.61% (10)	4.49% (7)	4.49% (7)	4.68% (7)
10	Primary metals	3.98% (8)	3.44% (9)	3.36% (8)	3.14% (10)	2.71% (10)	2.36% (10)	3.47 % 8	3.53 % (9)	4.34% 7	4.07% (9)	4.42% (8)	2.81% 13	3.78% (8)	3.78% (8)	3.56% (8)
19	Food and beverage and tobacco products	3.11% (10)	3.20% (10)	2.81% (10)	3.26% (9)	3.23% (9)	3.34% (8)	3.22 % (10)	3.09 % (11)	3.02% (11)	3.02% (11)	3.19% (11)	3.63% (9)	3.38% 10	3.38% 10	3.37% (9)
18	Miscellaneous manufacturing	4.83% (6)	4.90% (7)	4.58% (7)	5.04% (7)	5.05% (7)	4.78% (7)	4.48 % (7)	4.37 % (7)	4.22% (8)	4.26% (7)	4.05% (9)	4.16% (7)	3.59% (9)	3.59% (9)	3.32% (10)
	Correlation with 2012 import composition	88%	89%	93%	94%	93%	96%	97%	99%	99%	99%	98%	98%	99%	99%	100%

* *Note:* Authors' calculations, see Appendix, Table A-3.(in parenthesis the ranking of industries)

In Table 5, we observe that over the years the ratio between the capital intensity of exports and imports widens as it falls from 0.89 in 1998 to 0.85 in 2012 while in 2011 it reached its minimum equal to 0.77. Hence, our results like those derived by Wolff (2004) —for the benchmark years 1947, 1958, 1967, 1977, 1987 and 1996—ascertain the Leontief's paradox; however, unlike Wolff's speculation about the possible disappearance of the Leontief's paradox in the post-1996 years, our results indicate that the ratio of factor content of exports to imports falls over the years, thereby strengthening rather than weakening the original Leontief's results.

A referee of this journal suggested testing the sensitivity of the results without the wholesale industry (27) on the grounds that it is not an industry proper. The reason is that the output of the wholesale industry is the trade margin allocated over the other industries as well as over the exported and imported goods and services. The wholesale trade margin of the exports is by far higher than that of imports (see Tables A2 and A3) and given that we are dealing (after the year 2000) with a labour-

intensive industry (see Table A1) which may affect the overall outcome.[10] In Table 5 in the second set of three columns, we report the results without the wholesale industry which paint essentially the same picture, i.e. the US exports are labour and not capital-intensive. In effect, the difference between the first two sets of columns is minimal.

We cannot say the same with respect to the oil and gas industry (number 3) which is one from the top capital-intensive industries (see Table A1) and also its imports exceed by far its exports (see Tables 4, A2 and A3). The effect of this particular industry may be mainly responsible for the paradoxical for the H-O theory results. Thus, the third set of three columns of Table 5 reports the results of our sensitivity analysis without accounting for the effects of oil and gas industry. We observe that only for the year 1998 the US exports are labour-intensive, but from the year 1999 onwards our sensitivity analysis shows that the USA might be characterized as capital-intensive goods exporting country but not overwhelmingly so. The capital-labour ratio of exports to imports is somewhat above one meaning that with a slight change in the distribution of income the ever-present likelihood of factor intensity reversals to occur increases. Furthermore, since we have a ratio a little above one by 11 percent on an average this by no means lends robust support to the H-O model. The Leontief paradox holds in the sense that the US an overwhelmingly capital-abundant country exports goods and services whose capital-intensity is only slightly higher than the capital intensity of the imported goods. Results such as the above suggest that the rest of the world on an average is endowed approximately with the same combination of factor endowments as the US economy. We know though that the US economy's capital-intensity measured by the capital-labour ratio is approximately three to four times higher than the world average over the years (see Table 2).

If we continue this hypothetical exercise to exclude both wholesale trade and oil and gas industries the results shown in the fourth set of columns do not change the overall picture. The difference between the capital intensity of exported goods relative to imported increased on an average by 13 percent. Even if that were the case, these results may provide only fragile support to the H-O model. First, because it is not permissible to simply assume away industries because of difficulties in definitions

[10] The capital and labour-intensities of industries are estimated in terms of vertically integrated respective coefficients and are displayed in Table A1 in the Appendix.

and estimating methods. Second, a theory must prove itself under the worse for its premises circumstances and not to eliminate whatever it stands as an obstacle to its falsification. Third, the above are just average results, and under these circumstances the likelihood that individual industries switch characterization from capital to labour-intensive increases considerably.

Table 5: Capital - Labour Ratio of exported and imported goods in the US economy, 1998-2012 per million of constant 2005 dollars.

Year	(1)			(2)			(3)			(4)		
	L_x	L_M	L_x/L_M	L_x*	L_M*	L_x*/L_M*	L_x*	L_M*	L_x*/L_M*	L_x*	L_M*	L_x*/L_M*
1998	53.33	60.17	0.89	55.22	59.74	0.92	52.32	49.56	1.06	55.6693	51.508	1.08
1999	57.75	64.81	0.89	61.59	67.78	0.91	56.51	53.40	1.06	60.2043	55.598	1.08
2000	63.23	72.40	0.87	65.16	60.16	1.08	61.02	57.18	1.07	60.1644	56.5074	1.06
2001	84.80	89.52	0.95	84.80	89.52	0.95	81.87	70.41	1.16	81.8664	70.4133	1.16
2002	91.94	102.63	0.90	99.24	107.82	0.92	88.85	80.03	1.11	95.7899	83.6291	1.15
2003	102.53	114.59	0.89	110.53	120.19	0.92	96.93	86.09	1.13	104.2541	89.7215	1.16
2004	116.74	134.84	0.87	129.00	145.38	0.89	106.24	94.76	1.12	115.4866	99.5101	1.16
2005	135.23	164.98	0.82	145.61	173.28	0.84	117.95	104.91	1.12	126.3914	109.1446	1.16
2006	148.66	190.94	0.78	160.83	201.06	0.80	123.84	111.58	1.11	132.9886	116.1802	1.14
2007	171.29	205.13	0.83	168.44	205.43	0.82	147.74	127.36	1.16	144.5419	125.3484	1.15
2008	183.84	226.10	0.81	199.37	236.99	0.84	146.38	132.93	1.10	157.7726	138.0145	1.14
2009	171.22	219.60	0.78	187.24	230.64	0.81	156.75	142.81	1.10	170.8085	148.8258	1.15
2010	188.25	224.50	0.84	194.37	233.12	0.83	165.55	143.52	1.15	170.6482	148.1098	1.15
2011	192.12	250.12	0.77	207.91	262.53	0.79	168.27	160.85	1.05	181.4037	167.6052	1.08
2012	196.13	230.04	0.85	208.71	240.28	0.87	177.49	160.18	1.11	187.88	165.03	1.14
Ratio of 2012 to 1998	**3.68**	**3.82**	**0.96**	3.78	4.02	0.94	**3.39**	**3.23**	**1.05**	3.37	3.20	1.05
Average			0.85			0.88			1.11			1.13

Note:(1) indicate estimations including all industries, (2) estimations without the wholesale trade industry, (3) estimations without the oil and gas extraction industry, (4) estimations without the oil and gas extraction and wholesale trade industries.

5. Summary and Conclusions

In this paper, we tested whether or not Leontief's Paradox continues to hold in the face of recent input-output data for the US economy spanning the period 1998-2012. We estimated both the capital and labour content of exports and imports of the US economy and we found that the US on an average exports labour-intensive products and imports capital-intensive ones, a result which contradicts the predictions of the H-O model. In other words, our results confirm that the so-called paradox not only

persists over the years, but it is reinforced with the passage of time. The findings suggest that the capital intensity of exports and imports falls from the peak of 0.89 in 1998 to 0.85 in 2012 while in 2011 reached its minimum equal to 0.77. As a consequence, Wolff's (2004) conjecture for the eclipse of the paradox in the post-1996 years does not hold true in the face of more recent data.

In our sensitivity analysis, we found that the paradoxical for the H-O results hold true in the case we assume away the effects of the labour-intensive wholesale trade industry. It is interesting to note that when we continued our sensitivity exercises by assuming away the oil and gas industry the results gave weak support to the H-O model, in the sense that even a slight change in income distribution (e.g., a change in wages or taxes) may overturn the ratio of capital intensities of exported to imported goods to a figure smaller than one. The combined effect of both (wholesale trade and oil and gas) industries gave a deviation from one by 13 percent rendering the Leontief paradox an issue that continues to raise serious questions about the consistency of neoclassical theory of value and distribution and its extension to international trade and this because a theory must be tested under the worse, not the best possible circumstances.

Finally, our data on exports and imports showed that the structure of the US economy's trade is characterized by relative stability as this can be judged by the standard deviation of the shares and the ranking of the industries over the years. Also, the capital intensities of industries in the US economy during the years of our investigation displayed an overall rising trend that was interrupted by the great recession of 2008.

Refferences

Baldwin R. (1971) Determinants of the commodity structure of us trade. *American Economic Review* 61:126-146.

Bharadwaj R. (1962) Factor proportions and the structure of india-u.s. trade. *Indian Economic Journal* 10:105-116

Bowen H., Leamer E. and Sveikauskas L. (1987) Multicountry, multi-factor tests of the factor abudance theory. *American Economic Review*, 77(5):791-809.

Branson W. and Monoyios N. (1977) Factor inputs human capital and whether a stock or a flow measure of in U.S. Trade. *Journal of International Economics* (7):111-131.

Buchanan N. (1955) Lines on the Leontief Paradox. *Economia Internazionale*, 8:791-794.

Davis D., Weinstein D., Bradford S. and Shimpo K. (1997) Using international and Japanese regional data to determine when the factor abundance theory of trade works. *American Economic Review*, 87(3): 421-46.

Davis D. Weinstein D. (2001) An account of global factor trade. American Economic Review, 91: 1423- 1453

Diab M. (1956) *The United States capital position and the structure of its foreign trade*. Amsterham: North- Holland Publishing Co.

Dietzenbacher E. and Temurshoev U. (2012) Input-output impact analysis in current or constant prices: does it matter? *Journal of Economic Structures*, 1(1), p.4.

Duchin F. (1990) Technological change and intrernational trade. *Economic Systems Research,* 2: 47-52.

Ellsworth P. (1954). The structure of american foreign trade: A new view examined, *The Review of Economics and Statistics* 36: 279-285.

Feenstra R., Inklaar R. and Timmer M. (2013) The next generation of the Penn World Table, available for download at www.ggdc.net/pwt

Hakura D. (1999) A Test of the General Validity of the Heckscher-Ohlin Theorem for Trade in the European, IMF Working Papers 99/70*, International Monetary Fund*.

Hirsch S. (1979) The Leontief Paradox in a Multi-Country Setting: Reply, *Review of World Economics* (*Weltwirtschaftliches Archiv*), 115:146-148

Houthakker H. (1957) An international comparison of household expenditure patterns, commemorating the centenary of conclusions engel's law. *Econometrica* 25:532-551.

Kreinin M. (1965) Comparative labour effectiveness and the leontief scarce-factor paradox. *The American Economic Review*, Vol. 55, No. ½.

Krugman P., Obstfeld M. and Melitz M. (2011) *International Economics* (9th Edition).

Leamer E. (1980) The Leontief Paradox, Reconsidered. *Journal of Political Economy*, 88(3): 495-503.

Leontief W. (1953) Domestic production and foreign trade: The american capital position re-examined. *Proceedings of the American Philosophical Society*, 97:332-49

Leontief W. (1956) Factors proportion and the structure of american trade: Further theoritical and empirical Analysis, *The Review of Economics and Statistics*, 38(4): 386-407

Leontief W. (1985). Technological change, prices, wages and rates of return on capital in the U.S. economy. In W. Leontief (1986), *Input-Output Economics* (pp. 392-417). Oxford: Oxford University Press.

Pasinetti L. (1981) Structural Change and Economic Growth. Cambridge: Cambridge University Press.

Pasinetti L. (1988) Technical Progress and International Trade. *Empirica* 15(1): 139-147

Samuelson P. (1948b) International trade and equalization of factor prices. *Economic Journal* 58:163-184. Reprinted in ed. JE Stiglitz (1966), 847-868.

Schefold B. and Han Z. (2006) An empirical investigation of paradoxes: Reswitching and reverse capital deepening in capital theory. *Cambridge Journal of Economics*, 30:737-765;

Steedman I. (1979) *Trade Among Growing Economies*. Cambridge: Cambridge University Press.

Steedman I. and Metcalfe J. (1977) Reswitching, primary inputs and the Heckscher-Ohlin-Samuelson theory of trade. *Journal of International Economics* 7:201-208.

Stern R. and Maskus K. (1981) Determinants of the structure of U.S. foreign trade, 1958-76. *Journal of International Economics* 11:207-24.

Stolper W. and Roskamp K. (1962) Input-Output table for east germany, with applications to foreign trade. *Social Research*, 29(2): 225-237.

Swerling B. (1953) Capital shortage and labour surplus in the United States. *Review of Economics and Statistics*, 36:286-289.

Tatemoto M. Ichimura S. (1959) Factor proportions and foreign trade: the case of Japan, *Review of Economics and Statistics* 41:442–46.

Trefler D. (1993) International factor price differences: Leontief was right!, *Journal of Political Economy* 101: 961-87.

Trefler D. (1995) The case of the missing trade and other mysteries. *American Economic Review*, 85(5): 1029-46.

Tsaliki P. (2008) Economic development, human capital and technical change: the question of machinery revisited. *International Review of Economics*, Springer, vol. 55(4): 363-371.

Tsao J. (1980) Factor endowments and trade of the United States and Taiwan: The Leontief paradox re-examined. *Empirical Economics*,.5(1):245-253.

Tsoulfidis L. and Mariolis T. (2007) Labour values, prices of production and the effects of income distribution: evidence from the greek economy, *Economic Systems Research*, 19(4): 425-437.

Vanek J. (1963) *The natural resource content of United States foreign trade*, 1870–1955. Cambridge, MA: The MIT Press.

Vanek J. (1968) The Factor Proportions Theory: the *N*-Factor Case, *Kyklos* 21:749–756

Wahl D. (1961) Capital and labour requirements for Canada's foreign trade. *Canadian Journal of Economics and Political Science*, 26:359-369.

Wolff E. (2004) What has happened to the Leontief Paradox?, chapter 11 in Wassily Leontief and Input- Output Economics, Cambridge Unversity Press, New York.

Appendix: Data and Estimating Methods

The data for the estimation of matrix of technological coefficients **A** and most of the other variables are available from the Bureau of Economic Analysis (BEA) site http://www.bea.gov. More specifically, the BEA provides data at various industry detail from which we opted for the 65 by 65 interindustry structure. The last four industries are government enterprises which although they do not engage in international trade in any direct way; nevertheless, we used them in our estimation in order to have the complete interindustry interactions. In particular, the BEA site gives

the Leontief inverse $[\mathbf{I} - \mathbf{A}]^{-1}$ from which we can derive the matrix of technological coefficients **A** truncating the last four rows.

The price deflators are also provided for three-digit NAICS industry in BEA database using 2005 as the base year. The deflating process is carried out in the following way:

$$< \mathbf{p} >^{-1} \mathbf{A} < \mathbf{p} >= \mathrm{A}^{*}$$

where **p** stands for the vector of prices and < > expresses the diagonalization of a vector. The vector of employment coefficients, **a** is estimated as

$$\mathbf{a} = \mathbf{l} < q >^{-\mathbf{1}}$$

where **l** denotes the total hours in millions that individuals contribute to the production of the value of gross output **q** of domestic goods and services evaluated in constant 2005 prices.

For the estimation of the vector of capital stock coefficients, **k**, we divide the real net capital stock of each industry in prices of 2005 (www.bea.gov) by the gross output, **q** also estimated at constant prices of 2005. Finally, the column vectors of exports **x** and imports **m** are also available in the input-output tables. The next step was to form shares of exports and imports by dividing each industry's exports or imports but the respective total magnitudes.

In Table A1 below we display the nomenclature of our 61 industries and their capital-intensities estimated by the ratio of vertically integrated capital to vertically integrated employment coefficients. Tables A2 and A3 display the export and import shares and in the parentheses are indicated the ranking of each industry with respect to the year 2012.

Table A-1. Classification of industries according to North American Industry Classification System (NAICS) and the capital-intensity of each industry *

	Industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1	Farms	5.29	3.93	4.72	5.09	5.16	5.88	6.55	7.10	7.06	7.50	9.42	7.09	8.20	10.31	7.68
2	Forestry, fishing, and related activities	2.00	1.75	1.89	1.91	1.95	2.07	2.17	2.55	2.55	2.86	3.70	2.85	4.29	3.51	2.60
3	Oil and gas extraction	3.13	2.18	5.05	6.02	6.26	9.71	14.24	20.51	25.37	28.65	37.25	18.53	18.77	23.69	32.24
4	Mining, except oil and gas	3.26	2.51	3.36	3.52	3.79	4.24	4.93	5.65	5.23	7.90	9.68	9.66	9.39	11.50	10.43
5	Support activities for mining	2.71	1.99	2.38	2.36	2.73	3.02	3.41	3.88	3.31	4.84	5.83	5.38	4.78	5.88	2.29
6	Utilities	7.69	4.86	6.46	6.36	8.42	11.60	15.79	16.73	18.37	23.57	28.06	23.80	25.66	30.50	20.71
7	Construction	1.11	0.85	1.11	1.15	1.19	1.32	1.52	1.82	1.81	2.10	2.60	2.48	2.13	2.52	1.69
8	Wood products	1.70	1.52	1.73	1.82	1.91	2.08	2.33	2.68	2.79	3.23	4.05	3.50	3.80	4.05	3.14
9	Non metallic mineral	2.11	1.84	2.16	2.30	2.40	2.68	3.08	3.59	3.41	4.54	5.76	5.37	5.41	6.18	4.50

	products															
10	**Primary metals**	2.52	2.00	2.50	2.72	2.90	3.19	3.77	4.31	3.79	5.65	6.88	6.39	6.40	7.73	5.40
11	**Fabricated metal products**	1.72	1.51	1.77	1.92	2.03	2.21	2.49	2.84	2.68	3.48	4.20	3.79	3.70	4.48	3.29
12	**Machinery**	1.92	1.79	1.99	2.16	2.28	2.42	2.67	2.94	2.81	3.54	4.13	3.89	3.73	4.40	3.45
13	**Computer and electronic products**	3.54	3.80	2.73	2.86	3.11	3.15	3.19	3.37	3.42	3.37	3.80	3.56	3.20	3.52	4.29
14	**Electrical equipment, appliances, and components**	2.13	1.89	2.07	2.21	2.30	2.44	2.77	3.12	2.92	3.84	4.49	4.07	4.16	4.89	3.35
15	**Motor vehicles, bodies and trailers, and parts**	1.99	1.90	1.97	2.12	2.19	2.17	2.64	3.01	2.96	3.64	4.39	4.20	4.14	4.86	3.67
16	**Other transportation equipment**	2.06	1.79	1.97	1.99	2.05	2.10	2.33	2.48	2.42	3.03	3.46	3.09	3.01	3.33	3.55
17	**Furniture and related products**	1.31	1.17	1.35	1.45	1.60	1.73	1.95	2.24	2.20	2.72	3.45	2.99	2.98	3.53	3.36
18	**Miscellaneous manufacturing**	1.78	1.63	1.82	1.94	2.04	2.20	2.36	2.66	2.59	3.18	3.66	3.18	3.25	3.96	2.47
19	**Food and beverage and tobacco products**	2.79	2.34	2.78	3.01	3.06	3.37	3.89	4.33	4.38	5.14	6.45	5.15	5.51	6.79	3.84
20	**Textile mills and textile product mills**	2.19	2.00	2.25	2.43	2.54	2.88	3.21	3.72	3.83	4.57	5.78	5.21	5.32	6.40	3.86
21	**Apparel and leather and allied products**	1.51	1.47	1.64	1.76	1.82	2.05	2.26	2.65	2.77	2.77	3.12	2.84	3.08	3.58	3.36
22	**Paper products**	2.49	2.17	2.62	2.76	2.80	3.13	3.58	4.16	4.06	5.12	6.40	5.45	5.62	6.42	2.85
23	**Printing and related support activities**	1.51	1.45	1.67	1.81	1.92	2.09	2.39	2.77	2.73	3.27	3.96	3.49	3.52	4.01	3.93
24	**Petroleum and coal products**	3.05	2.10	4.59	5.18	5.03	8.27	12.11	16.74	18.63	23.15	30.94	15.31	16.86	21.51	8.71
25	**Chemical products**	2.85	2.45	3.15	3.35	3.49	4.03	4.82	5.61	5.60	7.09	9.47	7.62	8.08	10.27	6.20
26	**Plastics and rubber products**	2.09	1.84	2.20	2.36	2.45	2.74	3.15	3.71	3.63	4.62	5.91	4.94	5.05	6.20	7.08
27	**Wholesale trade**	1.01	1.08	1.18	1.25	1.39	1.48	1.71	1.99	1.98	2.15	2.47	2.06	2.31	2.62	3.19
28	**Retail trade**	1.45	1.43	1.71	1.84	2.03	2.23	2.68	3.07	3.10	3.55	4.05	3.80	3.86	4.27	3.33
29	**Air transportation**	2.92	2.69	3.41	3.56	3.67	4.07	4.70	5.78	5.60	7.54	10.49	6.90	7.23	8.97	5.61
30	**Rail transportation**	6.83	6.14	7.89	8.64	9.17	10.04	10.76	11.31	10.32	14.66	17.65	18.68	16.35	19.52	13.26
31	**Water transportation**	3.16	2.89	3.96	4.15	4.52	5.27	6.11	7.92	7.98	8.96	10.78	6.60	7.62	9.70	5.20
32	**Truck transportation**	1.18	1.02	1.38	1.46	1.60	1.77	2.12	2.88	3.07	3.79	5.34	3.42	3.69	4.60	3.29
33	**Transit and ground passenger transportation**	1.87	1.62	2.17	2.26	2.29	2.46	2.77	3.26	3.29	3.65	4.07	3.39	3.49	3.69	2.97
34	**Pipeline transportation**	4.94	4.41	5.67	7.31	7.42	8.86	12.62	14.80	14.44	17.34	24.46	24.46	26.74	36.57	22.57
35	**Other transportation and support activities**	1.51	1.38	1.75	1.87	1.98	2.12	2.29	2.74	2.81	3.46	4.56	3.31	3.50	4.16	2.56
36	**Warehousing and storage**	0.98	1.10	1.23	1.49	1.78	2.01	1.95	2.05	2.22	2.46	2.91	2.54	2.61	2.89	3.33
37	**Publishing industries (includes software)**	1.56	1.45	1.69	1.89	2.12	2.32	2.59	2.88	2.83	3.11	3.51	3.31	3.17	3.52	2.91
38	**Motion picture and sound recording industries**	3.79	3.84	4.38	5.05	5.52	5.63	6.33	6.92	7.04	8.02	8.46	8.56	8.18	8.81	6.98
39	**Broadcasting and telecommunications**	5.23	4.91	5.02	5.49	5.83	6.04	6.58	6.97	7.22	7.74	8.47	8.51	8.62	9.28	7.96
40	**Information and data processing services**	1.18	1.44	1.60	1.82	2.19	2.39	2.53	2.88	2.86	3.78	4.13	3.95	4.00	4.52	4.01
41	**Federal Reserve banks, credit intermediation, and related activities**	1.75	1.72	2.09	2.21	2.41	2.58	2.93	3.21	3.20	3.70	4.35	2.12	4.20	4.58	5.58
42	**Securities, commodity contracts, and investments**	1.09	1.29	1.38	1.13	1.39	1.71	2.04	2.22	2.05	2.45	2.57	3.02	2.65	2.95	2.04
43	**Insurance carriers and related activities**	1.05	0.98	1.18	1.28	1.43	1.56	1.72	1.90	1.84	2.02	2.32	2.03	1.90	2.18	1.80
44	**Funds, trusts, and other financial vehicles**	1.77	1.80	1.90	2.38	2.92	3.25	3.74	4.28	4.17	4.78	5.32	5.73	5.76	5.88	4.82
45	**Real estate**	24.92	24.19	27.88	31.04	34.00	37.17	38.33	38.88	40.29	49.84	58.92	64.60	56.42	64.84	52.62
46	**Rental and leasing services and lessors of intangible assets**	2.24	2.27	2.99	3.61	4.19	4.60	5.21	5.85	6.04	7.10	7.49	7.45	7.39	7.95	6.03
47	**Legal services**	0.97	0.81	0.94	1.01	1.13	1.35	1.38	1.48	1.57	1.77	1.81	1.65	1.35	1.74	0.97
48	**Computer systems design and related services**	0.62	0.74	0.84	0.95	1.06	1.22	1.43	1.63	1.63	1.80	1.89	1.75	1.61	1.84	0.73
49	**Miscellaneous professional, scientific, and technical services**	1.04	0.92	1.12	1.19	1.28	1.41	1.58	1.81	1.76	1.97	2.15	2.03	1.86	2.03	1.91
50	**Management of companies and enterprises**	1.62	1.41	1.68	1.73	1.84	1.92	2.21	2.42	2.27	2.53	2.77	2.68	2.60	2.87	1.28
51	**Administrative and support services**	0.83	0.78	0.90	0.92	0.96	1.06	1.27	1.49	1.56	1.78	2.20	1.81	1.66	2.08	3.98

52	**Waste management and remediation services**	2.58	2.20	2.81	2.91	2.97	3.22	3.64	4.00	3.94	4.67	5.35	5.02	4.87	5.50	3.46
53	**Educational services**	2.36	2.02	2.74	3.00	3.04	3.30	3.66	4.12	4.12	4.96	5.63	5.33	5.46	5.96	1.44
54	**Ambulatory health care services**	1.26	1.13	1.34	1.40	1.20	1.55	1.77	2.01	2.13	2.34	2.49	2.17	1.88	2.18	3.68
55	**Hospitals and nursing and residential care facilities**	2.01	1.80	2.37	2.56	2.74	2.91	3.23	3.67	3.75	4.35	4.58	4.32	4.32	4.73	4.10
56	**Social assistance**	0.93	0.79	1.07	1.28	1.37	1.51	1.61	1.83	1.89	2.15	2.44	2.28	2.89	2.46	2.13
57	**Performing arts, spectator sports, museums, and related activities**	1.61	1.26	1.70	1.99	2.11	2.23	2.56	2.90	2.85	3.57	3.90	3.88	3.71	3.96	2.99
58	**Amusements, gambling, and recreation industries**	2.06	1.83	2.21	2.44	2.61	2.89	3.33	3.86	3.90	4.46	5.30	5.18	5.00	5.42	5.01
59	**Accommodation**	2.67	3.29	2.91	3.25	3.54	3.81	4.26	4.74	4.75	5.82	7.27	6.89	6.41	6.94	5.26
60	**Food services and drinking places**	1.54	1.38	1.65	1.79	1.91	2.07	2.35	2.76	2.72	2.95	3.42	2.98	2.98	3.44	2.34
61	**Other services, except government**	1.58	1.08	1.62	1.77	1.80	1.99	2.28	2.59	2.63	3.04	3.45	3.14	3.07	3.40	2.83
	Average	2.63	2.36	2.86	3.12	3.36	3.82	4.42	5.05	5.17	6.26	7.60	6.55	6.55	7.71	5.90

Table A-2. Percentage composition of US exports, with industries ranked by 2012 exports (numbers and ranking of each industry)

	industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
25	Chemical products	7.25% (5)	7.18% (6)	7.64% (4)	7.83% (4)	8.34% (3)	8.94% (2)	9.80% (2)	9.62% (2)	9.42% (2)	9.45% (1)	9.66% (1)	9.28% (2)	9.45% (1)	9.45% (1)	9.33% (1)
27	Wholesale trade	9.11% (2)	8.85% (2)	9.15% (2)	8.77% (2)	8.70% (2)	8.40% (3)	8.55% (3)	8.61% (3)	8.84% (3)	8.78% (3)	9.38% (2)	9.29% (1)	9.24% (2)	9.24% (2)	8.78% (2)
12	Machinery	8.05% (4)	7.67% (4)	8.42% (3)	8.03% (3)	7.68% (5)	7.25% (5)	8.06% (4)	8.10% (4)	8.07% (4)	8.01% (4)	7.88% (3)	6.97% (4)	7.19% (3)	7.19% (3)	7.20% (3)
13	Computer and electronic products	14.40% (1)	15.14% (1)	16.40% (1)	14.49% (1)	12.74% (1)	11.82% (1)	11.36% (1)	10.50% (1)	9.90% (1)	9.02% (2)	7.88% (4)	7.24% (3)	6.32% (5)	6.32% (5)	6.81% (4)
24	Petroleum and Coal products	0.93% (25)	0.95% (2)5	1.25% (23)	1.22% (24)	1.19% (24)	1.38% (21)	1.60% (19)	2.10% (14)	2.60% (10)	2.96% (10)	4.70% (9)	3.60% (10)	6.34% (4)	6.34% (4)	6.50% (5)
16	Other transportation equipment	8.33% (3)	7.77% (3)	6.39% (6)	7.36% (5)	7.02% (6)	6.37% (6)	5.89% (7)	6.32% (6)	6.85% (6)	6.83% (5)	6.10% (5)	6.74% (5)	5.36% (7)	5.36% (7)	5.93% (6)
15	Motor vehicles. bodies and trailers. and parts	7.15% (6)	7.24% (5)	7.20% (5)	7.22% (6)	7.79% (4)	7.60% (4)	7.21% (5)	6.96% (5)	6.92% (5)	6.80% (6)	6.03% (6)	4.68% (8)	5.71% (6)	5.71% (6)	5.78% (7)
50	Management of companies and enterprises	2.97% (9)	3.37% (9)	3.50% (8)	3.98% (8)	4.40% (8)	4.43% (8)	4.36% (8)	4.01% (8)	4.44% (8)	5.07% (8)	4.82% (8)	5.67% (6)	5.02% (9)	5.02% (9)	4.19% (8)
49	Miscellaneous professional. scientific. and technical services	1.58% (17)	1.79% (14)	1.15% (24)	1.37% (22)	1.56% (19)	1.30% (24)	1.45% (23)	1.64% (21)	1.80% (19)	1.74% (20)	1.73% (20)	1.94% (17)	1.85% (17)	1.85% (17)	3.71% (9)
19	Food and beverage and tobacco products	3.86% (8)	3.53% (8)	3.40% (9)	3.69% (9)	3.59% (9)	3.60% (9)	3.28% (9)	3.27% (9)	3.14% (9)	3.27% (9)	3.57% (10)	3.67% (9)	3.65% (10)	3.65% (10)	3.68% (10)
46	Rental and leasing services and lessors of intangible assets	4.31% (7)	4.70% (7)	4.68% (7)	4.82% (7)	5.61% (7)	5.65% (7)	6.09% (6)	6.15% (7)	5.44% (7)	5.41% (7)	5.25% (7)	5.41% (7)	5.14% (8)	5.14% (8)	3.28% (1 1)
1	Farms	2.19% (12)	1.87% (13)	1.91% (13)	2.03% (13)	2.18% (13)	2.41% (10)	2.41% (10)	1.96% (15)	1.94% (17)	2.35% (13)	2.83% (11)	2.61% (12)	2.78% (11)	2.78% (11)	2.92% (12)
29	Air transportation	2.71% (10)	2.60% (10)	2.54% (10)	2.34% (11)	2.34% (10)	2.07% (12)	2.23% (11)	2.29% (11)	2.13% (14)	2.18% (14)	2.46% (13)	2.37% (13)	2.48% (13)	2.48% (13)	2.52% (13)
37	Publishing industries (includes software)	1.45% (20)	1.52% (18)	1.56% (17)	1.56% (17)	1.53% (20)	1.44% (19)	1.46% (22)	1.57% (22)	1.57% (22)	1.88% (18)	1.73% (19)	2.14% (15)	1.84% (18)	1.84% (18)	2.14% (14)
10	Primary metals	1.54% (18)	1.37% (21)	1.46% (19)	1.42% (20)	1.33% (23)	1.36% (22)	1.57% (20)	1.82% (18)	2.09% (15)	2.16% (15)	2.30% (14)	1.76% (20)	2.09% (14)	2.09% (14)	2.04% (15)
42	Securities. commodity contracts. and investments	1.06% (24)	1.22% (23)	1.36% (21)	1.40% (21)	1.65% (17)	1.72% (16)	2.20% (12)	2.22% (12)	2.34% (12)	2.57% (11)	2.59% (12)	3.04% (11)	2.68% (12)	2.68% (12)	2.02% (16)
41	Federal Reserve banks. credit intermediation. and related activities	1.30% (22)	1.33% (22)	1.33% (22)	1.36% (23)	1.45% (22)	1.34% (23)	1.48% (21)	1.43% (23)	1.45% (23)	1.55% (22)	1.71% (21)	1.97% (16)	1.67% (21)	1.67% (21)	1.98% (17)

18	**Miscellaneous manufacturing**	1.67% (15)	1.72% (15)	1.88% (14)	2.17% (12)	2.19% (11)	2.13% (11)	2.16% (13)	2.34% (1)0	2.34% (11)	2.37% (12)	2.30% (15)	2.27% (14)	2.06% (15)	2.06% (15)	1.92% (18)
11	**Fabricated metal products**	1.99% (13)	2.00% (12)	2.04% (12)	1.95% (14)	1.92% (14)	1.83% (15)	1.82% (16)	1.86% (17)	1.88% (18)	1.86% (19)	1.84% (18)	1.80% (19)	1.82% (19)	1.82% (19)	1.83% (19)
32	**Truck transportation**	1.72% (14)	1.70% (16)	1.76% (15)	1.84% (15)	1.82% (15)	1.85% (14)	1.94% (15)	1.96% (16)	2.01% (16)	1.98% (17)	2.07% (16)	1.94% (18)	1.86% (16)	1.86% (16)	1.80% (20)
14	**Electrical equipment. appliances. and components**	0.0220 (11)	0.0225 (11)	0.0237 (11)	0.0237 (1)0	0.0218 (12)	0.0206 (13)	0.0214 (14)	0.0218 (13)	0.0221 (13)	0.0207 (16)	0.0195 (17)	0.0171 (21)	0.0177 (20)	0.0177 (20)	0.0173 (21)

Table A-3. Percentage composition of US imports with industries ranked by 2012 imports (numbers and ranking of each industry)

	Industry	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
3	**Oil and gas extraction**	4.79% (7)	5.89% (6)	8.52% (3)	8.37% (5)	7.46% (5)	9.22% (3)	10.52% (3)	12.67% (2)	13.19% (2)	13.52% (1)	18.51% (1)	12.91% (2)	15.48% (1)	15.48% (1)	13.82% (1)
13	**Computer and electronic products**	17.48% (1)	18.60% (1)	18.21% (1)	16.32% (1)	15.22% (1)	14.31% (2)	14.19% (1)	13.79% (1)	13.40% (1)	13.05% (2)	12.55% (2)	13.89% (1)	12.57% (2)	12.57% (2)	12.34% (2)
15	**Motor vehicles. bodies and trailers and parts**	13.83% (2)	15.85% (2)	14.19% (2)	15.18% (2)	15.04% (2)	14.34% (1)	13.17% (2)	12.10% (3)	11.93% (3)	11.05% (3)	9.81% (3)	8.43% (4)	9.76% (3)	9.76% (3)	11.13% (3)
25	**Chemical products**	7.13% (4)	7.51% (4)	7.23% (5)	8.44% 4	8.26% 3	8.62% (4)	8.23% (4)	8.38% (4)	8.36% (4)	8.42% (4)	9.28% (4)	9.72% (3)	9.00% (4)	9.00% (4)	8.55% (4)
21	**Apparel and leather and allied products**	8.65% (3)	8.54% (3)	7.90% (4)	8.69% 3	7.98% (4)	7.80% (5)	7.15% (5)	6.78% (5)	6.39% (5)	6.09% (5)	5.83% (5)	6.40% (5)	5.85% (5)	5.85% (5)	6.07% (5)
12	**Machinery**	7.10% (5)	6.84% (5)	6.14% (6)	6.17% (6)	5.40% (6)	5.56% (6)	5.78% (6)	5.89% (6)	5.91% (6)	5.70% (6)	5.75% (6)	5.08% (6)	5.66% (6)	5.66% (6)	5.97% (6)
24	**Petroleum and coal products**	1.15% 23	1.38% 22	2.07% (13)	2.25% (13)	1.84% (13)	2.20% 12	2.70% 11	3.73% (8)	3.66% (9)	4.17% (8)	4.76% (7)	3.61% (10)	4.49% (7)	4.49% (7)	4.68% (7)
10	**Primary metals**	3.98% (8)	3.44% (9)	3.36% (8)	3.14% (10)	2.71% (10)	2.36% (10)	3.47% 8	3.53% (9)	4.34% 7	4.07% (9)	4.42% (8)	2.81% 13	3.78% (8)	3.78% (8)	3.56% (8)
19	**Food and beverage and tobacco products**	3.11% (10)	3.20% (10)	2.81% (10)	3.26% (9)	3.23% (9)	3.34% (8)	3.22% (10)	3.09% (11)	3.02% (11)	3.02% (11)	3.19% (11)	3.63% (9)	3.38% 10	3.38% 10	3.37% (9)
18	**Miscellaneous manufacturing**	4.83% (6)	4.90% (7)	4.58% (7)	5.04% (7)	5.05% (7)	4.78% (7)	4.48% (7)	4.37% (7)	4.22% 8	4.26% (7)	4.05% (9)	4.16% (7)	3.59% (9)	3.59% (9)	3.32% (10)
14	**Electrical equipment. appliances. and components**	3.24% (9)	3.44% (8)	3.24% (9)	3.51% (8)	3.32% (8)	3.24% (9)	3.22% (9)	3.21% (10)	3.27% (10)	3.25% (10)	3.20% (10)	3.28% (11)	3.20% (11)	3.20% (11)	3.30% (11)
49	**Miscellaneous professional. scientific. and technical services**	1.54% (17)	1.72% (15)	1.41% 18	1.67% 16	1.77% 14	1.77% (15)	1.64% 16	1.65% (15)	1.94% (13)	2.03% 14	2.44% (13)	3.01% ((12))	2.72% (12)	2.72% (12)	2.89% (12)
11	**Fabricated metal products**	2.24% 12	2.28% 12	2.14% 12	2.31% 12	2.32% 12	2.23% (11)	2.28% 12	2.33% 12	2.36% 12	2.38% 12	2.37% 14	2.27% 14	2.21% 14	2.21% 14	2.41% 13
43	**Insurance carriers and related activities**	0.78% 25	0.87% 25	0.86% 24	1.43% 20	1.73% 15	1.83% 14	1.81% 14	1.59% 16	1.86% 14	2.22% 13	2.71% 12	3.75% 8	2.42% (13)	2.42% (13)	2.18% 14
26	**Plastics and rubber products**	1.55% 16	1.65% 17	1.47% 17	1.57% 18	1.59% 17	1.63% 16	1.66% 15	1.72% 14	1.69% 16	1.65% 16	1.65% 16	1.74% 16	1.83% 15	1.83% 15	1.91% 15
16	**Other transportation equipment**	2.71% (11)	2.73% (11)	2.46% (11)	3.03% (11)	2.36% (11)	2.07% (13)	1.90% (13)	1.85% (13)	1.80% 15	1.97% 15	1.96% 15	1.99% 15	1.66% 16	1.66% 16	1.85% 16
29	**Air transportation**	1.91% 14	1.92% (13)	1.78% 14	1.83% 14	1.46% 20	1.41% 20	1.43% 20	1.36% 20	1.31% 19	1.26% 19	1.42% 17	1.43% 18	1.29% 19	1.29% 19	1.41% 17
27	**Wholesale trade**	2.00% (13)	1.84% 14	1.66% 15	1.80% 15	1.60% 16	1.58% 18	1.48% 19	1.43% 19	1.36% 18	1.36% 18	-1.36% 61	1.36% 19	1.38% 17	1.38% 17	1.41% 18
1	**Farms**	1.52% 18	1.40% 20	1.13% 23	1.24% 24	1.16% 24	1.13% 24	1.01% 24	1.03% 24	1.04% 24	1.10% 23	1.11% 21	1.44% 17	1.36% 18	1.36% 18	1.36% 19
17	**Furniture and related products**	1.17% 22	1.37% 23	1.34% 20	1.44% 19	1.52% 18	1.59% 17	1.58% 17	1.57% 17	1.52% 17	1.43% 17	1.32% 18	1.32% 20	1.18% 20	1.18% 20	1.18% 20

20	**Textile mills and textile product mills**	1.39% 20	1.39% 21	1.28% 22	1.37% 22	1.40% 21	1.40% 21	1.38% 21	1.35% 21	1.28% 20	1.22% 20	1.15% 20	1.22% 21	1.16% 21	1.16% 21	1.16% 21
48	**Computer systems design and related services**	0.36% (27)	0.58% (27)	0.49% (27)	0.57% (26)	0.52% (26)	0.56% (26)	0.55% (26)	0.60% (26)	0.69% (26)	0.72% (26)	0.79% 23	1.08% 23	1.06% 22	1.06% 22	0.99% 22
22	**Paper products**	1.67% 15	1.65% 16	1.56% 16	1.64% 17	1.46% 19	1.42% 19	1.37% 22	1.30% 22	1.26% 21	1.16% 21	1.16% 19	1.13% 22	0.96% 23	0.96% 23	0.90% 23
9	**Non-metallic mineral products**	1.39% 21	1.49% 19	1.37% 19	1.37% 23	1.26% 23	1.24% 23	1.23% 23	1.23% 23	1.22% 23	1.10% 22	0.98% 22	0.87% (24)	0.86% 24	0.86% (24)	0.86% 24
2	**Forestry. fishing. and related activities**	0.92% (24)	0.91% 24	0.85% 25	0.90% 25	0.86% 25	0.87% 25	0.80% 25	0.76% 25	0.77% 25	0.72% 25	0.75% (24)	0.74% 25	0.84% 25	0.84% 25	0.68% 25
8	**Wood products**	1.44% 19	1.63% 18	1.29% 21	1.39% 21	1.35% 22	1.31% 22	1.56% 18	1.44% 18	1.25% 22	0.94% 24	0.70% 25	0.61% 27	0.51% (26)	0.51% (26)	0.57% (26)
31	**Water transportation**	0.56% (26)	0.61% (26)	0.53% (26)	0.54% (27)	0.49% (27)	0.52% (27)	0.53% (27)	0.52% (27)	0.49% (27)	0.57% (27)	0.72% 60	0.62% (26)	0.43% (27)	0.43% (27)	0.40% (27)