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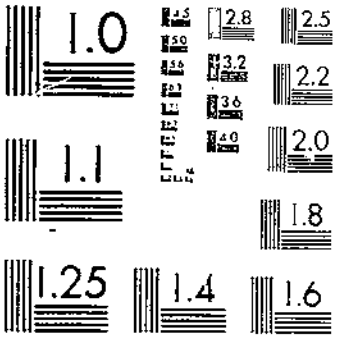

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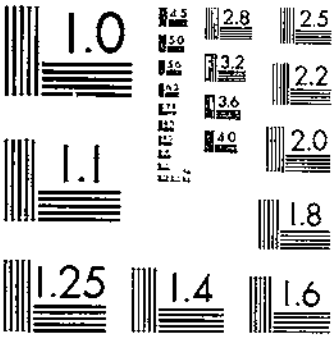

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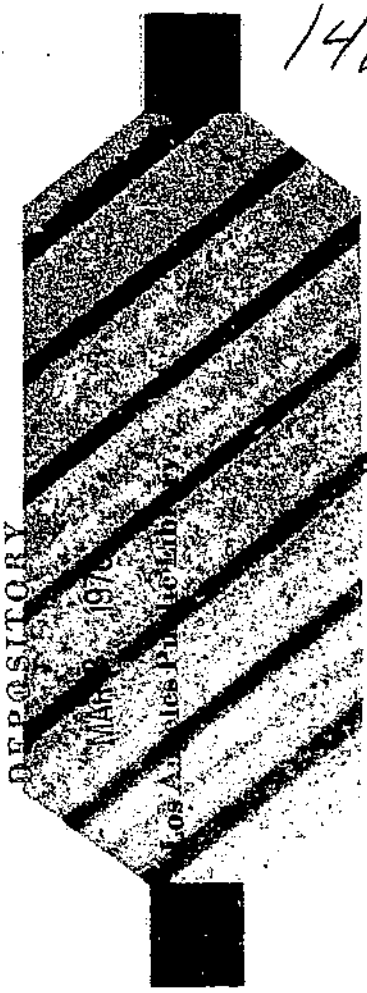

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USE OF INPUT-OUTPUT ANALYSIS IN STUDYING INDUSTRY PROBLEMS

APPLIED TO EMPLOYMENT CHANGES IN THE U.S. TEXTILE INDUSTRY

TECHNICAL BULLETIN NO. 1411
ECONOMIC RESEARCH SERVICE / U.S. DEPARTMENT OF AGRICULTURE

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Preface

This input-output analysis provides additional insight into effects on domestic industries of increased textile imports and interfiber substitution. Further refinements in the input-output tables will be required before this type of analysis can provide the quality of information required for policy decisions.

This study serves to demonstrate a potentially useful research technique and to provide background essential to the refinements planned for future work. And it has methodological implications of a broad nature, far transcending problems of any particular industry.

This report is based on a dissertation by Philip F. Rice in partial fulfillment of the requirements for the degree of doctor of philosophy in engineering management, Clemson University, May 1968.

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Washington, D.C. 20250 February 1970

Summary

This input-output analysis indicates that the effects of increased imports on employment in the U.S. textile industry will depend partly on the form of the imports and that substitution of manmade fibers for cotton would result in net reduction in total employment.

Apparel imports valued at $100 million were found to be more detrimental to employment in the textile industry than were $100 million of textile mill products. Further, since $100 million of apparel actually represents an equivalent physical quantity of $45 million of textile mill products, apparel imports were, on a relative basis, even more detrimental than the study indicated.

Suppliers of cotton and manmade fibers, however, lost more employment when the imports were textile mill products, rather than apparel. But, when equivalent physical quantities were considered, employment loss to suppliers of manmade fibers was about the same for both forms of imports, whereas cotton producers still suffered more employment loss from imports of textile mill products

An increase in substitution of manmade fibers for cotton adversely affected employment of cotton producers, while benefiting suppliers of manmade fibers. Another industry that showed employment loss was agricultural services, since need for such services as cotton ginning and crop dusting was reduced. Other industries that were adversely affected were cottonseed oil mills, trade, finance, insurance, and real estate. Overall, a net loss in employment was recorded.

Input-output analysis considers both direct and indirect effects of changes in the economy. In the analysis, all purchases and sales in the economy were represented by an interindustry transactions table. For this study, a 1966 table was constructed from the 1958 table by (a) developing industry control totals, (b) revising the coefficient matrix, and (c) generating a new table, using national income data to improve accuracy.

It was assumed that both the imports and the synthetics displaced domestic demand on a 1-to-1 basis. This assumption is quite restrictive. Therefore, although this study provides a good demonstration of input-output analysis, the results cannot be used as a basis for policy decisions.

Use of Input-Output Analysis in Studying Industry Problems: Applied To Employment Changes in the U.S. Textile Industry

by

Philip F. Rice and Preston E. LaFerney [1]

Introduction

Input-output analysis is receiving increased attention among both public and private researchers as a tool for studying structural interrelationships in economic systems (*5*).[2] The first part of this report provides a brief description of the input-output technique, presents a method of input-output table construction of special use to small research groups, and demonstrates typical uses of input-output analysis in studying industry problems.[3] Because of the unique nature of table construction employed, methodology is discussed at length. The second part of the report applies the developed methodology to determine probable effects of increased textile imports and increased substitution of manmade fibers for cotton. These changes are measured in terms of their effect both within the textile industry and on the industry's relationship with other industries. Specific effects examined are changes in sources of supply, final sales, and employment within the textile and related industries.

An analysis of the effects on the U.S. economy of changes in demand or product substitutions must consider the economy's interindustry structure. That is, industries are highly interdependent; growth or decline of sales in one industry affects the sales of other industries. Further, a thorough analysis of interindustry relationships should consider both direct and indirect effects of economic changes.

Consider producer *A* who buys from producers *B*, *C*, and *D*, and sells to producers *B*, *D*, *E*, and to final users. These transactions rep-

---

[1] Formerly industrial economist and agricultural economist, respectively, Marketing Economics Division, Economic Research Service.

[2] Italic numbers in parentheses refer to the "Selected References," p. 26.

[3] For a more comprehensive description of the work introduced in this report, see Rice (*8*).

resent the direct relationships existing between A and other producers and final users. To stop here, however, would omit the indirect relationships which exist. Producer B, as a supplier of A, is directly influenced by the needs of A. If A increases its production, B must increase its production to meet the new input requirements of A. But B's increased production will require additional inputs, part of which comes from H (an industry that has no direct relationship with A). To meet the new requirements of B, H must also increase its production. Thus, the output of H has been indirectly influenced by the increased production of industry A. Input-output analysis is useful in studying changes in the economy since it accounts for both the direct and indirect effects.

For input-output analysis, a representation of purchases and sales, known as a transactions table, is required. A hypothetical two-sector transactions table is shown below:

	Agriculture	*Manufacturing*	*Final demand*	*Total output*
Agriculture	$15	$35	0	$50
Manufacturing	20	10	$70	100
Value added	15	55		
Total input	50	100		

Agriculture's sales to manufacturing, $35, are shown in row 1, and the sum of the row, $50, is the total sales (output) of agriculture. The purchases of agriculture are shown in column 1. Agriculture purchases $20 from manufacturing and had total inputs of $50.

The total outputs, referred to as control totals, represent a unique way of measuring the output originating in each sector, as the following explains (*19*, p. 56):

> The row total for a given industry * * * includes not only the primary and secondary products made in the industry but also (1) the primary products of the industry made in other industries as a secondary activity and (2) the domestic port value of imported goods that can be used for production and can be substituted for the industry's primary output.

Sectors in the input-output table are generally classified on an establishment basis.[4] An establishment is placed in a sector according to the establishment's principal output. The principal output is known as the primary product while all other output is called secondary. Once an establishment is classified as belonging to a certain sector or industry, the output of the establishment, both primary and secondary, becomes part of that sector's total output.

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[4] "An establishment is an economic unit which produces goods and services—for example, a farm, a mine, a factory, a store. In most instances, the establishment is at a single physical location, and it is engaged in one, or predominantly one, type of economic activity for which an industry code is applicable" (*13*, p. 3). Exceptions are construction, transportation, trade, and services, which are classified largely on an activity basis (*17*, appendix 1).

Basic Concept

The basic concept on which an input-output table is constructed is that the total output of any industry can be divided into two categories: (*a*) The interindustry transactions and (*b*) the final demand sales. That is, a firm sells its output either to another producing firm or industry or to a subsector of the final demand sector (private consumers, investment, government, or net export). Thus, total output of any industry can be expressed by the following equation:

$$\sum_{j=1}^{n} X_{ij}+C_i=X_i \qquad (i=1,\ldots,n), \tag{1}$$

where

X_{ij} = amount of output industry i ships to industry j,
C_i = final demand for output of industry i,
X_i = total output of industry i.

The transactions of the economy then can be represented by a system of linear equations, one equation for each industry.

To utilize the system of equations representing the economy, it is necessary to assume constant technical coefficients of production. A technical coefficient is a ratio of input to output, and can be written as follows:

$$a_{ij}=\frac{X_{ij}}{X_j}, \tag{2}$$

where

a_{ij} = technical coefficient,
X_{ij} = value of shipments from industry i to industry j,
X_j = total output of industry j.[5]

As an example, consider the agriculture and manufacturing industries in the two-sector transactions table. Total output of manufacturing is valued at $100, and raw materials shipped from agriculture to manufacturing are valued at $35. Then the technical coefficient (ratio of input to output) is $35 divided by $100, or 0.35. Specifically, 0.35 is the value of agricultural output required to produce $1 worth of output in manufacturing.

Assumptions

Generally, a system based on the assumption of fixed technical coefficients describes an economy that has a fixed physical structure

[5] The value of X_j corresponds to the value of X_i in equation (1), shown above, when $i=j$. That is, the row and column totals of the transactions table are equal for $i=j$.

and linear homogeneous production functions. Thus, the assumption rules out input substitutions arising from factors such as relative price changes (price competition), changes in technology, or industrial integration. Economies of scale also are ruled out. If the coefficients are fixed, inputs from each source remain a constant proportion of a sector's output; furthermore, the sources of input supply are constant. Similarly, the assumption implies a constant product mix—the output of a sector is assumed to be homogeneous over time.[6]

The assumption of constant coefficients is not easy to defend theoretically. Consequently, the use of input-output analysis rests not so much on strong theoretical validity, as on the concept that in the short run the assumptions are close enough to reality to provide a satisfactory basis for analysis.

Substituting the value of X_{ij} from equation (2) into equation (1) yields

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + C_i \qquad (i=1, \ldots n). \tag{3}$$

In matrix notation, this is

$$X = aX + C, \tag{4}$$

where

$$X = \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{bmatrix}, \quad a = \begin{bmatrix} a_{11} a_{12} & \ldots & a_{1n} \\ a_{21} a_{22} & \ldots & a_{2n} \\ \cdot & & \\ \cdot & & \\ \cdot & & \\ a_{n1} a_{n2} & \ldots & a_{nn} \end{bmatrix}, \quad C = \begin{bmatrix} C_1 \\ C_2 \\ \cdot \\ \cdot \\ \cdot \\ C_n \end{bmatrix}.$$

This is equivalent to

$$(I-a)X = C, \tag{5}$$

where

$$I = \begin{bmatrix} 1 & 0 & 0 & \ldots & 0 \\ 0 & 1 & 0 & \ldots & 0 \\ \cdot & \cdot & & & \cdot \\ \cdot & \cdot & & & \cdot \\ \cdot & \cdot & & & \cdot \\ 0 & 0 & 0 & \ldots & 1 \end{bmatrix}.$$

When $(I-a)^{-1}$ exists,

$$X = (I-a)^{-1} C. \tag{6}$$

Defining $(I-a)^{-1}$ as A, then

---

[6] For a detailed discussion on assumptions, see Rice (*8*, pp. 9–15) and Chenery and Clark (*2*, pp. 33–42).

$$X = AC. \tag{7}$$

Equation (7) can be written as

$$\begin{aligned} X_1 &= A_{11}C_1 + A_{12}C_2 + \ldots + A_{1n}C_n \\ X_2 &= A_{21}C_1 + A_{22}C_2 + \ldots + A_{2n}C_n \\ &\vdots \\ X_n &= A_{n1}C_1 + A_{n2}C_2 + \ldots + A_{nn}C_n, \end{aligned} \tag{8}$$

where A_{ij} is the direct plus indirect output of industry i required for industry j to deliver a dollar's worth of output to final demand. Equation (8) shows that the total output of any industry is affected not only by its own final demand, but by the final demand of other sectors as well. Thus, a change in the final demand of one sector may affect the total outputs of all sectors.

Analyses in this paper will make use of the inversion process to compute total outputs given certain changes in the economy. The new outputs reflect only current account purchases and do not include the effect of respending of income.

Generation of a Current Table

The most recent transactions table available, published by the U.S. Department of Commerce, is for the year 1958 (*19*, pp. 34–39). In that table, the economy was divided into 83 producing industries for the purpose of presenting the flow of goods and services between industries. The table, as it stood, presented serious problems: it was dated and available data sources for 1966 were difficult to reconcile with the 83-sector structure. Thus, a 1966 table was developed in which some industries were aggregated to aid in reconciliation. Reconciliation was accomplished by constructing the aggregated 1958 control totals from published data sources. The 1966 numbering resulted in 44 producing sectors, as shown in table 1. The 1966 table construction was essentially a three-step process: (*a*) Developing industry control totals, (*b*) revising the technical coefficient matrix, and (*c*) generating a new table, using national income data to improve accuracy.

The 1966 control totals were developed in a variety of ways making use of several sources (*8*, pp. 46–65). Each control represents what appeared to be the strongest estimate. No 1966 estimates were made until a reconciliation had been performed for each control in the 1958 aggregated table. Secondary products were assumed to represent the same percentage of output as in 1958, since the 1958 transfer matrix provided by the U.S. Department of Commerce represented the latest information on secondary production.

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TABLE 1.—*Industry numbering in the 1966 transactions table*

Industry number and title	Related 1958 industry number[1]
1. Agricultural products, except cotton	[2] 1, 2
2. Cotton	(3)
3. Forestry, fisheries and services	3, 4
4. Iron and ferroalloy ores	5
5. Nonferrous metal ores	6
6. Coal	7
7. Crude petroleum and natural gas	8
8. Stone and clay	9
9. Chemical and fertilizer minerals	10
10. New construction	11
11. Maintenance and repair constructions	12
12. Ordnance and accessories	13
13. Food and kindred products	14
14. Tobacco manufactures	15
15. Textile mill products	16, 17
16. Apparel and fabricated products	18, 19
17. Lumber and wood products	20, 21
18. Furniture and fixtures	22, 23
19. Paper and allied products	24, 25
20. Printing and publishing	26
21. Chemicals, etc	27–30
22. Petroleum refining and related products	31
23. Rubber and miscellaneous plastic products	32
24. Leather tanning, etc	33, 34
25. Glass and stone	35, 36
26. Primary iron and steel manufacturing and nonferrous manufacturing	37, 38
27. Fabricated metal products	39–42
28. Machinery, except electrical	43–52
29. Electrical equipment	53–58
30. Transportation equipment	59–61
31. Scientific instruments	62, 63
32. Miscellaneous manufacturing	64
33. Transportation and warehousing	65
34. Communication and utilities	66–68
35. Wholesale and retail trade	69
36. Finance, insurance, real estate and rental	70–71
37. Lodging, personal and business services	72–73
38. Research and development	74
39. Auto repair	75
40. Amusements, medical and educational services	76, 77

TABLE 1.—*Industry numbering in the 1966 transactions table*—Con.

Industry number and title	Related 1958 industry number [1]
41. Federal Government enterprises	78
42. State and local government enterprises	79
43. Gross imports	80
44. Dummy industries	81–83
45. Government	84
46. Rest of world industry	85
47. Household industry	86

[1] For industries corresponding to numbers, see (*19*, pp. 34–39).
[2] Except cotton. [3] Cotton (unpublished).

After developing the 1966 control totals, 1958 coefficients could have been used to calculate the interindustry transactions by the relationship $X_{ij}=a_{ij}X_j$. This method, however, would have produced a 1966 table with an economy structured the same as that for 1958. Eight years seemed to be too long a period to adhere rigidly to the assumption of fixed coefficients. Consequently, two adjustments were applied to the 1958 aggregated coefficients. First, an adjustment was made for price changes between the input and output making up a coefficient, and then an index of coefficient change was applied to each row in the transactions table.

With the first adjustment the coefficients were made to reflect the 1966, rather than 1958 price relationships. Any coefficient is denoted as follows:

$$a_{ij}=\frac{X_{ij}}{X_j}=\frac{P_iQ_{ij}}{P_jQ_j},$$

which is the price of ith good times the quantity of ith good shipped to j, divided by the price of jth good times the quantity of jth good produced. If the physical relationship Q_{ij}/Q_j is assumed constant, the coefficient a_{ij} remains constant, providing the ratio of P_i to P_j does not change. In the 1966 table, all coefficients were adjusted for changes in the price ratios between 1958 and 1966 by use of a separate price index for the output of each sector.[7] Thus, only 44 price indexes were required. However, the adjustment for relative price change was made individually for each cell in the 44×44 table, since the ratio P_i/P_j was different for each.[8]

[7] Price indices were developed from several sources; the primary source was U.S. Bureau of Labor Statistics Bulletin 1555 (*10*).

[8] (*11*, pp. 103–104). The rates of change for the original 83 producing industries were weighted by the 1958 intermediate sales to form the 44 rates of change needed for the 1966 table.

Finally, the adjusted coefficients and the control totals were used to generate a 1966 transactions table. Each intermediate transaction X_{ij} was calculated by the following relationship:

$$X_{ij}=a_{ij}X_j.$$

Then the final demand by sector was determined using equation (1). That is,

$$X_i=\sum_{j=1}^{n} X_{ij}+C_i \qquad (i=1, \ldots, n),$$

or

$$C_i=X_i-\sum_{j=1}^{n} X_{ij} \qquad (i=1, \ldots, n).$$

This states that all sales not shipped to intermediate users are sold to final consumers. Thus, the sum of the C_i's should yield the gross national product for the year under investigation. Similarly, value added (shown in the hypothetical two-sector transactions table cited earlier), when summed for all industries, should yield GNP. These two facts were used to check and improve the transactions table.

In developing the new table, two other checks on its validity were observed. The first was provided by the decision not to permit any C_i to be less than zero. Admittedly, a negative net inventory change could have caused a negative GNP, but inventory information could not be obtained on many sectors, so all net inventory changes were assumed to be zero. Consequently, the five sectors that did show negative GNP's were inspected, and coefficients that seemed out of line were given further adjustment.[9]

The second check made use of the value added figure generated for each sector in the 1966 table. The generated figure was compared with a value-added figure derived from available sources. The check is not perfect since the derived and generated figures can be expected to agree only on a total basis, and not sector by sector.[10] The same problem existed in the 1958 table. Thus, it was felt that a comparison of the 1958 and 1966 ratios of derived to generated values added, sector by sector, would aid in locating columns where the 1966 generated value added was out of line. Using this comparison, seven sectors were identified as needing closer investigation.[11] After all adjustments were made, the table showed a gross national product

[9] The application of average rates of change to each coefficient was recognized as an oversimplification.

[10] The sector deviations occur because of the difference in defining the economic unit in input-output work and in national income accounts (*17*, p. 4).

[11] For detail on adjustments, see Rice (*8*, pp. 66–77).

of $745.1 billion, which deviates from the published figure of $743.3 billion by 0.24 percent.[12]

The final 1966 transactions table is shown in the appendix table. A primary limitation of the table is the aggregation to 44 sectors. Perhaps the table reflects more reliable information in the agriculture and manufacturing sectors than in other sectors, since these were of primary interest in this research project. Final demand was not broken into its components in this table.

On the positive side, the table appears reasonable and generates the total gross national product for 1966 quite accurately. Its apparent success in picturing the 1966 economy is sufficient to give credit to the methodology employed in its construction.

To utilize the 1966 table for employment analysis, two modifications were made. Generation of total outputs, given final demands, requires inversion of the $[I-a]$ matrix. For the inversion, industries 43 (imports) and 44 (dummy industries) were omitted because neither industry generated employment. This necessitated the following modification.

Since industry 44 is actually the distribution channel for products (such as paper clips, index cards, and rubber bands) that are made in other industries, shipments to the dummy industries must be counted. For the purpose of the analyses, the shipments to industry 44 were considered exogenous and were added to the appropriate final demand element.

The revised final demands, when multiplied by the inverse, produced the generated control totals. Results of this multiplication are shown in table 2. Slight deviations from the original control totals occurred, but they are less than 1.2 percent, with the majority being less than 0.1 percent. The following analyses were based on the generated control totals. At this point, the table was considered to be satisfactory and appropriate for analytical use.[13]

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[12] For published GNP, see (*18*, p. 10).

[13] For this paper, the control total of industry 2 (cotton) was revised to $1,652 million on the basis of information available after the dissertation was completed. This forced the revision of all coefficients in column 2; and a_{2-13} changed from 0.001950 to 0.002922.

TABLE 2.—*Comparison of original control totals and generated control totals*

1966 industry number[1]	Original	Generated	Deviation
	Million dollars	*Million dollars*	*Percent*
1	57, 172	57, 175	0. 005
2	1, 652	1, 652	----------
3	3, 519	3, 521	. 057
4	1, 824	1, 826	. 110
5	2, 279	2, 280	. 044
6	2, 606	2, 608	. 077
7	16, 114	16, 116	. 012
8	2, 569	2, 569	----------
9	1, 000	1, 000	----------
10	74, 369	74, 369	----------
11	23, 939	23, 941	. 008
12	9, 224	9, 225	. 011
13	90, 381	90, 384	. 003
14	6, 901	6, 901	----------
15	19, 593	19, 603	. 051
16	28, 212	28, 213	. 004
17	12, 533	12, 548	. 120
18	8, 087	8, 183	1. 187
19	22, 579	22, 585	. 027
20	20, 650	20, 652	. 010
21	44, 122	44, 131	. 020
22	23, 649	23, 652	. 013
23	13, 735	13, 741	. 044
24	5, 774	5, 794	. 346
25	15, 670	15, 674	. 026
26	54, 205	54, 246	. 076
27	34, 943	34, 951	. 023
28	50, 697	50, 700	. 006
29	45, 533	45, 535	. 004
30	78, 448	78, 449	. 001
31	9, 807	9, 808	. 010
32	9, 426	9, 427	. 011
33	46, 671	46, 680	. 019
34	52, 648	52, 655	. 013
35	140, 281	140, 291	. 007
36	151, 226	151, 234	. 005
37	58, 674	58, 680	. 010
38	8, 877	8, 877	----------
39	11, 824	11, 825	. 008
40	50, 438	50, 439	. 002
41	6, 818	6, 818	----------
42	7, 945	7, 946	. 013

[1] For industries corresponding to numbers, see table 1.

Analyses

Effect of Increased Textile Imports

Effect of tariff reductions on employment can be identified if the proposed tariff reductions can, in effect, be translated into imports, and if the rate of substitution between imports and domestic production is known.

In the Kennedy Round of GATT negotiations, the following tariff reductions were accepted (*3*, p. 5):

> The United States agreed to cotton textile tariff reductions that amounted to a weighted average reduction of 21%. Reductions on apparel items averaged 17%; fabric tariffs were reduced 24%; and yarn, 28% * * *. The United States agreed to a weighted average tariff reduction of 15% on imports of man-made fiber textiles, excluding fibers. Man-made fiber apparel duties were reduced by an average of approximately 6%, fabrics by 18%, yarn by 37%.

To effectively examine the impact of the tariff reductions, they must be translated into changes in domestic sales. Such a translation, however, becomes a difficult task due to changing prices and market conditions.

Lack of information necessitated a subjective estimate of the impact of tariff reductions on domestic demand for domestic products. It was decided to introduce imports of $100 million in the form of either textile mill products or apparel. This amount will provide a convenient base for comparison with better estimates when they are known. That is, since the relationships between output and employment are linear, a $50 million actual increase in imports would produce one-half the change in employment caused by our estimated increase in imports of $100 million. Since our analysis only illustrates what happens if imports are increased by $100 million, the results cannot be used as a basis for policy decisions.

It is assumed that imports displace domestic production unit for unit. This assumption is severely restrictive but allows a simplified demonstration of input-output analysis. Although initially the total domestic supply might be increased due to the influx of imports and the resulting price decreases, our assumption disallows this. Ultimately the lower priced imports likely would displace domestic production, resulting in somewhat lower average prices and higher domestic consumption. Since no reliable estimates of the actual effects are available, we assume immediate and perfect substitution of imports for domestic production.

The analysis was completed in two steps. First, the $100 million of imports was introduced into the final demand sectors of industry 15 (textile mill products) and industry 16 (apparel and fabricated products), displacing $100 million of domestic production in each case. The inversion procedure, previously explained, was utilized to generate the new total outputs required to support the reduced demand for domestic output.

Second, the new total outputs were compared with the generated control totals. The dollar difference for each industry was converted to employment, using a ratio of 1,000 employees to $1 million of output. The ratio was constructed by dividing the number of employees by total output in 1966 for each sector.[14] Results are shown in table 3. If the simplifying assumptions hold or if, when the assumptions are relaxed, the updating procedures convert the 1958 physical industry structure to that of 1966, the use of a ratio in determining employment as a function of output is appropriate.

The employment loss in industries 15 and 16 (total textiles) was 5,592 workers when the increased imports were textile mill products, and 8,937 when the imports were apparel and fabricated products. Thus, imports in the form of apparel appear to be more detrimental to employment in textiles than do imports of textile mill products. There are at least two factors which help to illuminate this result.

First is the fact that apparel imports have a greater effect on employment in industry 15 (textile mill products) than imports of textile mill products have on industry 16 (apparel). That is, $100 million of apparel imports causes industry 15 to lose 1,867 employees, whereas $100 million of textile mill products imports only causes a loss of 71 employees in industry 16. This happens because imported apparel bypasses domestic manufacturing, whereas imported fabric and yarn must be converted domestically. Second, employment per dollar of output in industry 15 is only 62 percent of that in industry 16. Consequently, the employment effect per dollar loss is greater in industry 16. The fact that apparel imports are more detrimental to employment in the textile industry is reflected in recent tariff actions. Tariff reductions, for both cotton and manmade textiles, were greater on yarn and fabrics than on apparel.

The two major fibers used in textiles are cotton and manmade fibers, industries 2 and 21, respectively. Industry 21 also contains the majority of other chemical products purchased for textiles. Table 3 shows that industry 2 loses 719 employees when the $100 million of imports are textile mill products, and 250 employees when the imports are apparel. Industry 21 also loses more employees from imports of textile mill products than from apparel imports—606 and 260 employees, respectively. Thus, as far as minimizing employment loss, the fiber suppliers would have favored somewhat different tariff reductions than actually occurred.

It should be noted, however, that in the preceding analysis the import changes were fixed (equal) dollar volumes. Thus, $100 million of apparel represents a smaller physical quantity of goods than does

[14] Employment totals by industry (except industries 1 and 2) were obtained from unpublished data of the U.S. Bureau of Labor Statistics. Employment totals for industries 1 and 2 were obtained from *Agricultural Statistics* (*14*, p. 580).

TABLE 3.—*Decrease in employment resulting from $100 million of imports introduced into final demand sector*

1966 industry number [1]	When imports are apparel	When imports are textile mill products
	Man-hours	*Man-hours*
1	148	313
2	250	719
3	154	142
4	1	2
5	2	4
6	14	28
7	5	9
8	3	7
9	4	10
10	0	0
11	51	76
12	0	1
13	19	40
14	0	0
15	1, 867	5, 520
16	7, 070	72
17	27	33
18	8	7
19	107	132
20	52	62
21	260	606
22	9	18
23	59	67
24	39	6
25	20	42
26	35	54
27	37	55
28	36	77
29	16	24
30	7	11
31	9	9
32	125	33
33	279	488
34	111	167
35	874	980
36	147	179
37	425	488
38	0	1
39	32	47
40	39	44
41	62	62
42	28	43

[1] For industries corresponding to numbers, see table 1.

$100 million of fabric and yarn imports. In fact, in terms of production, $100 million of apparel is equivalent to $42 million of textile mill products, based on relationships existing in the 1966 transactions table.[15] If this equivalent is considered, the employment loss attributed to imports of textile mill products shown in table 3 would be reduced 58 percent, and the apparel imports would be, on a relative basis, even more detrimental to domestic textile employment than the table implies.

On this equivalent basis, the fiber suppliers' position on form of imports softens somewhat. In fact, when the employment loss attributed to textile mill products is reduced 58 percent, industry 21 (chemicals) becomes somewhat indifferent to the form of textile imports, but apparel imports would still be preferred in order to minimize the net adverse employment effects in industry 2 (cotton). Apparently, this is the result of particular all-cotton products, such as sheets, pillowcases and towels, originating in industry 15 (textile mills) and passing directly to the consumer through the retailer, thereby bypassing industry 16 (apparel). This implies that cotton is tied more closely to industry 15 than industry 16. Consequently, imports of textile mill products are more detrimental to cotton producers.

Effect of Interfiber Substitution

The second analysis was performed to investigate the effect of substituting manmade fibers for cotton as an input of industry 15. The analysis was accomplished by substituting $100 million of manmade fibers for $100 million of cotton. The substitution had to be in dollars due to the nature of the transactions table, which represents purchases and sales in dollars. Displacement rate of a dollar's worth of manmade fiber for a dollar's worth of cotton rests on the following calculation:

	Cotton	*Manmade*	*Ratio (manmade cotton)*
Raw price	[16] $0.30	[17] $0.4546	1.5153
Cotton equivalent	1.0	[18] 1.2247	1.2247

[15] The unemployment resulting from $100 million of imported apparel is compared with that resulting from $100 million of apparel produced domestically from imported textiles, thereby comparing effects of equal physical quantities of imported textile goods at different stages of manufacturing.

[16] Average cotton price for August–December, 1967 (*15*).

[17] Represents weighted average price of 1.5 denier polyester staple and viscose rayon staple. The polyester price ($0.658/lb.) represents the average monthly wholesale price for 1967 (*12*). The viscose rayon price ($0.28/lb.) is the monthly average price for 1967 (*10*, p. 29).

[18] Represents weighted cotton equivalent of polyester and viscose rayon. For cotton equivalents, see (*16*, table 239, p. 146). For weighting factors (1967 production) of polyester and viscose rayon used in calculating manmade price and cotton equivalent, see (*10*, p. 29).

The ratio 1.5153/1.2247 (equals 1.2373) implies that manmade fiber is 24 percent more costly than cotton as an input to get the same value of output if output prices were equal. The exact relationship of the output prices is not known, but the output produced from manmade fibers is believed to sell at a higher price. Consequently, to get equal value of output, less manmade fiber input is needed. Therefore, the substitution rate of manmade fiber for cotton necessary to hold output value constant is not $1.25 to $1, but may be more like $1 to $1. Thus, for lack of more precise information, we assume a substitution elasticity of 1.

The analytical procedure was the same as in the previous analysis. The [*I-a*] matrix, with changed coefficients, was inverted, and new total outputs were generated.[19] The new outputs were converted to employment, and the results are shown in table 4.

As expected, the two industries that are affected most by the substitution are the fiber suppliers: cotton suppliers suffer a loss of 11,653 employees and chemical suppliers gain 2,507 employees. The gain in the chemical industry is actually the net result of increased shipments of manmade fibers and decreased shipments of agricultural chemicals necessitated by the reduced cotton output.

Industry 3 (forestry, fisheries, and agricultural services) suffers a large employment loss—2,061—mainly cotton ginners and cropdusters. This adverse effect is certainly attributable to the decline in cotton production. Industry 1 (agricultural products) suffers a similar loss (2,262 employees) due to losses in sales of the cotton sector and its suppliers. Also directly related to the decrease in cotton production is industry 13 (food and kindred products), which registers a loss of 742 employees. This loss reflects the decline in output of cottonseed oil in that industry.

Three other industries showing employee losses greater than 300 are industry 35 (wholesale and retail trade), industry 36 (finance, insurance, real estate, and rental), and industry 37 (lodging, personal and business services). These losses occur because each industry experiences a reduction in total output due to reduced cotton production.

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[19] The shipment of industry 2 (cotton) to industry 15 (textile mill products) was reduced $100 million, and the shipment of industry 21 (chemicals) to industry 15 was increased $100 million. Concurrently, less cotton implies less seed, so shipment of industry 2 to industry 13 (food and kindred products) was reduced to reflect seed loss of $25 million. And finally, less seed implies a reduction, estimated to be $29 million, in production of cottonseed oil and cottonseed meal. These four shipment changes necessitated changing the corresponding coefficients in the coefficient matrix.

TABLE 4.—*Employment change resulting from substitution of $100 million of manmade fiber for $100 million of cotton*

1966 industry number [1]	Employment change
1	−2,262
2	−11,653
3	−2,061
4	+6
5	+12
6	+26
7	−4
8	−15
9	+33
10	0
11	−266
12	0
13	−742
14	0
15	−7
16	0
17	+14
18	+8
19	+110
20	−21
21	+2,507
22	−9
23	+5
24	−7
25	+24
26	+74
27	+32
28	−7
29	−7
30	−12
31	+10
32	+2
33	−18
34	−36
35	−616
36	−755
37	−315
38	+2
39	−60
40	−26
41	−3
42	−15
Net change	−16,057

[1] For industries corresponding to numbers, see table 1.

Appendix Table

APPENDIX TABLE—*Interindustry*

[In million dollars,

Industry number and title	1	2	3	4	5	6	7	8	9	10	11
1. Agricultural products excluding cotton.	13,007	144	996							285	
2. Cotton		8	60								
3. Forestry, fisheries, and services.	1,197	271	40								
4. Iron and ferroalloy ores				102	19						
5. Nonferrous metal ores				70	365			2			
6. Coal	7			7	1	385		4			
7. Crude petroleum and natural gas.							342		1		
8. Stone and clay	76	6				3		19	14	790	166
9. Chemical and fertilizer minerals.	32	2			2			2	52		
10. New construction											
11. Maintenance and repair construction.	669	38	2	2	2	2	6	3		8	1
12. Ordnance and accessories.										3	
13. Food and kindred products.	3,858		39							22	
14. Tobacco manufactures											
15. Fabrics, yarns, goods, and rugs.	43		24		3	2	2			4	1
16. Apparel and fabricated products.	51	1									1
17. Lumber and wood products.	126			10	2	10	9			4,100	522
18. Furniture and fixtures										596	19
19. Paper and allied products.	20		27		2	7	9	26	8	303	83
20. Printing and publishing.	12	1				1	1	1		9	1
21. Chemicals, etc	1,308	146	2	22	68	40	84	29	28	711	1,198
22. Petroleum refining and related products.	995	51	22	16	12	28	73	66	7	1,131	430
23. Rubber and miscellaneous plastic products.	212	10	13	2	7	25	49	48	5	406	86
24. Leather tanning, etc	4	1									
25. Glass and stone	32	2		2	9	6	5	158		5,133	775
26. Primary iron and steel mfg. and nonferrous metals mfg.	2			41	94	42	16	40	19	4,006	718

transactions, 1966

at producers' prices]

12	13	14	15	16	17	18	19	20	21	22	23	24	25
------	26,353	1,184	252	------	280	------	------	------	40	------	------	64	------
------	246	------	905	9	------	------	------	------	------	------	------	------	4
------	368	------	------	243	1,158	------	------	------	30	------	------	1	------
------	------	------	------	------	------	------	------	------	104	4	------	------	14
------	------	------	------	------	------	------	------	------	111	------	------	------	6
------	21	1	23	1	2	3	98	------	143	11	18	2	88
------	------	------	------	------	------	------	------	------	44	12,113	------	------	------
------	4	------	------	------	------	------	59	------	48	85	14	------	875
------	10	------	2	------	------	------	28	------	730	1	18	1	41
------	------	------	------	------	------	------	------	------	------	------	------	------	------
15	294	------	11	13	21	3	88	70	68	34	15	------	6
78	------	------	------	------	------	------	1	5	------	------	------	------	------
------	14,782	42	68	------	------	50	135	------	875	16	2	285	10
------	1	1,274	------	------	------	------	------	------	------	------	------	------	------
------	10	1	6,512	7,912	3	398	112	28	16	------	1,230	120	24
6	181	------	114	4,669	17	13	56	------	84	5	47	24	10
10	134	11	2	------	3,644	841	1,116	2	90	3	24	38	114
------	------	------	9	21	35	135	3	8	------	------	4	1	8
43	1,599	154	227	252	134	174	6,289	3,609	1,374	125	171	86	664
16	146	13	13	26	43	4	191	2,399	119	1	43	22	27
29	597	134	2,510	326	235	161	802	312	10,930	844	2,972	116	646
18	341	3	45	12	104	15	223	16	1,468	1,607	35	6	140
228	197	12	183	159	81	259	303	26	480	10	437	256	149
------	------	------	5	98	1	12	3	2	------	------	31	1,389	2
82	784	------	46	------	60	191	92	------	436	51	150	19	1,762
573	50	8	15	3	41	464	31	26	842	4	63	1	88

APPENDIX TABLE—*Interindustry*

[In million dollars,

Industry number and title	1	2	3	4	5	6	7	8	9	10	11
27. Fabricated metal products.	128	8	11	3	3	31	93	2	------	7,561	1,173
28. Machinery	258	13	------	45	58	142	240	182	32	1,227	96
29. Electrical equipment	35	2	------	4	10	10	72	5	5	1,890	370
30. Transportation equipment.	61	2	19	4	1	10	12	8	1	4	------
31. Scientific instruments	------	------	------	------	------	------	2	------	------	262	22
32. Miscellaneous manufacturing.	1	------	3	------	------	4	------	2	------	105	69
33. Transportation and warehousing.	1,142	30	45	232	88	26	508	49	05	2,686	443
34. Communications and utilities.	359	39	16	43	68	91	161	88	60	425	71
35. Wholesale and retail trade.	2,171	75	30	36	54	92	199	93	22	5,865	1,630
36. Finance, insurance, real estate, and rental.	2,257	382	115	168	101	103	2,635	108	18	925	120
37. Lodging, personal, and business services.	785	72	154	16	19	20	678	33	8	4,186	97
38. Research and development.	------	------	------	------	------	------	------	------	------	------	------
39. Auto repair	156	6	------	------	------	1	26	------	------	398	33
40. Amusements and medical and educational services.	200	1	2	2	2	3	15	2	------	77	13
41. Federal Government enterprises.	7	------	2	1	1	3	------	1	------	------	------
42. State and local government enterprises.	1	------	------	------	------	1	6	2	------	16	2
43. Gross imports	703	23	310	804	634	3	1,671	459	149	------	------
44. Dummy industries	54	3	2	8	10	18	275	19	9	388	65
45. Government industry	------	------	------	------	------	------	------	------	------	------	------
46. Rest of world industry	------	------	------	------	------	------	------	------	------	------	------
47. Household industry	------	------	------	------	------	------	------	------	------	------	------
Total intermediate inputs.	29,883	1,335	1,036	1,638	1,633	1,129	7,190	1,451	490	43,671	6,197
Value added	27,289	317	1,583	186	646	1,477	8,923	1,118	510	30,798	15,742
Total	57,172	1,652	3,519	1,824	2,279	2,606	16,114	2,569	1,000	74,369	23,939

transactions, 1966—Continued

at producers' prices]

12	13	14	15	16	17	18	19	20	21	22	23	24	25
167	2,296	10	22	88	132	519	247	39	859	436	228	85	296
1,039	23	------	125	2	52	75	120	78	380	6	84	1	54
637	45	1	6	------	18	24	32	20	47	10	60	8	75
1,664	------	------	3	1	10	10	------	27	1	------	37	------	
230	------	------	------	17	------	17	11	95	100	2	27	13	13
23	39	8	59	503	18	64	20	54	54	10	70	17	35
115	4,084	97	668	283	757	193	1,009	370	1,722	1,510	398	89	1,012
99	880	12	338	225	153	111	539	471	1,196	532	273	49	715
252	2,074	85	788	986	525	419	841	472	1,317	246	503	137	506
113	053	26	283	564	189	158	312	1,107	1,002	407	286	86	33
137	2,781	392	293	416	120	172	360	1,242	2,260	642	501	168	336
------	6	------	3	------	------	------	3	------	78	10	------	------	3
------	445	3	14	12	119	18	22	20	60	32	5	3	54
10	91	7	22	34	14	11	25	27	49	24	17	7	18
7	33	13	15	43	4	4	20	128	114	39	12	13	10
2	38	------	5	3	7	2	21	3	15	9	4	------	18
45	3,468	9	1,200	822	1,339	67	1,628	106	815	1,129	591	337	311
168	487	12	146	208	100	79	430	535	589	55	150	34	218
------	------	------	------	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------
------	------	------	------	------	------	------	------	------	------	------	------	------	------
5,776	64,793	3,522	14,974	17,901	9,176	4,674	15,272	11,353	28,696	20,023	8,573	3,451	8,608
3,448	25,588	3,379	4,619	10,311	3,357	3,413	7,307	9,347	15,426	3,626	5,162	2,823	7,061
9,224	90,381	6,901	19,593	28,212	12,533	8,087	22,579	20,650	44,122	23,649	13,735	5,774	15,670

APPENDIX TABLE—*Interindustry*

[In million dollars

Industry number and title	26	27	28	29	30	31	32	33	34	35
1. Agricultural products excluding cotton.							11	40		
2. Cotton						5				
3. Forestry, fisheries, and services.			6				5	1		188
4. Iron and ferroalloy ores	1,518		2	10						
5. Nonferrous metal ores	1,395	4		11		2			4	
6. Coal	720	7	12	9	33	3	1	25	629	4
7. Crude petroleum and natural gas.									1,557	
8. Stone and clay	105	3	18					1		4
9. Chemical and fertilizer minerals.	18							1		
10. New construction										
11. Maintenance and repair construction.	223	23	66	43	190	4	26	1,393	1,182	954
12. Ordnance and accessories	2	4	13	203	677	98	1			11
13. Food and kindred products.	15		2			24	14	124		651
14. Tobacco manufactures							2			4
15. Fabrics, yarns, goods, and rugs.	34	22	12	30	288	60	204	24	10	41
16. Apparel and fabricated products.	42	36	45	45	373	23	27	22	12	112
17. Lumber and wood products.	57	185	117	111	262	8	171	30	4	184
18. Furniture and fixtures	3	62	22	354	136	27	11			32
19. Paper and allied products	168	327	183	600	259	198	532	47	38	996
20. Printing and publishing	60	48	31	41	45	4	43	70	164	289
21. Chemicals, etc	832	376	196	796	591	240	375	102	20	303
22. Petroleum refining and related products.	305	160	190	82	180	16	26	1,616	348	894
23. Rubber and miscellaneous plastic products	145	202	560	835	1,605	103	335	311	22	292
24. Leather tanning, etc		9	20	20	20	14	118	4		25
25. Glass and stone	600	280	342	755	817	120	65	10	34	278
26. Primary iron and steel mfg. and nonferrous metals mfg.	13,360	10,963	6,382	4,710	7,623	598	601	104	135	28

transactions, 1966—Continued

at producers' prices]

36	37	38	39	40	41	42	43	44	45	46	47	Total intermediate outputs	Final demand	Total
2,902	------	------	------	32	792	------	--	134	--	--	--	46,517	10,655	57,17
105	------	------	------	------	151	------	--	------	--	--	--	1,573	9	1,652
10	------	------	------	5	------	2	--	23	--	--	--	3,458	61	3,519
6	------	------	------	------	3	------	--	------	--	--	--	1,781	43	1,824
6	------	------	------	------	------	------	--	------	--	--	--	1,975	304	2,279
18	32	------	11	------	63	106	--	------	--	--	--	2,517	89	2,606
168	------	2	------	------	------	31	--	------	--	--	--	14,258	1,856	16,114
10	------	------	------	------	------	------	--	------	--	--	--	2,301	268	2,569
------	------	------	------	------	------	------	--	------	--	--	--	941	59	1,000
------	------	------	------	------	------	------	--	------	--	--	--	------	74,369	74,369
8,712	75	------	144	1,237	22	1,922	--	------	--	--	--	17,579	6,360	23,939
3	------	871	------	------	------	------	--	4	--	--	--	1,974	7,250	9,224
101	19	7	------	290	463	2	--	3,138	--	--	--	25,036	65,345	90,381
2	------	------	------	------	------	------	--	214	--	--	--	1,496	5,405	6,901
57	201	6	20	40	------	3	--	110	--	--	--	17,629	1,964	19,593
89	346	7	26	122	3	3	--	27	--	--	--	6,641	21,571	28,212
39	6	------	------	4	------	------	--	3	--	--	--	12,000	533	12,533
6	18	------	------	------	------	------	--	------	--	--	--	1,512	6,575	8,087
212	310	15	5	169	54	3	--	525	--	--	--	20,132	2,447	22,579
615	6,809	------	12	496	58	18	--	1,146	--	--	--	13,048	7,602	20,650
203	488	194	98	955	------	46	--	63	--	--	--	30,088	14,034	44,122
631	317	29	34	108	9	61	--	14	--	--	--	11,892	11,757	23,649
153	193	51	395	110	2	9	--	25	--	--	--	9,049	4,686	13,735
9	10	------	------	22	2	------	--	42	--	--	--	1,864	3,910	5,774
38	74	2	186	9	20	2	--	7	--	--	--	13,396	2,274	15,670
47	30	31	------	------	------	3	--	375	--	--	--	52,178	2,027	54,205

[In million dollars,

Industry number and title	26	27	28	29	30	31	32	33	34	35
27. Fabricated metal products.	1,235	1,605	2,084	2,196	4,514	294	276	65	228	261
28. Machinery	1,055	1,488	5,986	1,482	3,459	334	76	181	19	299
29. Electrical equipment	453	505	2,475	6,388	2,892	620	146	183	269	230
30. Transportation equipment.	110	380	1,060	335	17,110	186	31	554	8	355
31. Scientific instruments	23	195	179	674	755	610	13	33	------	95
32. Miscellaneous manufacturing.	46	83	112	78	106	42	496	56	34	137
33. Transportation and warehousing.	2,590	721	707	758	1,596	142	177	2,905	671	487
34. Communications and utilities.	1,810	471	717	591	862	100	123	640	6,930	8,800
35. Wholesale and retail trade.	1,730	1,172	1,813	1,955	2,275	417	568	1,100	418	1,946
36. Finance, insurance, real estate, and rental.	668	547	920	723	726	181	245	2,294	766	8,149
37. Lodging, personal, and business services.	620	593	990	1,896	1,807	364	294	748	841	6,122
38. Research and development.	41	3	25	10	52	4	------	------	------	------
39. Auto repair	27	56	52	20	33	5	16	1,147	73	1,016
40. Amusements and medical and educational services.	55	37	48	53	87	10	11	70	512	236
41. Federal Government enterprises.	30	28	45	103	97	12	15	58	544	1,205
42. State and local government enterprises.	20	8	4	6	14	------	2	835	3,601	440
43. Gross imports	2,677	400	1,064	882	1,319	469	777	1,565	114	36
44. Dummy industries	1,960	418	711	903	480	193	133	218	273	2,361
45. Government industry	------	------	------	------	------	------	------	------	------	------
46. Rest of world industry	------	------	------	------	------	------	------	------	------	------
47. Household industry	------	------	------	------	------	------	------	------	------	------
Total intermediate inputs.	24,781	21,615	27,205	27,718	51,344	5,449	6,049	16,582	19,461	32,265
Value added	19,204	13,428	23,492	17,815	27,104	4,358	3,377	30,089	33,187	108,016
Total	64,205	34,943	50,697	45,533	78,448	9,807	9,426	46,671	52,648	140,281

transactions, 1966—Continued

at producers' prices]

36	37	38	39	40	41	42	43	44	45	46	47	Total intermediate outputs	Final demand	Total
35	89	61	156	31	5	35	--	185	--	--	--	27,646	7,297	34,943
183	1,320	372	161	5	2	2	--	243	--	--	--	20,996	29,699	50,697
77	540	1,595	223	37	2	2	--	252	--	--	--	20,283	25,250	45,533
62	38	2,513	1,366	31	13	17	--	214	--	--	--	26,271	52,177	78,448
21	556	259	24	628	------	------	--	119	--	--	--	4,996	4,811	9,807
53	694	17	8	190	------	------	--	407	--	--	--	3,700	5,726	9,426
1,116	331	4	122	271	1,465	139	--	4,732	--	--	--	36,561	10,110	46,671
2,029	4,879	4	377	1,435	186	887	--	------	--	--	--	32,657	19,991	52,648
1,883	1,221	19	880	739	98	66	--	506	--	--	--	39,120	101,161	140,281
17,272	3,070	32	823	4,095	68	223	--	5	--	--	--	53,578	97,648	151,226
4,990	2,162	43	277	1,852	121	163	--	1,817	--	--	--	41,547	17,127	58,674
------	------	------	------	------	2	------	--	------	--	--	--	242	8,635	8,877
358	383	------	222	77	72	10	--	------	--	--	--	4,999	6,825	11,824
454	72	978	12	84	------	------	--	247	--	--	--	3,638	46,800	50,438
785	794	------	5	2,386	9	6	--	------	--	--	--	6,601	217	6,818
714	35	------	30	20	2	------	--	------	--	--	--	5,893	2,052	7,945
177	------	------	------	186	306	------	--	973	--	--	--	27,330	−27,330	------
877	926	23	145	992	95	73	--	------	--	--	--	14,872	679	15,551
------	------	------	------	------	------	------	--	------	--	--	--	------	76,599	76,599
------	------	------	------	------	------	------	--	------	--	--	--	------	4,163	4,163
------	------	------	------	------	------	------	--	------	--	--	--	------	4,028	4,028
45,291	25,947	7,140	5,759	16,659	4,096	3,835	--	15,551	--	--	--	681,767	------	------
105,935	32,727	1,737	6,065	33,779	2,721	4,110	--	------	--	--	--	------	745,118	------
151,226	58,674	8,877	11,824	50,438	6,818	7,945	--	15,551	--	--	--	------	------	1,426,885

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