Inter industry linkages in New Zealand

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DISCLAIMER

The views expressed in this paper are those of the author and do not necessarily reflect the views of the New Zealand Treasury. The paper is presented not as policy advice, but with a view to inform and stimulate wider debate.

Contents

List of Figures

List of Tables

List of Boxes

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Abstract

The purpose of this paper is to examine the structure of production of the New Zealand economy using input output analysis. The paper analyses the 1996 input output tables at the 126 industry level by constructing indices of backward and forward linkages and measures of industry interconnectedness. Measures of connectedness are fairly similar across industries and large, in particular for backward linkages. This suggests that New Zealand industries had strong inter industry linkages in 1996. The ranking of industries by degree of connectedness depends on whether direct transactions or both direct and indirect transactions are considered.

JEL CLASSIFICATION C67 (input output models), L16 (macroeconomic industrial structure)

KEYWORDS Input output models, inter industry dependencies

1 Introduction

Input output analysis refers to an analytical framework developed by Wassily Leontief in the late 1930s, for which he received the Nobel Prize in Economic Science in 1973. Input output tables, which are at the core of input output analysis, are a summary of the process of production, the use of goods and services (products) and the income generated in that production (United Nations, 1993). Input output tables serve two purposes. 1) As a statistical tool, they provide a framework for checking the consistency of statistics on flows of goods and services obtained from different statistical sources.[1] 2) The input output framework can be used as an analytical tool, to assess the interdependence of industries in an economy, for example. It has also been used in regional economics, environmental economics, trade and transport economics, the study of technological change and employment, growth and development economics.

Inter industry studies are usually conducted five yearly by Statistics New Zealand. The last study is the interim release of the inter industry study 1996 tables at the 49 and 126 industry levels (National Accounts Division Statistics New Zealand, 2001). The release is "interim" as the explanatory text of the study is not yet complete, but the data are final.

The purpose of this paper is twofold: (i) to gain a better understanding of input output tables, and (ii) to examine the structure of production of the New Zealand economy using the 1996 data. The analysis in this paper is undertaken at the most disaggregated level data are available, the 126 industry level. This study is the first in a series of papers. Future studies will examine structural change in the New Zealand economy over time and compare the structure of production across OECD countries. The remainder of this paper proceeds as follows. Section 2 describes input output tables and section 3 the methodology. The results are discussed in section 4 and section 5 summarises and concludes.

2 Input output tables[2]

With the release of the 1996 input output tables, Statistics New Zealand has completed the ninth inter industry study for New Zealand. Tables are also available for 1952-53, 1954-55, 1959-60, 1965-66, 1971-72, 1976-77, 1981-82 and 1986-87.[3] The input output tables for the four years 1971-72, 1976-77, 1981-82 and 1986-87 are based on the 1968 System of National Accounts (SNA68). The 1996 tables are based on SNA93 and Australian and New Zealand Standard Industrial Classification (ANZIC) to define industries and Australian and New Zealand Standard Commodity Classification (ANZSCC) for commodity definitions.[4]

Input output tables provide information on the flows of goods and services between industries and sectors of an economy. There are two types of input output tables (matrices): supply and use tables and symmetric input output (or Leontief) tables. Supply and use

[1] In New Zealand, these include the national accounts, business surveys, external trade statistics, income tax statistics, the household economic survey, the crown accounts and local authority surveys (see Statistics New Zealand, 2001).
[2] United Nations (1993) provides a useful reference.
[3] No official tables were produced for the early 1990s.
[4] The 1996 tables are hence not directly comparable to earlier data.

tables are *product by industry* tables. However, the focus of input output analysis tends to be on the inter industry transactions table or (symmetric) *industry by industry* flow matrices. Examples of the types of information contained in input output tables are given in Box 1. They are taken from the interim release of the 1996 tables (National Accounts Division Statistics New Zealand, 2001).

Box 1: Supply and use tables and symmetric input output tables

Supply tables show the supply of products by industries.

The bars, clubs, cafes and restaurants industry produces $995m meal services and $554m beverage services.

New Zealand industries produce $730m of domestic appliances, while $247m of this commodity is imported.

Use tables show the use of products by industry and final demand categories.

The bakery, sugar and confectionery manufacturing industry consumed $170m of grain products and $283m of sugar.

The ship and boat building industry paid $106m in salaries, wages and allowances to its employees, either in cash or in kind.

Symmetric input output tables show how much each industry buys from and sells to every other industry.

The non-building construction industry buys $45m worth of products from other mining and quarrying and $122m worth of imported goods and services.

Central government administration purchased $62m of goods and services from the legal services industry.

Households purchased $476m of goods and services from the lotteries, casinos and other gambling industry.

The seafood processing industry exports $1,066m of its output.

All commodity and industry flows in the input output tables are in dollar millions and recorded at *basic prices*. "At basic prices" means that transactions are valued at the prices received by the producers rather than those paid by the buyers. *Producer prices*, i.e. prices paid by buyers, include taxes and trade and transport margins. The link between basic and producer prices is given in Box 2.

Table 1 shows (parts of) the 1996 industry by industry transactions matrix.[5] The rows of the table describe the distribution of an industry's output throughout the economy (forward linkages). The columns describe the composition of inputs required by a particular industry to produce its output (backward linkages). These inter industry transactions of products constitute the shaded portion of Table 1.

The column labelled "total industry" shows the total of intermediate products supplied by a particular industry. The additional columns record the sales by each sector for final demand, i.e. final consumption expenditure (by households, private non-profit institutions serving households, central and local government), gross capital formation and exports, where gross capital formation consists of gross fixed capital formation and change in inventories. The

[5] For more details and an excellent introduction to inter industry transactions and input output analysis see Dixon (1996).

column labelled "total economy" is the sum of sales of intermediate and final demand products. It is equal to the row labelled "total supply in basic prices".

Box 2: Link between basic and producer prices

Products flows	
Basic price of a product	
Plus:	Taxes on the product
Plus:	Trade and transport margin in delivering the product to the purchaser
Equals:	Producer price of the product
Inter industry transactions	
Products purchased by each industry at producer prices	
Less:	Taxes on the products
Equals:	Value of the products at basic prices

The row labelled "total use in purchasers' prices" is the sum of inputs purchased from domestic producers and imports required by a particular industry to produce its output. The other rows account for other inputs to production, such as labour. Compensation of employees, operating surplus, consumption of fixed capital, other taxes on production and subsidies add up to total value added. Table 1 also shows the link between total use in basic prices and purchasers' prices.

The inter industry transactions table can be used to construct input output *coefficients*. The matrix of *technical or input coefficients* reports the inputs directly required from one industry in order to produce one dollar's worth of output of another industry. The matrix of *total requirements coefficients* shows how much extra output is needed by every industry if a particular industry is to produce one more dollar worth of final output.

Total requirements coefficients are useful for evaluating the effects of a change in the circumstances of one industry upon all other industries as long as the coefficients are constant or only changing slowly. The coefficients will be constant or only changing slowly if:

- both relative prices and quantities are constant;
- industry composition is constant;
- technical coefficients (i.e. quantities of inputs per unit of output) are constant; this implies that inputs cannot be substituted for each other.

Table 1: Inter industry transactions in basic prices (dollar millions)

	Other horticulture	Apple and pear growing	Kiwifruit growing	…	Personal and other community services	Waste disposal, sewerage and drainage services	Total Industry	Final consumption expenditure	Gross capital formation	Exports	Total economy
Other horticulture	7	3	2	…			427	125	9	188	749
Apple and pear growing				…			40	23	5	207	276
Kiwifruit growing	2	1	1	…			38	3	2	228	270
…	…	…	…	…	…	…	…	…	…	…	…
Personal and other community services				…	17		503	1,052	10	84	1,648
Waste disposal, sewerage and drainage services				…	21	65	258	6	3	3	271
Imports	40	15	13	…	103	7	15,468	6,051	4,620	503	26,641
Total use in basic prices	385	146	139	…	753	135	101,054	65,801	20,304	27,002	214,161
Taxes on products	8	3	3	…	15	4	2,346	6,164	768	348	9,626
Total use in purchasers' prices	394	149	142	…	768	139	103,400	71,965	21,073	27,350	223,788
Total value added	355	127	128	…	880	132	84,120				
Compensation of employees	151	110	30	…	604	46	39,450				
Operating surplus	125	-11	68	…	185	65	29,621				
Consumption of fixed capital	67	25	24	…	76	17	12,407				
Other taxes on production	15	5	6	…	17	4	2,957				
Subsidies	-3	-2	-1	…	-1		-315				
Total supply in basic prices	749	276	270	…	1,648	271	187,520				

Gross national product

3 Measures of backward and forward linkages and industry interconnectedness

The methodology in this paper follows Soofi (1992), who adopts a technological definition of structure of production to compare three African countries, Egypt, Morocco and Zambia. This definition refers to "the input coefficients of an input output model derived from Leontief-type fixed-proportion production functions" (Soofi, 1992). Soofi uses two types of measures: (i) backward and forward linkages, and (ii) industry interconnectedness. These are described in more detail in this section.

Backward and forward linkages, which were first proposed by Rasmussen (1956), are descriptive measures of the economic interdependence of industries, while industry interconnectedness refers to the number of direct and indirect inter industry transactions.

3.1 Measures of backward and forward linkages

The input output model in its most basic form consists of a system of linear equations, each of which describes the distribution of an industry's product through the economy. The basic input output identity can be expressed as follows

$$X = AX + F \tag{1}$$

where $X = [X_1,\ldots,X_N]'$ is the vector of gross output, N denotes the number of industries, $A = [a_{ij}]$ is the matrix of technical coefficients and $F = [F_1,\ldots,F_N]'$ is the vector of final demand. Technical or input coefficients are the inputs directly required from one industry in order to produce one dollar's worth of output of another industry.

Equation (1) can be solved for X to obtain

$$X = [I - A]^{-1}F \tag{2}$$

where $[I - A]^{-1}$ is non-singular and I is the identity matrix. The matrix $[I - A]^{-1}$ is called the inverted Leontief matrix or total requirement matrix. Total requirement coefficients show how much output is required directly and indirectly from each industry in the economy for every dollar's worth of output produced for final use. The elements of $[I - A]^{-1}$ are denoted b_{ij} and the elements of the final demand weighted Leontief inverse by b^w_{ij}, where

$$b^w_{ij} = b_{ij}\frac{F_i}{\sum_{i=1}^{N} F_i} \tag{3}$$

The sum of the elements i in column j

$$b^w_{.j} = \sum_{i=1}^{N} b^w_{ij} \tag{4}$$

shows the input requirements for a unit increase in the final demand for sector j's output. It is called the *backward linkage* as it measures the impact on the supplier industries of a unit increase in the final demand for a product. Expressing backward linkage as an index

$$U_j^w = \frac{(1/N)b_{.j}^w}{(1/N^2)\sum_{j=1}^{N} b_{.j}^w} = \frac{Nb_{.j}^w}{\sum_{j=1}^{N} b_{.j}^w} \tag{5}$$

allows making inter industry comparisons. The numerator in equation (5) measures the average stimulus to other sectors, according to each sector's share in total final demand, resulting from a unit increase in the final demand for sector j's output. The denominator measures the average stimulus to the whole economy resulting from a unit increase in the final demand for the output of all sectors.

Conversely, the index of *forward* linkage is given by

$$U_i^w = \frac{(1/N)b_{i.}^w}{(1/N^2)\sum_{i=1}^{N} b_{i.}^w} = \frac{Nb_{i.}^w}{\sum_{i=1}^{N} b_{i.}^w} \tag{6}$$

where the sum of the elements j in row i

$$b_{i.}^w = \sum_{j=1}^{N} b_{ij}^w \tag{7}$$

shows the increase in the output of sector i needed to supply the inputs required to produce a unit of the final demand output in sector j, given each sector's share in total final demand.

Indices (5) and (6) are averages and hence sensitive to extreme values. For example, a sector with high forward linkages could be selling large amounts of output to only a few sectors. To account for extreme values, Rasmussen (1956) supplements the linkage indices with coefficient of variation indices. They measure the dispersion of a given stimulus and are given by

$$V_j^w = \frac{\left[(1/N)\sum_{i=1}^{N}\left[b_{ij}^w - (1/N)b_{.j}^w\right]^2\right]^{\frac{1}{2}}}{(1/N)b_{.j}^w} \tag{8}$$

and

$$V_i^w = \frac{\left[(1/N)\sum_{j=1}^{N}\left[b_{ij}^w - (1/N)b_{i.}^w\right]^2\right]^{\frac{1}{2}}}{(1/N)b_{i.}^w} \tag{9}$$

The numerators in equations (8) and (9) are the standard deviations and the denominators the averages.

The index V_j^w (V_i^w) measures the relative evenness with which industry j (i) purchases from (sells to) other sectors. A relatively large value of V_j^w (V_i^w) implies that sector j (i) purchases (sells) inputs from (to) only a few industries in the economy.

3.2 Measures of industry interconnectedness

Backward and forward linkages assess the magnitude of transactions between industries. Measures of industry interconnectedness, on the other hand, focus on the number of direct and indirect industry sales or purchases. They are related to coefficients of variation.

To determine the degree of industry interconnectedness, Soofi (1992) uses two measures: (i) a measure of concentration, and (ii) entropy as a measure of variation. Measures of concentration focus on the intermediate sector, while entropy based measures of dispersion of inter industry transactions are more descriptive of the characteristics of the economy as a whole.

To derive the measure of concentration, suppose that final demand is zero, i.e.

$$X_i = \sum_{j=1}^{N} a_{ij} X_j \qquad (10)$$

This allows normalising the elements of the matrix of technical coefficients A with the corresponding row sums $a_{i.} = \sum_{j=1}^{N} a_{ij}$ and column sums $a_{.j} = \sum_{i=1}^{N} a_{ij}$ for all i and j, resulting in matrices $C_i = [c_{i,ij}]$ and $C_j = [c_{j,ij}]$, where $c_{i,ij} = a_{ij} / a_{i.}$ and $c_{j,ij} = a_{ij} / a_{.j}$.[6]

Measures of concentration are then defined as

$$G_i(a_{ij}) = \left[N\left(1 - \sum_{j=1}^{N} (c_{i,ij})^2 \right) \right]^{1/2} \qquad (11)$$

and

$$G_j(a_{ij}) = \left[N\left(1 - \sum_{i=1}^{N} (c_{j,ij})^2 \right) \right]^{1/2} \qquad (12)$$

where equation (11) is the forward concentration index and (12) the backward index.

When sector i sells the same proportion of output to all sectors j, i.e. $c_{i,ij} = 1/N$ for all j, $G_i(a_{ij}) = [N-1]^{1/2}$ and complete *uniformity* of intersectoral distribution prevails. Complete *skewness* of intersectoral distribution occurs when sector i sells all the output to one sector j, i.e. $c_{i,ij} = 1$ for one j and $c_{i,ij} = 0$ for all other j and $G_i(a_{ij}) = 0$.

Conversely, when sector j buys the same quantity of inputs from all sectors i, i.e. $c_{j,ij} = 1/N$ for all i, complete uniformity of intersectoral distribution occurs and $G_j(a_{ij}) = [N-1]^{1/2}$. In contrast, complete skewness of intersectoral distribution occurs when sector j purchases all the inputs from industry i, i.e. $c_{j,ij} = 1$ for one i and $c_{j,ij} = 0$ for all other i. This implies $G_j(a_{ij}) = 0$.

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[6] The matrix of technical coefficients is given by $A = \hat{A}\hat{X}^{-1}$, where $\hat{A}$ is the intermediate input flow matrix and $\hat{X}$ is the diagonal matrix containing on its diagonal the elements for the vector of gross output X.

The larger is the measure of concentration, $G.(.)$, the more direct industries ties. Conversely, the smaller the measure of concentration $G.(.)$ is, the fewer inter industry sales or purchases.

Measures of concentration can also be calculated for total requirement matrices, taking into account both direct and indirect requirements.

An alternative measure of industry interconnectedness is entropy. The entropy of sector i is calculated as follows

$$H_i(a_{ij}) = \sum_{i=1}^{N} c_{i,ij} \log\left(\frac{1}{c_{i,ij}}\right) \tag{13}$$

and of sector j as

$$H_j(a_{ij}) = \sum_{j=1}^{N} c_{j,ij} \log\left(\frac{1}{c_{j,ij}}\right) \tag{14}$$

Note that $c_{.,ij} \log\left(\frac{1}{c_{.,ij}}\right)$ is generally replaced by $\lim_{c_{.,ij}\to 0}\left[c_{.,ij} \log\left(\frac{1}{c_{.,ij}}\right)\right] = 0$ for $c_{.,ij} = 0$ (Theil, 1971).

Entropy is a measure of disorder, which has its origin in physics. The (row) entropy $H_i(a_{ij})$ is zero when sector j is the only sector that purchases additional output from sector i following a one dollar increase in sector i's delivery of output to final demand. $H_i(a_{ij}) = \log(N)$ when all sectors of the economy purchase an equal amount of output after sector i delivers one dollar's worth of its output to final demand.

Similarly, the (column) entropy $H_j(a_{ij})$ is zero if sector j purchases additional output from only one industry in response to a one dollar increase in sector i's delivery of output to final demand. $H_j(a_{ij}) = \log(N)$ if sector j uniformly increases its intra industry and inter industry purchases in response to a change in sector i's delivery of output to final demand.

The entropies for the weighted total requirement coefficients matrices, taking into account direct and indirect linkages, can be calculated accordingly.

Finally, entropy can be measured taking into account inter industry sales as well as sales to final demand. To measure the impact of deliveries to both the intermediate and final demand sectors normalise

$$X_i = a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{iN}X_N + F_i \tag{15}$$

by dividing both sides of (15) by X_i and applying the entropy formula in equation (13) to the proportions. $H_i = 0$ if sector i sells to one sector only and $H_i = \log(N+1)$ when sector i sells an equal amount of output to all intermediate and final demand sectors.

4 Empirical results

This section presents the results of backward and forward linkages and measures of industry interconnectedness after a brief discussion of some descriptive statistics of the New Zealand business sector.

4.1 Some descriptive statistics

In 1996, slightly less than half (45.6 percent) of total gross output in New Zealand consisted of intermediate products, i.e. inputs into other industries' production. The remainder (54.4 percent) went to final demand, of which 58.6 percent were for final consumption expenditure, 15.4 percent for gross capital formation and 26 percent were exported abroad. The share of value added in gross output was 44.9 percent.

Table 2 shows the industry breakdown. In 1996, New Zealand's largest industries in terms of percent of total gross output were wholesale and retail trade (7.9 and 5.8 percent respectively) and ownership of owner-occupied dwellings (4.6 percent). In terms of value added, dairy cattle farming and air transport, services to transport and storage contributed the most to total, economy wide value added at 2.3 percent, followed by commercial property operators (2.2 percent) and central government administration (2.0 percent).

The contribution to value added was negative for investors in other property and virtually zero for services to mining, superannuation fund operation, owner builders, oil and gas exploration, petroleum and coal product manufacturing nec, health insurance, and prefabricated building manufacturing. The contribution of these industries to value added was low, in part because these industries are small. However, the value added for investors in other property, superannuation fund operation, and owner builders was also small as a proportion of their own gross output, at -0.5, 1.7 and 6.4 percent respectively. Operating surplus of investors in other property, services to mining, superannuation fund operation, oil and gas exploration, health insurance and apple and pear growing contributed negatively to value added.

Value added as a share of industry output was largest for public order and safety services, at 80.3 percent, followed by 79.5 percent for primary and secondary education and 78.8 percent for commercial property operators. Value added is high in these industries, in part because of a large labour component.

New Zealand's two largest exporting industries are meat processing and dairy product manufacturing. In 1996, their share of total exports was about 11.4 and 11.3 percent respectively. Wholesale trade (9 percent) and air transport, services to transport and storage (7.8 percent) were also important exporters.

Exports made up about 60.9 percent of total gross output of the dairy product manufacturing industry and 65.1 percent of meat processing's total gross output. Only other leather product manufacturing, apple and pear growing, seafood processing and kiwifruit growing exported a larger proportion of their gross output, with kiwifruit growing having the highest share (84.4 percent).

The largest providers of intermediate goods and services were wholesale trade and finance with 3.7 and 2.2 percent of total gross output, while superannuation fund operation and ownership of owner-occupied dwellings did not supply any intermediate products.

Table 2: Some descriptive statistics

	Industry share of total gross output	Industry share of total value added	Value added as a share of industry output	Industry share of total exports	Intermediate products as a share of industry output	Exports as a share of industry output	Intermediate products as a share of total gross output	Consumption expenditure as a share of total gross output	Gross capital formation as a share of total gross output
Other horticulture	0.4	0.4	47.4	0.7	57.0	25.1	0.2	0.1	0.0
Apple and pear growing	0.1	0.2	46.0	0.8	14.5	75.0	0.0	0.0	0.0
Kiwifruit growing	0.1	0.2	47.4	0.9	14.1	84.4	0.0	0.0	0.0
Other fruit growing	0.1	0.1	43.8	0.2	38.6	35.8	0.0	0.0	0.0
Mixed livestock and cropping	0.4	0.3	39.6	0.2	82.9	8.3	0.3	0.0	0.0
Sheep and beef cattle farming	1.6	1.3	36.9	1.0	96.8	8.8	1.5	0.0	-0.1
Dairy cattle farming	1.9	2.3	52.8	0.1	94.0	1.0	1.8	0.0	0.1
Other farming	0.4	0.3	41.7	0.2	76.9	9.3	0.3	0.0	0.0
Services to agriculture, hunting and trapping	0.5	0.5	45.3	0.1	88.3	3.1	0.4	0.0	0.0
Forestry	1.1	1.0	40.6	2.7	49.4	33.6	0.6	0.0	0.2
Services to forestry	0.1	0.1	57.9	0.1	87.1	11.1	0.1	0.0	0.0
Logging	0.2	0.2	62.8	0.1	92.6	5.2	0.2	0.0	0.0
Fishing	0.4	0.3	34.3	0.6	78.4	20.8	0.3	0.0	0.0
Coal mining	0.1	0.1	45.6	0.3	56.4	38.2	0.1	0.0	0.0
Services to mining	0.0	0.0	38.9	0.0	88.9	0.0	0.0	0.0	0.0
Other mining and quarrying	0.4	0.4	44.5	0.9	61.5	34.7	0.2	0.0	0.0
Oil and gas extraction	0.5	0.7	63.6	0.6	79.1	16.8	0.4	0.0	0.0
Oil and gas exploration	0.0	0.0	26.7	0.0	37.3	8.0	0.0	0.0	0.0
Meat processing	2.5	1.3	23.6	11.4	20.4	65.1	0.5	0.4	0.0
Poultry processing	0.2	0.1	24.8	0.0	43.0	2.4	0.1	0.1	0.0
Bacon, ham and small good manufacturing	0.1	0.1	26.3	0.0	28.1	4.6	0.0	0.1	0.0
Dairy product manufacturing	2.6	0.8	13.8	11.3	15.2	60.9	0.4	0.4	0.2
Fruit and vegetable, oil and fat, cereal and flour manufacturing	0.7	0.4	24.4	1.1	38.1	23.3	0.3	0.2	0.0
Bakery, sugar and confectionery manufacturing	0.6	0.4	25.0	0.6	34.2	13.0	0.2	0.3	0.0
Seafood processing	0.7	0.4	27.3	4.0	10.6	82.1	0.1	0.0	0.0
Other food manufacturing	0.6	0.4	29.2	0.9	43.7	21.8	0.3	0.2	0.0
Soft drink, cordial and syrup manufacturing	0.2	0.2	34.5	0.1	32.1	5.0	0.1	0.1	0.0
Beer, wine, spirit and tobacco manufacturing	0.7	0.4	28.6	0.5	27.2	11.5	0.2	0.4	0.0
Textile manufacturing	0.7	0.5	30.5	1.5	52.6	29.3	0.4	0.1	0.0
Clothing manufacture	0.5	0.4	38.3	0.9	17.1	29.2	0.1	0.2	0.0
Footwear manufacture	0.1	0.1	43.6	0.2	3.2	39.1	0.0	0.0	0.0
Other leather product manufacturing	0.2	0.1	25.8	1.2	24.5	69.7	0.1	0.0	0.0
Log sawmilling and timber dressing	0.8	0.5	26.8	1.4	74.1	24.9	0.6	0.0	0.0
Other wood product manufacturing	0.7	0.5	32.7	1.6	63.6	30.7	0.5	0.0	0.0
Paper and paper product manufacturing	1.5	1.3	38.1	3.8	53.0	34.5	0.8	0.2	0.0
Printing and services to printing	0.8	0.8	42.6	0.3	82.5	5.3	0.7	0.1	0.0
Publishing, recorded media manufacturing	0.8	0.9	47.6	0.2	79.1	2.6	0.7	0.2	0.0
Petroleum refining	0.7	0.1	7.3	0.4	57.0	8.3	0.4	0.2	0.0
Petroleum and coal product manufacturing nec	0.0	0.0	25.3	0.0	64.6	12.7	0.0	0.0	0.0
Fertiliser manufacturing	0.3	0.2	21.2	0.0	92.7	1.6	0.3	0.0	0.0
Other industrial chemical manufacturing	0.6	0.4	28.7	1.3	63.9	30.1	0.4	0.0	0.0
Medicinal, detergent and cosmetic manufacturing	0.5	0.3	29.5	1.0	30.7	27.8	0.2	0.2	0.0
Other chemical product manufacturing	0.4	0.2	26.5	0.6	71.1	23.5	0.3	0.0	0.0
Rubber manufacturing	0.2	0.2	39.6	0.3	61.6	24.7	0.1	0.0	0.0
Plastic product manufacturing	0.8	0.7	37.7	1.1	67.7	19.6	0.5	0.1	0.0
Glass and glass product and ceramic manufacturing	0.2	0.2	43.4	0.2	80.2	12.0	0.1	0.0	0.0
Other non-metallic mineral product manufacturing	0.6	0.5	42.1	0.1	93.0	2.7	0.5	0.0	0.0
Basic metal manufacturing	1.0	0.6	30.4	2.4	62.5	36.2	0.6	0.0	0.0
Structural, sheet and fabricated metal product manufacturing	1.5	1.3	37.0	1.9	73.6	17.6	1.1	0.0	0.1
Motor vehicle and part manufacturing	0.9	0.4	18.5	0.4	27.7	6.8	0.2	0.2	0.4
Ship and boat building	0.2	0.2	40.4	0.3	20.6	21.8	0.0	0.1	0.1
Other transport equipment manufacturing	0.3	0.3	43.8	0.2	79.2	12.1	0.2	0.0	0.0
Photographic and scientific equipment manufacturing	0.1	0.1	40.6	0.3	41.1	36.5	0.0	0.0	0.0
Electronic equipment and appliance manufacturing	1.1	0.8	32.7	1.9	32.7	25.5	0.3	0.2	0.3
Agricultural machinery manufacturing	0.2	0.1	41.0	0.2	25.3	19.1	0.0	0.0	0.1
Other industrial machinery and equipment manufacturing	0.9	0.8	40.8	1.4	31.1	22.1	0.3	0.0	0.4
Prefabricated building manufacturing	0.1	0.0	25.2	0.1	82.0	14.4	0.0	0.0	0.0
Furniture manufacturing	0.5	0.4	33.4	0.4	25.8	9.7	0.1	0.2	0.2
Other manufacturing	0.2	0.2	40.1	0.5	37.5	33.4	0.1	0.0	0.0
Electricity generation	0.7	0.8	54.4	0.0	69.1	0.1	0.5	0.2	0.0
Electricity transmission	0.3	0.5	71.4	0.0	99.4	0.0	0.3	0.0	0.0
Electricity supply	1.5	1.0	30.2	0.0	69.2	0.0	1.0	0.5	0.0
Gas supply	0.3	0.2	39.0	0.3	59.7	16.4	0.1	0.1	0.0

Table 3: Some descriptive statistics (cont.)

	Industry share of total gross output	Industry share of total value added	Value added as a share of industry output	Industry share of total exports	Intermediate products as a share of industry output	Exports as a share of industry output	Intermediate products as a share of total gross output	Consumption expenditure as a share of total gross output	Gross capital formation as a share of total gross output
Water supply	0.2	0.2	42.8	0.0	100.0	0.0	0.2	0.0	0.0
Residential building construction	1.4	0.7	21.4	0.0	12.5	0.3	0.2	0.0	1.2
Owner builders	0.4	0.0	1.7	0.0	7.3	0.0	0.0	0.0	0.4
Non residential building construction	1.1	0.4	15.8	0.1	27.1	1.2	0.3	0.0	0.8
Non building construction	1.3	1.0	33.5	0.0	35.6	0.3	0.5	0.0	0.9
Site preparation services	0.4	0.3	39.9	0.0	33.3	0.1	0.1	0.0	0.2
Building structure services	0.3	0.2	39.9	0.0	69.1	0.0	0.2	0.0	0.1
Plumbing services	0.3	0.3	37.4	0.0	44.5	0.2	0.2	0.0	0.2
Installation trade services	0.8	0.6	36.8	0.1	55.6	1.3	0.4	0.0	0.3
Building completion services	0.7	0.7	43.0	0.0	69.0	0.2	0.5	0.0	0.2
Other construction services	0.2	0.2	41.9	0.0	79.9	0.0	0.1	0.0	0.0
Wholesale trade	7.9	7.7	44.0	9.0	46.6	16.2	3.7	2.3	0.7
Retail trade	5.8	6.7	51.2	3.4	26.1	8.1	1.5	3.6	0.3
Accommodation	0.6	0.6	42.8	1.7	14.0	40.5	0.1	0.3	0.0
Bars, clubs, cafes and restaurants	1.1	0.8	32.9	1.9	7.7	24.3	0.1	0.8	0.0
Road freight transport	1.4	1.4	45.0	0.2	95.7	2.1	1.3	0.0	0.0
Road passenger transport	0.3	0.3	49.5	0.4	40.3	19.0	0.1	0.1	0.0
Water and rail transport	0.8	1.0	58.2	2.2	54.0	38.2	0.4	0.1	0.0
Air transport, services to transport and storage	2.6	2.3	38.8	7.8	39.5	41.6	1.0	0.5	0.0
Communication services	2.5	3.5	61.6	1.0	64.2	5.6	1.6	0.7	0.1
Finance	2.8	3.9	62.0	0.4	77.4	1.8	2.2	0.6	0.0
Life insurance	0.4	0.3	31.7	0.0	10.3	0.1	0.0	0.3	0.0
Superannuation fund operation	0.1	0.0	6.4	0.0	0.0	0.0	0.0	0.1	0.0
Health insurance	0.0	0.0	32.9	0.0	17.1	0.0	0.0	0.0	0.0
General insurance	0.5	0.6	52.6	0.0	65.2	1.1	0.3	0.2	0.0
Services to finance and insurance	0.7	0.7	46.8	0.1	96.0	1.7	0.6	0.0	0.0
Residential property operators	1.3	1.7	61.7	0.0	1.6	0.4	0.0	1.2	0.0
Commercial property operators	1.3	2.2	78.8	0.0	99.4	0.5	1.3	0.0	0.0
Real estate agents	0.7	0.7	41.0	0.0	49.1	0.1	0.4	0.0	0.3
Ownership of owner-occupied dwellings	4.6	7.5	72.6	0.0	0.0	0.0	0.0	4.6	0.0
Investors in other property	0.2	0.0	-0.6	0.1	88.0	9.9	0.2	0.0	0.0
Vehicle and equipment hire	0.6	0.7	52.0	0.7	80.9	16.8	0.5	0.0	0.0
Scientific research	0.3	0.4	63.4	0.1	43.4	5.1	0.1	0.1	0.0
Technical services	0.9	1.1	55.8	0.2	74.9	3.8	0.6	0.0	0.2
Computer services	0.8	0.9	54.9	0.1	88.1	2.4	0.7	0.0	0.1
Legal services	0.6	0.9	69.4	0.1	75.7	3.1	0.5	0.1	0.1
Accounting services	0.5	0.8	69.9	0.1	95.2	2.6	0.5	0.0	0.0
Advertising and marketing services	0.9	0.8	37.7	0.2	95.4	2.7	0.9	0.0	0.0
Business administrative and management services	0.7	0.8	49.4	0.1	94.5	2.7	0.7	0.0	0.0
Employment, security and investigative services	0.4	0.5	60.2	0.0	97.7	1.0	0.4	0.0	0.0
Pest control and cleaning services	0.2	0.4	68.8	0.0	89.5	0.7	0.2	0.0	0.0
Other business services	0.7	0.6	39.5	0.3	87.7	6.4	0.6	0.0	0.0
Central government administration	2.0	2.0	46.2	0.2	10.1	1.2	0.2	1.7	0.0
Defence	0.5	0.7	62.7	0.0	0.6	0.6	0.0	0.5	0.0
Public order and safety services	0.5	0.9	80.3	0.0	1.2	0.2	0.0	0.5	0.0
Local government administration services and civil defence	1.5	1.5	45.0	0.1	7.9	0.9	0.1	1.3	0.0
Pre-school education	0.1	0.2	67.1	0.0	2.7	0.9	0.0	0.1	0.0
Primary and secondary education	1.4	2.4	79.5	0.3	4.9	3.0	0.1	1.3	0.0
Post school education	0.8	1.3	70.1	0.5	6.2	8.1	0.0	0.7	0.0
Other education	0.3	0.3	52.2	0.2	62.8	9.4	0.2	0.1	0.0
Hospitals and nursing homes	1.7	2.7	71.0	0.1	2.1	0.4	0.0	1.7	0.0
Medical, dental and other health services	1.0	1.5	63.6	0.1	13.7	1.0	0.1	0.9	0.0
Veterinary services	0.1	0.1	62.7	0.0	42.2	3.7	0.0	0.0	0.0
Child care services	0.1	0.1	63.6	0.0	33.6	0.0	0.0	0.0	0.0
Accommodation for the aged	0.3	0.4	61.4	0.0	13.6	0.6	0.0	0.2	0.0
Other community care services	0.2	0.3	53.9	0.0	9.2	1.6	0.0	0.2	0.0
Motion picture, radio and TV services	0.7	0.6	38.5	0.2	75.3	4.7	0.5	0.1	0.0
Libraries, museums and the arts	0.2	0.2	46.1	0.2	36.3	10.3	0.1	0.1	0.0
Horse and dog racing	0.1	0.1	33.5	0.2	56.0	28.2	0.1	0.0	0.0
Lotteries, casinos and other gambling	0.3	0.4	62.4	0.2	5.2	8.3	0.0	0.3	0.0
Other sport and recreational services	0.5	0.4	32.7	0.8	15.4	21.7	0.1	0.3	0.0
Personal and other community services	0.9	1.0	53.4	0.3	30.5	5.1	0.3	0.6	0.0
Waste disposal, sewerage and drainage services	0.1	0.2	48.7	0.0	95.2	1.1	0.1	0.0	0.0

In 1996, ownership of owner-occupied dwellings, retail and wholesale trade were the largest suppliers of final consumption expenditure, with 14.6, 11.2 and 7.1 percent of total final consumption expenditure. Services to mining and water supply did not provide any final consumption expenditure, with water supply not producing any final demand output.

New Zealand industries produce a relatively small share of gross capital formation, 8.4 percent of total gross output in 1996, of which residential building construction supplied most of gross fixed capital (1.2 percent of total gross output), followed by non building construction (0.9 percent) and non residential building construction (0.8 percent). Gross capital formation, which is the sum of gross fixed capital formation and the change in inventories, was negative for some industries because of a decline in inventories.

4.2 Backward and forward linkages

The structure of production of the New Zealand economy can be assessed more formally with measures of backward and forward linkages. Backward and forward indices reported in this section are based on total requirement coefficients and hence take into account both direct and indirect linkages. Backward linkages measure the impact on the supplier industries of a dollar increase in the final demand for a particular industry's product. Forward linkages, on the other hand, measure the increase in the output of industry i needed to supply the inputs required to produce a unit of the final demand output in industry j.

Figures 1 and 2 plot the indices of backward and forward linkages for all 126 industries, using each sector's share in total final demand as a set of weights. Wholesale trade, ownership of owner-occupied dwellings, and retail trade have the largest backward linkage followed by dairy product manufacturing and meat processing. A high backward linkage means that an increase in the final demand of any of these industries' output will have a large impact on industries that supply inputs in the production of these industries' output.

Wholesale trade has also the largest forward linkage. This means that output in the wholesale trade sector must increase following an increase in final demand output in other industries in order to provide the required inputs for the production of an additional dollar's worth of final demand. Retail trade has the second largest forward linkage although substantially smaller than wholesale trade.[7] Air transport, services to transport and storage, ownership of owner-occupied dwellings, communication services, meat processing, finance, and dairy product manufacturing also have relatively large forward linkages. These industries, apart from air transport, services to transport and storage, communication services, and finance, also have large backward linkage. At the bottom of the ranking for forward linkages is water supply as it does not produce any final output.

Alternatively, backward and forward linkages can be weighted by exports, with the results reported in Figures 3 and 4. Backward linkages are highest for meat processing, dairy product manufacturing, wholesale trade and air transport, services to transport and storage, largely because of their high proportion of total exports. Other leather product manufacturing and seafood processing also have high backward linkages and an increase in final demand in these industries will affect the output of other industries.

[7] Chatterjee (1989) notes a bias in the forward linkage. This issue requires further investigation.

When weighted by exports, wholesale trade, air transport, services to transport and storage, meat processing, and dairy product manufacturing have large backward as well as forward linkages. The forward linkages of retail trade, and paper and paper product manufacturing are also relatively high.

Backward and forward linkages are sensitive to extreme values and coefficient of variation indices are often calculated in addition. The backward and forward coefficient of variation indices weighted by final demand are plotted in Figures 5 and 6 and weighted by exports in Figures 7 and 8. The backward (forward) index measures the relative evenness with which an industry purchases from (sells to) other sectors. A relatively large value implies that a sector purchases (sells) inputs only from (to) a few industries in the economy.

The backward coefficient of variation indices weighted by final demand and exports are high, i.e. the number of transactions with other industries is low, for some of the industries with large backward linkages, like ownership of owner-occupied dwellings, wholesale and retail trade, meat processing, dairy product manufacturing, and air transport, services to transport and storage. This indicates that the strong backward linkage of these industries is mainly the result of large inter industry transactions with only a few industries rather than widespread transactions with many different industries. The index is relatively stable for most sectors, varying between 3 and 6.5 for about 82 percent of the industries.

The rankings of industries by forward coefficients of variation are very similar for the indices weighted by final demand and exports. Measured in terms of evenness of transactions across industries, wholesale trade is the sector with most forward linkages. In fact, wholesale trade sells output to all industries except mining. Meat processing, on the other hand, moves down in the ranking when industry linkages are measured in terms of evenness of transactions across industries, while finance and communication services move up.

4.3 Industry interconnectedness

Indices of concentration as a measure of industry interconnectedness focus on the number of sales or purchases (either direct or both direct and indirect) across industries (rather than the magnitude of transactions) and are hence related to coefficients of variation.

Figures 9 and 10 plot the backward and forward concentration indices for input coefficients, which measure direct transactions. Figure 9 shows that the backward concentration index is very similar across industries, at around 11. This means that industries tend to buy from a large number of supplier industries. Among the industries with somewhat lower backward concentration are meat processing, fertiliser manufacturing, electricity transmission, commercial property operators, seafood processing, other leather product manufacturing, life insurance, real estate agents, general insurance, log sawmilling and timber dressing, water supply, and dairy product manufacturing. A low backward concentration index means that these industries do not require inputs from a lot of other industries to produce an additional unit of final output.

Some of these industries with low backward concentration have larger forward indices, i.e. they sell to more industries than they buy from, and hence move up in the ranking for forward concentration, like general insurance and commercial property operators, for example.

The forward concentration index is slightly more variable across industries than the backward index, in particular at the bottom end. Wholesale and retail trade have the largest forward

concentration, while the index could not be calculated for industries that do not have forward linkages, namely ownership of owner-occupied dwellings and superannuation fund operation.

Backward and forward concentration indices for total requirement coefficients, taking account of both direct and indirect transactions, are plotted in Figures 11 and 12. The backward concentration index for total requirement coefficients indicates how widespread across the economy the effects on supplier industries are from a dollar increase in final demand output by a particular industry. As in the case of the backward index for input coefficients (direct transactions), the effect on other industries is fairly even, i.e. the backward index is not very different across industries, and large. That is, industries purchase inputs from a large number of different industries to produce an additional dollar of final output.

However, a comparison of Figures 9 and 11 shows that the ranking of some industries changes dramatically when taking into account indirect linkages. For example, dairy product manufacturing purchases the least from other industries directly, but moves up to 15th place when also accounting for indirect transactions. Another example is scientific research, which moves from most direct backward transactions to 90th place for direct and indirect purchases.

A comparison of the backward and forward concentration indices for total requirement coefficients (Figures 9 and 10) shows that the forward concentration index differs more widely across industries than the backward index. Some industries (those with a high forward index) sell output to a large number of industries, while those with a low index only sell to a few. The forward index is largest for wholesale trade, finance, retail trade, and communication services and small or zero for pre-school education, public order and safety services, defence, lotteries, casinos and other gambling, footwear manufacture, ownership of owner-occupied dwellings, and superannuation fund operation. A small or zero index means that these industries are generally unaffected by changes in final output in the rest of the economy.

Taking into account indirect transactions does not change the industry ranking as much as for the forward concentration index. This indicates that industries that indirectly sell to a lot of industries also have strong direct inter industries ties.

A second measure of industry interconnectedness is entropy. The row entropy is conceptually parallel to the backward concentration index and the column index to the forward index. A small row entropy means that following an increase in industry i's final output, industry i only sells additional output to a few industries. A small column entropy, on the other hand, implies that other industries only purchase additional output from a few industries following an increase in industry i's final output.

The row and column entropy for input coefficients are plotted in Figures 13 and 14. Two main points emerge from the comparison of the entropy measures and concentration indices for input coefficients. First, although the ranking of industries is different for the two measures, those industries that are in the top (bottom) half for the entropy measure are also in the top (bottom) half for the concentration index. Second, the column entropy shows larger variation than the row entropy, which is in line with the forward concentration index differing more across industries than the backward index.

The row and column entropies for total requirement coefficients weighted by final demand, i.e. taking into account both direct and indirect transactions, are plotted in Figures 15 and 16 and weighted by exports in Figures 17 and 18. The ranking of industries for total

requirement coefficient entropies weighted by final demand and exports are similar, but different from the input coefficient entropies.

Industries with large row entropies for total requirement coefficients include non residential building construction, owner builders, residential building construction, and investors in other property. That is, a large number of industries will buy additional output from these industries following an increase in final demand for the output of these industries. Industries with small row entropies include ownership of owner-occupied dwellings, other transport equipment manufacturing, and public order and safety services. An increase in the final output of these industries will largely leave other industries unaffected.

Column entropies weighted by final demand or exports are largest for wholesale trade. They are also high for a few other industries, including retail trade, air transport, services to transport and storage, communication services, paper and paper product manufacturing, meat processing, and dairy product manufacturing. A large column entropy means that following an increase in these industries final demand output will have a large stimulatory effect on the rest of the economy.

Finally, the (row) entropy, taking into account both inter industry sales and sales to final demand is plotted in Figure 19. When taking into account intermediate and final sales, accounting services, business administration and management services, other business services, and employment, security and investigative services have the largest entropy. That is, a large number of households, private non-profit institutions serving households and government institutions will buy additional output from these industries following an increase in these industries' output. Moreover, other industries will also buy additional output from these industries in the form of intermediate products. The entropy is small for hospitals and nursing homes, residential property operators, pre-school education, footwear manufacture, public order and safety services and defence, and zero for ownership of owner-occupied dwellings, and superannuation fund operations.

5 Concluding remarks

This paper has investigated the production structure of the New Zealand business sector using the recently released 1996 input output tables. Measures of industry interconnectedness are fairly similar across industries and large, in particular for backward linkages. This suggests that New Zealand industries generally had strong industry ties in 1996. Backward and forward linkages show how much each industry buys from (sells to) other industries, directly and indirectly, following a unit increase in the final demand for its output. In 1996, wholesale and retail trade, ownership of owner-occupied dwellings, meat processing, dairy product manufacturing, and air transport, services to transport and storage had the strongest backward and forward linkages. Measured in terms of number of transactions, the backward linkages of some of these industries are less strong. Moreover, it was found that the ranking of industries by degree of interconnectedness can change dramatically depending on whether direct transactions or both direct and indirect transactions are considered. When taking into account intermediate and final sales, accounting services, business administration and management services, other business services, and employment, security and investigative services have the largest inter industry ties.

The next step of the analysis will be to calculate statistics of inter industry linkages that incorporate value added.

***Figure 1**:* Backward linkages (weighted by final demand)

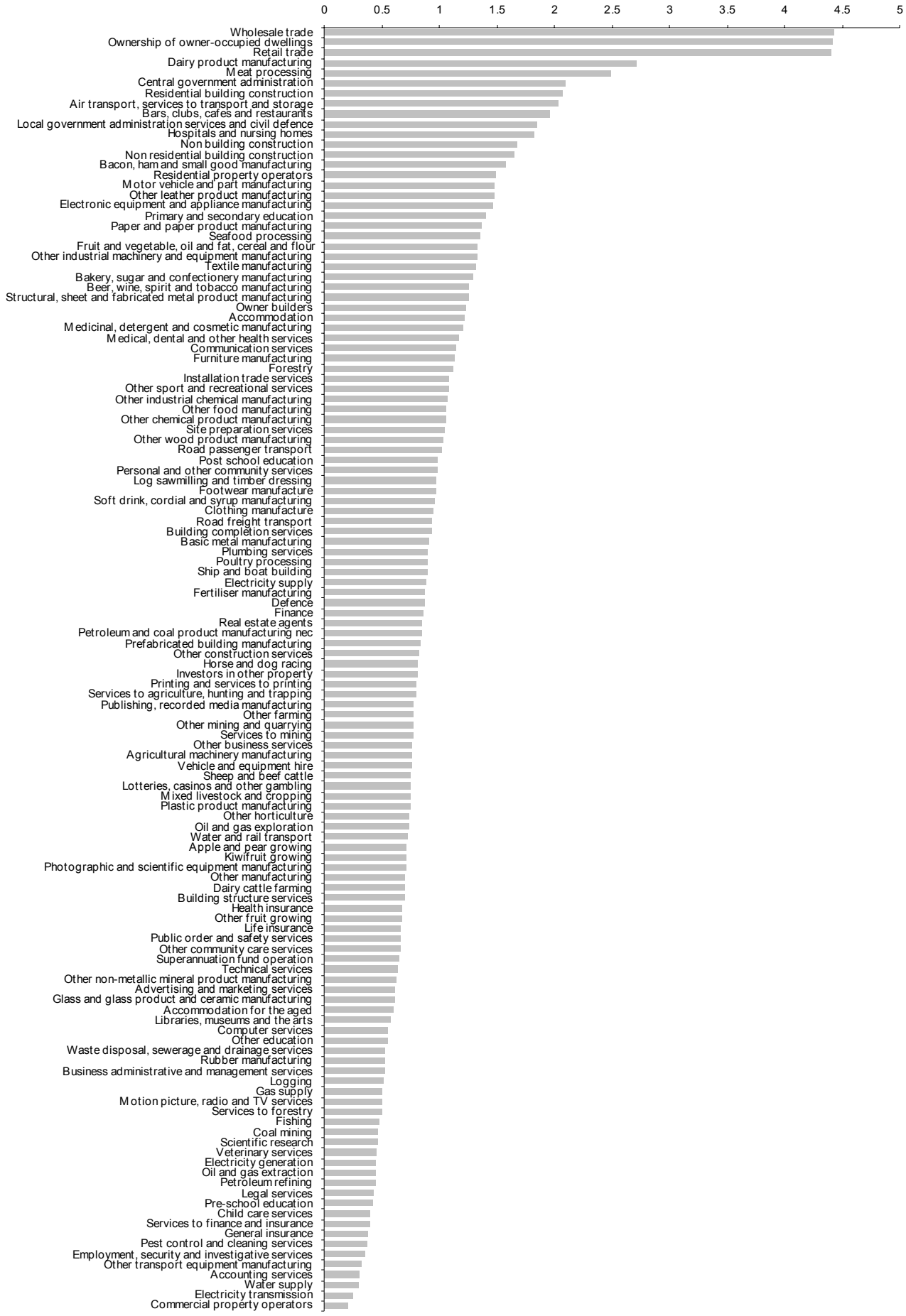


Figure 2: Forward linkages (weighted by final demand)

Figure 3: Backward linkages (weighted by exports)

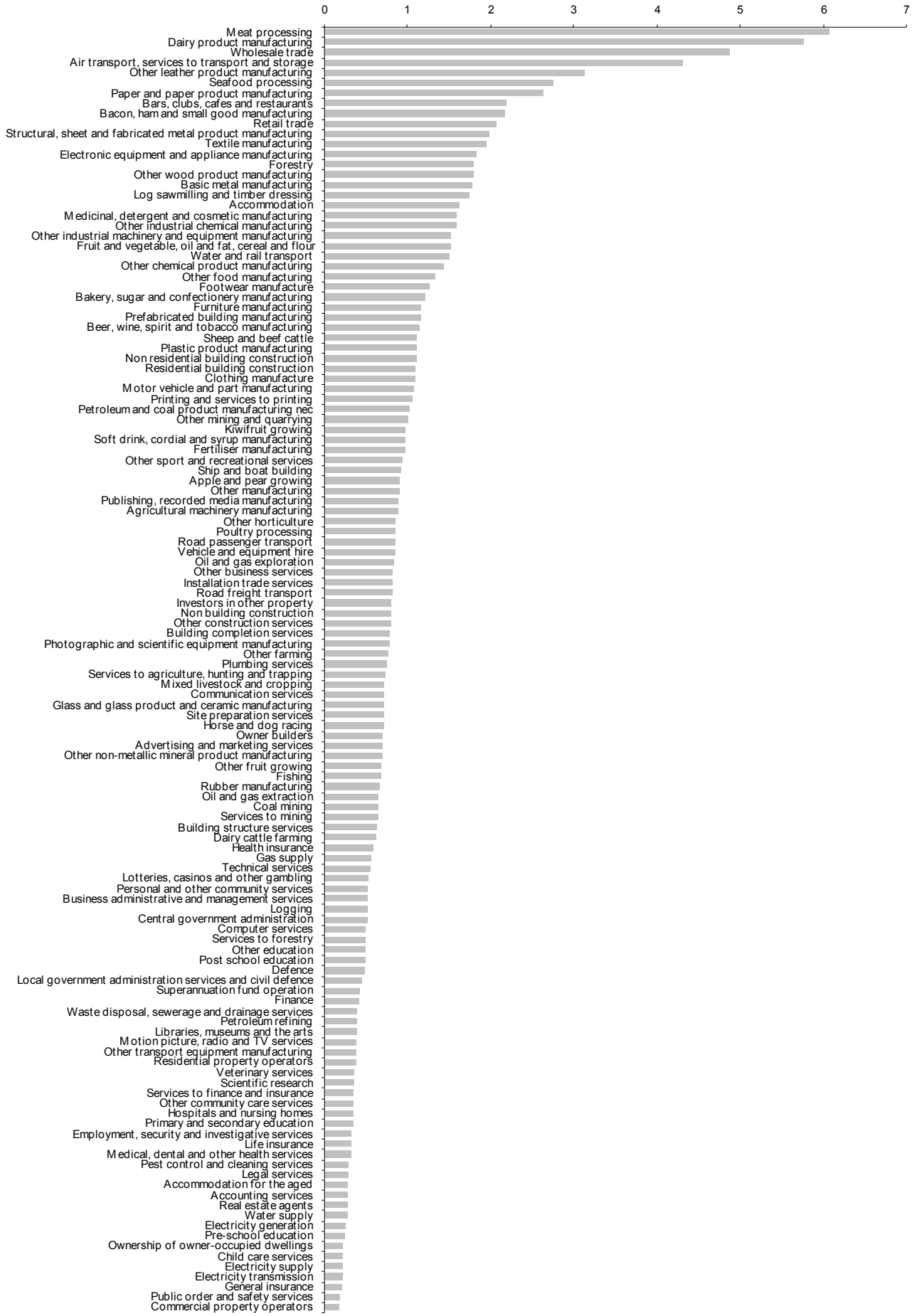


Figure 4: Forward linkages (weighted by exports)

Figure 5: Backward coefficient of variation index (weighted by final demand)

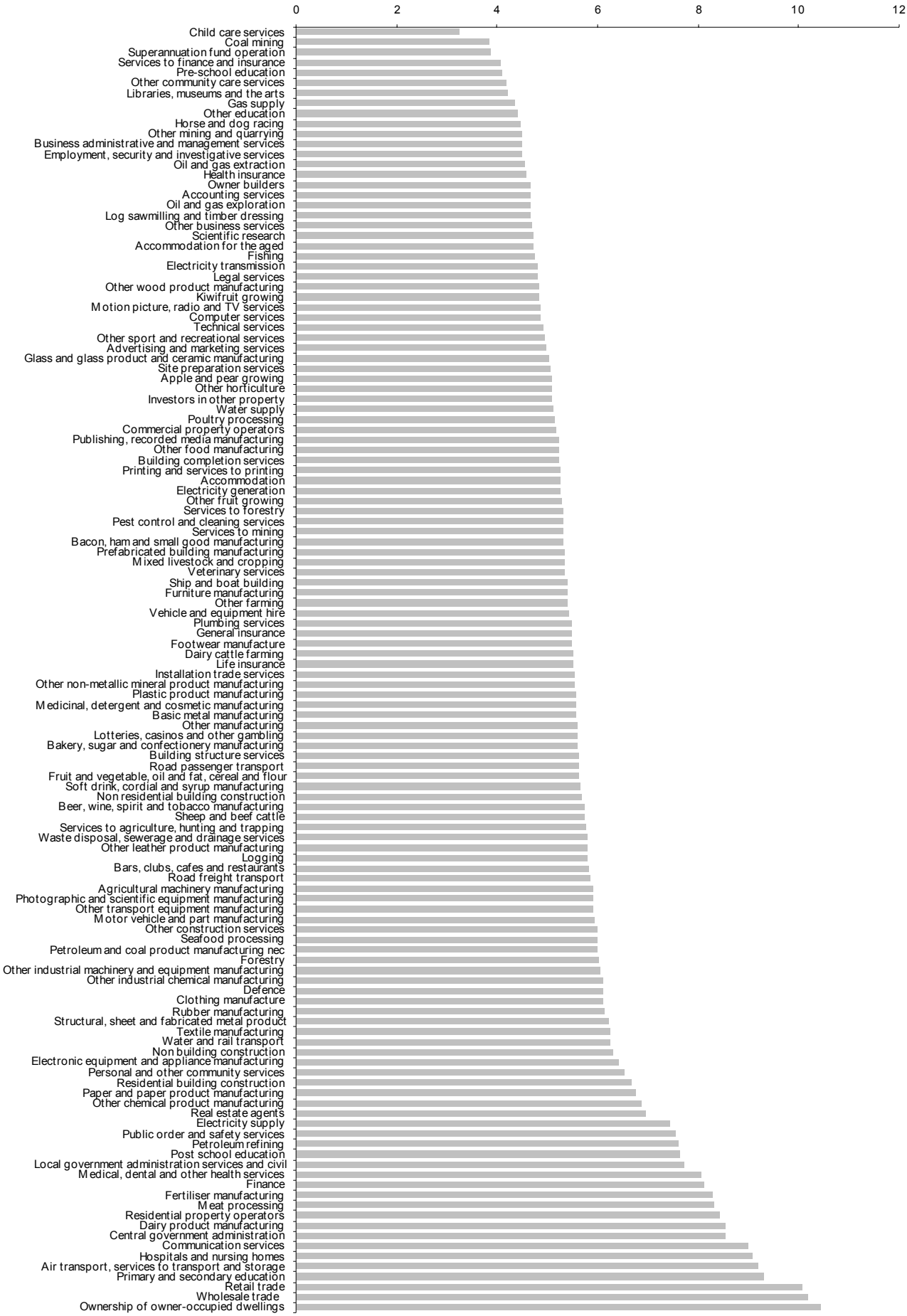


Figure 6: Forward coefficient of variation index (weighted by final demand)

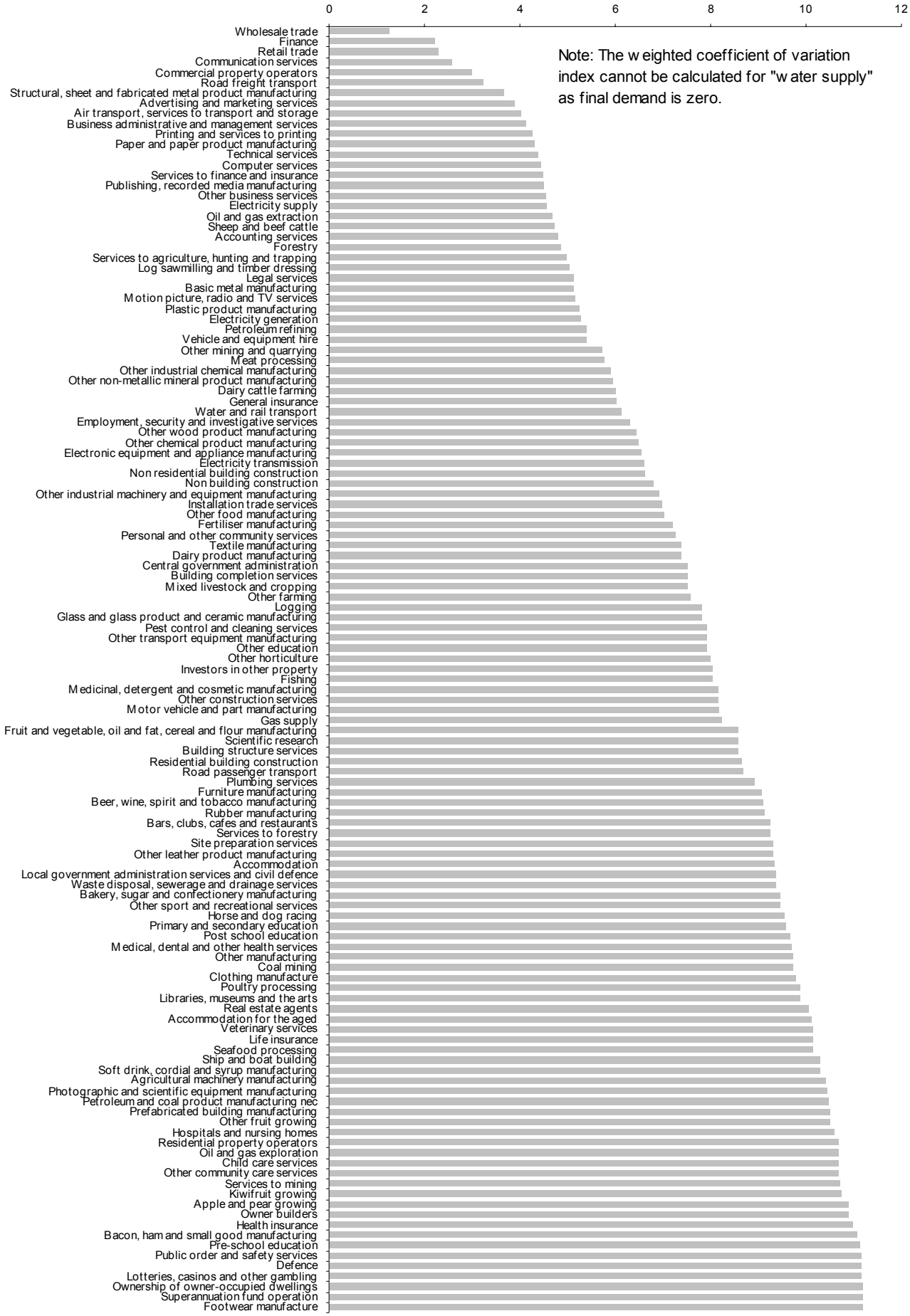


Figure 7: Backward coefficient of variation index (weighted by exports)

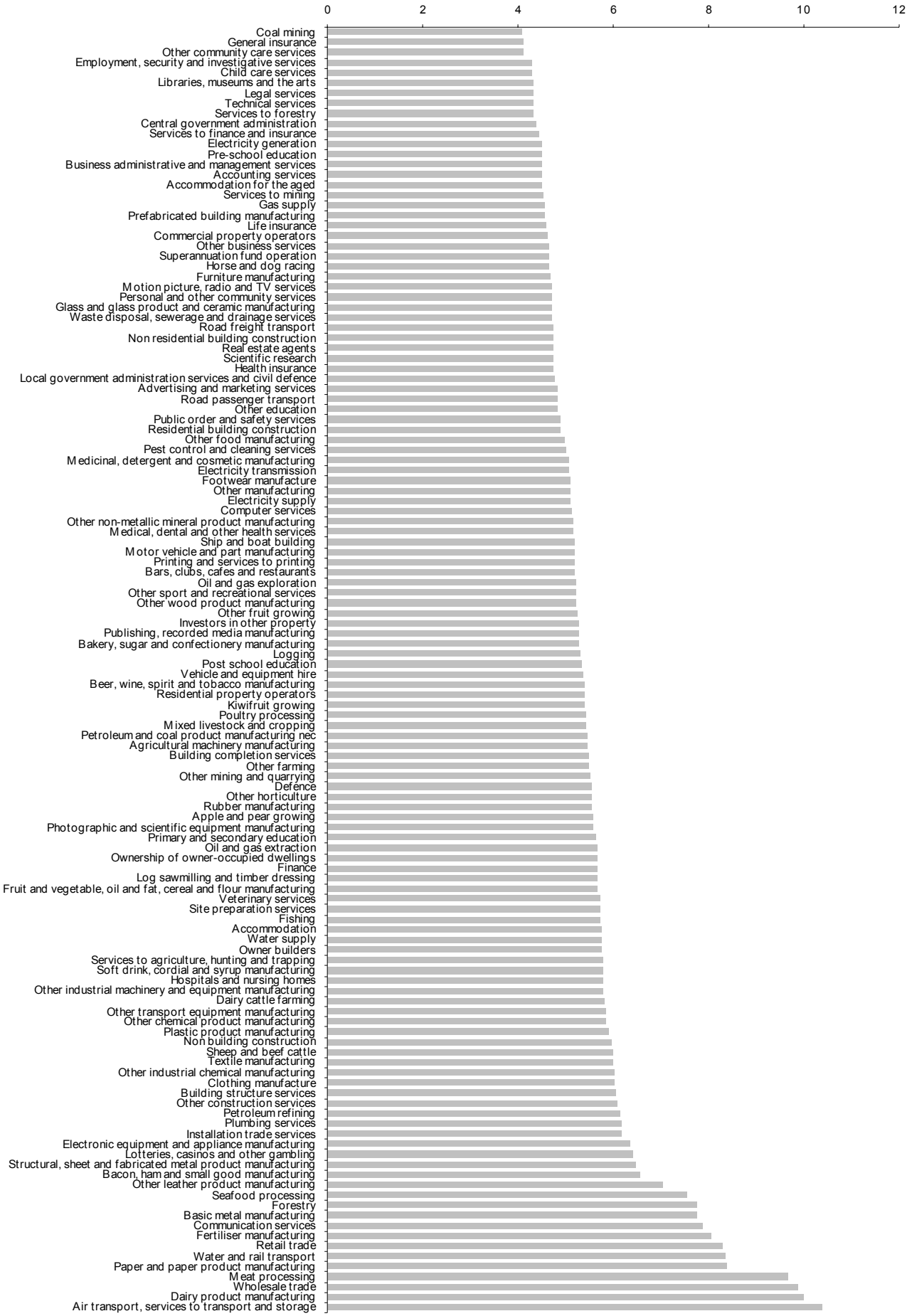
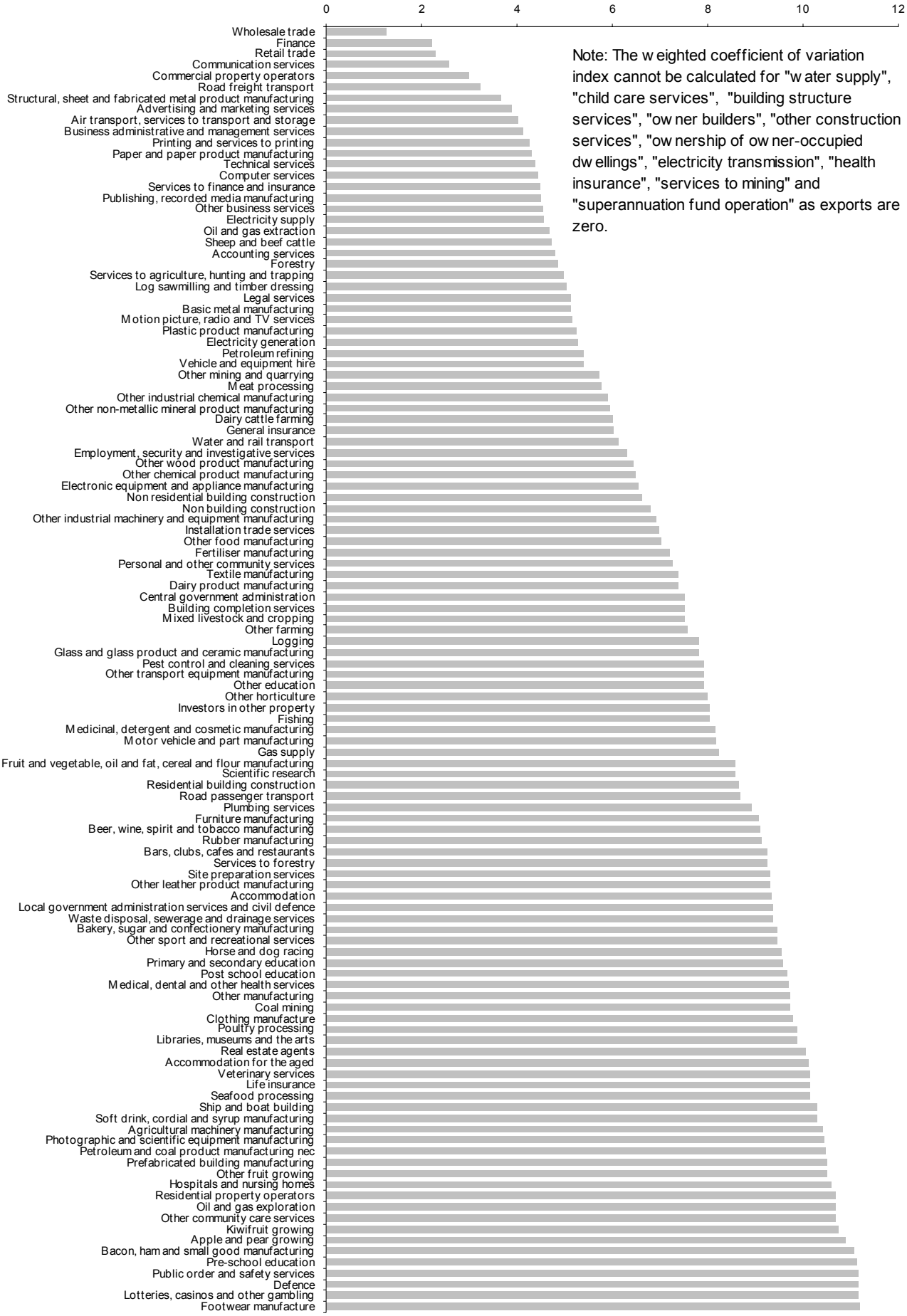


Figure 8: Forward coefficient of variation index (weighted by exports)



Note: The weighted coefficient of variation index cannot be calculated for "water supply", "child care services", "building structure services", "owner builders", "other construction services", "ownership of owner-occupied dwellings", "electricity transmission", "health insurance", "services to mining" and "superannuation fund operation" as exports are zero.

Figure 9: Backward concentration index for input coefficients

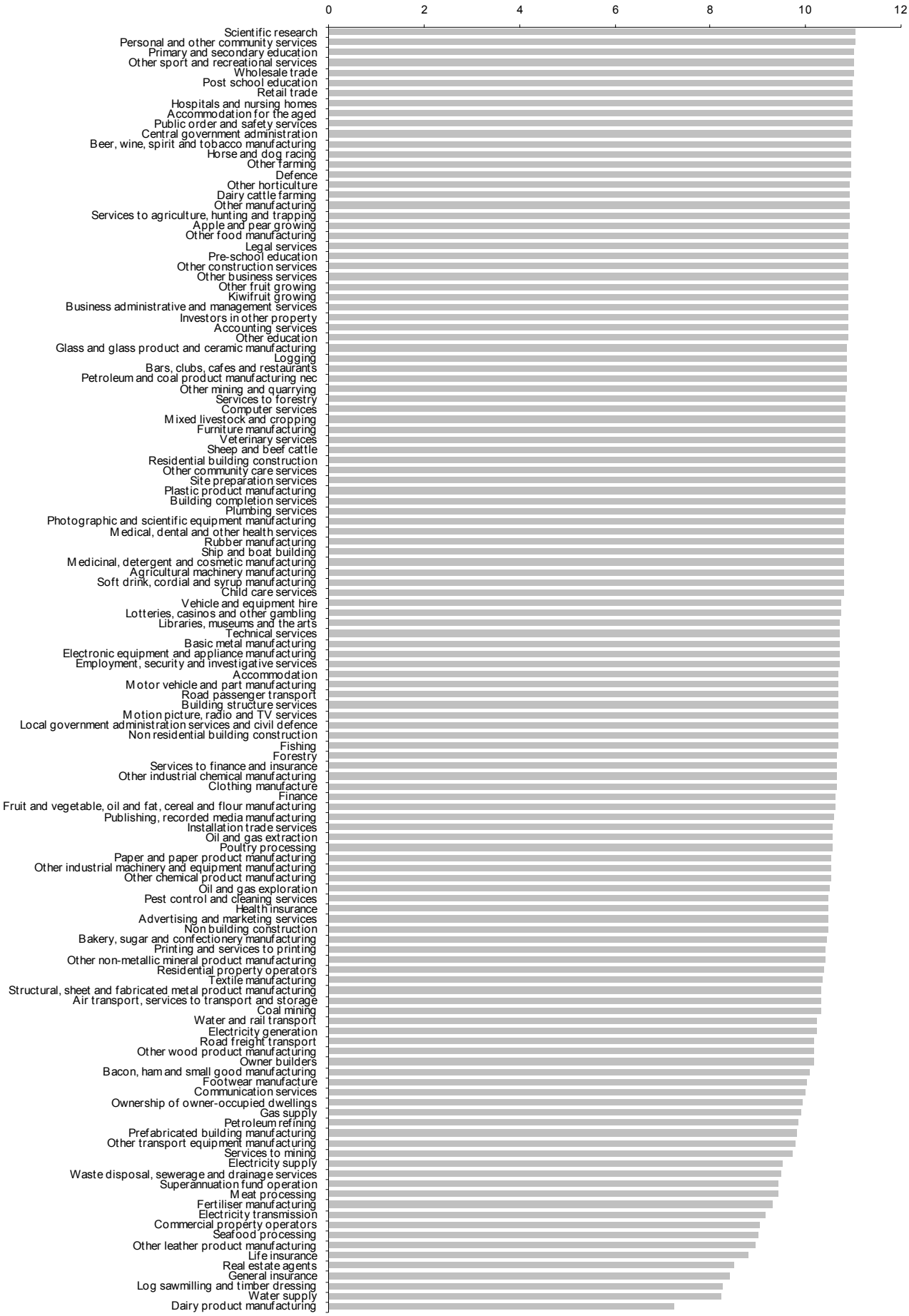


Figure 10: Forward concentration index for input coefficients

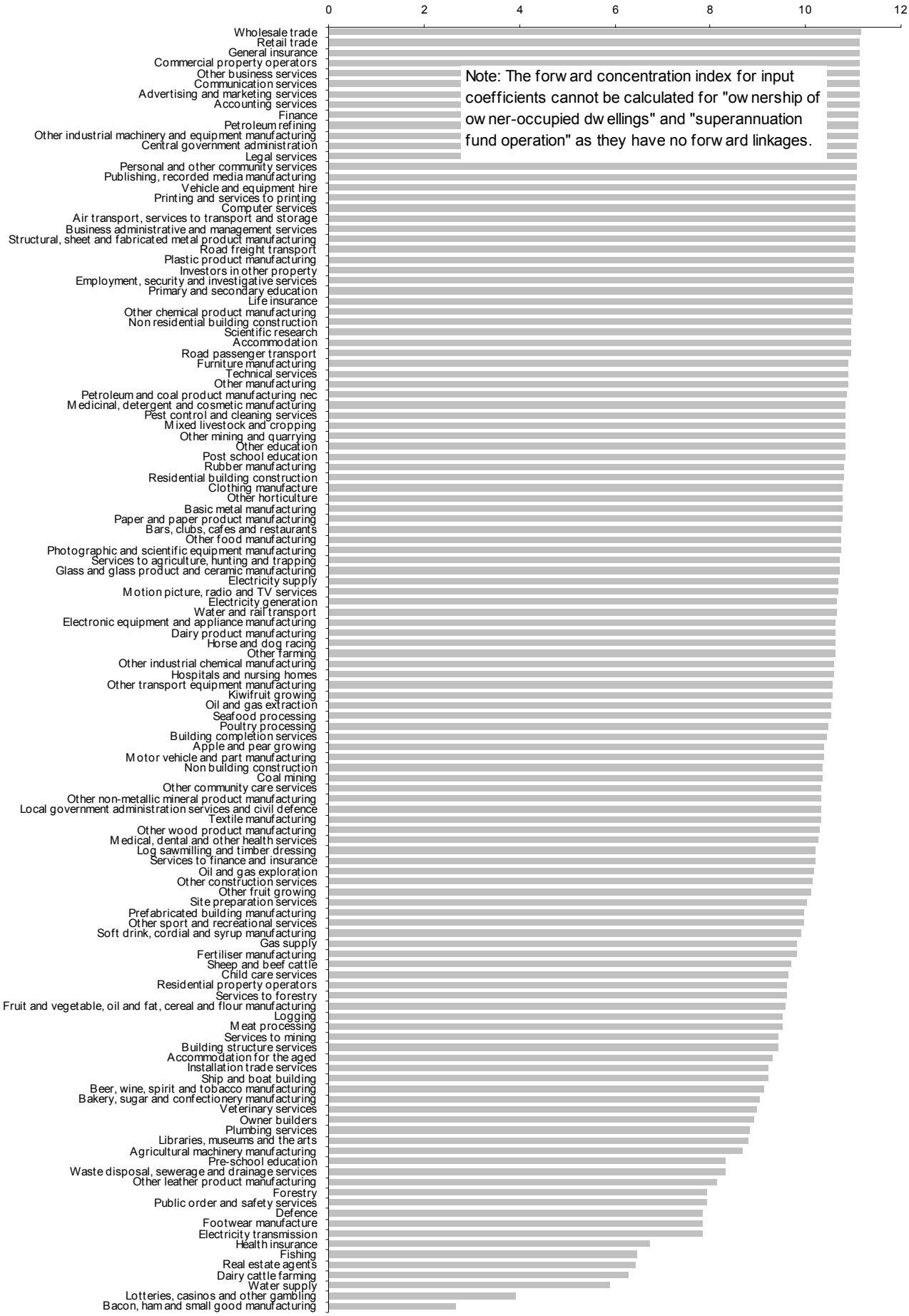


Figure 11: Backward concentration index for total requirement coefficients

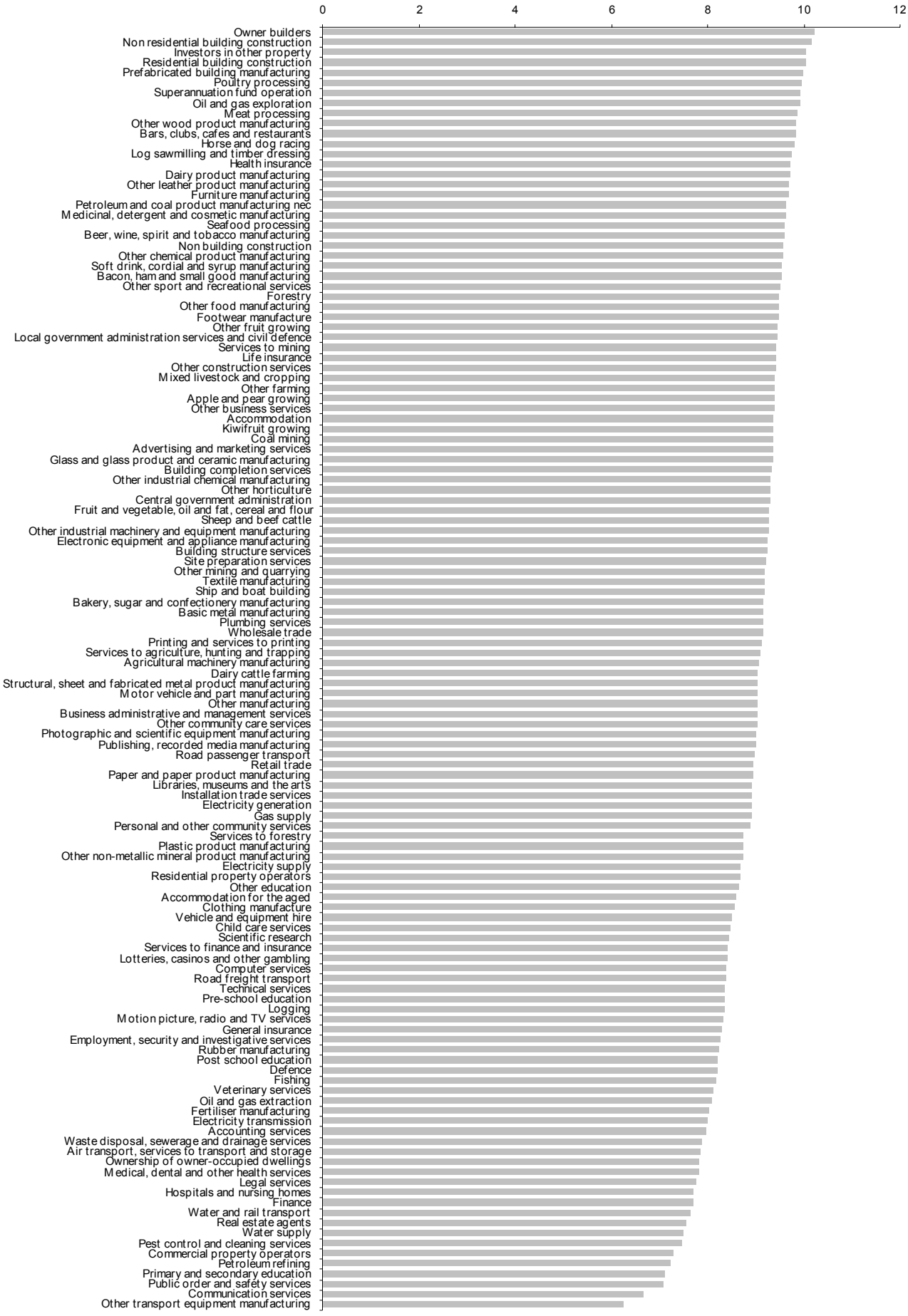


Figure 12: Forward concentration index for total requirement coefficients

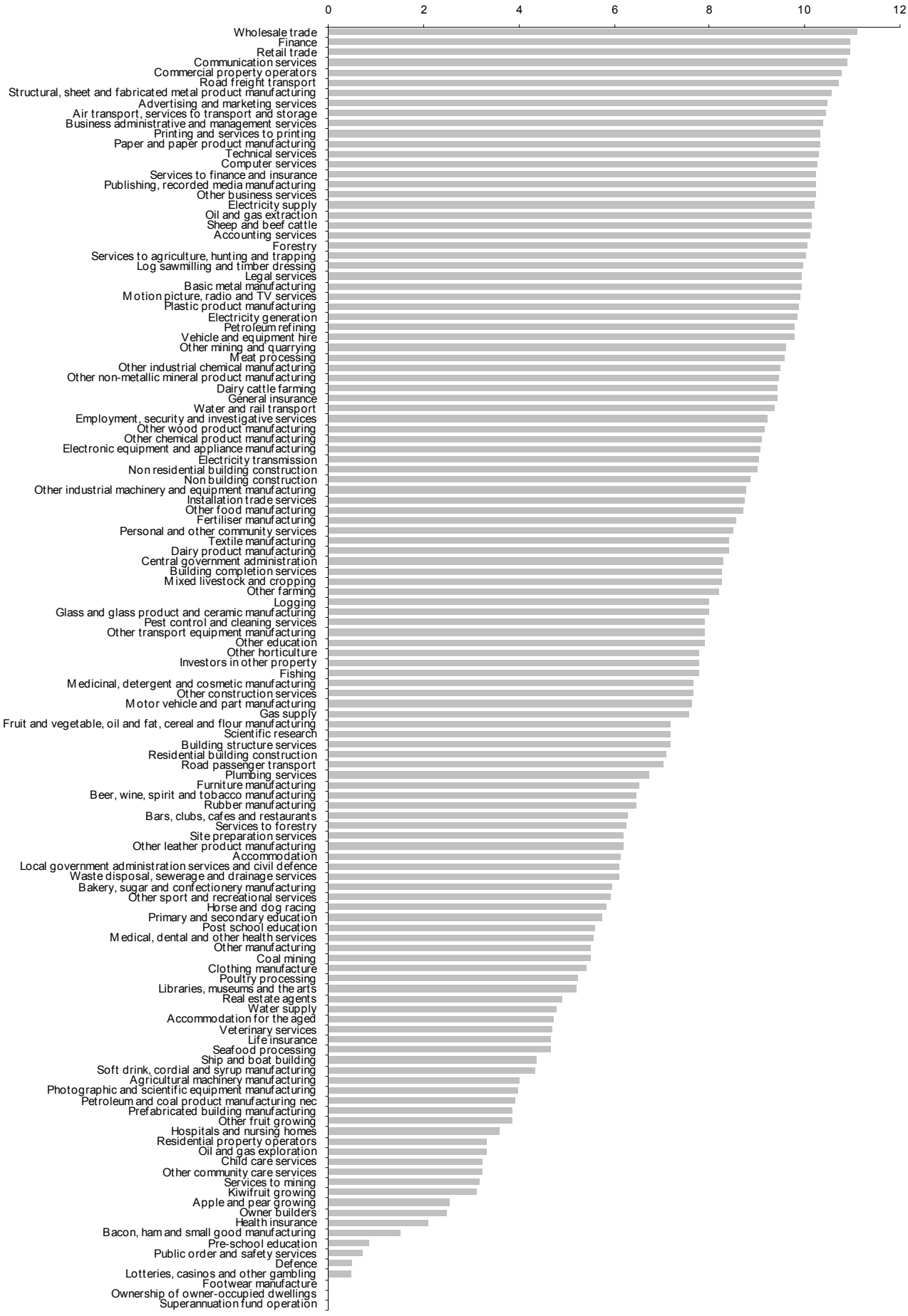


Figure 13: Row entropy for input coefficients

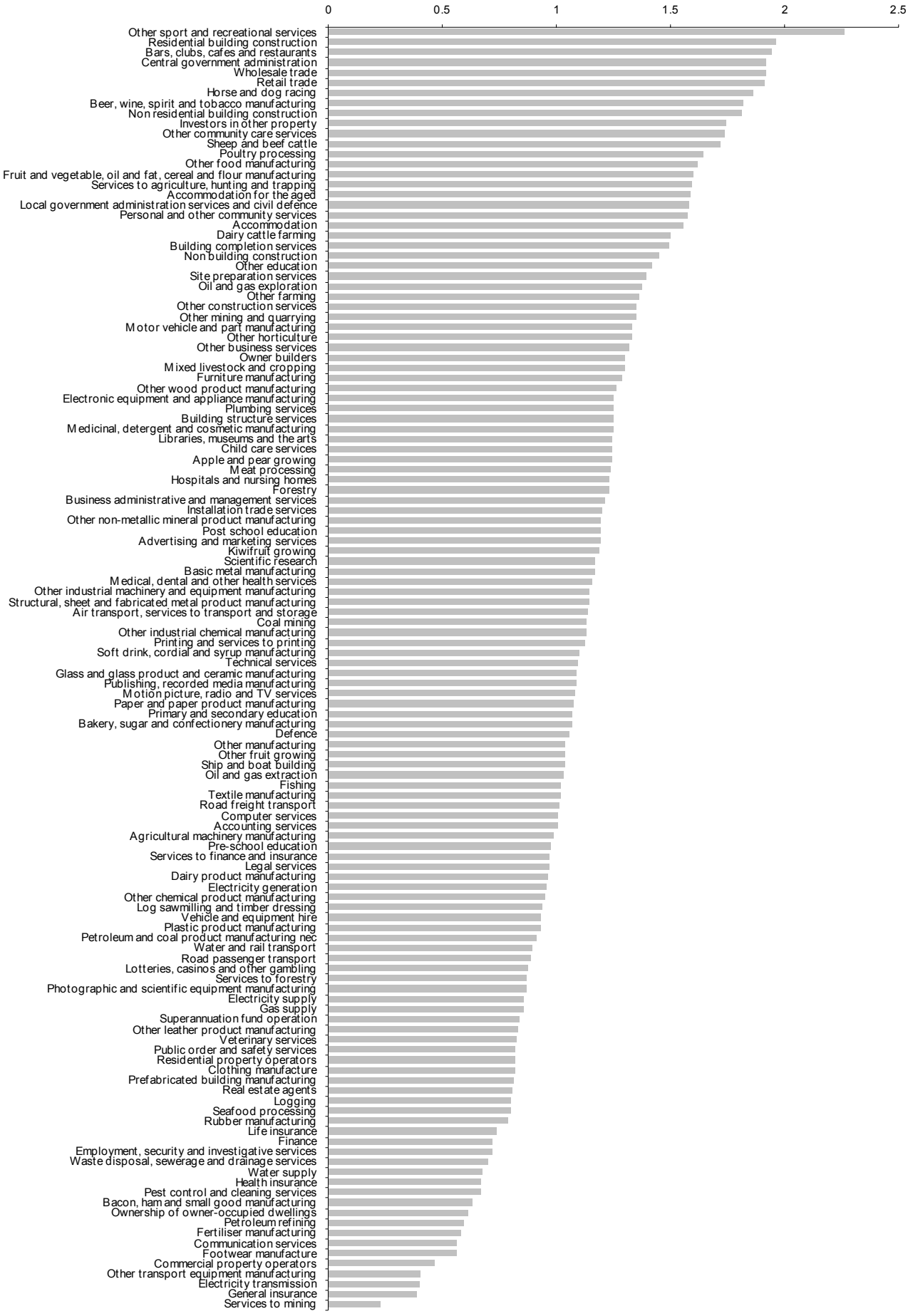


Figure 14: Column entropy for input coefficients

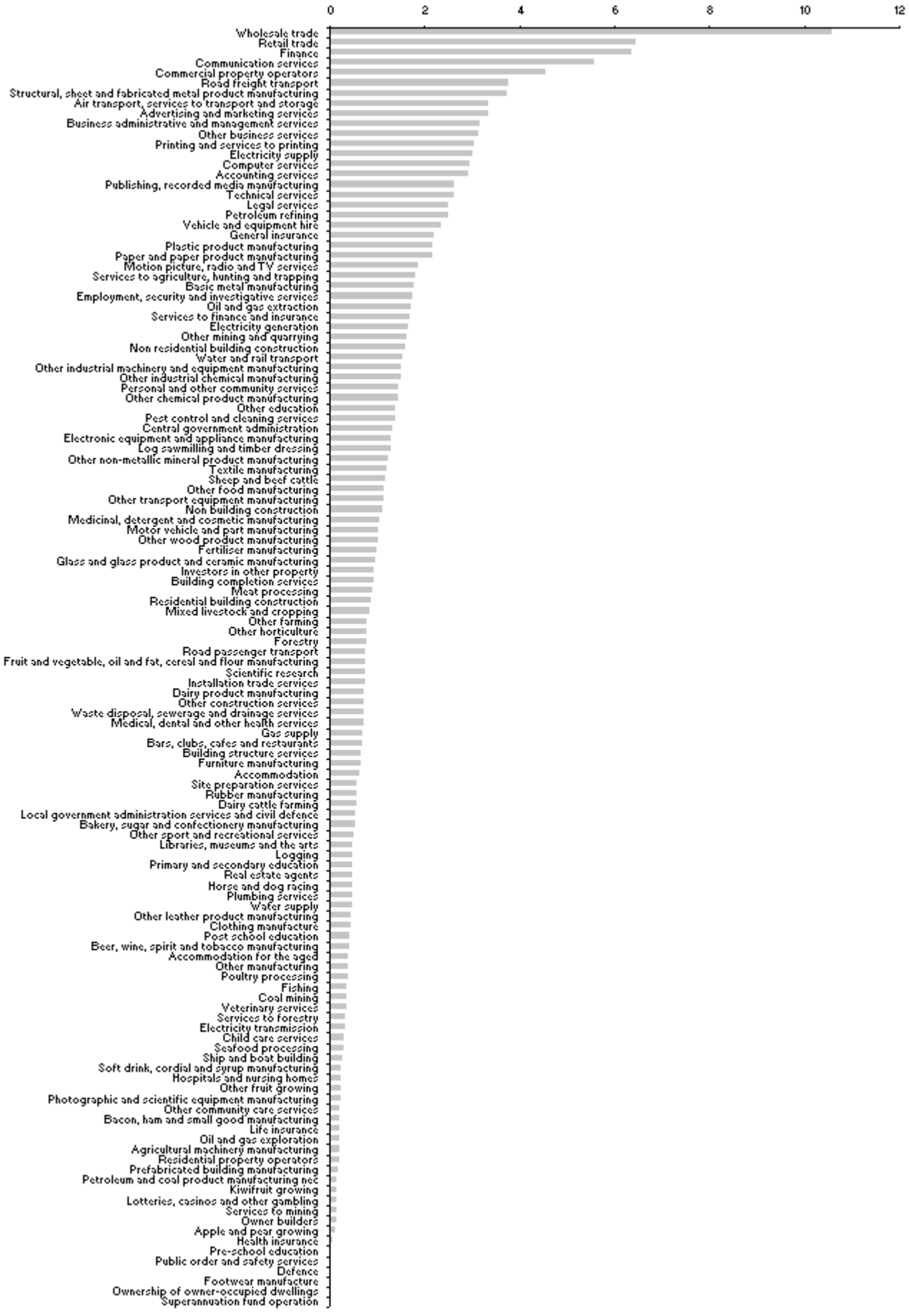


Figure 15: Row entropy for final demand weighted total requirement coefficients

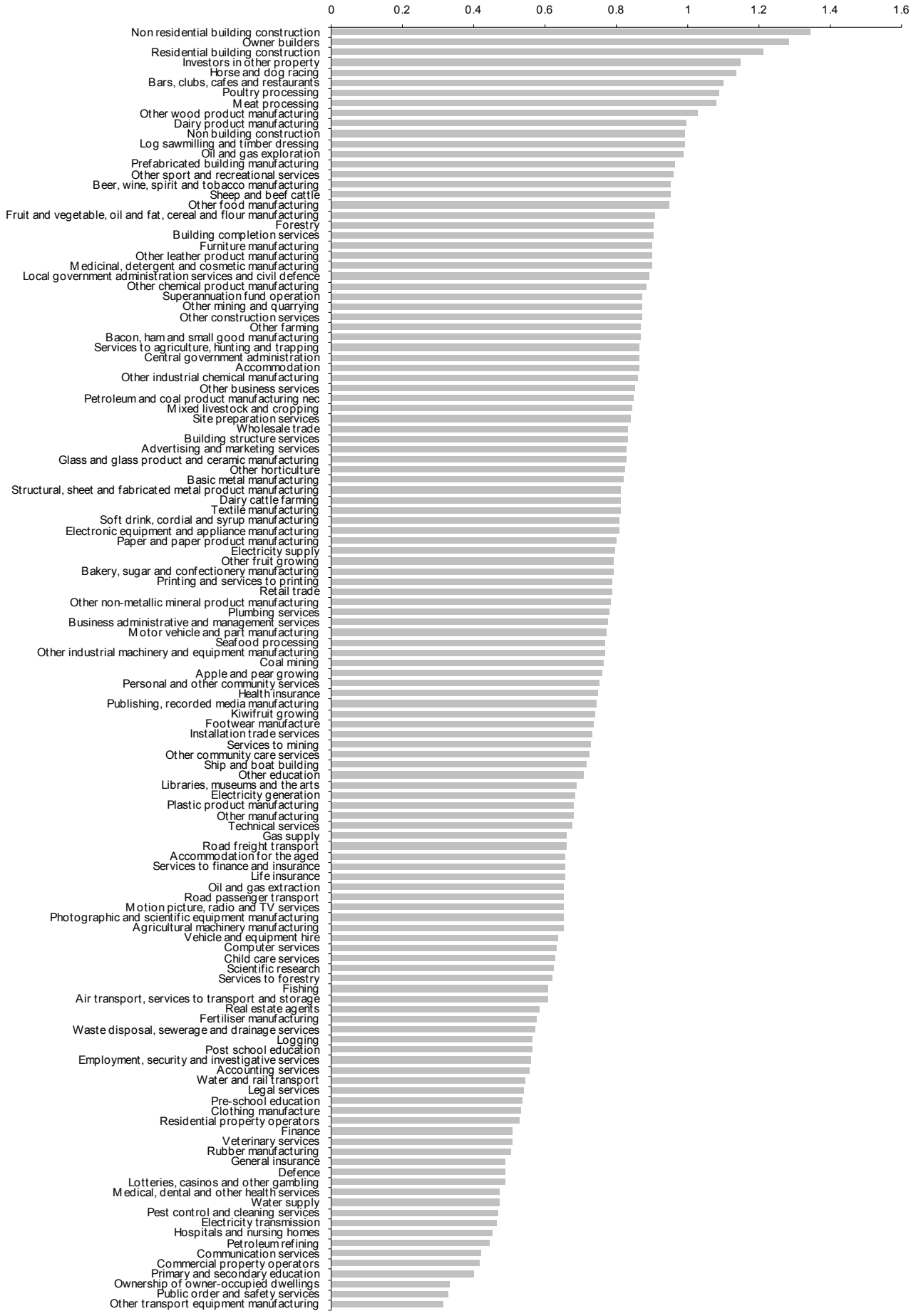


Figure 16: Column entropy for final demand weighted total requirement coefficients

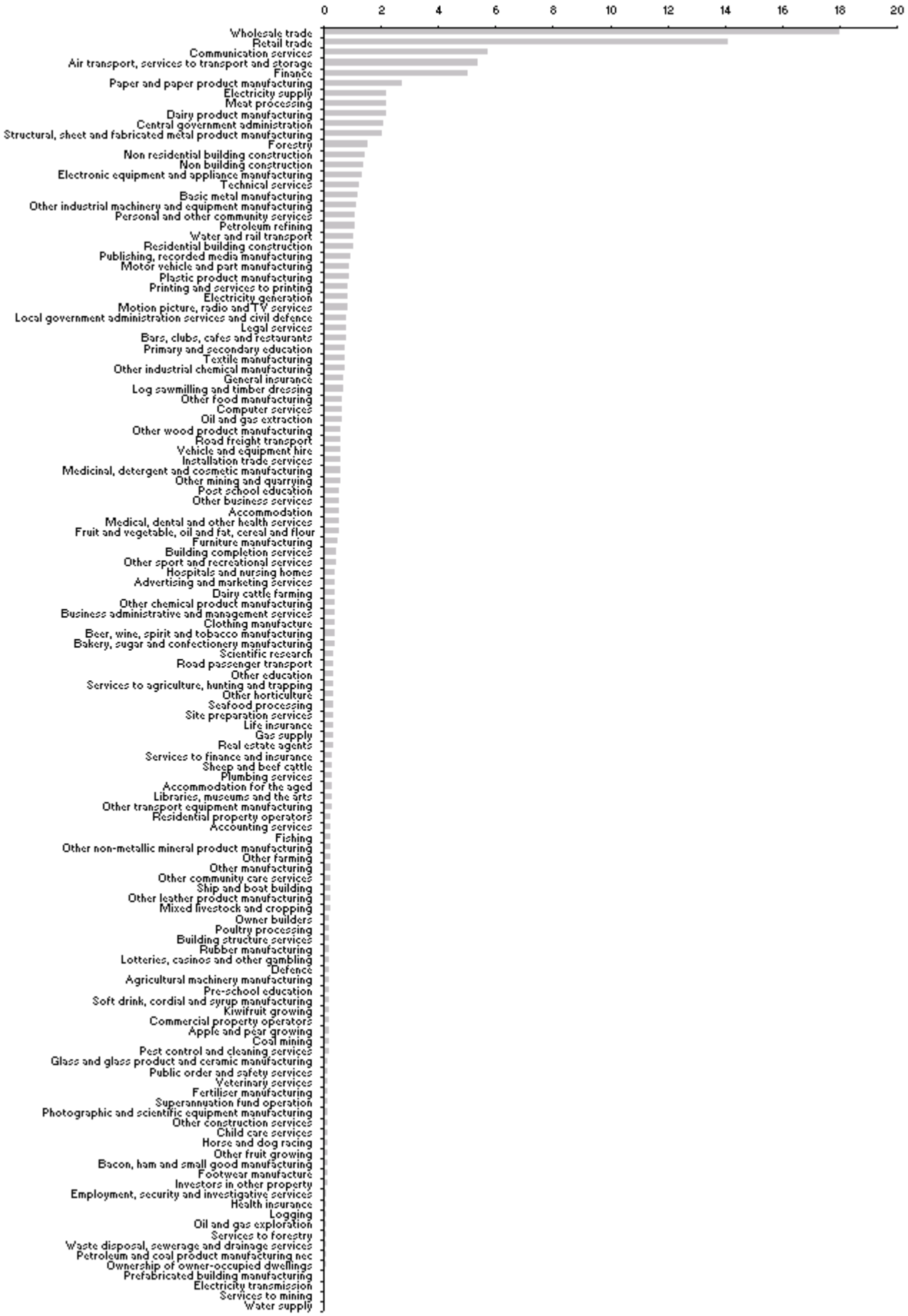


Figure 17: Row entropy for export weighted total requirement coefficients

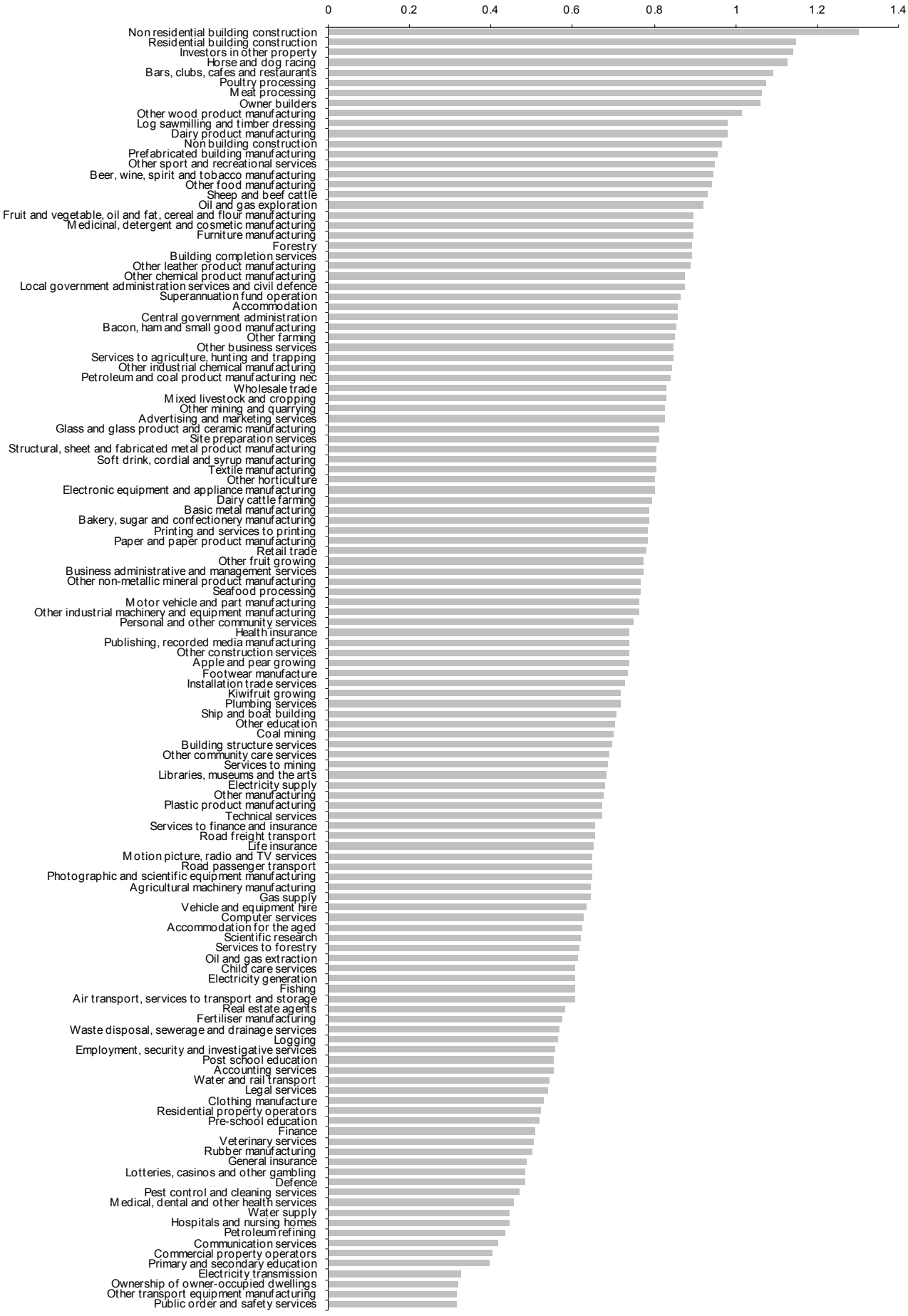
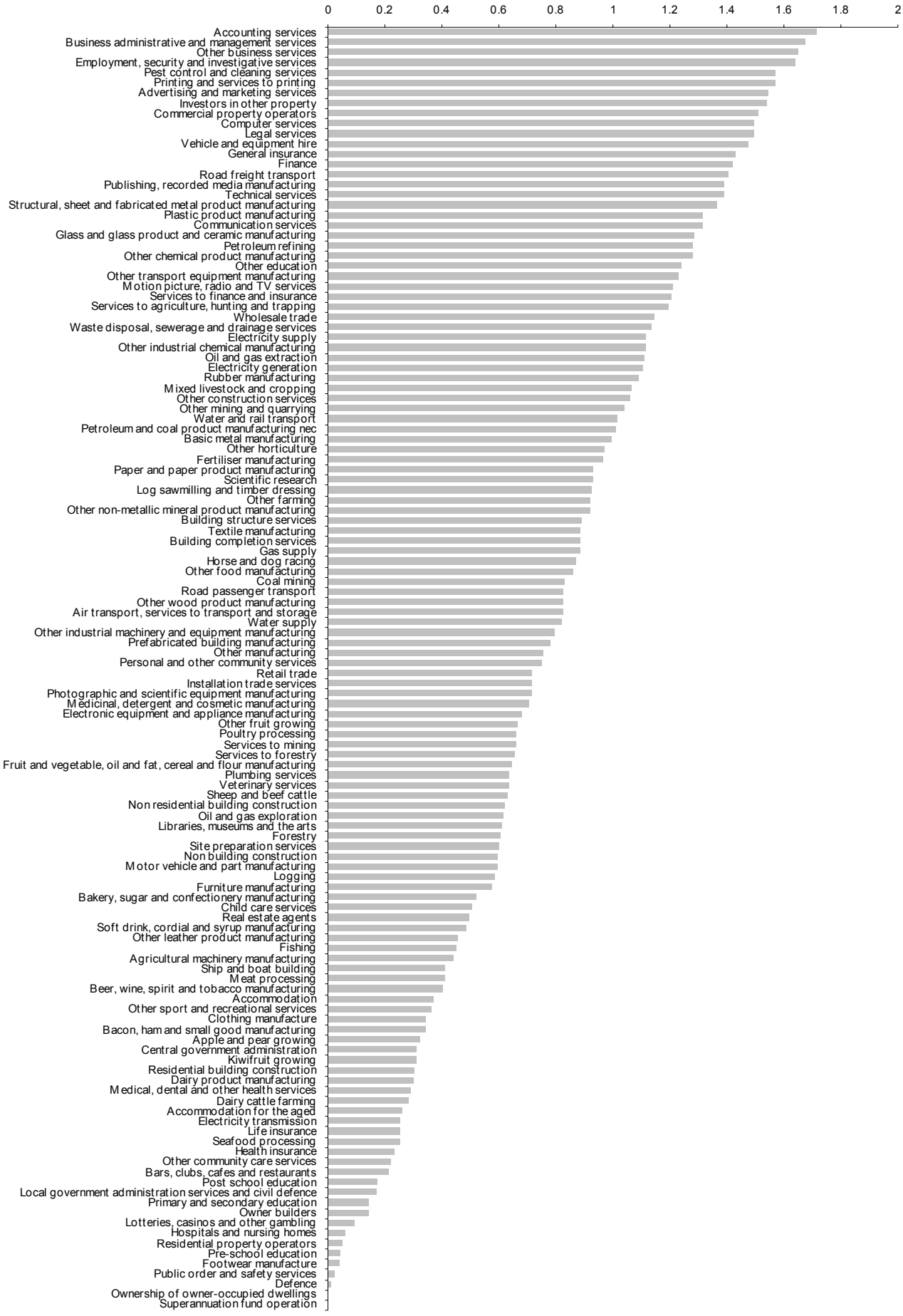


Figure 18: Column entropy for export weighted total requirement coefficients

Figure 19: Row entropy for sales flows



References

Chatterjee, S (1989) "Policy conflicts in economic restructuring: A New Zealand case study in input-output framework." *Massey Economic Papers*.

Dixon, R (1996) "Inter-industry transactions and input-output analysis." *Australian Economic Review* 115 (3rd quarter): 327-336.

National Accounts Division Statistics New Zealand (2001) "New Zealand System of National Accounts: Inter-industry study 1996 interim release of tables, 126 industries." *http://intranet/information/library/publications/ExplanatoryNote_InterIndustryTables.doc*.

Rasmussen, P N (1956) *Studies in inter-sectoral relations*: North-Holland.

Soofi, A (1992) "Industry linkages, indices of variation and structure of production: An international comparison." *Economic Systems Research* 4 (4): 349-375.

Statistics New Zealand (2001) "Information about the inter industry study." http://www.stats.govt.nz/__4c256426000e65c9.nsf/240803edd94086ae4c256809000746f1/4f1b29f4de910b01cc256a09007fb342?OpenDocument.

Theil, H (1971) *Principles of econometrics*: John Wiley & Sons, Inc.

United Nations (1993) "Supply and use tables and input-output." *System of National Accounts 1993*.