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KEY SECTORS IN THE KYRGYZSTAN ECONOMY

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Discussion Paper No. 2004 – 135

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Umed Temurshoev[†]

Abstract

The total significance of any sector in the economy can be estimated by examining the inter-industry linkage effects, i.e. the effect of a one unit increase in exogenous final demand or exogenous total value added components on the level of production of each industry. The sector uses inputs from other industries in its production process. This reflects the sector's *backward linkage*. Again, a sector may supply inputs to other industries. This indicates the *forward linkage* of the sector with other industries to which it supplies inputs. Thus, industries with large backward and forward linkages are termed "key" sectors, and play an important role in the development strategy of a country.

This paper investigates the production structure of the Kyrgyzstan economy using 1998 input-output tables. Applying traditional methods of Chenery-Watanabe (1958) and Rasmussen (1956), and the hypothetical extraction method of Dietzenbacher and van der Linden (1997), key sectors are determined. Type I and Type II output multipliers are calculated as well. The outcome of the paper may be used for the development strategy of Kyrgyzstan economy.

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1. Introduction

Inter industry linkage analysis, used to examine the interdependency in the production structures, was introduced to the field of input-output analysis in the pioneering work of Chenery & Watanabe (1958), Rasmussen (1956) and Hirschman (1958) on the use of linkages to compare international productive structures, and since that has been improved and extended in several ways. The measures, including backward and forward linkages, have widely been used for the analysis of both interdependencies between economic sectors, and for the formation of development strategies (Hirschman, 1958).

The purpose of this paper is to examine the production structure of the Kyrgyzstan economy, using the 1998 input-output tables (National Statistical Committee of Kyrgyz Republic 2001). This results in ascertaining the strategic industries, also called key sectors, in the economy, the overall outcome of which would be useful for the economic development strategy. A *key sector* is a sector which, on the one hand, is largely dependent on other industries, that is, it utilizes the products of other sectors in its production process, and on the other hand, other sectors use its output as an intermediate product in their production processes. Investments in key sectors would thus initiate economic development due to the tight interrelations with other production sectors.

The analysis is based on three methods. First, the mutual linkages between sectors are analyzed on the basis of the method that was developed by Chenery and Watanabe, then on the basis of the Rasmussen method, and finally with the help of non-complete hypothetical extraction method of Dietzenbacher and van der Linden. The last method was suggested by authors in 1997 for determining the sectoral and spatial linkages of the production structure of European Countries.

The content of this paper proceeds as follows. In the second section basic methodological background for the analysis is given. The traditional and hypothetical extraction methods of identifying key sectors with their applications are analyzed in the third part of the paper. Linkage indicators for the three methods have been calculated for Kyrgyzstan sectors and the analysis of the results is given. Fourth section gives the result of input-output multipliers applied to Kyrgyzstan economy. The last section of this paper represents an overall presentation of the findings of the analysis and contains some concluding remarks.

2. Methodological background for the analysis

Open Leontief model. If, besides the n industries, the model also contains an "open" sector (say, households) which exogenously determines a final demand (noninput demand) for the product of each industry and which supplies a primary input (say, labor service) not produced by the n industries themselves, the model is an *open model*.

Let a_{ij} be the unit input coefficient denoting the amount of input i needed to produce a unit of good j (the order of the subscripts can be mnemonically recorded by the word "input-output"). Thus, to produce X_j units of good j, one needs $a_{ij}X_j$ units of input i. Knowing that X_{ij} is the input of sector i required by industry j, obviously $X_{ij} = a_{ij}X_j$. So the direct input coefficient is calculated by:

$$a_{ij} = \frac{X_{ij}}{X_j}; \qquad i, j = \overline{1, n}. \qquad (1)$$

The table of technical coefficients of sectors is called direct requirements table. These coefficients show the *direct* effects in all sectors due to a one som (dollar) change in output in particular sector. Suppose a_{ij}=0.12. This means that each som (dollar) worth of output in industry j will require 12 tiyin (cents) worth of input from industry i. The input coefficients, thus, give the direct interindustry linkages that tie the economy together.

For each sector i the value of total production (X_i) is the sum of the intermediate demand (X_{ij}) and final demand (Y_i):

$$X_i = \sum_{j=1}^{n} X_{ij} + Y_i \ ; \qquad i = \overline{1, n}. \qquad (2),$$

where X_{ij} symbolizes the value of sales from sector i to sector j , Y_i is the amount of sales from sector i to final demand. Using equation (2) the equilibrium of the total supply and the total demand for each good can be written as:

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + Y_i \ ; \qquad i = \overline{1, n}. \qquad (3)$$

Forming column vectors of total sectoral output and final demand, it is possible to utilize linear matrix algebra to arrive at a reduced form of input-output economy. The output column vector, **X**, is endogenous and the column final demand, Y, is exogenous. Given output vector $\mathbf{X}^T$= ($X_1, X_2, \ldots, X_n$), final demand vector $\mathbf{Y}^T$= ($Y_1, Y_2, \ldots, Y_n$) and the $n \times n$ matrix input coefficients $\mathbf{A}$=(a_{ij}), the equation (3) can be expressed in the following matrix form[1]:

[1] T denotes transposition of a given matrix.

$$\mathbf{X=AX+Y} \qquad (4)$$

This equation is the fundamental equation of the open Leontief system, which states that the gross output, X, is the sum of all intermediary output, AX, and final demand, Y. We can solve equation (4) for X: **(I - A) X = Y** , where I is an identity matrix and the matrix *I-A* is called the *technology matrix*. If I-*A* is a nonsingular matrix, i.e. if $|I-A| \neq 0$, then the inverse $(I-A)^{-1}$ exist and the output of each good will be given by the solution:

$$X=(I-A)^{-1}Y \qquad (5)$$

The inverse of technology matrix $(I-A)^{-1}$ is called *Leontief inverse* or *total requirements matrix*. Let denote this matrix by matrix B=(b_{ij}). Then the total requirements coefficients of b_{ij} show how much output is required *directly* and *indirectly* from each industry in the economy for every som's worth of output produced for final use. The total requirements table recognizes that an increase in demand for a sector's output has a greater impact on the economy then the direct effect. Industries that supply inputs to the sector experiencing the increase in demand must also increase their purchase of inputs for their production. "The indirect requirements are those output increases necessary to supply inputs to industries supplying the direct inputs plus output increases necessary to enable the expansion of those industries supplying inputs to the industries supplying inputs the industries providing the direct inputs, etc".[2]

Closed Leontief system. Input-output model where labor and consumption demand are included into the interindustry transaction table, hence considered as another industry, is called a *closed Leontief model*. Instead of $n\times n$ matrix input coefficients **A**=(a_{ij}), the closed Leontief system is characterized by $(n+1)\times(n+1)$ dimension matrix of $\widetilde{A}$:

$$\widetilde{A}=\begin{pmatrix} A & \widetilde{a}_{i,n+1} \\ \widetilde{a}_{n+1,i} & \widetilde{a}_{n+1,n+1} \end{pmatrix}, \qquad (6) \ ,$$

where $\widetilde{a}_{n+1,i}=\dfrac{X_{n+1,i}}{X_i}$; $\widetilde{a}_{i,n+1}=\dfrac{X_{i,n+1}}{X_{n+1}}$.

The value $\widetilde{a}_{i,n+1}$ represents the percentage of personal consumption expenditure of the household on each industry goods. The value $\widetilde{a}_{n+1,i}$ is a constant coefficient technology for each industrial sector with respect to labor. It also can be interpreted as a per sectoral output value of income (wages) that the household receives from corresponding industry. The value of $\widetilde{a}_{n+1,n+1}$

[2] Emerson M. Jarvin, "The Kansas Input-Output Model: A Study in Economic Linkages", Bulletin 655, *Agricultural Experiment Station*, Kansas State University, 1989.

shows inner household expenditures, household expenditures for households' services. In the closed Leontief system the output can be find in the following reduced form:

$$\widetilde{X} = (I_{n+1} - \widetilde{A})^{-1}\widetilde{Y} \qquad (7)$$

The Leontief inverse of a closed model reflects the *initial, direct, indirect and induced effects*. The induced effects include the effects of household income and spending. If final demand of an industrial sector increases this not only increases the demand for this particular industry's inputs but also for labor and thus consumption. In the closed Leontief system as industrial sector households produce consumption and provide labor. The exogenous final demand sectors in the closed Leontief system usually contain government spending, exports and investment.

Ghoshian Allocation system. Supply-driven model relates sectoral output to primary inputs and was first formulated by Ghosh (1958). The primary inputs consist of value added components. The core assumption of Ghoshian allocation system is that output distribution patterns of interindustry flows are proportionally fixed by sectoral origin. It is an alternative analog to the Leontief demand-side input-output model and widely is used in order to find forward linkages of the sectors of the economy. Let V_i represents the total value added payments of sector i. Then a vector of total value added payments is: $V^T = (V_1, V_2, ..., V_n)$. Knowing that the following input-output identity holds:

$$X_i = \sum_{j=1}^{n} X_{ij} + V_i \quad , \qquad (8)$$

where X_i is the output of sector i and $\sum_{j=1}^{n} X_{ij}$ is the amount sector i supplies to all sectors in the economy for use of its output as inputs in their production process. With the assumption of fixed output coefficients the *output coefficient* matrix can be calculated as:

$$\varpi{A} = \left(\frac{X_{ij}}{X_i}\right) = \left(\varpi{a}_{ij}\right), \qquad (9)$$

The element of ϖ{a}_{ij} denotes the share of the output of sector i that flows to sector j. Since

$$\left(X_{ij}\right) = \hat{X}\overset{\omega}{A}, \qquad (10),$$

where $\hat{X}$ is the diagonal matrix of the sectoral values of the production, that is

$$\hat{X} = \begin{pmatrix} X_1 & 0 & ... & 0 \\ 0 & X_2 & ... & 0 \\ . & . & ... & . \\ 0 & 0 & 0 & X_n \end{pmatrix}$$

Using this, the equation (8) can be written in the matrix form as:

$$X^T = e^T \hat{X}\breve{A} + V^T \ , \qquad (11)$$

where T stands for transposition and e is a column summation vector with all elements of ones. Since $e^T \hat{X} = X^T$ then the equation (11) can be written as:

$$X^T = X^T \breve{A} + V^T \ , \qquad (12)$$

The solution of the equation (12) with respect to sectoral output is:

$$X^T \left(I - \breve{A}\right) = V^T$$
$$X^T = V^T \left(I - \breve{A}\right)^{-1} \ , \qquad (13)$$

Equation (13) says that for every nonnegative value added components there exists the vector of output X^T. The matrix $\left(I - \breve{A}\right)^{-1} = (g_{ij})$ is called the *Ghoshian inverse* or the *output inverse matrix*. The element of Ghoshian inverse g_{ij} represents the change in total output of sector i in response to the one som increase in value added available to sector j as an input in production. The exogenous variable in Ghoshian system is primary (value added) components of the economy, whereas the exogenous variable in Leontief system is final demand components.

Input-Output Multipliers. Multipliers are another means of estimating the overall change in the economy due to changes in final demand. A change in final demand generates activity in the economy as various industries buy and sell from one another. These interindustry relations cause the total effect on the economy to exceed the initial change. The ratio of total change in the economy to the initial change in final demand is the economic multiplier. Equations (5) and (7) show multiplicative impact of change of exogenous final demand components on sectoral output. Thus the summary measures of $\left(I - A\right)^{-1}$ and $\left(I - \widetilde{A}\right)^{-1}$ are termed input-output multipliers. Multipliers may be either type I or type II. The type I multipliers are used for an open model analysis and the type II multipliers are used for a closed Leontief model analysis.

The simple output multiplier of sector i is:

$$S_i = \sum_j a_{ji} \ , \qquad (14)$$

where $\left(I_n - A\right)^{-1} = (a_{ij})$ and I_n is an n by n identity matrix. The value of S_i represents the total value of production (direct and indirect effects) in all sectors of an open Leontief economy that is necessary in order to satisfy one som's worth of final demand of sectoral output of industry i.

Total output multiplier of sector i is equal:

$$T_i = \sum_j \widetilde{a}_{ji} \ , \qquad (15)$$

where $\left(I_{n+1}-\widetilde{A}\right)^{-1}=(\widetilde{a}_{ij})$. This is similar to the simple output multiplier except that it is with respect to the closed Leontief system and therefore, in addition to capturing the direct and indirect effects, the induced effects are considered. The induced effects can be estimated since the closed Leontief economy endogenizes households. The value of T_i shows the total value of production (direct, indirect and induced effects) in all industries in a closed Leontief economy that is necessary in order to satisfy one som's worth of final demand of sector *i*. Under reasonable conditions the simple output multiplier is less or equal to the total output multiplier.

It must be noted the type I multiplier understates the overall effects by ignoring wage-earner's increased spending while the type II multipliers overstate the impacts. Because of these discrepancies, the type I and type II output multipliers are often used together to give a range of impact.

3. Methodology and Application

Product flows may be approached from two opposite directions, which are best characterized by the following questions (Augustinovics, 1970, p. 251). "Where do they come from?" and "Where do they go?" The first question is directed backwards and inquires after the composition of the inputs (per unit of output). The second is directed forwards and asks for the allocation of the production (per unit of output). Correspondingly, the input matrix **A** is the basis for measuring the backward linkages, the output matrix **B** for measuring the forward linkages[3] (note that in this work we indicated output matrix by $\breve{A}$ since matrix B represents Leontief inverse).

The examination of backward and forward linkages by various measures enables one to identify leading sectors in the economy and investigate the structure of production of the economy.

The examination of backward and forward linkages are made using the traditional methods of Chenery-Watanabe and Rasmussen methods, and the non complete hypothetical extraction method of Dietzenbacher and van der Linden.

3.1. The Analysis of Intersectoral Linkages on the basis of Chenery-Watanabe Method

On the basis of input-output model the first attempts to supply quantitative evaluation of backward and forward linkage were made by Chenery and Watanabe (1958) in their studies on the international comparison of the structure of production. This method is based on the distinction

[3] Dietzenbacher E. *Perturbations and Eigenvectors: Essays*. University of Groningen, 1991. p.181.

between direct and indirect use of factors of production. The first one is the backward linkage and denotes the dependence of a given industry on other industries. It measures the indirect use of factors of production and for a given industry can be found by calculating the ratio of total inputs to the value of total production. The second measure is forward linkage and denotes the dependence of other industries on a given industry. It represents the direct use of factors of production and can be computed by finding the ratio of intermediate demand to total demand for a given product. The Chenery-Watanabe (CW) backward linkage is simply the sum of the appropriate column of a matrix of technical coefficients **A**, since its elements show where the production materials for the production of this sector come from. The strength of the backward linkages of a sector j is defined as:

$$BL_j^{CW} = \sum_{i=1}^{n} \frac{X_{ij}}{X_j} = \sum_{i=1}^{n} a_{ij} \tag{16}$$

where BL_j^{CW} denotes the backward linkage of sector j for CW method, X_{ij} is the magnitude of sector i's output used as production input by sector j, X_j is the output of sector j, and a_{ij} is the input coefficient of sector j to sector i.

The CW forward linkage is the sums of rows of matrix of the output coefficients that show the share of the production of an individual sector used in the production of all sectors. The strength of the forward linkages of sector i may be defined as:

$$FL_i^{CW} = \sum_{j=1}^{n} \frac{X_{ij}}{X_i} = \sum_{j=1}^{n} \overset{\varpi}{a}_{ij} \tag{17}$$

where FL_i^{CW} denotes the forward linkage of sector i for CW method, $\overset{\varpi}{a}_{ij}$ is the output coefficient of sector i to sector j. In the matrix form equations (16) and (17) can be written correspondingly as:

$$BL^{CW} = e'A \tag{16'}$$
$$FL^{CW} = \overset{\varpi}{A}e \tag{17'}$$

where e is the column summation vector (that is e_i=1 for all i) and a prime denotes transposition.

Using the two indicators, i.e. the total intermediate input coefficients and total intermediate output coefficients[4], Chenery and Watanabe compared the structure of production for four countries (the United States, Japan, Norway, and Italy).

[4] Chenery and Watanabe labeled backward and forward linkages as u and w respectively.

The CW method, based on the direct input or output coefficients, measures only the first round of effects generated by the interrelationships between sectors. So these indices are also called direct backward and forward linkages.

However, CW method has some disadvantages. "*First*, they take into account only the direct repercussions of an increase in the output of a given industry and ignore the indirect repercussions which may be very significant in many cases. *Second*, they are only average measures and do not bring out the extent of skewness in the input or the deliveries pattern of industries. *Third*, these are unweighted indices, which imply that all industries are of equal importance in an input-output table. As a matter of fact, different industries occupy different degrees of importance in bringing about a structural change in the economy. Therefore, in an effort to identify the key sectors in an economy a weighting structure is needed to bring out the relative strength of various industries in the economy"[5].

The third deficiency in CW method may be corrected if we use weighted input (or output) coefficient instead of unweighted ones. For this reason the direct input coefficients are weighted in accordance to the importance of each sector in the final demand, and output coefficients are weighted in accordance to the importance of each sector in the total value added. In the demand-driven input-output model final demand is an exogenous variable that is why the share of sectors' final demand to total final demand will be a good weight for identifying the relative strength of backward linkages of various industries in the economy. In the supply-driven input-output model value added (primary inputs) is an exogenous variable, thus a good weighting measure would be the share of a given sector's value added to total value added in the economy, which highlights the relative strength of forward linkages of various sectors in the economy. The elements of the final demand weighted direct requirements matrix $\boldsymbol{A^w}$ are denoted by a_{ij}^{w}, where

$$a_{ij}^{w} = a_{ij} \frac{Y_j}{\sum_{j=1}^{n} Y_j} \qquad (18)$$

Accordingly, the elements of value added weighted direct output matrix $\overset{\varpi}{A}{}^{w}$ are denoted by $\overset{\varpi}{a}{}_{ij}^{w}$, where:

$$\overset{\varpi}{a}{}_{ij}^{w} = \overset{\varpi}{a}_{ij} \frac{V_i}{\sum_{i=1}^{n} V_i} \qquad (19)$$

[5] Prem S. Laumas, (1975) "Key Sectors in Some Undeveloped Countries", *KYKLOS*, Vol. 28, p. 64.

Recall that Y_i stands for final demand for sector i's output and V_i stands for value added (primary inputs) of sector i. Then with the use of weighted direct input and output coefficients CW backward and forward linkages in equations (16') and (17') can be written as:

$$BL^{CW} = e'A^w \quad (20)$$

$$FL^{CW} = \overset{\varpi}{A}{}^w e \quad (21)$$

Equation (20) is the column sum of the final demand weighted input coefficients, written as row vector, and equation (21) is the row sum of value added weighted output coefficients, written as column vector.

The key sectors, that are the most important sectors for the economy, are the sectors, whose values of both backward linkage and forward linkage are above the corresponding average. For simplicity, the linkage indicators are normalized, such that their average is equal one. The key sector is therefore the sector with both backward and forward indicators larger than one. The normalized values of backward and forward linkages will be calculated on the basis of the following formulas:

$$BL_N^{CW} = ne'A^w / (e'A^w e) \quad (22)$$

$$FL_N^{CW} = n\overset{\varpi}{A}{}^w e / (e'\overset{\varpi}{A}{}^w e) \quad (23)$$

The symbols stand for:

$BL_N^{CW} = \{BL_j\}$ - vector of normalized values of CW backward linkages;

$FL_N^{CW} = \{FL_i\}$ - vector of normalized values of CW forward linkages;

n – number of sectors in the input-output table.

The empirical analysis is based on the 1998 Input-Output Table constructed by National Statistic Committee of Kyrgyz Republic in 2001(more recent tables were not available). The input-output transactions table is shown in Appendix 1. All commodity flows between industries and other economic agents in the input-output table are in thousands of soms and recorded in *basic prices*. The basic price of a good or service is the amount receivable by the producer from the purchaser minus any tax payable and plus any subsidy receivable (except subsidy on import). The *producer price* is the amount receivable by the producer from purchaser minus any deductible goods and services tax invoiced to the purchaser. The *purchaser's price* is the amount paid by the purchaser, excluding any deductible goods and services tax in order to take delivery of a unit of a commodity. In the case of goods, the purchaser's price includes any trade margins and transport charges paid by the purchaser. Both basic and producer prices exclude transport charges invoiced separately by the producer.

Table 1 below shows the normalized values of forward and backward linkages of *thirty four* sectors in the economy of Kyrgyz Republic. Here the direct input and output coefficients as well as weighted directed input and output coefficients are used. In order to find backward and forward linkages first the input and output coefficients matrices were constructed.

According to the size of the various linkage indicators, all sectors of an economy may be grouped into four categories. If the values of both backward linkage and forward linkage of a sector are all above the corresponding average (that is the normalized values of both backward and forward linkages is greater than 1), the sector is called as *"key" sector*. If only the backward linkages of a sector are greater than the average (only the normalized value of backward linkages is greater than one), the sector can be termed *a strong backward linkages sector*. Similarly, if only the forward linkages of a sector are greater than the average (i.e. only the normalized value of forward linkages is greater than one), the sector is called *a strong forward linkages sector*. The fourth group refers to the *weak linkages* category. This is the case where a sector's backward linkages and forward linkages are all less than the averages, i.e. the normalized values of backward and forward linkages are smaller than one. Table 1 shows these four groups of sectors according to CW method. The letters in this table indicate which category a sector belongs to. The letters *K*, *B*, *F* and *L* denote key sector, strong backward linkage, strong forward linkage, and weak linkage categories, respectively. To make the table easier to study, the key sectors are shaded.

As we see, in 1998 in Kyrgyzstan according to CW method there were eight key sectors. The sector is defined as the key sector if one of the weighted linkages or unweighted linkages or both of them show the strong backward and forward linkages. These key sectors are: Agriculture, hunting and forestry (1), Fishing and pisciculture (2), Ore extraction (4), Foodstuffs and tobacco goods production (6), Textile and clothing industry, leather manufacture (7), Water generation, purification and distribution (19), Wholesale trade (21), and Finance (27). Agriculture, hunting and forestry is defined as a key sector by weighted linkages since this sector contribute a large to the economy output and value added. Its shares to total demand and primary inputs account for 28.4 and 31.9 percent, respectively (see Appendix 2). The unweighted linkages define agriculture, hunting and forestry as a sector with strong backward linkages.

The sectors with strong backward linkages are Metallurgy industry (12), Retail trade (22), Hotels and restaurants (24), Transportation, subsidiary transport activities (25), Government

Table 1. Backward linkages and forward linkages. Chenery-Watanabe method

	Production Sectors	Unweighted Linkages		Weighted Linkages		Results
		Backward linkages	Forward linkages	Backward linkages	Forward linkages	
1	Agriculture, hunting and forestry	1.043	0.915	7.835	11.221	K
2	Fishing and pisciculture	1.579	1.467	0.007	0.013	K
3	Coal, crude oil and gas production	0.467	2.161	0.007	0.329	F
4	Ore extraction	1.007	2.433	0.050	6.725	K
5	Other minerals (mining) industries	0.478	0.000	0.004	0.000	L
6	Foodstuffs and tobacco goods production	1.852	0.503	4.393	1.053	K
7	Textile and clothing industry, leather manufacture	1.997	1.030	1.585	0.902	K
8	Wood and woodwork production	0.923	1.925	0.006	0.063	F
9	Paper manufacturing, publishing and typography	0.411	1.733	0.015	0.275	F
10	Coke production, oil refining, chemical industry, rubber and plastic product manufacturing	0.368	1.459	0.044	0.546	F
11	Other non-metallic mineral product manufacturing	0.810	1.525	0.192	1.054	F
12	Metallurgy industry	3.307	0.071	7.978	0.021	B
13	Production of finished metallic articles	0.755	0.000	0.034	0.000	L
14	Production of machinery and equipment	0.581	0.324	0.317	0.247	L
15	Other industries and secondary processing	0.805	0.438	0.077	0.057	L
16	Electricity generation and transmission	0.483	1.547	0.180	1.920	F
17	Gas fuel production and distribution	0.075	1.077	0.007	0.263	F
18	Steam and hot water supply	0.997	1.591	0.104	0.484	F
19	Water generation, purification and distribution	1.293	2.148	0.022	0.252	K
20	Construction	0.599	0.450	0.974	1.081	F
21	Wholesale trade	1.197	1.124	0.430	0.715	K
22	Retail trade	0.933	0.129	3.323	0.522	B
23	Car sale and servicing, private and house use goods maintenance	0.305	1.288	0.012	0.140	F
24	Hotels and restaurants	1.645	0.282	0.670	0.102	B
25	Transportation, subsidiary transport activities	1.054	0.506	1.289	0.796	B
26	Post and communication services	0.814	1.149	0.191	0.564	F
27	Finance	1.834	2.287	0.062	0.704	K
28	Operations with real estate, rent and services for business	0.901	1.889	0.325	3.103	F
29	Government administration	1.350	0.237	1.936	0.341	B
30	Education	0.743	0.075	0.853	0.102	L
31	Public health and social services	0.788	0.079	0.664	0.078	L
32	Environment purity protection services	0.459	0.880	0.017	0.062	L
33	Associations and unions, rest, culture and sport organizations activities	1.326	0.440	0.311	0.115	B
34	Rendering of individual services	0.821	0.836	0.087	0.149	L
	Standard deviation	0.621	0.747	2.004	2.188	

administration (29) and Associations and unions, rest, culture and sport organizations activities (33). Note that Metallurgy industry, Transportation, and Government administration are considered strong backward linkages according to both weighted and unweighted CW linkage indicators. Table 1 also shows that twelve sectors in 1998 had strong forward linkages and the rest eight industries were sectors with low linkages indicators.

According to both weighted and unweighted Chenery-Watanabe the highest backward linkages has metallurgy industry (12) (see Appendix 3). The second ranking in weighted backward linkages has Agriculture, hunting and forestry (1), while for unweighted linkages it is Textile and clothing industry (7). Both weighted and unweighted linkages show that Foodstuffs and tobacco goods production (6) has the third largest backward linkages. The lowest rankings of weighted and unweighted backward linkages have Other mining industries (5), and Gas fuel production and distribution (17), respectively. What concerns forward linkages, Ore extraction (4), and Finance (27) have the largest unweighted forward linkages. The weighted forward linkages in the first two rankings place Agriculture, hunting and forestry (1) and Ore extraction (4). The smallest both weighted and unweighted forward linkages have Other minerals industries (5), and Production of finished metallic articles (13).

3.2.The Linkage Analysis based of the Rasmussen Method

As we mentioned earlier the main criticism of CW method is that it considers only direct linkages between industries but neglects indirect which are more important in some sectors. Rasmussen proposed to use the column and row sums of the Leontief inverse, $(I-A)^{-1}$, to measure intersectoral linkages. The backward linkage, based on the Leontief inverse matrix, is simply defined as the column sums of the inverse matrix, i.e.,

$$BL_j^R = \sum_{i=1}^{n} b_{ij} \qquad (24)$$

where b_{ij} is the ij-th element of Leontief inverse that is denoted by B, i.e. $B=(I-A)^{-1}$. Sector j's backward linkage, BL_j^R, reflects the effects of an increase in final demand of sector j on overall output. In other words, it measures the extent to which a unit change in final demand for the product of sector j causes production increases in all sectors. It should represent the power of the sectoral backward linkage. That is why Rasmussen called this sum the index of the power of dispersion.

Similarly, the corresponding forward linkage can be defined as the sum of the rows of the Leontief inverse matrix. Thus a measure of forward linkage of sector *i* is as:

$$FL_i^R = \sum_{j=1}^{n} b_{ij} \qquad (25)$$

It measures the magnitude of output increase in sector *i*, if the final demand in each sector were to increase by one unit. In other words, it measures the extent to which sector *i* is affected by an expansion of one unit in all sectors. Rasmussen named this sum the index of sensitivity of dispersion.

Rasmussen's measures take into account indirect effects. However, there is still problem with his forward linkage. Jones argued, it "measures direct plus indirect effects on supplier industries, but not on user industries: i.e., backward but not forward linkages". In relation to Rasmussen forward linkage (equation (25)), Jones argued that "it is not very enlightening to ask what happens to an industry if all industry, large or small, are to expand by identical unit increments in final demand" (Jones, 1976, p326). Thus Rasmussen's measures of forward linkage (the row sum of the Leontief inverse) do not provide a measure of forward linkages symmetrical to that provided by the column sum for backward linkages.

Jones suggests using the row sum of the output inverse matrix derived from the output coefficient matrix (that is intermediate sales as share of total sales including final demand) to measure total forward linkages. This concept of forward linkage based on an output inverse matrix was introduced earlier by Augustinovics (1970).

We called the output inverse matrix Ghoshian inverse and denoted it as $G = \left(I - \overset{\omega}{A}\right)^{-1} = (g_{ij})$. So forward linkages based on the output coefficient matrix can be written as:

$$FL_i^{Ro} = \sum_{j=1}^{n} g_{ij} \qquad (26)$$

where g_{ij} is the *ij*-th element of Ghoshian inverse, FL_i^{Ro} denotes the forward linkage of sector *i.* It measures the extent to which a unit change in the primary input (value added) of all sectors causes production increases of sector *i*. In the matrix form equations (24) and (26) may be written as:

$$BL^R = e'(I - A)^{-1} = e'B \qquad (27)$$

$$FL^{Ro} = (I - \overset{\varpi}{A})^{-1} e = Ge \qquad (28)$$

The elements of the final demand weighted Leontief inverse are denoted by b_{ij}^w, where

$$b_{ij}^{w} = b_{ij} \frac{Y_j}{\sum_{j=1}^{n} Y_j} \tag{29}$$

The total requirements coefficients matrix is weighted by final demand to avoid a possible bias. Then the column sum of weighted Leontief inverse is defined as the weighted Rasmussen backward linkage and is calculated as:

$$BL_j^R = \sum_{i=1}^{n} b_{ij}^{w} \tag{30}$$

It shows the input requirements for a unit increase in the final demand for sector j's output given each sector's share in total final demand. Expressing the backward linkage as an index (that is in normalized values) is as follows:

$$BL^R = \frac{(1/n)BL_j^R}{(1/n^2)\sum_{j=1}^{n} BL_j^R} = \frac{BL_j^R}{(1/n)\sum_{j=1}^{n} BL_j^R} \tag{31}$$

The numerator in equation (31) 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.

The index of weighted forward linkage is given by

$$FL^R = \frac{(1/n)FL_i^{Ro}}{(1/n^2)\sum_{i=1}^{n} BL_i^{Ro}} = \frac{FL_i^{Ro}}{(1/n)\sum_{i=1}^{n} FL_i^{Ro}} \tag{32}$$

where the sum of the elements of Ghoshian inverse in row i :

$$FL_i^{Ro} = \sum_{j=1}^{n} g_{ij} \frac{V_i}{\sum_{i=1}^{n} V_i} = \sum_{j=1}^{n} g_{ij}^{w} \tag{33}$$

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

The forward linkage would be subject to bias noted in Chatterjee (1989) if the total requirements matrix wasn't weighted. This is because "for the row sum to measure the forward linkage in an unbiased fashion, it is necessary to make the assumption that the demands for all sectors increase by one unit. All sectors are unlikely in practice to be of equal importance in the structure of demand, so if a small sector *j* uses inputs from sector *i* disproportionately largely, the forward linkage index will be blown up artificially by the assumption of equal expansion of all sectors"[6]. In the case of supply-driven input-output model the same is true. That is the forward linkage is based on the assumption of a unit increase in primary inputs for all sectors. However, all sectors are not of equal importance in the structure of economy value added (primary inputs). So weighting the total requirements matrix avoids this problem.

Equations (31) and (32) in the matrix form can be defined as follows:

$$BL_N^R = ne'(I - A^w)^{-1} / [e'(I - A^w)^{-1} e] \tag{34}$$

$$FL_N^{Ro} = n(I - \overset{\varpi}{A}{}^w)^{-1} e / [e'(I - \overset{\varpi}{A}{}^w)^{-1} e] \tag{35}$$

The symbols stand for:

$BL_N^R = \{BL_j\}$ - vector of normalized values of Rasmussen backward linkages;

$FL_N^{Ro} = \{FL_i\}$ - vector of normalized values of Rasmussen forward linkages based on output matrix;

Again the normalization in equations (34) and (35) is that the arithmetic mean of the indicators is equal to one.

Table 2 shows the normalized values of backward and forward linkages of industries of Kyrgyzstan for 1998 based on Rasmussen method. The key sectors have been defined in the same way as in previous section and have been shaded. In comparison with the CW method there are ten key industries for Rasmussen method. However, according to Rasmussen method Ore extraction (4) is no longer a key sector and is defined as a sector with strong forward linkages. It may be the result of insignificancy of indirect effects in this sector. The new sectors among key sectors appear Construction (20), Retail trade (22), and Transportation, subsidiary transport activities (25), which were considered by CW method to have strong forward, strong backward and strictly backward linkages, respectively. The weighted Rasmussen backward and forward linkages defined these sectors to be the new key sectors. This is because that these sectors contributed largely to the economy final demand and value added. Their shares of the economy final demand are 6.1, 13.4 and 4.6 percent, respectively. Accordingly their shares of total primary inputs are equal to 6.3, 10.5 and 4.1 percent, respectively (see Appendix 2).

[6] Chatterjee, S, "Policy Conflicts in Economic Restructuring: A New Zealand Case Study in Input-Output

Table 2. Backward linkages and forward linkages. Rasmussen method

	Production Sectors	Unweighted Linkages		Weighted Linkages		Results
		Backward linkages	Forward linkages	Backward linkages	Forward linkages	
1	Agriculture, hunting and forestry	1,008	0,967	9,029	11,132	K
2	Fishing and pisciculture	1,256	1,289	0,007	0,011	K
3	Coal, crude oil and gas production	0,830	1,618	0,015	0,231	F
4	Ore extraction	0,993	1,385	0,059	3,594	F
5	Other minerals (mining) industries	0,837	0,625	0,008	0,006	L
6	Foodstuffs and tobacco goods production	1,269	0,783	3,588	1,540	K
7	Textile and clothing industry, leather manufacture	1,390	1,045	1,315	0,859	K
8	Wood and woodwork production	0,972	1,251	0,008	0,039	F
9	Paper manufacturing, publishing and typography	0,823	1,248	0,037	0,186	F
10	Coke production, oil refining, chemical industry, rubber and plastic product manufacturing	0,812	1,175	0,115	0,413	F
11	Other non-metallic mineral product manufacturing	0,923	1,157	0,261	0,751	F
12	Metallurgy industry	1,631	0,649	4,692	0,177	B
13	Production of finished metallic articles	0,953	0,625	0,051	0,030	L
14	Production of machinery and equipment	0,907	0,747	0,590	0,535	L
15	Other industries and secondary processing	0,991	0,787	0,113	0,097	L
16	Electricity generation and transmission	0,833	1,212	0,370	1,414	F
17	Gas fuel production and distribution	0,733	0,993	0,085	0,228	L
18	Steam and hot water supply	0,962	1,140	0,119	0,326	F
19	Water generation, purification and distribution	1,024	1,360	0,021	0,150	K
20	Construction	0,870	0,773	1,688	1,745	K
21	Wholesale trade	1,043	1,008	0,447	0,602	K
22	Retail trade	0,960	0,673	4,079	2,550	K
23	Car sale and servicing, private and house use goods maintenance	0,792	1,169	0,037	0,119	F
24	Hotels and restaurants	1,151	0,715	0,559	0,243	B
25	Transportation, subsidiary transport activities	1,001	0,803	1,460	1,188	K
26	Post and communication services	0,930	1,035	0,260	0,477	F
27	Finance	1,361	1,845	0,055	0,533	K
28	Operations with real estate, rent and services for business	0,953	1,310	0,410	2,021	F
29	Government administration	1,101	0,716	1,883	0,967	B
30	Education	0,910	0,652	1,245	0,833	B
31	Public health and social services	0,930	0,653	0,934	0,605	L
32	Environment purity protection services	0,828	0,928	0,036	0,062	L
33	Associations and unions, rest, culture and sport organizations activities	1,097	0,760	0,307	0,186	B

Framework", (1989), *Massey Economic Papers*, P.96.

34	Rendering of individual services	0,926	0,903	0,117	0,151	L
	Standard deviation	0,192	0,305	1,852	1,964	

Metallurgy industry (12) is a sector with strong backward linkages, which is shown by both weighed and unweighted Rasmussen backward and forward linkages. Moreover, it has the largest unweighted backward linkages, followed by textile and clothing industry, leather manufacture (7). Government administration (29) make up another sector with backward linkages greater than the corresponding averages. Education (30) is defined a strong backward linkages sector according to weighted Rasmussen indicators.

The first two ranking in weighted backward linkages have Agriculture, hunting and forestry (1) and Metallurgy industry (12) that is similar to the ranking positions for weighted CW backward linkages. It shows the significance of these industries to Kyrgyzstan economy (see Appendix 3). The lowest ranking of both weighted and unweighted backward linkages have Fishing and pisciculture (2), Wood and woodwork production (8), and Other minerals industries (5).

As for forward linkages there are also some differences in ranking positions of some sectors. For example, Agriculture, hunting and forestry is ranked 18th sector with unweighted forward linkages whereas weighted forward linkages define it as a sector with largest weighted forward linkages. Both weighted and unweighted forward linkages show that Other minerals industries (5) has the lowest ranking among all the thirty four sectors. Production of finished metallic articles (13) and Fishing and pisciculture (2) also have low forward linkages. This picture is in accordance with the rankings given to these above three industries by weighted and unweighted CW forward linkages.

3.3 The Analysis of Intersectoral Linkages on the basis of Dietzenbacher and van der Linden Method

3.3.1 Original Extraction Method

First time the extraction method was suggested by Strassert (1968). The basic idea of Strassert's method is to extract one sector hypothetically from an economic system. In order to understand this method we will start with the basic balance equation of Leontief model (5): $X=(I-A)^{-1}Y$. If one sector is extracted, for example *k*th sector, we have the input matrix ***A*** with deleted (not replaced by zero) *k*th row and column. Thus the equation (7) can be rewritten as:

$$\widetilde{X}(k)=(I-\widetilde{A}(k))^{-1}\widetilde{Y}(k) \qquad (36)$$

where $\widetilde{A}(k)$ is an $(n\text{-}1)\times(n\text{-}1)$ input matrix by deleting kth sector from $\boldsymbol{A}$; $\widetilde{X}(k)$ and $\widetilde{Y}(k)$ are $(n\text{-}1)$ dimensions vectors by deleting kth row corresponding to output vector X and final demand vector Y, respectively.

Given the vectors of final demand, Y and $\widetilde{Y}(k)$, the results of $\widetilde{X}(k)$ should be less than X, i.e.,

$$\widetilde{X}_i(k) < X_i \quad \text{for } i = 1,2, \ldots, k\text{-}1, k\text{+}1, \ldots, n. \tag{37}$$

Then, the sum of the differential between the output vector X *excluding* kth element and $\widetilde{X}(k)$ may measure the linkage effect of the extracted sector k on total output, i.e.,

$$L(k) = \sum_{i=1, i \neq k}^{n} \left[X_i - \widetilde{X}_i(k) \right] \tag{38}$$

where $L(k)$ denotes the linkage indicator of sector k.

For example, for discriptive purposes only, for agriculture, hunting and forestry of Kyrgyzstan economy for 1998 this linkage indicator was equal to 1,064,280 thousands soms, whereas for fishing and pisciculture it was only 1,898 thousands soms. This shows the relative importance of Agriculture, hunting and forestry for the economy of Kyrgyz Republic rather than Fishing and pisciculture.

However, there are two shortcomings of the above original extraction method. First, it does not distinguish the total linkages into backward and forward linkages (Cella, 1984). Second, “also the hypothesis of simply scrapping an entire sector from the economy seems to be rather excessive”[7].

3.3.2 Non-Complete Hypothetical Extraction Method of Dietzenbacher and van der Linden and its Application for Kyrgyzstan Economy

Recognizing the two deficiencies of Strassert’s extraction method, Dietzenbacher and van der Linden improved the methodological framework suggesting a non-complete extraction method. Their approach is based on the assumption that backward linkages should reflect sector’s interdependence on inputs that are produced within the economy. Therefore, only these intermediate inputs should be hypothetically eliminated (it is assumed that the required inputs are imported) in order to measure the backward linkages. Then the sum of difference in the total

[7] Dietzenbacher, E. and J.A. van der Linden (1997), “Sectoral and Spatial Linkages in the EC Production Structure”, *Journal of Regional Science*, vol. 37, 235-257.

output of actual production and production in the hypothetical case, where a particular industry does not depend on domestic sectors, measures the total backward linkages. In the same way the forward linkages is determined. Since forward linkages reflect others sectors' dependence on a particular sector's deliveries, it is further assumed that this sector does not provide any deliveries to other production sectors.

"In brief, Strassert's original method compares the actual production with the production in the case where all intermediate deliveries to and from a particular sector are hypothetically extracted. The method that we propose allows for a natural distinction between backward and forward linkages by extracting precisely these (and only these) linkages. For the backward linkages of a sector, all intermediate deliveries that it buys are hypothetically extracted. For the forward linkages, all intermediate deliveries that a sector sells are extracted"[8].

How the backward linkages of industry *k* are determined? For this reason it is assumed that sector *k* buys no intermediate inputs from any production sectors within the economy but buys them rather from outside the system (i.e. imports). Therefore the corresponding column elements of sector *k* of the technical coefficients matrix are set equal to zero. This yields the input coefficients matrix of $A(k^0)$. Solving the basic balance equation of Leontief model (5) for the total output after extracting we obtain:

$$X(k^0) = (I - A(k^0))^{-1} Y \qquad (39)$$

where $X(k^0)$ denotes the total output vector after extracting sector *k*, and *Y* is the vector of final demand. Then the absolute backward dependence of sector *k* on sector *i* is defined as $X_i - X_i(k^0)$. This output decrease is the dependence of sector *k* on other sectors ($i \neq k$) and on itself ($i=k$). Why the output is reduced?

The absolute backward dependence $X_i - X_i(k^0)$ with $i \neq k$ comprises two parts. First, the output is reduced because the sectors i ($\neq k$) no longer contribute to the final demand of sector *k*. Second, in satisfying the final demand of sectors *i* , inputs from sector *k* are required. In turn, these require inputs from the sectors *i* again, but these inputs have been omitted in the hypothetical case. In the same way, the absolute backward dependence of sector *k* upon itself has two parts; sector *k*'s contribution to its own final demand, and to the final demand in sector *i*, which is reduced.[9]

[8] Ibid., p.237.
[9] Ibid., p.238.

The sum of output reductions in all sectors due to the extraction of sector k is then the total absolute backward linkages of sector k, that is the absolute backward linkages of sector k are defined as follows:

$$ABL_k^{DL} = \sum_{i=1}^{n} \left[X_i - X_i(k^0) \right] \qquad (40)$$

where ABL_k^{DL} is the absolute backward linkages of sector k for the Dietzenbacher and van der Linden (DL) method. If in reality sector k does not buy any inputs from other sectors, that is the actual situation is as the hypothetical situation, then the absolute backward linkages of sector k are equal to zero.

For an alternative interpretation of DL method, consider that the economy is divided into two separate blocks of industries, agriculture and manufacturing, and we want to calculate the backward linkages for agriculture. By our assumption agriculture does not buy any inputs from domestic production industries, rather they are imported. Then the fundamental equation of open Leontief system of (4) can be expressed as:

$$X(a^0) = \begin{pmatrix} \tilde{X}_a \\ \tilde{X}_m \end{pmatrix} = \begin{pmatrix} 0 & A_{am} \\ 0 & A_{mm} \end{pmatrix} \begin{pmatrix} \tilde{X}_a \\ \tilde{X}_m \end{pmatrix} + \begin{pmatrix} Y_a \\ Y_m \end{pmatrix} \qquad (41)$$

where, $\tilde{X}_a$ is the vector of output for agricultural sectors, $\tilde{X}_m$ is the vector of output of manufacturing sectors, A_{am} is the matrix of technical coefficients for the demand of the products of agricultural sectors by manufacturing, A_{mm} is the matrix of technical coefficients for self consumption of manufacturing sectors, Y_a is the final demand vector of agricultural sectors, and Y_m is the final demand vector of manufacturing sectors. Solving the above system for the total output vector after extracting $X(a^0)$ (i.e. $\tilde{X}_i$ ($i=a,m$)) we obtain:

$$X(a^o) = \begin{pmatrix} \tilde{X}_a \\ \tilde{X}_m \end{pmatrix} = \begin{pmatrix} I & A_{am}(I - A_{mm})^{-1} \\ 0 & (I - A_{mm})^{-1} \end{pmatrix} \begin{pmatrix} Y_a \\ Y_m \end{pmatrix} \qquad (42)$$

The absolute backward linkage is defined as the difference between actual total output of the economy and that after extraction of agricultural sectors. The latter is less than former due to the fact that agricultural sectors depend no longer on other industries that was clearly mentioned above. This output decrease reflects the dependence of agricultural sector on manufacturing as well as itself. Then we have:

$$ABL_a^{DL} = e'\begin{pmatrix} X_a - \widetilde{X}_a \\ X_m - \widetilde{X}_m \end{pmatrix} = \begin{pmatrix} H - I & (H-I)^{-1} A_{am} G_{mm} \\ G_{mm} A_{ma} H & G_{mm} A_{ma} H A_{am} G_{mm} \end{pmatrix} \begin{pmatrix} Y_a \\ Y_m \end{pmatrix} \tag{43}$$

$$\begin{aligned} ABL_a^{DL} &= \left[(H-I) + e' G_{mm} A_{ma} H\right] Y_a \\ &\quad + \left[(H-I) A_{am} G_{mm} + e' G_{mm} A_{ma} H A_{am} G_{mm}\right] Y_m \end{aligned} \tag{44}$$

where, $G_{mm} = (I - A_{mm})^{-1}$, $H = (I - A_{aa} - A_{am} G_{mm} A_{ma})^{-1}$ and e is a vector of one. The magnitude of the above absolute backward linkage is determined by two factors: first the relative size of the sector and second, its dependence per unit of output (its output multiplier). Since the primary concern of linkage analysis is the structure of production, the size effect of sectors should be eliminated in the linkage measurements. Hence Dietzenbacher and van der Linden suggest to normalize the above value by dividing the absolute figures by the value of sectoral output. This results the backward dependence of agricultural sectors on manufacturing as:

$$BL_a^{DL} = \frac{ABL_a^{DL}}{X_a} \tag{45}$$

In similar manner with backward linkages, forward linkage indicators can be obtained using the supply-driven input-output Leontief system. If backward linkages measure the dependence on inputs from buyer's viewpoint, the forward linkages measure the seller's dependence from the seller's viewpoint. Forward linkages are based on the output coefficients. For this it is assumed that sector k sells no output to any production sectors. For the above example in order to find the forward linkages of agricultural sector, the row of agricultural sectors in the output matrix $\overset{\varpi}{A}$ is set to zero. Using equation (13) for the Ghoshian allocation system the corresponding output $\widetilde{X}'(a^0)$ can be obtained as:

$$X(a^o) = \begin{pmatrix} \widetilde{X}'_a & \widetilde{X}'_m \end{pmatrix} = \begin{pmatrix} V_a & V_m \end{pmatrix} \begin{pmatrix} I & 0 \\ Z_{mm} \overset{\varpi}{A}_{ma} & Z_{mm} \end{pmatrix} \tag{46}$$

The difference between actual total output of the economy and that after extraction of agricultural sectors is the absolute forward linkage, i.e.,

$$AFL_a^{DL} = \begin{pmatrix} X_a - \widetilde{X}_a \\ X_m - \widetilde{X}_m \end{pmatrix} e = \begin{pmatrix} V_a & V_m \end{pmatrix} \begin{pmatrix} \hat{H} - I & \hat{H} \overset{\varpi}{A}_{am} Z_{mm} \\ Z_{mm} \overset{\varpi}{A}_{ma} (\hat{H} - I) & Z_{mm} \overset{\varpi}{A}_{ma} \hat{H} \overset{\varpi}{A}_{am} Z_{mm} \end{pmatrix} e \tag{47}$$

$$\begin{aligned} AFL_a^{DL} &= V_a \left[(\hat{H} - I) + \hat{H} \overset{\varpi}{A}_{am} Z_{mm} e_m\right] \\ &\quad + V_m \left[Z_{mm} \overset{\varpi}{A}_{ma} (\hat{H} - I) + Z_{mm} \overset{\varpi}{A}_{ma} \hat{H} \overset{\varpi}{A}_{am} Z_{mm}\right] e_m \end{aligned} \tag{48}$$

where, $Z_{mm} = (I - \overset{\omega}{A}_{mm})^{-1}$, $\hat{H} = (I - \overset{\omega}{A}_{aa} - \overset{\omega}{A}_{am} Z_{mm} \overset{\omega}{A}_{ma})^{-1}$ and V is the row vector of primary inputs, that is, value added terms plus imports. The relative forward linkage of agricultural sectors can, accordingly, be defined as:

$$FL_a^{DL} = \frac{AFL_a^{DL}}{X_a} \qquad (49)$$

In order to do backward and forward linkages more readable in finding key sectors we again normalize them so that the average is equal to one. Then the backward and forward linkages given in equations (45) and (49) but in general case (not only for the agriculture), correspondingly, can be normalized as follows:

$$BL_N^{DL} = n\left(BL^{DL}\right)' / e'BL^{DL} \qquad (50)$$

$$FL_N^{DL} = nFL^{DL} / FL^{DL} e \qquad (51)$$

where BL_N^{DL} and FL_N^{DL} - vectors of the normalized backward and forward linkages for DL method, respectively; BL^{DL} - a column vector of backward linkages for DL method; FL^{DL} - a row vector of forward linkages for DL method.

Table 3 below shows the results achieved using non-complete hypothetical extraction method of Dietzenbacher and van der Linden. Each time the corresponding column (or row) was set to zero and the backward (or forward) linkages indicator was found according to the above mentioned method. The calculations were made 34×2=68 times. Note that DL method shows that there were only four key sectors in Kyrgyzstan economy for 1998. These are Fishing and pisciculture (2), Water generation, purification and distribution (19), Wholesale trade (21), and Finance (27). Sectors with strong backward linkages are Foodstuffs and tobacco goods production (6), Textile and clothing industry, leather manufacture (7), Metallurgy industry (12), Other industries and secondary processing (15), Hotel and restaurants (24), Transportation, subsidiary transport activities (25), Government administration (29), and Associations and unions, rest, culture, and sport organizations activities (33). After the four mentioned key sectors these industries according to DL method have a large impact on the economy activity. If the demand increases exogenously for the product of these sectors they can largely influence other sectors because of having strong backward linkages.

Agriculture, hunting and forestry falls in a weak linkage category, although it seems to be a key sector according to the first two mentioned methods. So it seems that DL method underestimates its backward and forward linkages.

Such industries as Coal, crude oil and gas production (3), Other mining industries (5), Wood and woodwork production (8), Paper manufacturing, publishing and typography (9), Coke production, oil refining, chemical industry, rubber and plastic product manufacturing (10), Other non-metalic product manufacturing (11), Gas fuel production and distribution (17), Steam and hot water supply (18), and Car sale and servicing, private and house use goods maintenance (23) have a strong forward linkages, although according to Rasmussen method all of them fell in a weak linkage category.

Appendix 3 shows that the highest rank among backward linkages for DL has Metallurgy industry(12), which is followed by Foodstuffs and tobacco goods production (6), and Textile and clothing industry, leather manufacture (7). Gas fuel production and distribution (17) has the lowest backward linkages indicator. On the other hand the largest forward linkages has Coal, crude oil and gas production (3). The other sectors with high forward linkages are Finance (27), Water generation, purification and distribution (19), and Ore extraction (4). The lowest forward linkages have Other minerals industries (5), and Production of finished metallic articles (13), which is almost similar to their ranking positions for CW and Rasmussen methods.

The standard deviations given in the bottom row of Tables 1, 2, and 3 indicate the variability of the calculated indicators of backward and forward linkages. The lowest standard deviation has Rasmussen method with the use of unweighted coefficients. CW method with the use of weighted coefficients has the largest standard deviation. Note also that DL method has the largest standard deviation among unweighted CW and Rasmussen methods, and the lowest among the weighted backward and forward linkages. Rasmussen method has the highest standard deviation because the weights of sectors in final demand and primary demand are very different and disproportionate.

Appendix 3 shows us the ranking positions of each sector for the three methods discussed. It shows that unweighted CW and Rasmussen backward and forward linkages are very similar to those for DL method. The ranking numbers corresponding to each other are shaded appropriately. In particular, for eleven industries their ranking positions of backward or forward linkages exactly

Table 3. Backward linkages and forward linkages. Dietzenbacher and van der Linden method

	Production Sectors	Backward linkages	Forward linkages	Results
1	Agriculture, hunting and forestry	0,857	0,758	L
2	Fishing and pisciculture	1,327	1,237	K
3	Coal, crude oil and gas production	0,447	2,911	F
4	Ore extraction	0,907	1,879	F
5	Other minerals (mining) industries	0,482	0,000	L
6	Foodstuffs and tobacco goods production	1,850	0,401	B
7	Textile and clothing industry, leather manufacture	1,821	0,860	B
8	Wood and woodwork production	0,995	1,838	F
9	Paper manufacturing, publishing and typography	0,426	1,849	F
10	Coke production, oil refining, chemical industry, rubber and plastic product manufacturing	0,381	1,633	F
11	Other non-metallic mineral product manufacturing	0,754	1,462	F
12	Metallurgy industry	3,568	0,070	B
13	Production of finished metallic articles	0,933	0,000	L
14	Production of machinery and equipment	0,746	0,357	L
15	Other industries and secondary processing	1,072	0,476	B
16	Electricity generation and transmission	0,462	1,731	F
17	Gas fuel production and distribution	0,074	1,096	F
18	Steam and hot water supply	0,940	1,487	F
19	Water generation, purification and distribution	1,198	2,159	K
20	Construction	0,608	0,439	L
21	Wholesale trade	1,283	1,137	K
22	Retail trade	0,961	0,141	L
23	Car sale and servicing, private and house use goods maintenance	0,304	1,617	F
24	Hotels and restaurants	1,708	0,269	B
25	Transportation, subsidiary transport activities	1,079	0,509	B
26	Post and communication services	0,833	1,203	F
27	Finance	1,530	2,194	K
28	Operations with real estate, rent and services for business	0,824	1,793	F
29	Government administration	1,508	0,271	B
30	Education	0,767	0,080	L
31	Public health and social services	0,844	0,084	L
32	Environment purity protection services	0,444	0,899	L
33	Associations and unions, rest, culture and sport organizations activities	1,239	0,333	B
34	Rendering of individual services	0,828	0,827	L
	Standard deviation	0,628	0,772	

coincide with each other. These sectors are, for instance, Coal, crude oil and gas production (3), Paper manufacturing, publishing and typography (9), Metallurgy industry(12), Retail trade (22), Transportation, subsidiary transport activities (25), Education (30), Public health and social services (31), etc. Yet, for other sectors the difference between ranking positions given by the above mentioned methods is insignificant.

4. Output Multipliers in the economy of Kyrgyz Republic

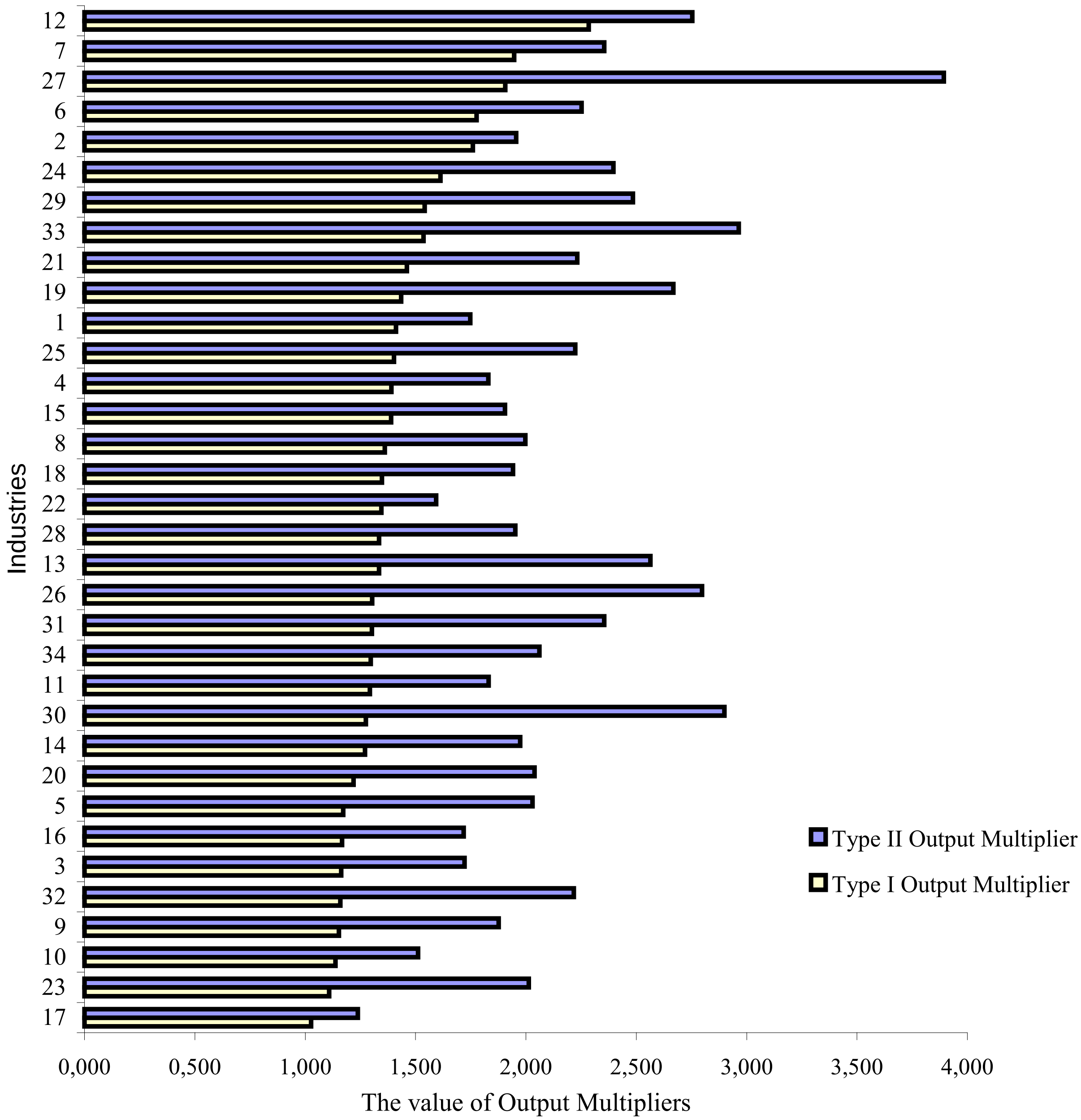
Type I output multiplier (14) shows the value of production (direct and indirect effects) in all sectors in order to satisfy one som's worth of final demand of a particular industry. It was also called the simple output multiplier. Type II output multiplier (15) represents the value of production (direct, indirect and induced effects) in all sectors in order to satisfy one som's worth of final demand of an industry to which the column belongs.

For the reason of finding both multipliers the direct and total requirements matrices were constructed where household was considered as another sector. The resulting matrices were matrices of 35×35 dimension. The thirty fifth row represents compensation for employees, and the thirty fifth column includes consumption. The direct and total coefficients were found in the same way as in the open Leontief system.

It is very important to remember that input-output approach assumes the economy is driven by demand and not by supply. This means that a sector increases its production because the demand for its products increases. In the theoretical section we also mentioned that the type I multiplier understates the overall effects by ignoring wage-earner's increased spending while the type II multipliers overstate the impacts. Because of these discrepancies, the type I and type II output multipliers are often used together to give a range of impact. For the case of Kyrgyzstan these multipliers are shown in the Figure 1.

The highest type I output multiplier has metallurgy industry (12) which is equal to 2.284. It is followed by textile and clothing industry (7), and finance (27) with the type I output multipliers 1.947 and 1.907 respectively. We can conclude that these sectors largely depend on other sectors of the economy. When the induced effects are taken into account then such industries as finance (27), associations and unions, rest, culture and sport organizations' activities (33), education (30), and post and communication services (26) have the largest type II output multipliers that are equal to 3.893, 2.964, 2.900, and 2.798 correspondingly.

Figure 1. 1998 Output Multipliers of Kyrgyzstan economy sectors



These numerical values show that, for example, in order to satisfy one som's worth of final demand of metallurgy industry the value of production including direct and indirect effects of all sectors of 2.284 som and the value of production throughout the economy including direct, indirect and induced effects of 2.754 som (type II output multiplier of metallurgy industry) are required. The real impact of one som increase in final demand on the production of all sectors including metallurgy industry itself is in the interval between the value of type I and type II multipliers, that is in the range of (2.284; 2.754).

Figure 1 above shows that the lowest output multipliers in 1998 had gas fuel production and distribution (17) with type I and type II output multipliers of 1.027 and 1.238 correspondingly. The second industry, which had a relatively small impact on other sectors, was car sale and servicing, private and house use goods maintenance (23) for type I output multiplier that is equal to 1.109, and the second industry with the lowest type II output multiplier was coke production, oil refining, chemical industry, rubber and plastic product manufacturing (10) that is equal to 1.511.

Table 4. Top fifteen industries with the largest output multipliers

Industry	Type I Output Multiplier	Type II Output Multiplier	Induced effect
Metallurgy industry (12)	2,284	2,754	0,469
Textile and clothing industry, leather manufacture (7)	1,947	2,355	0,408
Finance (27)	1,907	3,893	1,987
Foodstuffs and tobacco goods production (6)	1,777	2,253	0,476
Fishing and pisciculture (2)	1,759	1,955	0,196
Hotels and restaurants (24)	1,612	2,397	0,784
Government administration (29)	1,542	2,485	0,944
Associations and unions, rest, culture and sport organizations activities (33)	1,536	2,964	1,428
Wholesale trade (21)	1,461	2,232	0,771
Water generation, purification and distribution (19)	1,435	2,669	1,234
Agriculture, hunting and forestry (1)	1,411	1,747	0,336
Transportation, subsidiary transport activities (25)	1,402	2,224	0,821
Ore extraction (4)	1,391	1,830	0,439
Other industries and secondary processing (15)	1,389	1,905	0,516
Wood and woodwork production (8)	1,361	1,997	0,636

The highest difference between type I and type II multipliers has finance (27) that is equal to 1.987. This means that the induced effects are largest in this sector that includes the effects of household income and spending. The change in final demand also has high induced effects in education (30), and post and communication services (26) with the induced effects of 1.625 and

1.496. So an increase in final demand in these three sectors will increase demand for labor and thus consumption much higher than in other industries. This is approved since namely these industries heavily rely on labor force. The top fifteen industries with the largest output multipliers are given in the Table 4 above.

5. Conclusion

This work has investigated the production structure and the intersectoral linkages of Kyrgyzstan economy for 1998. The analysis was undertaken at the relatively disaggregated level of industries for which data are available. These are thirty four production sectors. This work is an attempt to empirically identify key sectors. Type I and type II output multipliers and indices of backward and forward linkages based on Chenery-Watanabe, Rasmussen, and Dietzenbacher and van der Linden methods were calculated. Backward and forward linkages show how much each industry buys from and sells to other industries, directly and indirectly caused by the unit increase in final demand and primary inputs. So for the development strategy it is very important to determine which industries posses high backward and forward linkages. Then stimulating final demand or primary inputs namely of these industries could positively influence the economic activity of the country.

In order to find out the key sectors of Kyrgyzstan the results of CW, Rasmussen, and DL methods are presented together in the Table 5. Then it is taken into account that a key sector is a sector, which is placed into this group by at least two methods used. In this way it had been found out that in 1998 in Kyrgyzstan economy there were seven sectors that belonged to the category of key sectors. These are Agriculture, hunting and forestry (sector 1), Fishing and pisciculture (sector 2), Foodstuffs and tobacco goods production (sector 6), Textile and clothing industry, leather manufacture (sector 7), Water generation, purification and distribution (sector 19), Wholesale trade (sector 21), and Finance (sector 27). All three methods identify Fishing and pisciculture (2), Water generation, purification and distribution (19), Wholesale trade (21), and Finance (27) as a key sectors. Investment in these sectors would initiate economic development due to the interrelations with other industries. It must be noted that DL method identified Agriculture, hunting and forestry (1) as a sector with a low backward and forward linkages. This is probably to the fact that this method is based on the ratio of each sector's effects to the output of the sector. Therefore, in this

Table 5. Key sectors (K), sectors with strong backward linkages (B), sectors important to forward linkages (F) and sectors with low linkages (L) in Kyrgyzstan economy for 1998

	Production Sectors	CW	Rasmussen	DL	Results
1	Agriculture, hunting and forestry	K	K	L	**K**
2	Fishing and pisciculture	K	K	K	**K**
3	Coal, crude oil and gas production	F	F	F	F
4	Ore extraction	K	F	F	F
5	Other minerals (mining) industries	L	L	L	L
6	Foodstuffs and tobacco goods production	K	K	B	**K**
7	Textile and clothing industry, leather manufacture	K	K	B	**K**
8	Wood and woodwork production	F	F	F	F
9	Paper manufacturing, publishing and typography	F	F	F	F
10	Coke production, oil refining, chemical industry, rubber and plastic product manufacturing	F	F	F	F
11	Other non-metallic mineral product manufacturing	F	F	F	F
12	Metallurgy industry	B	B	B	**B**
13	Production of finished metallic articles	L	L	L	L
14	Production of machinery and equipment	L	L	L	L
15	Other industries and secondary processing	L	L	B	L
16	Electricity generation and transmission	F	F	F	F
17	Gas fuel production and distribution	F	L	F	F
18	Steam and hot water supply	F	F	F	F
19	Water generation, purification and distribution	K	K	K	**K**
20	Construction	F	K	L	FKL
21	Wholesale trade	K	K	K	**K**
22	Retail trade	B	K	L	BKL
23	Car sale and servicing, private and house use goods maintenance	F	F	F	F
24	Hotels and restaurants	B	B	B	**B**
25	Transportation, subsidiary transport activities	B	K	B	**B**
26	Post and communication services	F	F	F	F
27	Finance	K	K	K	**K**
28	Operations with real estate, rent and services for business	F	F	F	F
29	Government administration	B	B	B	**B**
30	Education	L	B	L	L
31	Public health and social services	L	L	L	L
32	Environment purity protection services	L	L	L	L
33	Associations and unions, rest, culture and sport organizations activities	B	B	B	**B**
34	Rendering of individual services	L	L	L	L

case the relative high output of Agriculture, hunting and forestry induced low backward and forward linkages.

Other sectors, which have the second highest impact on the whole economy activity, are the sectors with large backward linkages. This is because sectors from strongly backward linkages category are largely dependent on other production sectors and can increase their demand for intermediate products, thus stimulating other industries. To this group of industries belong Metallurgy industry (12), Hotels and restaurants (24), Transportation, subsidiary transport activities (25), Government administration (29), and Associations and unions, rest, culture and sport organizations' activities (33). Note that they are defined as sectors with strongly backward linkages by all the three methods used, except for the Transportation (25) that is considered as a key sector according to the Rasmussen method. The ranking position of Metallurgy industry among the backward linkages indicators is the highest for the all three methods (see Appendix 3). This shows the significance of this industry for the Kyrgyzstan economy. Note also that all key sectors and sectors with strong backward linkages are included to the list of top fifteen industries with the highest output multipliers (see Table 4).

Because of inconsistency of linkages indicators of three methods used, Construction (20) and Retail trade (22) are not precisely defined in terms of which category of industries they are belong to. However, we may determine them as important sectors for Kyrgyzstan economy, since they both had sufficiently large share in the total gross output and total value added of the whole economy (see Appendix 2).

The present work may be used by policy makers in terms of which sectors of the economy stimulate (for example, by means of creating extra final demand, decreasing taxes, or with the help of subsidizing) in order to gain better results in the sphere of economic development of Kyrgyzstan. However, it must be mentioned that the analysis is based on the assumption of fixed input and output coefficients, i.e. they remained unchanged since 1998.

References

Alpha C. Chiang. *Fundamental Methods of Mathematical Economics.* Third ed., McGraw-Hill, Inc., 1984.

Andreosso-O'Callaghan B, Guoqiang Yue. "Intersectoral Linkages and Key Sectors in China 1987-1997. An Application of Input-output Linkage Analysis", *Papers of the 13th International Conference on Input-Output Techniques.*

Augustinovics, M. (1970) "Methods of International and Intertemporal Comparisons of Structures," in Carter, A.B. and Brody, A. (eds), *Contributions to Input-outputAnalysis*, Amsterdam, North-Holland P.C., Vol.I.

Bhalla, A.S., and MA, Y. (1990) "Sectoral Interdependence in the Chinese economy in comparative perspective", *Applied Economics*, 22, pp.1063-81.

Cella, G., (1984) "The Input-Output Measurement of Interindustry Linkages", *Oxford Bulletin of Economics and Statistics*, 46, 73-84.

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

Chenery, H.B. and Watanabe, T (1958), "International Comparisons of the Structure of Production", *Econometrica*, 26 (4), October, pp.487-521.

Chris G. Christopher. *Macroeconometric Modeling, Forecasting and Policy Analysis: Input-Output Modeling.* State University of New York at Albany, 2002.

Claus I. "Inter industry linkages in New Zealand", *New Zealand Treasury Working Paper 02/09*, 2002.

Dietzenbacher E. *Perturbations and Eigenvectors: Essays.* University of Groningen, 1991.

Dietzenbacher, E. and J.A. van der Linden (1997) "Sectoral and Spatial Linkages in the EC Production Structure", *Journal of Regional Science*, vol. 37, 235-257.

Emerson M. Jarvin, "The Kansas Input-Output Model: A Study in Economic Linkages"*,* Bulletin 655, *Agricultural Experiment Station*, Kansas State University, 1989.

Frederick V. Waugh. "Inversion of the Leontief Matrix by Power Series", *Econometrica*, April, 1950.

Ghosh, A., (1958) "Input-Output Approach in an Allocation System", *Economica*, 25, 58-64.

Gillis M, Perkins D.H, Roemer M, Snodgrass D.R. *Economics of Development,* Fourth ed., New York, 1996.

Hirschman, A.O. (1958),*The Strategy of Economic Development*. New York: Yale University Press.

Jones, L.P. (1976), "The Measurement of Hirschmanian Linkages", *Quarterly Journal of Economics*, XC, 323-33.

Laumas, P.S. (1976), "The Weighting Problem in Testing the Linkage Hypothesis", *Quarterly Journal of Economics*, XC, pp.319-22.

Leatherman J.C. "Input-Output Analysis of the Kickapoo River Valley", *Staff Paper 94.2,* Center for Community Economic Development, Department of Agricultural Economics, University of Wisconsin-Madison/Extension.

Leontief, W. *Essays in Economics. Theories, theorizing, facts, and policies.* New Brunswick and Oxford, 1985.

Leontief, W. *Input – Output Economics.* Second ed., New York, Oxford University Press, 1986.

Lovrenc Pfajfar, Alesa Lotric Dolinar. “Intersectoral linkages in the Slovenian economy in the years 1990, 1992, 1993 and 1995. Key sectors in the Slovenian economy”, *Papers of the 13th International Conference on Input-Output Techniques.*

National Statistic Committee of Kyrgyz Republic, Input-Output Tables for 1998 *(Межотраслевой баланс производства и использования товаров и услуг Кыргызской Республики за 1998 год.* Национальный статический комитет Кыргызской Республики, Бишкек, 2001).

Prem S. Laumas, (1975), “Key sectors in some undeveloped countries”, *KYKLOS*, Vol. 28, 62-79.

Rasmussen, P.N. (1956). *Studies in Intersectorial Relations*, Amsterdam, North-Holland P.C.

Schultz S. (1977) Approaches to Identifying Key Sectors Empirically by Means of Input-Output Analysis, *Journal of Development Studies*, 14, 77-96.

Shaffer, Ron. 1989. *Community Economics: Economic Structure and Change in Smaller Communities.* Ames, IA: Iowa State University Press.

Strassert, G., (1968), “Zur Bestimmung strategischer Sektoren mit Hilfe von Input-Output-Modellen, *Jahrbucher fur nationalokonomie und Statistik*, 182, 211-215.

Wade Hands, D. *Introductory Mathematical Economics.* Lexington, Massachusetts, 1991.

Yan, C. and E. Ames, (1965), “Economic Interrelatedness”, *Review of Economic Studies*, 32, 299-310.

Yotopulos, P.A. and Nugent, J.B (1973), "A Balanced-Growth Version of the Linkage Hypothesis: A Test", *Quarterly Journal of Economics*, LXXXVII (2), May, pp.157-71.

Appendix 1. Inter Industry Transactions Table of Kyrgyzstan for 1998 year in basic prices (in thousands of soms)

		1	2	…	34	Total industry	Consumption	Government spending	Gross capital formation	Exports	Total used	Imports	Expenditures on domestic output
1	Agriculture, hunting and forestry	5235359	30	…	317	9449254	143146	1843709	1545660	12981768	20596647	212109	20384538
2	Fishing and pisciculture	0	7515	…	0	7578	617	0	0	8195	20070	1160	18910
3	Coal, crude oil and gas production	7294	25	…	1726	62840	34655	-7817	9107	98785	2136694	1930063	206632
4	Ore extraction	0	0	…	0	0	0	-63422	144291	80869	4853697	324359	4529338
	…	…	…	…	…	…	…	…	…	…	…	…	…
32	Environment purity protection services	8	0	…	8669	34059	21413	40558	0	0	96030	0	96030
33	Associations and unions, rest, culture and sport organizations activities	36	0	…	149	86676	261348	132310	0	14416	494749	6865	487884
34	Rendering of individual services	0	0	…	0	92065	180999	10	0	0	273074	0	273074
	Intermediate consumption	7979009	9294	…	121096	36500823	28679557	6116550	5514200	12166570	88977699	20614602	68363098
	Total use in basic prices	7979009	9294	…	121096	36500823	28679557	6116550	5514200	12166570	88977699	20614602	68363098
	Taxes on product	94014	122	…	3646	823820	1450730	84171	175915	304010	2838646	0	2838646
	Subsidies on product	-1945	0	…	-2026	-135944	-75692	-378	0	-81	-212095	0	-212095
	Total use in purchasers' prices	8071078	9416	…	122716	37188698	30054596	6200342	5690115	12470500	91604250	0	91604250
	Total value added	12313460	9494	…	150358	31174400							
	Compensation of employees	1774700	657	…	65065	10419950							
	Operating surplus	9329512	8837	…	73210	14751350							
	Consumption of fixed capital	844048	0	…	6869	4901500							
	Other taxes on production (less subsidies)	365200	0	…	5214	1101600							
	Total supply in basic prices	20384538	18910	…	273074	68363099	30054596	6200342	5690115	12470500	91604250	0	0

Appendix 2. Some descriptive statistics

	Production Sectors	Sector share of total gross output	Sector share of total value added	Sector share of total exports	Exports as a share of sector output	Sector share of total imports	Imports as a share of sector output	Value added as a share of sector output	Intermediate goods as a share of total gross output	Gross capital formation as a share of total gross output
1	Agriculture, hunting and forestry	29.8	39.5	12.7	7.6	1.0	1.0	60.4	11.1	2.7
2	Fishing and pisciculture	0.0	0.0	0.0	0.0	0.0	6.1	50.2	0.0	0.0
3	Coal, crude oil and gas production	0.3	0.3	0.1	4.4	9.4	934.1	47.5	3.0	0.0
4	Ore extraction	6.6	8.0	1.2	3.2	1.6	7.2	55.1	7.0	-0.1
5	Other minerals (mining) industries	0.0	0.0	0.3	218.3	0.5	699.4	41.7	0.1	0.0
6	Foodstuffs and tobacco goods production	7.5	3.6	9.7	23.2	9.8	39.8	21.8	2.7	-0.2
7	Textile and clothing industry, leather manufacture	3.4	1.5	4.2	21.9	7.7	68.6	19.7	2.2	-0.1
8	Wood and woodwork production	0.1	0.1	0.1	30.3	1.0	396.3	38.1	0.4	-0.1
9	Paper manufacturing, publishing and typography	0.3	0.3	0.6	37.0	3.3	321.4	50.9	0.8	0.3
10	Coke production, oil refining, chemical industry, rubber and plastic product manufacturing	0.7	0.4	2.5	61.8	19.3	807.7	26.1	4.7	-0.6
11	Other non-metallic mineral product manufacturing	1.5	1.0	3.4	39.5	1.1	22.5	29.7	1.3	-0.1
12	Metallurgy industry	6.2	0.1	34.4	98.6	2.4	11.8	0.4	0.9	-0.1
13	Production of finished metallic articles	0.1	0.1	0.6	101.2	2.4	638.4	44.2	0.8	-0.1
14	Production of machinery and equipment	1.6	1.6	10.8	121.9	19.7	378.7	46.2	2.6	2.0
15	Other industries and secondary processing	0.3	0.2	1.0	58.9	1.3	130.0	24.8	0.2	0.1
16	Electricity generation and transmission	2.5	2.1	4.2	30.5	0.7	8.3	38.7	1.7	0.0
17	Gas fuel production and distribution	0.4	0.8	0.0	0.0	0.0	0.0	89.5	0.2	0.0
18	Steam and hot water supply	0.7	-1.0	0.0	0.0	0.0	0.0	-61.7	0.5	0.0
19	Water generation, purification and distribution	0.3	0.3	0.0	0.0	0.0	0.0	42.5	0.3	0.0
20	Construction	5.0	5.3	1.2	4.2	1.0	6.1	49.0	0.9	3.9
21	Wholesale trade	1.6	1.2	2.6	28.6	0.0	0.0	34.3	0.7	0.0
22	Retail trade	9.4	11.7	0.7	1.4	0.0	0.0	56.5	0.5	0.2
23	Car sale and servicing, private and house use goods maintenance	0.2	0.2	0.0	0.0	0.0	0.0	45.0	0.1	0.0
24	Hotels and restaurants	1.2	0.9	0.0	0.0	0.0	0.0	37.2	0.1	0.0
25	Transportation, subsidiary transport activities	3.8	3.4	4.7	22.0	10.2	79.8	39.8	3.5	0.1
26	Post and communication services	1.1	1.5	1.6	26.5	0.9	23.7	64.4	0.7	0.0
27	Finance	1.1	0.4	0.4	6.9	1.4	37.9	15.4	1.4	0.0
28	Operations with real estate, rent and services for business	3.8	4.9	1.9	8.7	5.0	39.9	59.6	4.2	0.2
29	Government administration	4.0	3.2	0.8	3.6	0.3	2.4	36.7	0.4	0.0
30	Education	3.0	4.4	0.0	0.0	0.0	0.0	68.4	0.1	0.0
31	Public health and social services	2.2	2.5	0.0	0.0	0.0	0.0	51.3	0.1	0.0
32	Environment purity protection services	0.1	0.2	0.0	0.0	0.0	0.0	52.0	0.0	0.0
33	Associations and unions, rest, culture and sport organizations activities	0.7	0.8	0.1	3.0	0.0	1.4	49.7	0.1	0.0
34	Rendering of individual services	0.4	0.5	0.0	0.0	0.0	0.0	55.1	0.1	0.0

Appendix 3. Rankings of backward and forward linkages for 1998

	Production Sectors	Backward linkages					Forward linkages				
		CW		Rasmussen		DL	CW		Rasmussen		DL
		UBL	WBL	UBL	WBL		UFL	WFL	UFL	WFL	
1	Agriculture, hunting and forestry	12	2	11	1	18	18	1	18	1	20
2	Fishing and pisciculture	6	32	5	34	7	11	32	6	33	13
3	Coal, crude oil and gas production	29	31	29	31	29	3	17	2	21	1
4	Ore extraction	13	23	13	24	17	1	2	3	2	4
5	Other minerals (mining) industries	28	34	27	32	27	33	33	34	34	34
6	Foodstuffs and tobacco goods production	3	3	4	4	2	22	7	23	6	24
7	Textile and clothing industry, leather manuf.	2	6	2	8	3	17	8	14	10	18
8	Wood and woodwork production	16	33	15	33	13	5	28	7	31	6
9	Paper manufacturing, publishing and typog.	31	28	31	28	31	7	18	8	24	5
10	Coke production, oil refining, chemical industry, rubber and plastic product manuf.	32	24	32	21	32	12	13	10	18	9
11	Other non-metallic mineral product manuf.	20	16	23	17	24	10	6	12	12	12
12	Metallurgy industry	1	1	1	2	1	32	31	32	25	32
13	Production of finished metallic articles	23	25	19	26	16	34	34	33	32	33
14	Production of machinery and equipment	26	14	25	11	25	26	21	26	15	25
15	Other industries and secondary processing	21	21	14	22	12	25	30	22	29	22
16	Electricity generation and transmission	27	18	28	15	28	9	4	9	7	8
17	Gas fuel production and distribution	34	30	34	23	34	16	19	17	22	16
18	Steam and hot water supply	14	19	16	19	15	8	15	13	19	11
19	Water generation, purification and distrib.	9	26	10	30	10	4	20	4	27	3
20	Construction	25	8	26	6	26	23	5	24	5	23
21	Wholesale trade	10	12	9	13	8	15	10	16	14	15
22	Retail trade	15	4	17	3	14	29	14	29	3	29
23	Car sale and servicing, private and house use goods maintenance	33	29	33	27	33	13	23	11	28	10
24	Hotels and restaurants	5	10	6	12	4	27	26	28	20	28
25	Transportation, subsidiary transport activ.	11	7	12	7	11	21	9	21	8	21
26	Post and communication services	19	17	20	18	20	14	12	15	17	14
27	Finance	4	22	3	25	5	2	11	1	16	2
28	Operations with real estate, rent and services for business	17	13	18	14	22	6	3	5	4	7
29	Government administration	7	5	7	5	6	28	16	27	9	27
30	Education	24	9	24	9	23	31	25	31	11	31
31	Public health and social services	22	11	21	10	19	30	27	30	13	30
32	Environment purity protection services	30	27	30	29	30	19	29	19	30	17
33	Associations and unions, rest, culture and sport organizations activities	8	15	8	16	9	24	24	25	23	26
34	Rendering of individual services	18	20	22	20	21	20	22	20	26	19