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VERTICALLY INTEGRATED PRODUCTIVITY MEASURES: TESTS OF STANDARD ASSUMPTIONS

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In this paper we use an input-output framework to examine two criticisms of standard measures of total factor productivity. These criticisms are (1) that the contribution of capital to productivity growth is underestimated, and (2) that the use of cost shares to weigh factor input contribution is questionable. Using various vertically integrated productivity measures we find that capital's productivity contribution is underestimated in the neoclassical formulation. We also find that in a Pasinetti-Rymes growth model, factor shares do not approximate output elasticities. We conclude that the argument made by Pasinetti, Rymes, and others is supported, that in long-run productivity analysis capital should not be treated as a primary input, but should be measured as an intermediate, produced input.

I. INTRODUCTION

Following the seminal work of Solow (1957), the standard approach to productivity measurement has been to apply neoclassical production and cost function theory. In the last decade these measures have come under increasing criticism, even from those economists who pioneered research in productivity change. Young (1989) and Denison (1989) question the neoclassical concept of capital as a primary factor of production. Kendrick (1989) points out the problem in aggregating productivity growth rates for individual industries to arrive at a growth rate for the whole economy. Kendrick (1989) and Griliches (1988) lament the lack of progress in reaching a consensus as to the causal factors behind the productivity slowdown. More than a decade ago Richard Nelson (1981, p. 1032) wrote: "It is my belief that research, guided by the neoclassical paradigm, has reached a stage of sharply diminishing returns."

In this study we use an alternative, input-output framework to empirically examine two criticisms of the standard measures of total factor productivity (TFP) as discussed by Cornwall (1987). These are, first, the contribution of capital to productivity growth is seriously underestimated and second, the use of cost shares to weight factor input contribution has little empirical validity. We examine these criticisms using three vertically integrated productivity measures. Measure (1) follows the neoclassical assumption of treating capital as a primary input. Measure (2) is the Pasinetti-Rymes measure which treats capital as a produced (intermediate) means of production. The TFP estimates of measure (3) are used to examine the appropriateness of factor cost shares as estimators of output elasticities.

II. Vertically Integrated Input Requirements

The notion of vertical integration in multi-sector analysis has a long history (Leontief, 1953; Carter, 1970). A pioneering article containing the basic framework for the model presented here is that by Pasinetti (1973, 1981). Recent productivity studies using an IO framework have been done by Cas and Rymes (1991), Cekota (1988), Gowdy and Miller (1990), Ochoa (1986), Postner and Wesa (1983), Rymes (1986) and Wolff (1985). Using the Standard Leontief-Sraffa framework let:

$$X = [\mathbf{I} - \mathbf{A}]^{-1} Y \tag{1}$$

$$K = \mathbf{B}X = \mathbf{B}[\mathbf{I} - \mathbf{A}]^{-1} Y \tag{2}$$

Where X is an $(n \times 1)$ vector of gross sectoral output, K an $(n \times 1)$ vector of capital stock inputs, $\mathbf{A}$ an $(n \times n)$ matrix of direct input coefficients, $\mathbf{B}$ an $(n \times n)$ matrix of capital-output coefficients, and Y an $(n \times 1)$ vector of final demand, the vector of gross sectoral output may be written,

$$X = \mathbf{A}X + \mathbf{B}\hat{\mathbf{\Gamma}}X + Kg + C. \tag{3}$$

$\hat{\mathbf{\Gamma}}$ is a $(n \times n)$ diagonal matrix of depreciation rates for each sector, g an $(n \times 1)$ vector of each sector's net capital growth rate, C an $(n \times 1)$ vector of sectoral final demand less gross investment, and Kg is an $(n \times 1)$ vector of net investment requirements. Rearranging terms in equation (3) we have,

$$C + Kg = [\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]X. \tag{4}$$

Premultiplying both sides of (4) by $[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}$ yields,

$$[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}C + [\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}Kg = X. \tag{5}$$

Premultiplying both sides of (5) by $\mathbf{B}$ yields the vector of capital stock requirements,

$$\mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}C + \mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}Kg = \mathbf{B}X = K \tag{6}$$

solving for K and redefining g as a diagonal matrix yields,

$$(\mathbf{I} - \mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}\hat{\mathbf{g}})^{-1}\mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}C = K \tag{7}$$

where $\hat{\mathbf{g}}$ is an $(n \times n)$ diagonal matrix of net capital growth rates for each sector of the economy. Equations (6) and (7) measure the stock of capital (K) required to produce final output (C). Included in the stock requirements is the net capital required to keep the capacity of the economy growing at the constant trend sectoral growth rates (g), shown by the term $\mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}Kg$ of equation (6). The basic relationship shown in equations (5) and (7) are used below to test the plausibility of two treatments of the input of capital.

III. Capital as a Primary Input

We first examine the plausibility of treating capital as a primary input. Measure TFP (1) assumes two primary inputs, capital and labor. It is "neo-classical" in the sense that capital is on the same footing as labor as a productive input. The vertically integrated labor coefficient Θ_1 shows the labor hours required per dollar of final output,

$$\Theta_1 = l[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1}. \tag{8}$$

Where l is a $(1 \times n)$ row vector of labor hour requirements per dollar of gross output and Θ_1 is a $(1 \times n)$ row vector of vertically integrated labor coefficients, the vertically integrated capital coefficient is derived from equation (7),

$$i'\mathbf{K}\hat{\mathbf{C}}^{-1} = i'\{(\mathbf{I} - \mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1}\hat{\mathbf{g}})^{-1}\mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1}\} = \Theta_k. \tag{9}$$ [1]

$\mathbf{K}$ is the $(n \times n)$ matrix $(\mathbf{I} - \mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1}\hat{\mathbf{g}})^{-1}\mathbf{B}\hat{\mathbf{X}}$ where $\hat{\mathbf{X}}$ is a $(n \times n)$ diagonal matrix of gross outputs, $\hat{\mathbf{C}}^{-1}$ is an $(n \times n)$ diagonal matrix of the reciprocal of final output, and i' is a $(1 \times n)$ column sum vector. Θ_k is a $(1 \times n)$ vector of vertically integrated capital coefficients showing capital stock required per dollar of final output. Estimates of the vertically integrated labor and capital coefficients of equations (8) and (9) were made for each year between 1947–82 for seven sectors and total output. Construction of the input-output tables and capital matrices is discussed in Appendix A. Trend values for the vertically integrated capital and labor coefficients are estimated for the aggregate U.S. economy and seven sectors. The discussion below will be confined to the aggregate results. Findings for each sector are reported in Appendix B.

The long-run linear trend value of the vertically integrated labor coefficient is estimated by equation (10). "t" is a linear time trend for the 35 year period 1947 to 1982. Trend values are indicated by an asterisk. t-statistics are in parenthesis.

$$\begin{aligned} \Theta^*_{1t} &= 0.1340 - \underset{(19.4)}{0.0024t} \\ R^2 &= 0.92 \\ AV\Theta^*_1 &= 0.0920\,^2 \\ r\Theta^*_1 &= -0.0260\,^3 \\ t &= 0, \ldots, 35 \ (1947\text{–}82) \end{aligned} \tag{10}$$

Initial trend labor requirements were 0.1340 hours per 1982 dollar of final output. On trend labor requirements decreased by 0.0024 hours per year, for a productivity growth rate of 2.6 percent per year (a negative number means a reduction in

[1]Equations (8) and (9) show labor and capital requirements per dollar of final output. With two simplifying assumptions the basic forms of the two equations are identical. First assume labor to be a heterogeneous input, so the l vector in (8) is replaced by the L matrix of heterogeneous labor inputs. Second, let $g = 0$ in equation (9), then equations (8) and (9) may be rewritten:

$$\Theta_1 = i'\mathbf{L}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1} \tag{8a}$$

$$\Theta_k = i'\mathbf{B}[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1} \tag{9a}$$

where i' is the column sum vector. The L and $\mathbf{B}$ matrices represent the inputs of labor and capital needed per dollar of final output.

[2]The average trend coefficient is calculated by $\sum_{t=0}^{35} \Theta^*_{1t}/36$.

[3]The growth rate of labor requirements per dollar of final output $r\Theta_1$ is derived by dividing the slope coefficient of the trend regression by the average trend coefficient $AV\Theta_{1\bullet}$.

input requirements per dollar of final output and thus an increase in productivity). Trend values for the vertically integrated capital coefficient are calculated by,

$$\Theta^*_{kt} = 1.2200 + \underset{(1.3)}{0.0032t} \tag{11}$$

$$R^2 = 0.05$$

$$AV\Theta^*_k = 1.2800$$

$$r\Theta^*_k = r\Theta_k \hat{\mathbf{g}}^* = 0.0020$$

$$t = 0, \ldots, 35$$

Equation (11) shows that initial trend capital stock requirements were \$1.22 per dollar of final output (C). On trend, capital requirements increased by 0.0032 dollars per year. Trend capital requirements averaged \$1.28 and trend growth equaled 0.0020. Trend growth rates for the vertically integrated capital coefficient ($r\Theta^*_k$) equals the trend growth rate of the vertically integrated net capital coefficient ($r\Theta_k\hat{\mathbf{g}}^*$). This is because the vertically integrated coefficient Θ_k measures average capital requirements and the trend growth rates of net capital (g) are constant.

TFP measurements are calculated by assuming that average cost shares are equal to factor output elasticities. Since average cost shares are used, it is crucial to TFP measurements that cost shares be relatively stable over the time period from which the productivity measurements are taken. Vertically integrated labor cost shares are calculated by equation (12),

$$\Theta_w = w[\mathbf{I} - \mathbf{A} - \mathbf{B}\hat{\boldsymbol{\Gamma}}]^{-1} \tag{12}$$

where w is a $(1 \times n)$ row vector of labor costs per dollar of gross output. The aggregate trend values of vertically integrated labor cost shares are,

$$\Theta^*_{wt} = 0.5830 + \underset{(3.1)}{0.008t} \tag{13}$$

$$R^2 = 0.22$$

$$AV\Theta^*_w = 0.6000$$

$$r\Theta^*_w = 0.0013$$

$$t = 0, \ldots, 35.$$

Labor cost shares over the period 1947–82 for the U.S. averaged 0.60, and were very stable showing a 0.0010 growth rate per year. Capital cost shares are calculated as a residual:

$$\Theta^*_{pkt} = 1 - \Theta^*_w \tag{14}$$

For the aggregate economy TFP for measure (1) is,

$$\text{TFP}(1) = (AV\Theta^*_w \times r\Theta^*_1) + (AV\Theta^*_{pk} \times r\Theta_k\hat{\mathbf{g}}^*) = -0.0146. \tag{15}$$

Again, this measure does not take into account the increasing efficiency with which capital goods are produced.

IV. Capital as a Produced Means of Production

Rymes (1986, 1983, 1972) and Cas and Rymes (1991) argue that capital should be treated as a produced means of production not as a primary input. Making capital a produced means of production requires premultiplying the right side of equation (7) by the labor coefficient.

$$(16)\quad \Theta_{k1} = \Theta_1 \times \Theta_k = l\{[\mathbf{I}-\mathbf{A}-\mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}(\mathbf{I}-\mathbf{B}[\mathbf{I}-\mathbf{A}-\mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}\hat{\mathbf{g}})^{-1}\mathbf{B}[\mathbf{I}-\mathbf{A}-\mathbf{B}\hat{\mathbf{\Gamma}}]^{-1}\}$$

Equation (16) implies, following Rymes (1972, 1983), two primary inputs, labor and waiting. The trend value for the vertically integrated capital coefficient of (16) for the period 1947-82 is derived using equation (17),

$$(17)\quad \begin{gathered} \Theta^*_{k1t} = 0.1346 - \underset{(8.8)}{0.0020t} \\ R^2 = 0.70 \\ AV\Theta^*_{k1} = 0.0990 \\ r\Theta^*_{k1} = r\Theta_{k1}\hat{\mathbf{g}}^* = -0.0200 \\ t = 0, \ldots, 35. \end{gathered}$$

From equation (11) we see that initial trend capital requirements per dollar of output equaled \$1.22 and equation (17) shows that to replace this amount of capital would have required 0.1346 hours of labor. Equation (11) also shows that trend capital requirements increased by 0.0032 dollars per year while equation (17) shows labor hour requirements decreasing by 0.0200 hours per year. So while capital input requirements measured in real dollars were stable over the period, the growing efficiency of producing capital goods decreased input requirements measured in labor hours. The TFP measurement for measure two is,

$$(18)\quad \text{TFP}\,(2) = (AV\Theta^*_w \times r\Theta^*_1) + (AV\theta^*_{pk} \times r\Theta_{k1}\hat{\mathbf{g}}^*) = -0.0236.$$

Total factor productivity using measure TFP (2) is significantly larger than measure TFP (1) because the increasing efficiency of producing capital goods is taken into account in measure TFP (2).

V. Cost Shares as Factor Weights

Summing trend coefficients (10) and (17) gives total requirements per dollar of final output:

$$(19)\quad \begin{gathered} \Theta^*_{1t} + \Theta^*_{k1t} = \Theta^*_{Tt} = 0.2686 - 0.0044t \\ AV\Theta^*_T = 0.1910 \\ r\Theta^*_T = -0.0230 \\ t = 0, \ldots, 35. \end{gathered}$$

The growth of total requirements ($r\Theta^*_T$) should equal TFP (2) because both are derived from the same set of vertically integrated coefficients. The two growth measures differ in that TFP (2) uses exogenous weights—factor costs shares—to measure each factor's contribution to productivity growth. Since no exogenous weights are needed to derive $r\Theta_T^*$, it is a more desirable measure of total productivity. The disadvantage of using total requirements is the impossibility of measuring the separate contributions to productivity growth of labor and capital-as-waiting.

If factor output elasticities were known, total factor productivity would equal

$$\text{(20)} \qquad \text{TFP}(2) = r\Theta_T^* = e_l(r\Theta_l^*) + e_k(r\Theta_{kl}\hat{\mathbf{g}}^*),$$

where e_l and e_k are the output elasticities of labor and capital. The reason TFP (2) does not equal $r\Theta_T^*$ is the factor cost shares do not equal factor output elasticities. Substituting into equation (20) the trend estimates for $r\Theta_T^*$, $r\Theta l^*$, and $r\Theta_{kl}\hat{\mathbf{g}}^*$, we have:

$$\text{(21)} \qquad e_l(-0.0260) + e_k(-0.0200) = -0.0230.$$

Let a_l and a_k be fitted weights such that $0 < a_l < 1$, $0 < a_k < 1$, and $a_l + a_k = 1$. Given the restrictions on a_l and a_k, and substituting the fitted weights for the output elasticities into equation (21) yields,

$$\text{(22)} \qquad a_l(-0.0260) + a_k(-0.0200) = -0.0230.$$

Solving (22) for the fitted weights gives $a_l = 0.50$ and $a_k = 0.50$. Replacing cost shares in the Rymes-Pasinetti model with fitted weights changes the productivity measurement only slightly, from -0.0236 to -0.0230, but capital's contribution to total productivity increases from 34 percent to 43 percent.[4]

VI. Conclusion

Cornwall's argument that capital's productivity is much underestimated by neoclassical productivity measurements is supported by the above findings. Measure TFP (1) treats capital as a primary input. By this measure TFP grew at an annual rate of 1.46 percent. Since the capital-output ratio is nearly constant over the period 1947-82 (from equation (11)), capital's contribution to productivity growth using TFP (1) is near zero. Measure TFP (2) treats capital as a produced means of production. By this measure TFP grew at an annual rate of 2.30 percent. TFP (2) is larger than TFP (1) because the former measure takes into account the increasing productivity in producing capital as an output. Using fitted weights to estimate output elasticities, we show that the use of cost shares to weight productivity contributions underestimates the contribution of capital to productivity growth.

Appendix A—Capital Stock Estimates

The current account and capital stock matrices were estimated as follows. Benchmark current account matrices have been constructed by the Bureau of Economic Analysis, Department of Commerce for the years 1947, 1958, 1963,

[4]Capital's contribution to productivity growth is calculated in the two cases by: for TFP (2) by $(0.40 \times -0.0200)/(-0.0236) = 0.34$ and for $r\Theta_T^*$ by $(0.50 \times -0.200)/(-0.0230) = 0.43$.

1967, 1972 and 1977. The current account matrices for non-benchmark years were derived by linearly interpolating the coefficients of the benchmark direct coefficient tables. The 1982 transactions table was constructed by the Bureau of Labor Statistics from the 1977 BEA Table. Tables for the years between 1977–82 were constructed by linearly interpolating the direct coefficients from these two tables.

Total capital stock, total structures and total equipment, measured in current dollars, are the three control totals used to construct the capital stock matrix. This data is found in the BEA publication "Fixed Reproducible Tangible Wealth in the U.S. 1925–85." The construction sector (row three of the capital stock matrix) contains the control total "structures." This shows construction to be the input sector for producing structures. To estimate "equipment" we took the total value of equipment held by each sector and distributed it to the six equipment supplying sectors. This was done using the gross investment flow matrices produced by BEA for the years: 1958, 1963, 1967, 1972, and 1977.

(1) For each capital flow matrix we replaced row 3, the construction sector, with zeros, to get the equipment flow matrix (EFM).
(2) We then divided each column cell of the (EFM) by the column sum to get the coefficient matrix (E). This was done for each of the benchmark years.
(3) We assumed that the coefficients of the equipment flow matrix grew linearly and derived coefficient matrices for all non-benchmark years between 1958–77.
(4) All years before 1958 were assumed to have an equipment flow structure identical to 1958, and all years after 1977 to have an equipment flow structure identical to 1977.

To construct the equipment stock matrix for period t we began with the gross investment equipment matrix for period t and added the gross investment equipment matrix for period $t-1$ less depreciation. We continued to add the gross investment equipment matrices for succeeding years until the column totals of the equipment matrix equaled the total equipment control total. Filling in row 3 of the equipment stock matrix with the total structure control total gave the capital stock matrix.

Appendix B—Sectoral Estimates

		R^2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
1. Agriculture (1–4)**	$\Theta_1 = 0.191 - 0.0036t$	0.91	0.13	−0.028	18.4
	$\Theta_k = 0.600 + 0.0385t$	0.77	1.30	0.030	11.0
	$\Theta_w = 0.341 + 0.0050t$	0.93	0.43	0.012	21.3
	$\Theta_{k1} = 0.003 + 0.0024t$	0.51	0.05	0.053	5.8
	$\Theta_{t1} = 0.194 - 0.0012t$	0.12	0.17	0.007	2.2

$a_1 = 0.565$, $a_k = 0.435$, TFP (1) = 0.006, TFP (2) = 0.0175

		R^2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
2. Mining (5 – 10)**	$\Theta_l = 0.040 - 0.0007t$	0.51	0.03	−0.024	5.8
	$\Theta_k = 6.648 - 0.0780t$	0.22	5.20	0.015	3.0
	$\Theta_w = 0.630 - 0.0047t$	0.78	0.55	−0.009	10.7
	$\Theta_{kl} = 0.135 - 0.0013t$	0.46	0.11	−0.012	5.3
	$\Theta_{tl} = 0.172 - 0.0020t$	0.53	0.14	−0.014	6.1

$a_l = 0.200$, $a_k = 0.800$, TFP (1) = −0.020, TFP (2) = −0.0184

		R^2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
3. Construction (11 – 12)**	$\Theta_l = 0.106 - 0.0014t$	0.63	0.08	−0.016	7.5
	$\Theta_k = 0.885 + 0.0009t$	0.02	0.90	0.001	0.7
	$\Theta_w = 0.586 + 0.0024t$	0.59	0.63	0.004	6.9
	$\Theta_{kl} = 0.100 - 0.0014t$	0.55	0.08	−0.013	6.4
	$\Theta_{tl} = 0.206 + 0.0027t$	0.60	0.16	−0.017	7.1

$a_l = 0.610$, $a_k = 0.390$, TFP (1) = −0.009, TFP (2) = −0.017

		R_2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
4. Manufacturing (13-64)**	$\Theta_l = 0.140 - 0.0024t$	0.93	0.10	−0.025	20.7
	$\Theta_k = 0.845 + 0.0128t$	0.60	1.07	0.012	7.1
	$\Theta_w = 0.629 + 0.0013t$	0.28	0.65	0.002	3.5
	$\Theta_{kl} = 0.143 - 0.0018t$	0.63	0.11	−0.017	7.5
	$\Theta_{tl} = 0.283 - 0.0042t$	0.82	0.21	−0.021	12.0

$a_l = 0.500$, $a_k = 0.500$, TFP (1) = −0.012, TFP (2) = −0.220

		R_2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
5. Transport & Trade (65, 69)**	$\Theta_l = 0.190 - 0.0033t$	0.95	0.13	−0.025	25.3
	$\Theta_k = 0.809 + 0.0070t$	0.24	0.93	0.008	3.2
	$\Theta_w = 0.597 + 0.0012t$	0.61	0.64	0.003	7.2
	$\Theta_{kl} = 0.109 - 0.0024t$	0.37	0.06	−0.36	4.4
	$\Theta_{tl} = 0.299 - 0.0056t$	0.73	0.20	−0.029	9.3

$a_l = 0.660$, $a_k = 0.340$, TFP (1) = −0.130, TFP (2) = −0.0291

		R_2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
6. Utilities (68)**	$\Theta_l = 0.062 - 0.0014t$	0.24	0.04	−0.039	3.2
	$\Theta_k = 8.632 - 0.1113t$	0.38	6.62	−0.017	4.5
	$\Theta_w = 0.583 - 0.0034t$	0.06	0.52	−0.006	1.5
	$\Theta_{kl} = 0.411 - 0.0071t$	0.77	0.28	−0.025	10.4
	$\Theta_{tl} = 0.473 - 0.0085t$	0.67	0.32	−0.027	8.1

$a_l = 0.120$, $a_k = 0.880$, TFP (1) = −0.028, TFP (2) = −0.0324

APPENDIX B—continued

		R^2	$AV\Theta^*$	$r\Theta\hat{g}^*$	t-stat
7. Services	$\Theta_l = 0.100 - 0.0016t$	0.88	0.07	−0.024	15.6
(66, 67, 70-79)**	$\Theta_k = 0.0840 + 0.0090t$	0.30	1.00	0.009	3.7
	$\Theta_w = 0.521 + 0.0005t$	0.03	0.53	0.001	1.0
	$\Theta_{kl} = 0.116 - 0.0013t$	0.82	0.09	−0.014	12.1
	$\Theta_{tl} = 0.215 - 0.0030t$	0.89	0.16	−0.018	16.2

$a_l = 0.435$, $a_k = 0.565$, TFP (1) = −0.008, TFP (2) = −0.019

** 80 Sector Input-Output Classification

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