7 Counterfactuals

Econometric models can be used to answer counterfactual questions or to form predictions of the effects of policy actions. In this chapter the econometric model of net exports that has been reported in the previous chapter is used to estimate the effect of a rearrangement of the world's resources on trade flows and to predict the influence of price changes on the returns to factors.

The resources that have the greatest effect on world trade are identified in section 7.1. Based on the estimated model, the change in each resource endowment is computed that would reduce trade dependence as much as possible, holding fixed the levels of the other resources. Then by comparing the predicted reduction in trade dependence corresponding to each resource, the resources are identified that are the most important determinants of trade. Intellectual amusement is the primary reason for identifying the most important resources, since in the linear model with factor price equalization, there are no efficiency consequences of an uneven distribution of the world's resources. If the model is nonlinear, however, commodity trade is not a complete substitute for factor mobility, and the resources that are most influential in determining trade can also be expected to be the resources that have the greatest economic reward for international migration. Without formal justification, we might imagine that the identification of the most important resources for the nonlinear model would be similar to the identification for the linear model. The principal findings reported in section 7.1 are that in 1958 LABOR 1 was the most influential resource overall, followed closely by LABOR 3, LABOR 2, and LAND 4. In 1975 CAPITAL was by far the most influential, with OIL in second place, trailed considerably by LAND 4. The finding that the uneven distribution of the most highly skilled workers was the primary cause of trade in 1958 conforms with the conclusion reached in the previous chapter about the relative importance of LABOR 1. The finding about the importance of CAPITAL in 1975 seems initially surprising, since this was a period of increased international capital mobility. But much of the net trade that occurs in 1975 appears to be CAPITAL abundant countries paying the bill for petroleum imports with large amounts of manufactured exports. A leveling of the CAPITAL/OIL ratio around the world could be expected to have a dramatic effect on reducing trade.

Estimates of the elasticities of factor returns to changes in product prices are reported in section 7.2. These estimates are based theoretically

on the duality between the Stolper-Samuelson effects and the Rybczynski effects. The Rybczynski effects are computed by purging consumption effects from the estimated derivatives of net exports with respect to factor endowments. This amusingly subtle way of estimating the income distributional consequences of tariffs turns out to be rather suspicious for a variety of reasons outlined subsequently.

7.1 Most Important Resources

In the model with constant returns to scale, trade of commodities compensates for an uneven geographical distribution of the world's productive resources. It is an intellectually interesting problem to determine which resource is most unevenly distributed in the sense of being the primary cause of trade. This can be studied in a limited way using the estimated model described in the previous chapter. This model is based on the assumption that commodity prices are fixed, and we are consequently restricted to counterfactual questions that could sensibly be assumed to leave commodity prices undisturbed. The even model (with factor price equalization) does have the feature that small reallocations of the world's productive resources would leave product prices unchanged. We may therefore legitimately use it to ask this counterfactual: By how much would trade diminish if a particular resource were reallocated?

Let us write the counterfactual net export vector of some country as a function of some hypothetical change in the country's endowment of a particular factor, ΔV_i:

$$T^* = T + \beta(\Delta V_i),$$

where T is the actual trade vector and β is the vector of coefficients that indicate how resource i affects the net export vector. A measure of the amount of trade is the squared length of the trade vector

$$T^{*\prime}T^* = (T + \beta(\Delta V_i))'(T + \beta(\Delta V_i))$$
$$= T'T + 2T'\beta(\Delta V_i) + \beta'\beta(\Delta V_i)^2.$$

The vector of coefficients β is unknown, though estimates of it have been discussed in the previous chapter. To allow for this uncertainty we can find the ΔV_i that minimizes the expected amount of trade:

$$T'T + 2E(T'\beta)\Delta V_i + E(\beta'\beta)(\Delta V_i)^2.$$

This value for ΔV_i is

$$\Delta V_i = -T'E(\beta)/E(\beta'\beta), \tag{7.1}$$

and the square root of the corresponding percentage reduction in expected trade is

$$r = (T'T - T^{*\prime}T^*)^{1/2}/(T'T)^{1/2} = |T'E(\beta)|/(T'T)^{1/2}(E(\beta'\beta))^{1/2}. \tag{7.2}$$

Expression (7.1) for ΔV_i can be less than $-V_i$, where V_i is the original resource supply, and the country can be left with negative amounts of the resource. If this occurs, we restrict ΔV_i to $-V_i$, and the reduction in expected trade becomes

$$r = (2T'E(\beta)V_i - E(\beta'\beta)V_i^2)^{1/2}/(T'T)^{1/2}. \tag{7.3}$$

Values for $E(\beta)$ and $E(\beta'\beta)$ that are required to compute these numbers are taken from the Bayes estimates $\hat{\beta}_j$ and Bayes standard errors $\hat{\sigma}_j$ reported in the previous chapter. The mean $E(\beta_j)$ is the Bayes estimate $\hat{\beta}_j$, and the expected sum of squares of the coefficients is $E(\beta'\beta) = \sum_j(\hat{\beta}_j^2 + \hat{\sigma}_j^2)$.

It should be noted that this formulation will yield a ranking of resources that depends not only on the estimated coefficients but also on the uncertainty in the estimates because $E(\beta'\beta)$ depends on the estimated variances. If the coefficients attaching to a particular resource are very uncertain, then $E(\beta'\beta)$ will be large, ΔV_i will be small, and the reduction in expected trade is correspondingly small. In that sense, the reported numbers are similar to F-statistics for testing the joint significance across equations of a particular variable.

Notice also that the change in a resource (7.1) takes the opposite sign of $T'E(\beta)$. This means, for example, that a country with positive net exports of commodities that have positive capital coefficients and negative net exports of the commodities with negative capital coefficients would have a reduction in capital to reduce trade dependence. In that sense, the country is revealed to be abundant in capital.

This notion of factor abundance need not conform to the physical definition that a country is abundant in a factor if its endowment share exceeds it consumption share. The model we have used as a basis for this empirical work is summarized by the vector of equations $T = A^{-1}(V - sV_w)$, where A is the matrix of input intensities, V is the endowment vector, V_w is the world's endowment, and s is the consumption share. If trade is balanced, the consumption share is the GNP ratio $s = p'A^{-1}V/p'A^{-1}V_w$, where p is the vector of product prices. In the cross-section empirical work, with prices p and world endowments V_w fixed across countries, we imagine that we are estimating $\partial T/\partial V = A^{-1} - V_w p'A^{-1}/p'A^{-1}V_w \equiv B$. The inner product of this matrix with the vector T is used in formula (7.1) to define the revealed factor abundance vector:

$$(\partial T/\partial V)'T = B'T = B'A^{-1}(V - sV_w).$$

This vector will not necessarily have the same sign as the excess factor supply vector $V - sV_w$, since the transformation $B'A^{-1}$ need not preserve the signs of $V - sV_w$. What this means is that it is possible to find a factor that is abundant in the physical sense, yet in order to reduce trade the country would have to be provided even more of the factor. There is mathematical and conceptual similarity between this observation and Leamer and Bowen's (1981) comment that cross-section regressions of net exports on factor intensities need not reveal the sign of the factor abundance vector $V - sV_w$.

Tables 7.1 and 7.3 contain the expected percentage reduction of the square root of the sum of squares of the net export vectors induced by an optimally selected reallocation of resources. The corresponding reallocations of resources are reported in tables 7.2 and 7.4, where 99.9 indicates that the original level of the resource was zero so that the percentage change is $+\infty$.

Consider, for example, the U.S. numbers in tables 7.3 and 7.4. The CAPITAL columns of table 7.3 and 7.4 indicate that a reduction of the capital stock by 36% in the United States in 1975 would have been expected to reduce the size of the net export vector by 68%. No other resource offers a reduction as large. In that sense, U.S. trade in 1975 can be thought to have been primarily a consequence of CAPITAL abundance. Other important variables are OIL (scarce), LAND 4 (scarce), and LABOR 3 (scarce), where the words "scarce" and "abundant" refer to the signs of the resource changes in table 7.4. The 1958 results are rather different. LABOR 2 (scarce) was the most important variable, followed closely by LABOR 1 (abundant), LAND 4 (scarce), LABOR 3 (scarce), and COAL (abundant).

These conclusions compare interestingly with the findings of the rest of the empirical literature, as summarized by Deardorff (1982b): "It is

Table 7.1
Percentage trade reduction: 1958[a]

Country	CAPITAL	LABOR 1	LABOR 2	LABOR 3	LAND 1	LAND 2	LAND 3	LAND 4	COAL	MINERALS	OIL
AFG	52	75	41	**75**	0	63	0	0	75	8	9
ARG	67	66	23	20	0	31	**90**	0	61	12	13
AUSL	77	82	29	5	29	65	**90**	0	70	12	0
AUST	19	9	28	14	28	32	6	19	22	34	**38**
BLUX	42	42	14	**50**	31	35	28	33	20	25	40
BRAZ	39	62	67	50	**88**	8	29	0	62	5	3
BRMA	41	52	10	**58**	31	0	0	0	39	0	8
CAN	44	68	25	5	0	7	19	**97**	52	39	24
CHLE	4	48	38	19	13	1	0	0	13	**86**	18
CLUM	23	49	54	31	**71**	5	0	0	53	0	19
CSTA	23	54	38	15	37	0	0	0	54	1	0
CYPR	5	47	31	20	0	0	23	0	16	**61**	0
DEN	20	18	13	2	5	0	17	0	**25**	15	21
DORE	31	**58**	42	29	31	0	0	0	55	1	0
ECUA	25	51	51	32	**57**	0	0	0	52	1	6
EGPT	26	63	19	**63**	0	49	0	0	58	0	4
LSAL	25	60	40	38	24	0	0	0	**61**	1	0
FIN	11	16	14	2	8	13	0	**46**	30	7	14
FRA	53	77	35	**82**	68	51	46	50	43	36	59
GER	60	**92**	70	91	54	49	78	72	70	20	32
GANA	22	53	37	49	**53**	0	0	0	48	14	0
GRCE	52	**75**	46	40	0	0	65	0	65	11	0
HOND	30	**64**	44	45	52	0	0	0	62	5	0
HOKO	34	12	15	16	10	**39**	8	2	0	2	9
ICE	31	52	16	2	0	0	**67**	0	49	0	4
INDA	3	36	**75**	28	41	0	19	0	44	8	6
INDO	15	38	33	39	**68**	0	5	2	32	8	37
IRE	23	41	32	4	0	0	44	0	**46**	6	12
ISRL	2	33	**36**	13	0	7	12	0	29	4	10
ITLY	48	69	21	**72**	6	39	64	70	9	48	64
JAMC	11	56	41	17	13	0	0	0	31	**65**	0
JAP	63	67	4	**76**	42	56	54	46	34	29	53
KORA	63	43	14	43	22	54	32	12	33	6	20
LIBR	11	**64**	16	47	57	0	0	0	41	60	0
LIBY	16	**63**	18	37	0	20	0	0	56	0	0
MALY	7	**48**	33	25	24	0	0	0	38	29	0
MLTA	15	12	3	10	3	**17**	6	0	0	0	0
MAUR	12	**42**	5	32	10	0	0	0	41	1	0
MEX	35	74	74	50	32	26	0	0	72	29	27
NETH	5	9	**26**	2	0	5	12	0	15	18	25
NUZE	49	**68**	18	3	0	0	67	0	64	1	0
NIGR	45	83	31	**88**	61	0	0	0	70	5	10
NOR	34	**64**	32	3	0	0	40	42	57	11	0
PANM	31	**62**	47	32	58	0	0	0	54	2	0
PGRY	48	55	31	49	16	0	52	0	**56**	9	14
PERU	39	**82**	58	55	54	25	0	0	59	63	39
PLIP	64	**81**	47	63	46	0	0	0	72	15	0
PORT	7	42	**60**	36	0	6	33	0	52	2	13
SRIL	16	39	**46**	26	23	0	1	0	39	0	0
SING	8	7	19	6	2	15	0	0	0	0	**30**
SPAN	6	31	57	25	0	3	11	0	36	3	23
SWE	4	1	2	1	20	5	3	**43**	9	6	22
SWIT	53	**84**	75	81	52	48	66	54	0	20	38
THAI	25	**84**	41	78	56	0	0	0	73	12	0
TURK	79	88	51	**90**	0	47	80	0	75	21	8
UK	68	92	64	**95**	56	56	76	70	62	17	37
US	7	9	**74**	56	46	5	35	58	54	17	27
YUG	33	68	63	48	0	0	34	58	**70**	10	8
WORLD	20	**54**	42	50	23	13	30	40	32	4	10

a. Largest value for each country is in boldface.

Table 7.2
Percentage resource change: 1958

Country	CAPITAL	LABOR 1	LABOR 2	LABOR 3	LAND 1	LAND 2	LAND 3	LAND 4	COAL	MINERALS	OIL
AFG	−100	8	−100	−13	0	−49	0	0	6,928	120	∞
ARG	−100	53	−60	−100	0	−100	−74	0	68,666	476	194
AUSL	−100	115	−100	−100	−100	−100	−100	0	398	−58	0
AUST	42	−6	−65	3,817	∞	100	∞	−100	205	699	428
BLUX	160	−43	−90	16,843	∞	100	1,220	∞	−100	1,811	67,400
BRAZ	−100	47	−100	−100	−84	−100	−100	0	9,196	−64	115
BRMA	−100	15	5	−76	−51	0	0	0	∞	0	−100
CAN	−93	111	−100	−100	0	−100	−100	−96	2,213	−100	−100
CHLE	−21	54	−100	−100	−99	−16	0	0	426	−100	−100
CLUM	−100	60	−100	−100	−100	−100	0	0	1,536	−25	−100
CSTA	−100	162	−100	−100	−100	0	0	0	∞	−100	0
CYPR	−24	66	−100	−100	0	0	−100	0	∞	−100	0
DEN	−100	40	−100	−100	∞	0	−100	0	1,363	33,781	∞
DORE	−100	131	−100	−100	−100	0	0	0	∞	−100	0
ECUA	−100	75	−100	−100	−100	0	0	0	∞	615	−100
EGPT	−100	40	−80	−100	0	−100	0	0	∞	−24	−26
LASL	−100	132	−100	−100	−100	0	0	0	∞	196	0
FIN	−57	28	−100	−100	∞	∞	0	−100	42,312	165	∞
FRA	58	−37	74	13,351	∞	∞	227	∞	−100	280	6,488
GER	150	−88	251	38,163	∞	∞	2,716	10,017	−100	549	2,555
GANA	−100	84	−100	−100	−100	0	0	0	∞	−93	0
GRCE	−100	67	−77	−100	0	0	−100	0	2,226	−100	0
HOND	−100	81	−100	−100	−100	0	0	0	∞	−100	0
HOKO	508	−29	−100	419	∞	∞	3.500	∞	0	−100	∞
ICE	−100	196	−100	−100	0	0	−100	0	100	0	∞
INDA	5	4	−28	−5	−100	−2	−30	0	132	−41	999
INDO	−67	11	−32	−32	−100	0	100	∞	4,742	−54	−84
IRE	−100	53	−100	−100	0	0	−100	0	765	4,422	∞
ISRL	4	25	−100	−100	0	1,117	−100	0	∞	−100	1,656
ITLY	66	−29	23	1,008	∞	∞	428	4,436	−100	529	1,889
JAMC	−68	95	−100	−100	−100	0	0	0	∞	−96	0
JAP	101	−26	4	[illegible],956	∞	∞	587	1,567	−100	401	17,287
KORA	98	−10	6	65	∞	∞	149	65	−100	−100	∞
LIBR	−100	155	−100	−100	−100	0	0	0	∞	−100	0
LIBY	−100	187	−100	−100	0	−13	0	0	∞	0	0
MALY	−100	119	−100	−100	−100	0	0	0	555,560	−100	0
MLTA	104	12	−19	−100	∞	∞	−100	0	0	0	0
MAUR	−100	94	−100	−100	−100	0	0	0	∞	−100	0
MEX	−78	50	−100	−100	−100	−100	0	0	4,955	−100	−100
NETH	13	8	−100	−100	0	∞	−100	0	159	1,712	1,049
NUZE	−100	201	−100	−100	0	0	−100	0	2,258	1,331	−100
NIGR	−100	28	−88	−59	−100	0	0	0	7,299	−100	−100
NOR	−100	151	−100	−100	0	0	−100	−100	20,021	−100	0
PANM	−100	58	−100	−100	−100	0	0	0	∞	−100	0
PGRY	−100	25	−29	−100	08	0	−8	0	∞	100	∞
PERU	−100	104	−100	−100	−100	−100	0	0	9,124	−100	−100
PLIP	−100	37	−37	−100	−100	0	0	0	33,148	−100	0
PORT	−29	35	−100	−100	0	8,333	−94	0	2,179	26	∞
SRIL	−100	35	−100	−100	−100	0	∞	0	∞	−100	0
SING	405	11	−100	−100	−100	∞	0	0	0	0	∞
SPAN	−5	9	−41	−100	0	−100	−11	0	121	10	∞
SWE	−10	1	14	−100	∞	∞	100	−100	4,091	−42	∞
SWIT	122	−95	382	47,382	∞	∞	7,405	∞	0	46,454	∞
THAI	−100	59	−27	−100	−100	0	0	0	34,432	−100	0
TURK	−89	39	−41	−63	0	−100	−70	0	414	−100	−100
UK	258	−100	288	50,078	∞	∞	2,232	∞	−100	2,025	177,781
US	4	−22	177	7,804	124,563	103	221	827	−100	106	42
YUG	−19	17	−56	−100	0	0	−100	−100	146	−9	−100

Table 7.3
Percentage trade reduction: 1975[a]

Country	CAPITAL	LABOR 1	LABOR 2	LABOR 3	LAND 1	LAND 2	LAND 3	LAND 4	COAL	MINERALS	OIL
AFG	44	39	47	15	0	**55**	0	0	15	10	34
ARG	29	51	46	45	0	34	**86**	0	11	21	43
AUSL	56	48	64	23	23	34	**66**	0	45	62	33
AUST	8	3	14	1	13	2	0	19	22	30	**34**
BLUX	47	43	35	2	27	11	29	15	35	40	**60**
BRAZ	34	45	33	33	**62**	6	44	0	4	12	5
BRMA	70	**71**	69	**44**	57	0	0	0	3	12	57
CAN	70	53	65	19	0	5	18	**87**	19	50	48
CHLE	45	30	36	10	2	14	0	0	22	**91**	10
CLUM	54	13	7	3	**62**	6	0	0	18	1	35
CSTA	**37**	20	10	9	27	0	0	0	11	1	0
CYPR	27	**33**	11	31	0	0	20	0	0	22	19
DEN	6	**22**	20	13	0	0	18	0	2	7	20
DORE	**42**	27	19	14	41	0	0	0	1	12	0
ECUA	**57**	16	13	2	52	0	0	0	16	1	39
EGPT	**46**	13	7	6	7	7	0	0	4	4	2
LSAL	**44**	21	16	9	30	0	0	0	13	1	0
FIN	24	32	25	15	0	0	0	**41**	3	8	0
FRA	**90**	21	29	9	3	0	17	47	16	26	78
GER	**91**	41	32	1	29	24	52	68	8	13	65
GANA	31	18	12	7	**45**	0	0	0	5	9	0
GRCE	**44**	36	20	22	0	0	34	0	8	7	3
HOND	**46**	32	25	12	36	0	0	0	0	20	0
HOKO	4	12	28	11	19	23	13	13	29	**30**	23
ICE	40	28	40	8	0	0	**53**	0	0	0	0
INDA	13	22	35	17	14	0	2	0	1	14	**52**
INDO	76	3	12	18	4	2	0	0	9	3	76
IRE	17	19	22	0	0	0	**32**	0	1	2	5
ISRL	29	**39**	16	32	0	2	9	0	0	1	23
ITLY	78	43	55	2	15	26	41	52	26	27	**82**
JAMC	20	**41**	36	31	6	0	0	0	0	23	19
JAP	**98**	49	50	2	26	19	47	62	26	31	85
KORA	2	16	35	7	15	9	0	7	13	8	**41**
LIBR	44	33	41	11	14	2	0	0	0	**92**	0
LIBY	66	1	10	4	7	9	1	0	7	0	**73**
MALY	**68**	44	46	15	23	0	0	0	0	29	0
MLTA	35	41	16	**43**	12	14	4	0	0	0	9
MAUR	**24**	8	0	2	10	0	0	0	15	0	0
MEX	**69**	35	31	8	35	28	0	0	6	11	35
NETH	4	23	**34**	0	6	0	6	0	0	6	17
NUZE	46	43	49	19	0	0	**64**	0	5	1	7
NIGR	**76**	8	16	13	2	2	0	0	8	1	76
NOR	**74**	53	59	21	0	0	34	40	5	17	37
PANM	**56**	55	41	34	37	0	0	0	0	4	0
PGRY	64	57	58	22	25	0	**65**	0	0	4	0
PERU	53	42	52	20	37	16	0	0	9	**84**	37
PLIP	43	**45**	35	27	28	0	0	0	2	25	0
PORT	18	7	13	1	16	19	6	0	6	6	**33**
SRIL	2	13	25	11	17	2	7	6	12	2	**30**
SING	**69**	45	53	47	1	0	0	0	0	0	0
SPAN	17	5	20	14	0	1	5	0	17	22	58
SWE	**51**	2	1	4	10	10	12	17	0	4	42
SWIT	**77**	11	10	9	31	21	46	53	0	11	**58**
THAI	42	**42**	32	28	39	0	0	0	1	8	1
TURK	55	55	39	37	0	17	**59**	0	10	6	13
UK	**87**	19	31	14	28	24	46	60	2	15	81
US	**68**	11	13	29	1	9	6	30	14	0	42
YUG	**49**	48	29	33	0	0	20	36	9	1	3
WORLD	**69**	13	13	3	5	3	14	28	3	4	43

a. Largest value for each country in boldface.

Table 7.4
Percentage resource change: 1975

Country	CAPITAL	LABOR 1	LABOR 2	LABOR 3	LAND 1	LAND 2	LAND 3	LAND 4	COAL	MINERALS	OIL
AFG	135	−3	32	2	0	−31	0	0	−100	−100	−22
ARG	20	−43	48	1,604	0	−100	−38	0	2,554	476	−79
AUSL	60	−100	339	59,769	−100	−100	−100	0	−100	−96	−100
AUST	−5	6	−34	−100	∞	∞	0	−100	1,244	782	381
BLUX	−60	155	−100	−100	∞	∞	1,481	∞	1,736	12,997	223,942
BRAZ	42	−46	42	232	−100	−100	−100	0	−100	−53	−68
BRMA	108	−5	3	28	−20	0	0	0	−100	−80	−100
CAN	77	−100	359	51,623	0	−100	−100	−100	−100	−100	−91
CHLE	81	−50	48	226	−10	283	0	0	−100	−57	−49
CLUM	94	−10	6	−19	−100	−100	0	0	283	38	−87
CSTA	149	−48	34	628	−100	0	0	0	∞	−100	0
CYPR	44	−58	22	1,191	0	0	−76	0	0	−100	∞
DEN	−9	−63	123	39,337	0	0	−100	0	∞	4,651	6,616
DORE	158	−46	18	86	−100	0	0	0	∞	−100	0
ECUA	211	−16	12	−16	−100	0	0	0	∞	−100	−67
EGPT	119	−8	−13	15	∞	46	0	0	∞	123	5
LSAL	165	−33	17	42	−100	0	0	0	∞	−100	0
FIN	33	−100	177	51,237	0	0	0	−100	∞	159	0
FRA	−51	27	−81	11,764	∞	0	128	∞	600	499	3,030
GER	−100	139	−100	−100	∞	∞	3,536	24,836	126	947	3,118
GANA	118	−23	29	26	−100	0	0	0	∞	−100	0
GRCE	72	−100	65	1,067	0	0	−100	0	−100	−64	∞
HOND	161	−50	52	81	−100	0	0	0	0	−69	0
HOKO	−35	120	−100	2,460	∞	∞	12,227	∞	∞	47,617	∞
ICE	121	−100	549	57,768	0	0	−100	0	0	0	0
INDA	−11	3	−6	−4	−58	−0	2	0	2	−42	326
INDO	45,176	−3	10	−96	−34	∞	0	0	13,996	−35	−100
IRE	51	−76	124	−100	0	0	−100	0	−100	−40	∞
ISRL	41	−74	97	4,586	0	−100	−100	0	0	11	182
ITLY	−91	107	−100	−100	∞	∞	856	13,633	42,278	1,488	2,466
JAMC	73	−100	150	2,445	−100	0	0	0	0	−80	∞
JAP	−97	145	−100	−100	∞	∞	2,653	14,886	3,114	2,515	36,656
KORA	−6	39	−49	−84	∞	∞	4	−100	147	314	∞
LIBR	370	−100	688	107	−100	∞	0	0	0	−66	0
LIBY	676	25	2,362	−100	∞	179	∞	0	∞	−100	−100
MALY	226	−100	143	247	−100	0	0	0	0	−73	0
MLTA	150	−100	88	13,469	∞	∞	−100	0	0	−100	∞
MAUR	219	−17	−100	15	−100	0	0	0	∞	−100	0
MEX	53	−18	17	52	−100	−100	0	0	−100	−21	−39
NETH	4	−56	183	−100	∞	0	−100	0	0	−100	1,737
NUZE	101	−100	361	68,631	0	0	−100	0	−100	−100	−100
NIGR	621	−19	106	−80	−40	∞	0	0	12,086	114	−100
NOR	65	−100	386	66,736	0	0	−100	−100	−100	−100	−100
PANM	153	−96	95	930	−100	0	0	0	0	−100	0
PGRY	113	−23	16	69	−8	0	−5	0	0	−7	0
PERU	142	−32	55	127	−75	−100	0	0	−100	−63	−100
PLIP	90	−29	20	345	−100	0	0	0	−100	−89	0
PORT	31	−19	−32	22	∞	67,956	28	0	1,764	194	∞
SRIL	11	12	−16	−74	−100	∞	∞	∞	∞	−100	∞
SING	236	−100	539	5,827	−100	0	0	0	0	0	0
SPAN	−12	−10	−39	1,014	0	−100	−18	0	509	267	3,272
SWE	−58	6	−10	12,720	∞	∞	∞	−100	−100	33	∞
SWIT	−72	31	−57	26,757	∞	∞	8,166	∞	0	9,220	∞
THAI	93	−64	16	205	−100	0	0	0	−100	−80	−100
TURK	77	−57	47	128	0	−100	−100	0	−100	−92	−100
UK	−90	26	−78	17,390	∞	∞	823	∞	10	793	1,148
US	−36	−11	28	45,864	−100	−100	−45	645	−57	1	51
YUG	87	−37	35	668	0	0	−100	−100	−60	−7	−32

now quite clear that U.S. comparative advantage derives from the knowledge possessed by its workers or its firms .... As for the role of capital, it seems to have shifted over time to become positively related to U.S. net exports in recent years." Our findings are partly in agreement and partly to the contrary: Abundance of human capital was important in 1958 but not very important in 1975. Capital was actually scarce in 1958, though unimportantly so. In 1975 capital abundance was the primary determinant of U.S. trade.

The percentage trade reductions in tables 7.1 and 7.3 seem rather large. If, in 1958, Canada were to lose 96% of LAND 4, then its trade would be reduced by 97%. If, in 1975, Japan were to lose 97% of CAPITAL, then its trade would be reduced by 98%. These numbers do seem rather ridiculous, but there are two possible explanations for their magnitudes. (a) What is being reduced is not the ratio of trade to GNP but total trade. A reduction of the Japanese capital stock by 97% would lower GNP considerably and doubtlessly would have a dramatic effect on total trade. (b) The model can only be assumed to hold for variations of resources within the given "cone of diversification." Many of the resource changes that are considered would certainly move the country into another cone and alter the relation between trade and resources. In light of this observation it is probably best to focus on the ranking of resources rather than the predicted absolute trade changes.

The last rows of tables 7.1 and 7.3 indicate the reduction in trade in the world overall induced by optimally selected changes in the resources, where it needs to be repeated that it is assumed that these adjustments leave product prices unchanged. In 1958 the most important determinant of trade overall was LABOR 1, followed by LABOR 3, LABOR 2, and LAND 4. In 1975 CAPITAL was most important by a wide margin, with OIL and LAND 4 placing second and third. It is a rather interesting finding that the uneven distribution of highly skilled workers in particular and workers in general were the primary causes of trade in 1958; but keep in mind that LAND 4 was also quite important.

It is not surprising to find OIL having an increased impact in 1975, but it is surprising that CAPITAL was by far the most important variable, since this was a period in which the world's financial markets were more integrated than before. There is an interesting explanation for this that derives from a consideration of equation (7.2). The importance of a resource is found by taking the inner product of the coefficient vector and

Table 7.5
Estimated capital coefficients and U.S. net exports

	1958		1975	
	Coefficient	U.S. trade	Coefficient	U.S. trade
PETRO	−4.8	−1,098	−20.4	−23,858
MAT	−3.3	−437	−8.8	499
FOR	2.8	−946	−1.3	−11
TROP	6.9	−2,220	−2.7	−4,987
ANL	6.4	−606	.04	−1,625
CER	20.8	2,484	−4.3	18,096
LAB	−.9	377	1.0	−6,188
CAP	−6.5	849	16.5	−1,636
MACH	−8.5	5,544	29.1	23,929
CHEM	1.1	1,230	3.8	4,985

the trade vector. The estimated CAPITAL coefficient vectors and the U.S. net export vectors are reported in table 7.5. There have been substantial changes in the signs and relative magnitudes of these coefficients. The changes that are most important for these calculations occur for those commodities with large trade values: PETRO, TROP, CER, and MACH for the United States. To make it simple, suppose a country imported \$$x$ of PETRO, exported an equivalent amount of MACH, and otherwise did not trade. The inner product of the trade vector and the net export vector would then be $(4.8–8.1)x = -3.3x$ in 1958 and $(20.4 + 29.1)x = 49.5x$ in 1975. It would be inferred that this country was capital scarce in 1958 but capital abundant in 1975. The importation of PETRO makes the country appear capital abundant in both years, but in 1958 this is offset by the exportation of MACH, which is estimated to be associated with capital scarce countries. Thus the change in the sign of the MACH coefficient and the increased size of the PETRO coefficient both contribute to the conclusion that the scarcity of CAPITAL reversed itself.

The increased importance of CAPITAL as a source of trade is due partly to the increased negative CAPITAL coefficient on PETRO and the shift in sign of the coefficients of CHEM and MACH. It is also due partly to the change in the composition of trade. The big change that occurred in the trade of the United States and many other countries was a substantial increase in the relative importance of petroleum imports. These coefficient changes and the trade changes together have increased CAPITAL as a cause of trade especially for the petroleum importers.

But this is entirely sensible: CAPITAL abundance creates a demand for petroleum to fuel manufacturing facilities and a consequent need to earn export receipts from manufactured products. Reduction in CAPITAL in any given country could indeed be expected to reduce greatly petroleum imports as well as manufactured good exports.

Some of the other factor scarcities suggested by these calculations seem surprising. If the sign of a change in resource in tables 7.2 and 7.4 is positive, the country is revealed to be scarce in the resource, since trade would be reduced if more were available. In that sense the United States in 1958 was revealed to be scarce in CAPITAL, LABOR 2, LABOR 3, LAND 1, LAND 2, LAND 3, LAND 4, MINERALS, and OIL and abundant in LABOR 1 and COAL. In 1975 several of these changed. CAPITAL, LAND 1, LAND 2, and LAND 3 were abundant. These findings do not conform well with the abundant resources illustrated in the resource abundance profiles, where the United States is abundant only in CAPITAL and OIL in 1958, and only in COAL and OIL in 1975. But keep in mind that the physical definition of abundance is not linked directly to the trade-reducing definition used here, and also keep in mind that the United States is difficult to classify because of its unusual combination of exports of CER and MACH. For example, LAND 1 may appear abundant in 1975 because some countries use LAND 1 to produce rice, which is classified in CER. Because LAND 1 contributes positively to CER and because the United States has great exports of CER, there is a tendency to infer that the United States is abundant in LAND 1. This is best thought to be an error of aggregation—it would have been better to separate rice from CER. However, when one considers both the conceptual differences in these abundance definitions and also the measurement differences, the degree of conformity of results is remarkably high for most countries.

For ease of study, the most important resource for each country for each year is listed in tables 7.6a and 7.6b, together with the sign of the change needed to reduce trade. Thus a minus sign means that the country is abundant in the resource, and a plus sign indicates scarcity. This table also includes the abundance ratio (endowment share divided by GNP share) of each of the most influential resources. If this number exceeds one, the country is abundant in the resource and we may expect that the change in the endowment needed to reduce trade would be negative. For example, Afghanistan in 1958 is very abundant in LABOR 3, with an

Table 7.6a
Most important resources: 1958[a]

	Resource	Resource change	Abundance ratio	Trade change
AFG	LABOR 3	−13	6.6	75
ARG	LAND 3	−74	12.0	90
AUSL	LAND 3	−100	10.0	90
AUST	OIL	+428	1.0	38
BLUX	LABOR 3	+16,843	.0	50
BRAZ	LAND 1	−84	23.8	88
BRMA	LABOR 3	−76	11.8	58
CAN	LAND 4	−96	20.4	97
CHLE	MINERALS	−100	13.3	86
CLUM	LAND 1	−100	16.8	71
CSTA	COAL	+∞	0	54
CYPR	MINERALS	−100	15.4	61
DEN	COAL	+1,363	.4	25
DORE	LABOR 1	+131	1.1*	58
ECUA	LAND 1	−100	11.9	57
EGPT	LABOR 3	−100	5.4	63
LSAL	COAL	+∞	0	61
FIN	LAND 4	−100	7.9	46
FRA	LABOR 3	+13,351	.0	82
GER	LABOR 1	−88	1.0	92
GANA	LAND 1	−100	11.6	53
GRCE	LABOR 1	+67	1.2*	75
HOND	LABOR 1	+81	1.7*	64
HOKO	LAND 2	+∞	0	39
ICE	LAND 3	−100	22.3	67
INDA	LABOR 2	−28	3.9	75
INDO	LAND 1	−100	10.3	68
IRE	COAL	+765	1.3*	46
ISRL	LABOR 2	−100	.7*	36
ITLY	LABOR 3	+1,008	.3	72

Table 7.6a (continued)

	Resource	Resource change	Abundance ratio	Trade change
JAMC	MINERALS	−96	28.8	65
JAP	LABOR 3	+5,956	.1	76
KORA	CAPITAL	+98	.7	63
LIBR	LABOR 1	+155	1.9*	64
LIBY	LABOR 1	+187	1.1*	63
MALY	LABOR 1	+119	1.5*	48
MLTA	LAND 2	+∞	0	17
MAUR	LABOR 1	+94	1.9*	42
MEX	LABOR 1	+50	1.1*	74
NETH	LABOR 2	−100	1.1	26
NUZE	LABOR 1	+201	.8	68
NIGR	LABOR 3	−59	19.1	88
NOR	LABOR 1	+151	.8	64
PANM	LABOR 1	+58	1.4*	62
PGRY	COAL	+∞	0	56
PERU	LABOR 1	+104	1.3*	82
PLIP	LABOR 1	+37	1.5*	81
PORT	LABOR 2	−100	2.4	60
SRIL	LABOR 2	−100	4.5	46
SING	OIL	+∞	0	30
SPAN	LABOR 2	−41	1.9	57
SWE	LAND 4	−100	3.4	43
SWIT	LABOR 1	−95	.9*	84
THAI	LABOR 1	+59	2.3*	84
TURK	LABOR 3	−63	3.6	90
UK	LABOR 3	+50,078	.0	95
US	LABOR 2	+177	.4	74
YUG	COAL	+146	1.8*	70
WORLD	LABOR 1			54

a. *indicates a discrepancy between the two measurements of resource abundance: the negative of the sign of the resource change and the abundance ratio minus one.

Table 7.6b
Most important resources: 1975[a]

	Resource	Resource change	Abundance ratio	Trade change
AFG	LAND 2	−31	100.2	55
ARG	LAND 3	−38	13.9	86
AUSL	LAND 3	−100	6.6	66
AUST	OIL	+381	.3	34
BLUX	OIL	200,000	.0	60
BRAZ	LAND 1	−100	16.9	62
BRMA	LABOR 1	−5	17.2	71
CAN	LAND 4	−100	20.5	87
CHLE	MINERALS	−57	16.5	91
CLUM	LAND 1	−100	17.9	62
CSTA	CAPITAL	+149	.8	38
CYPR	LABOR 1	−58	2.0	33
DEN	LABOR 1	−63	.8*	22
DORE	CAPITAL	+158	.5	42
ECUA	CAPITAL	+211	.7	57
EGPT	CAPITAL	+119	.6	46
LSAL	CAPITAL	+165	.6	44
FIN	LAND 4	−100	5.6	41
FRA	CAPITAL	−51	1.2	90
GER	CAPITAL	−100	1.1	91
GANA	LAND 1	−100	10.3	45
GRCE	CAPITAL	+72	.9	44
HOND	CAPITAL	+161	.9	46
HOKO	MINERALS	+47,617	.0	30
ICE	LAND 3	−100	15.3	53
INDA	OIL	+326	.4	52
INDO	CAPITAL	+45,176	.0	76
IRE	LAND 3	−100	4.0	32
ISRL	LABOR 1	−74	1.3	39
ITLY	OIL	+2,466	.2	82

Table 7.6b (continued)

	Resource	Resource change	Abundance ratio	Trade change
JAMC	LABOR 1	−100	1.2	41
JAP	CAPITAL	−97	1.3	98
KORA	OIL	+∞	0	41
LIBR	MINERALS	−66	100.7	92
LIBY	OIL	−100	20.1	73
MALY	CAPITAL	+226	.8	68
MLTA	LABOR 3	+13,469	.2	43
MAUR	CAPITAL	+219	.7	24
MEX	CAPITAL	+53	.7	69
NETH	LABOR 2	+183	.5	34
NUZE	LAND 3	−100	9.9	64
NIGR	CAPITAL	+621	.6	76
NOR	CAPITAL	+65	1.5*	74
PANM	CAPITAL	+153	.8	56
PGRY	LAND 3	−5	135.0	65
PERU	MINERALS	−63	21.6	84
PLIP	LABOR 1	−29	4.1	45
PORT	OIL	+∞	0	33
SRIL	OIL	+∞	0	30
SING	CAPITAL	+236	1.2*	69
SPAN	OIL	+3,272	.1	58
SWE	CAPITAL	−58	1.1	51
SWIT	CAPITAL	−72	1.2	77
THAI	LABOR 1	−64	1.9	42
TURK	LAND 3	−100	3.7	59
UK	CAPITAL	−90	.96*	87
US	CAPITAL	−36	.9*	68
YUG	CAPITAL	+87	.5	49
WORLD	CAPITAL			69

a. * indicates a discrepancy between the two measurements of resource abundance: the negative of the sign of the resource change and the abundance ratio minus one.

endowment share 6.6 times the GNP share. This conforms with the finding reported in tables 7.1 and 7.2 that an 18% reduction in LABOR 3 would reduce trade dependence by 75%. Conflicts in these two measures of factor abundance are indicated in table 7.6, with an asterisk following the abundance ratio. For example, the Dominican Republic in 1958 is measured to be slightly abundant in LABOR 1, with an abundance ratio of 1.1, but nonetheless trade is reduced if the LABOR 1 endowment were increased by 131%. There are only 22 such conflicts out of a total possible of 116. Fourteen of these conflicts involve LABOR 1: the Dominican Republic, Greece, Honduras, Liberia, Libya, Malaysia, Mauritius, Mexico, Panama, Peru, the Philippines, and Thailand in 1958 have abundance ratios in excess of one but need increases in LABOR 1 to reduce trade. Switzerland in 1958 and Denmark in 1975 have abundance ratios less than one, but require a reduction of LABOR 1 to reduce trade. It seems clear that the abundance ratio is misleading in all of these cases. This may be due partly to the extrapolation/interpolation/imputation schemes used to measure LABOR 1, and partly to the fact that the composition of LABOR 1 is likely different in the developing countries, with relatively many doctors, lawyers, and teachers, and relatively few scientists and engineers. Other problems may be mismeasurement of GNP or a "world" that excludes too many countries. Four of the other conflicts in table 7.6 involve CAPITAL in 1975. These conflicts generate a reaction similar to the LABOR 1 conflicts—it is the abundance ratio that is at fault. (Singapore is best thought to be capital scarce, the United States and the United Kingdom capital abundant.) Overall, the surprising conformity of the two measurements of factor abundance contributes considerably to the credibility of the method by which the most important trade-reducing resources are identified.

7.2 Tariffs and the Functional Distribution of Income

Tariffs and trade restrictions are most often used for purposes of income redistribution, yet there is hardly any quantitative information that indicates the size of the redistributional effects. The redistributional consequences of trade restrictions can be studied either with a long run model in which factors are costlessly mobile between industries or with a short run model in which some mobility may occur but not without cost. Examination of the political pressure for trade restrictions as in Brock and Magee (1978) suggests that the short run model is the more suitable, since workers and owners ordinarily lobby for protection only in their own industries. If the long run model were a completely accurate description of reality, the interest of a class of workers would focus on a set of industries regardless of the industry in which workers happened to be located. Whatever gains might accrue to workers in the protected industry would be partly, if not completely, competed away by workers moving to the affected industry. In such a world we would not expect often to see workers or owners organize to exert political pressure, since the gains would be relatively small and the organizational costs relatively large.

The model that has been used in this book is a long run model, and it can be used to study the long run distributional consequences of tariffs. In light of the preceding comments it is fair to ask who might be interested in these long run effects. An answer is that the political process is likely to be myopic and possibly poorly informed as well. Workers and owners may be unaware how quickly gains would be competed away through the mobility of factors, or they may be relatively unconcerned about future events because of high discount rates. The length of time it takes for the long run model adequately to approximate reality is not something I care to conjecture seriously about; nor do I believe there exists much information about it. If the answer were as short as 5 years, I believe the long run consequences of trade restrictions could and should have a more noticeable effect on the political processes. I therefore present some estimates of the long run consequences of tariffs with the hope that future quantitative analysis will reveal the practical relevance of these effects in the sense of demonstrating that the speeds of adjustment are rather more than the current political processes seem to assume.

The approach to estimating the tariff effects rests on the reciprocity between the Stolper-Samuelson effects and the Rybczynski effects,

$$\partial X_j/\partial V_i = \partial w_i/\partial p_j, \tag{7.4}$$

which asserts that the derivative of final output X_j with respect to the total supply of the ith primary factor is equal to the derivative of the return to that factor with respect to the price of that good. Direct econometric estimation of the Stolper-Samuelson effects, $\partial w_i/\partial p_j$, could proceed by regressing a time series sample of factor rewards (or internal prices) for a particular country on time series of external product prices, as in Chipman (1977/1978). This approach is rendered difficult by the high degree of collinearity among the many product prices and the consequent need to use prior information about the coefficients. The approach is also questionable because the relation between factor prices and product prices will change with the technology, which is not credibly assumed constant for long periods of time.

The indirect econometric estimates of the Stolper-Samuelson effects that are reported in this section begin with cross-section estimates of the effects of factor endowments on net exports, $\partial T_j/\partial V_i$. In the trade model with equal numbers of factors and goods, this derivative is equal to

$$\partial T_j/\partial V_i = \partial X_j/\partial V_i - (X_{j\mathrm{w}}/Y_{\mathrm{w}})(\partial Y/\partial V_i),$$

where X_j is output, Y is GNP, and the w subscript indicates the world totals. The net export data we are using are expressed in value terms, and we may multiply this expression by p_j and rearrange to obtain

$$\begin{aligned} p_j \partial X_j/\partial V_i &= p_j(\partial T_j/\partial V_i) + (p_j X_{j\mathrm{w}}/Y_{\mathrm{w}})(\partial Y/\partial V_i) \\ &= \beta_{ji} + \gamma_j w_i, \end{aligned} \tag{7.5}$$

where β_{ji} is the coefficient of resource i in the net export equation for commodity j, γ_j is the share in final consumption of commodity j, and w_i is the wage rate of factor i. Then by appealing to the Samuelson reciprocity relations (7.4), we have the elasticity of factor earnings with respect to product prices:

$$(\partial w_i/w_i)/(\partial p_j/p_j) = p_j(\partial X_j/\partial V_i)/w_i = \beta_{ji}/w_i + \gamma_j. \tag{7.6}$$

The trade regressions are the source of estimates of the trade derivatives β_{ji}, and the GNP regressions may be used to obtain estimates of the factor returns w_i. The final product consumption shares are derived from BEA estimates as described subsequently.

Before proceeding with discussion of the actual estimates, it is wise to pause a bit to reflect on the believability of the approach. The reciprocity relations are reasonably insensitive to the form of the model. As Chang (1979) demonstrates, they apply in uneven models as well as even ones. It does seem entirely sensible to suppose that those industries that would increase exports most in response to the accumulation of a particular resource are the very same industries for which protection would be most beneficial to that resource. But equation (7.5), which purges the consumption effect from the trade effect to obtain the output effect, is specific to the even model, as is the assumption used in most of the previous chapters that $\partial T_j/\partial V_i$ is a constant independent of factor supplies V. For these reasons, the estimates that are now to be presented should be thought to have very large standard errors, partly because of estimation uncertainty in the computation of β_{ji}, γ_j, and w_i, but, more important, because of conceptual uncertainty attaching to formula (7.6). This is perhaps expressed most clearly by pointing out that formula (7.6) is used as if it applied to all countries, which means, for example, that a 10% tariff on steel imports in India is estimated to have the same impact on wages as a 10% tariff on steel imports in the United States.

In addition to these conceptual concerns, the numbers implied by equation (7.6) turn out to be disconcertingly dependent on the consumption shares, since the estimates of the trade sensitivities β_{ji} are often very small compared to estimates of the factor returns w_i (taken from the cross-section GNP regressions). This can be corrected mechanically by either reducing the consumption shares or the factor returns or increasing the trade sensitivities. I have unfortunately been unable to find a theoretical justification for doing any of these.

My first instinct was to reduce the consumption shares to adjust for the fact that part of income is spent on nontraded goods and services. It is somewhat surprising that this adjustment is groundless in theory. As is explained in chapter 1, if factor prices are equalized, the model with nontraded goods can be written, as always, as $T = A^{-1}(V - sV_w)$, where V and V_w refer to total supplies of factors, not just supplies to the traded goods sector. The relation between prices and wages is as before $w = A'^{-1}p$, and it is desired to recover A'^{-1} from the trade regressions. It is true that output of the traded goods is less sensitive to factor accumulation because part of the factors is used in the nontraded goods sector, and it is also true as a consequence that the reciprocity between the Stolper-Samuelson effects and the Rybczynski effects no longer holds unless the Rybczynski derivatives are taken with respect to factors allocated to the traded goods sector. Nonetheless, the trade equations remain exactly as before because the reduced sensitivity of production is offset by reduced sensitivity of consumption. There is one minor adjustment to (7.6) necessitated by the existence of nontraded goods. The consumption vector $A^{-1}V_w$ is the vector of world outputs of traded goods if all resources were devoted to the production of traded goods. The consumption shares in table 7.6 would therefore have to be adjusted for the hypothetical

output changes associated with reallocating all resources from nontraded goods to traded goods. These shares would still add to one; thus whatever adjustment might be made, the shares would still dominate formula (7.6).

There is another model discussed in chapter 1 that may also account for the fact that trade seems too insensitive to factor supplies compared with the sensitivity of GNP. The model to which I refer has trade impediments in the form of transportation costs, tariffs, or other ad valorem charges, and what I expect is that these costs that discourage trade would have a relatively large effect on the sensitivity of trade to factor supply changes. In particular, if log-linear production functions and log-linear utility functions are assumed, then the model is summarized by equations (1.6) and (1.8), which are repeated here:

$$\Theta' \ln(w) = \ln(p) + \ln(X_0), \tag{7.7}$$

$$PT = \Theta^{-1}WV - \gamma 1'P^{-1}\Theta^{-1}WV/1'P^{-1}\gamma, \tag{7.8}$$

where commodity units are assumed so that international prices are all equal to one, and p = vector of internal prices (exceeding one), $P = \text{diag}\{p\}$, w = vector of internal factor prices, $W = \text{diag}\{w\}$, Θ = matrix of fixed input value shares with column sums equal to one ($1'\Theta = 1'$), $\ln(z)$ = vector with elements $\ln(z_i)$, X_0 = vector of constants, γ = vector of fixed consumption shares, summing to one ($1'\gamma = 1$), T = vector of net exports, and V = vector of factor endowments. What we wish to do is to recover Θ'^{-1}, the matrix of elasticities of factor returns with respect to product prices, from a cross-section regression of trade on endowments. Assume that the internal prices p and w are approximately the same in all countries, so that a regression of trade on factor endowments would yield estimates of the trade sensitivities:

$$\partial PT/\partial V = \Theta^{-1}W - \gamma 1'P^{-1}\Theta^{-1}W/1'P^{-1}\gamma.$$

We may symbolize the matrix of derivatives $\partial PT/\partial V$ by B (thinking of regression coefficients) and rewrite (7.8) as

$$\Theta^{-1} = BW^{-1} + \gamma 1'P^{-1}\Theta^{-1}/1'P^{-1}\gamma, \tag{7.9}$$

which is a generalization (7.6). If there are no trade impediments and internal prices are all equal to one, then P is the identity matrix, and $1'P^{-1}\Theta^{-1}/1'P^{-1}\gamma = 1'$, since $1'\Theta = 1'$ implies $1' = 1'\Theta^{-1}$ and $1'\gamma = 1$. In this case (7.9) and (7.6) are identical expressions. Otherwise, the adjustment necessary for trade impediments involves substitution of the vector $1'P^{-1}\Theta^{-1}/1'P^{-1}\gamma$ for the vector $1'$. This would tend to correct the problem caused by the fact that the shares γ are generally an order of magnitude larger than trade estimates BW^{-1} if the vector $1'P^{-1}\Theta^{-1}/1'P^{-1}\gamma$ were less than the vector of ones. There is no reason for this to be the case. A typical element in this vector is the ratio of a weighted average of the elements of a column of Θ^{-1} divided by a weighted average of the elements in γ. Both simple averages are equal to one, and it is unclear whether the weights will make the numerator or the denominator larger.

It should be clear from the preceding discussion that I have been unable to find a logic for altering the elasticity formula, but nonetheless I remain uncomfortable with the implied elasticities, since they seem unduly influenced by the consumption shares γ_j in the several cases when the estimated wage rates are much higher than the estimated trade coefficients. Estimates of the trade derivatives β_{ji} are taken from the table of Bayes estimates, table 6.5. In order to get positive factor productivities for all resources, the prior for GNP was concentrated around the prior means. The estimated factor rewards that result are basically the prior means except for the returns to CAPITAL and LABOR 2. Consumption shares were formed from final consumption estimates[1] of the United States in the 1967 input-output table, using a concordance between the SITC categories and the SIC categories.

The wages, consumption shares, and the estimated elasticities are reported in table 7.7. The predominance of positive numbers in this table is a result of the influence of the consumption shares. For example, the CAPITAL column in 1958 is virtually identical to the consumption shares because the estimated derivatives of trade with respect to changes in CAPITAL are much smaller than the estimated derivatives of GNP. Because of the influence of the consumption shares, it is best to restrict comparisons to numbers in the same row of this table. It is particularly interesting to identify the factors that are estimated to have prices most sensitive to the price of each commodity. These are listed in table 7.8. Not surprisingly, if a petroleum tariff is imposed, OIL is the factor with the greatest percentage increase in factor price. The other results seem similarly sensible, and it is interesting to observe the changing effect of prices of manufactures on the labor categories in light of our earlier discussion of the reduced role of knowledge capital in trade in manufactures. In 1958 the estimated elasticities of the returns to the three labor

Table 7.7
Estimated elasticities of factor rewards with respect to changes in product prices

	Consumption share	CAP	LABOR 1	LABOR 2	LABOR 3	LAND 1	LAND 2	LAND 3	LAND 4	COAL	MINERALS	OIL
1958												
PETRO	.02	0.02	0.00	0.03	0.04	−0.02	−0.00	0.00	0.01	−0.04	0.01	0.45
MAT	.04	0.04	−0.04	0.11	0.09	0.07	0.03	0.04	0.11	0.11	0.86	0.52
FOR	.01	0.02	−0.03	0.06	0.04	−0.01	−0.04	−0.01	0.14	−0.13	−0.02	−0.04
TROP	.09	0.10	−0.05	0.26	0.16	0.50	0.21	0.07	0.06	−0.12	0.05	0.11
ANL	.13	0.14	0.04	0.20	0.17	0.09	0.23	0.20	0.15	−0.03	0.08	0.10
CER	.09	0.12	−0.09	0.08	0.21	0.18	0.38	0.20	0.12	−0.13	0.06	0.14
LAB	.15	0.14	0.18	0.18	0.11	0.10	0.08	0.13	0.09	0.17	0.09	0.04
CAP	.05	0.04	0.15	0.12	−0.04	−0.05	−0.01	−0.00	−0.02	0.09	−0.01	−0.06
MACH	.36	0.35	0.63	0.12	0.20	0.23	0.28	0.23	0.21	0.71	0.27	0.26
CHEM	.04	0.05	0.07	−0.03	0.04	0.01	−0.04	0.03	0.03	0.22	−0.03	−0.02
Wage		754.0	5,875.0	128.0	127.0	2.9	1.6	33.0	15.1	1.0	1.0	1.0
1975												
PETRO	.02	−0.02	−0.02	0.06	0.07	−0.02	−0.02	−0.00	0.02	−0.05	−0.02	0.40
MAT	.04	0.03	0.07	−0.17	0.05	0.03	−0.01	0.03	0.07	0.44	1.14	0.08
FOR	.01	0.01	0.01	−0.05	0.04	−0.01	−0.03	0.01	0.14	−0.02	−0.01	0.08
TROP	.09	0.08	0.06	0.17	0.11	0.39	0.19	0.15	0.06	−0.02	0.07	0.13
ANL	.13	0.13	0.10	0.06	0.17	0.09	0.26	0.20	0.13	0.08	0.09	0.16
CER	.09	0.08	0.18	−0.26	0.05	0.33	0.28	0.28	0.12	0.12	0.09	0.33
LAB	.15	0.15	0.08	0.43	0.16	0.09	0.10	0.13	0.10	0.08	0.09	0.10
CAP	.05	0.08	−0.13	0.50	0.14	−0.03	−0.00	−0.05	−0.00	−0.03	−0.02	−0.12
MACH	.36	0.41	0.25	0.64	0.38	0.29	0.30	0.24	0.21	0.31	0.28	0.19
CHEM	.04	0.05	0.09	−0.15	0.03	−0.04	0.00	−0.03	0.01	0.07	−0.01	−0.00
Wage		533.0	11,034.0	279.0	402.0	9.6	5.2	99.9	49.0	1.0	1.0	1.0

Table 7.8
Most sensitive factor returns

Protected commodity	Most sensitive factor return
PETRO	OIL
MAT	MINERALS
FOR	LAND 4
TROP	LAND 1
ANL	LAND 2
CER	LAND 2 (1958), LAND 1 (1975)
LAB	LABOR 2
CAP	LABOR 1 (1958), LABOR 2 (1975)
MACH	LABOR 1 (1958), LABOR 2 (1975)
CHEM	LABOR 1

categories with respect to the change in the price of CAP where .15, .12, and −.04. Thus it was slightly in the interest of both LABOR 1 and LABOR 2 to have tariff protection for CAP, but the return to LABOR 3 would have been slightly reduced by such a policy. In 1975 the elasticities changed sharply to −.13, .50, and .14. The return to LABOR 1 would have been reduced by protection of CAP, and the return to LABOR 2 would have been greatly increased. A similar change occurred for MACH, though the estimated elasticity of LABOR 1 with respect to MACH in 1975 remained positive. Although great uncertainty attaches to the elasticities in table 7.7, it is quite interesting that the period 1958–1975 witnessed a sharp change in the expressed desire for protection by labor unions such as the United Automobile Workers. In 1958 these unions were decidely on the side of free trade, but by 1975 and thereafter were activity seeking trade protection. This is quite consistent with the numbers presented in table 7.7.