Input-Output multiplier study of the UK and Scottish Fish Catching and Fish Processing sectors

Final Report

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The Fraser of Allander Institute
for Research on the Scottish Economy,
University of Strathclyde
100 Cathedral Street
Glasgow G4 OLN
Scotland, UK
Tel: 0141-548 3958
Email: fraser@strath.ac.uk
Website: www.fraser.strath.ac.uk

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Executive Summary

[1] In this report we use Input-Output analysis to identify the impact on the Scottish and UK economies of changes in the Sea Fishing and Fish Processing industries. The analysis relies on officially produced I-O Tables for the year 1998 for Scotland and the UK. However, we have extensively revised, augmented and disaggregated these Tables using more detailed information from the Sea Fishing and Fish Processing sectors.

[2] The basic building blocks for this approach are the multiplier values for individual industrial sectors. The output multiplier shows the change in the output of the economy as a whole resulting from a change in the output of a particular sector. This multiplier always takes a value greater than one. This is because the *direct* increase in output in one sector stimulates *indirect* changes in activity in other sectors that supply intermediate inputs to the first sector. Further, the increased employment and household income generates *induced* changes in demand for, and subsequent production of, consumption goods. Taking all these effects into account gives the following output multiplier results.

Scottish and UK output multipliers+

	Scottish		UK	
	Value	**Rank***	**Value**	**Rank***
Demersal	2.23	17	3.42	53
Shellfish	1.90	62	3.54	29
Pelagic	2.12	32	3.53	32
Sea Fishing	**2.13**	**28**	**3.47**	**42**
Fish Processing	**1.98**	**46**	**2.52**	**122**

+ The reported values are for Type II multipliers, that is they incorporate both indirect and induced effects.

* All the I-O sectors have been ranked by the size of their multiplier values. There are 127 other sectors in Scotland and 124 in the UK

[3] These results mean, for example, that an increase in the demand for Demersal fish of £1 million in Scotland would generate an increase in Scottish output of £2.23 million and the same increase in demand in the UK would generate an increase in UK output of £3.42 million. In general we expect the multiplier values that apply to smaller, more open, economies to be lower because more of the expenditure in each round of the multiplier process is lost to imports. Note that the multiplier values for Sea Fishing in general are relatively high. They are all in the top 50% of sectors ranked by multiplier value.

[4] Often for either practical or policy reasons, the total employment impact of changes in activity are of primary concern. The table below gives the total Scottish and UK employment (FTEs) generated by a £1 million increase in demand for the Sea Fishing and Fish Processing sectors. These are separated into the direct effects, which apply to the initially stimulated sector, and the indirect and induced effects (labelled indirect in the tables), which primarily apply to other sectors. The table also shows the employment multipliers, which measure the change in total employment in the economy as a whole resulting from a change in the employment in the initially stimulated sector.

Scottish and UK employment multipliers

	Scottish			UK		
	Employment Effect* (FTEs)		Employment Multiplier+	Employment Effect* (FTEs)		Employment. Multiplier+
	Direct	Indirect		Direct	Indirect	
Demersal	14.2	15.63	2.10	16.4	29.9	2.82
Shellfish	45.0	11.14	1.25	55.5	31.8	1.57
Pelagic	4.0	14.28	4.56	4.0	31.1	8.82
Sea Fishing	**17.9**	**14.34**	**1.80**	**24.7**	**30.6**	**2.24**
Fish Processing	**12.8**	**14.05**	**2.10**	**8.7**	**21.7**	**3.51**

+ Type II multipliers

* Effect per £1m increase in final demand

[5] These results should be interpreted as follows. An increase in the UK demand of £1 million for Shellfish, for example, would generate 55.53 direct full-time equivalent jobs (FTEs) in that sector and an additional 31.75 FTEs primarily in other sectors. The employment multiplier for Shellfish is calculated as the total employment change, 87.28, (= 55.53 + 31.75) divided by the direct employment change in the Shellfish sector, 55.53, which gives the result 1.57.

[6] A relatively labour-intensive sector will have a high direct employment impact per £1m additional demand. The indirect and induced employment effects are broadly proportional to the indirect and induced output effects discussed earlier. Note that the employment multipliers may differ quite markedly from the output multiplier. Also some sectors, for example Pelagic, with low employment effects per £1 million expenditure have high employment multipliers. These are sectors with a low labour intensity but a relatively high output multiplier.

[7] In calculating the impact of additional landings we have used the conventional multiplier approach but assumed additionally that there is a supply link between landings and Fish Processing. That is to say, we assume that a certain proportion of landed fish is processed. This produces the following results for a £1 million increase in landings:

Impact on the UK economy of £1m landings (domestic and non-domestic boats)+

	Scottish			UK		
	Employment Effect (FTEs)		Output (£ million)+	Employment Effect (FTEs)		Output (£ million)+
	At Sea	Onshore		At Sea	Onshore	
Demersal	12.3	32.2	3.37	14.0	46.6	4.92
Shellfish	38.9	28.3	3.08	54.7	52.3	5.49
Pelagic	3.5	31.0	3.27	3.3	46.7	4.90
Sea Fishing	**15.5**	**31.0**	**3.28**	**22.0**	**48.3**	**5.10**

+ Type II multipliers

[8] The impact of changes in Scottish and UK landings of fish can be quantified using the multiplier information given above.

Impact on the Scottish and UK economies of a 50% increase in landings+

	Employment (FTEs)			Output (£ million)
	At Sea	Onshore	Total	
Scottish Landings	2,532	5,074	7,606	536.38
UK Landings	5,974	13,125	19,099	1,384.43

+ Type II multiplier analysis

[9] Similar calculations can be made for the impact of increased use of imported fish by the Fish Processing sector. In these simulations there is no direct impact on Fish Processing output, but there is a big negative indirect effect on activity in Sea Fishing. The impacts in the UK are greater than in Scotland because both the initial size of the reduction in Sea Fishing is greater and the multiplier values are larger.

Impact on the Scottish and UK economies of a 25% increase in Fish Processing's imports of fish+

	Employment (FTEs)			Output (£ million)
	At Sea	Onshore	Total	
Scotland	-1,547	-1,237	-2,784	-183.79
UK	-6,964	-8,635	-15,599	-979.54

+ Type II multiplier analysis

[10] The most extreme simulations involve the total removal of the Sea Fish and Fish Processing sectors. This procedure models a situation where *all* the present domestic demand for the output of these sectors is replaced by imports. The results are given below. They suggest that in Scotland Sea Fishing supports over 12,000 FTEs,

7,166 directly employed in Sea Fishing and an additional 5,211 in other sectors. Sea Fishing and Fish Processing together support over 26,000 FTEs in Scotland and nearly 78,000 in the UK. This is associated with over £ 600 million and almost £2.3 billion value added (GDP) in Scotland and the UK respectively.

Impact on the UK and Scottish economy of removal of the Sea Fishing and Fish Processing sectors[+]

	Gross Output (£ million)	Employment (FTEs) Direct	Employment (FTEs) Indirect	Wage Income (£ million)	Value Added (£ million)
Scotland					
Sea Fishing	-824.86	-7,166	-5,211	-244.45	-379.21
Sea Fishing & Fish Processing	-1,885.54	-17,553	-8,557	-416.25	-634.27
UK					
Sea Fishing	-2,095.95	-16,328	-18,688	-604.31	-1,034.30
Sea Fishing & Fish Processing	-6,167.67	-35,350	-42,441	-1,391.55	-2,290.58

+ Type II multiplier analysis

Chapter 1: Outline of the report

[11] In this report, Input-Output (I-O) analysis is used to identify the impact on the Scottish and UK economies of the Sea Fishing and Fish Processing sectors. Standard demand-driven and supply-driven output, employment, income and value-added multipliers are derived for the Sea Fishing and Fish Processing Industries. The results for the Sea Fishing sector are broken down by different fish types. Whilst the analysis relies on officially produced I-O Tables for Scotland and the UK, these tables have been extensively revised, augmented and disaggregated, far more than had been envisaged at the start of the project.

[12] Chapter 2 is a theoretical overview of I-O analysis. Input-Output Tables attempt to capture the interaction of sales and purchases within the economy as intermediate transactions between firms and between firms and final users (consumers, government, exports etc.). By its nature, I-O analysis involves some technical difficulty but the discussion here is relatively mathematics-free and focuses primarily on how well I-O analysis captures economic behaviour.

[13] Chapter 3 outlines how the Scottish and UK I-O models used here have been constructed. Essentially this involves detailing how the tables have been customised to meet the needs of this study.

[14] Chapter 4 presents the results of various simulations undertaken with the tables whose construction is outlined in Chapter 3. A wide variety of multiplier values are calculated and discussed. These include not only standard demand- and supply-driven multipliers but also calculations used to assess the impact of landings which, whilst being primarily demand driven, incorporate supply linkages. The analysis is used in the conventional way to quantify the effect of changes in final demand for a commodity, but the effect of increased import penetration, complete closure of a sector and the price impacts of changes in efficiency are also calculated. Again, in this section we attempt to use intuitive arguments to explain the relative size of the different effects.

[15] Appendices 1, 2 and 3 contain technical information relating to Chapters 2, 3 and 4 respectively.

Chapter 2: The principles behind I-O analysis: multiplier effects

[16] In this report we make extensive use of multipliers drawn from the data incorporated in the Scottish and UK I-O tables. The conventional, demand-driven multiplier concepts are relatively straightforward to understand and these are given in section 2.1.

[17] However, care has to be taken in the precise interpretation of multiplier values, especially if one is comparing their values across different studies. Also in this particular study we report estimates of supply-driven multipliers and calculate hybrid multiplier values for fish landings that incorporate both demand- and supply-side linkages. Therefore sections 2.2 to 2.11 expand on these issues.

2.1 The multiplier concept

[18] An increase in the exogenous demand for the output of a particular sector in the economy, will generate knock on effects in other sectors. There will be an increase in the demand for intermediate inputs plus increased consumption demand as employment and household income rise. These further sources of expansion are known as the indirect (intermediate demand) and induced (consumption demand) effects.

[19] This first round increase in the demand will set in train similar second round increases in the demand for other sectors. A multiplier process is thereby set up, where the increase in output in each round gets smaller and smaller so that the total increase sums to a finite number.

[20] For an individual sector, the usual focus for multiplier analysis, the output multiplier is therefore the increase in total output of the economy that would be generated by a unit increase in the exogenous demand for that sector. Broadly, the output multiplier shows the increase in output for the economy as a whole that results from the increase in output of a particular sector.

[21] In the context of the present study if, for example, the output multiplier for Scottish Sea Fishing were 1.5, this would mean that an increase in export demand for Sea Fishing of £10 million would generate a change in total Scottish output of £15 million (10*1.5). This £15 million would include the initial £10 million export injection plus £5 million indirect and induced effects occurring primarily in other, non-Sea-Fishing, sectors of the economy,

[22] With any change in output, there will be associated changes in employment, income and value added. In the context of this study, employment is measured in full time equivalent (FTE) units, income is wage income and value added is that part of a sector's gross output that directly contributes to GDP, that is the payment to labour, land, capital and residual profits.

[23] There are two conventional multiplier measures that apply to these alternative indicators of economic activity. The first gives the total change in activity resulting from an increase in a sector’s exogenous demand by £1 million. These multipliers therefore calculate the total direct, indirect and induced employment, income or value added generated by a £1 million change in the demand for the output of a particular sector.

[24] A second type of multiplier calculates the increase in total activity as a ratio of the direct change in the activity associated with the initial demand shock. For example, in terms of employment this is the total increase in employment in the whole economy that is generated by an exogenous demand-induced unit increase in employment in a particular sector. Again, if the Sea Fishing employment multiplier were 2, this would mean that an increase in export demand for Sea Fishing that generates a direct employment increase in that sector of 50 FTEs would produce a total increase in employment in the whole economy of 100 (50*2). Of these 50 would be the direct employment increase in Sea Fishing and the further 50 would be the indirect and induced jobs primarily in other sectors.

[25] Therefore the employment multiplier shows the increase in employment for the economy as a whole that results from the increase in employment of a particular sector. Similarly, the income multiplier shows the increase in wage income for the economy as a whole that results from the increase in wage income of a particular sector (assuming wage rates are constant). Finally, the value added multiplier shows the increase in value added (GDP) for the economy as a whole that results from the increase in the value added of a particular sector.

2.2 Upstream and downstream multipliers

[26] The analysis in this report uses multipliers derived from the Scottish 1998 Input-Output (I-O) table and UK 1998 I-O accounts augmented by information on the Sea Fishing and Fish Processing sectors. This additional information was provided by the Department for Environment, Food and Rural Affairs (DEFRA), the Scottish Executive Environment and Rural Affairs Department (SEERAD) and the Sea Fish Industry Authority (SFIA). The underlying idea behind multipliers is that some independent (exogenous) disturbance occurring in one part of the economy can have subsequent "knock on" impacts in other parts of the economy and therefore on the economy as a whole. In this section we extend what was said in section 2.1 but the approach is still informal. An algebraic analysis is given in Appendix 1. For more detail, see Miller and Blair (1985, pp. 100-148).

[27] Multipliers are usually produced for individual sectors. These show the impact of an expansion in that sector on the economy as a whole. However, multipliers can also be presented for different types of aggregate expenditure, such as the consumption multiplier. Similarly multipliers can be calculated at a more disaggregated level than the sector, for particular types of plant, for example (Gillespie, 1998). Also the multiplier effects can themselves be disaggregated, so as to identify the impact of exogenous changes in one industry on activity in other, selected industries (rather than the sum of all industries).

[28] Input-Output tables are a set of accounts that identify the interaction (sales and purchases) between different sectors within the economy and between those sectors and elements of final demand over a particular time span. They therefore incorporate much information that is required to accurately measure multiplier values. Two broad generic types of multiplier are identified in the I-O literature. These are known variously as:

- Backward, demand-driven, Leontief, or upstream multipliers
- Forward, supply-driven, Ghoshian, or downstream multipliers.

[29] We give first a very brief outline of these two different multiplier concepts associated with I-O analysis. We then consider each in more detail. We stress the economic assumptions underlying their use. The assumptions required for the calculation of upstream multipliers are, in certain key respects, at complete variance to those required to calculate downstream multipliers. We also outline particular modifications that have been made to generate the multipliers used in this report. This is particularly relevant in our treatment of the impact of fish landings.

[30] Upstream multipliers identify the impact of a sector as a purchaser of inputs. When a sector expands it requires more inputs of intermediate goods and services and increases its employment and wage payments. This generates positive knock-on effects in sectors supplying the increased demand for intermediate and consumption goods. The expansion in these sectors will produce further increases in intermediate and consumption demands, the process continuing down successive rounds of the multiplier process, with the additional impact in each successive round becoming smaller and smaller. I-O analysis has a technique for capturing all these effects, as long as a number of assumptions hold.

[31] Downstream multipliers consider the impact of a sector as a supplier of commodities or services. In a supply-constrained economy, an expansion in one sector will allow the expansion of other sectors that use its inputs as intermediate inputs. Again, the process does not stop there. The expansion in these sectors allows further expansion in other sectors, so that again a multiplier process is set in train. As with downstream multipliers, if certain assumptions hold, I-O analysis can quantify these effects.

2.3 Backward, demand-driven, Leontief, or upstream multipliers

[32] A key characteristic of the procedure for determining the demand-driven multiplier values is to identify those elements of demand taken to be exogenous and those taken to be endogenous. The exogenous elements are those fixed independently of the level of activity within the economy. The endogenous demands are those determined by the level of activity in the economy. In conventional I-O demand-driven analysis, exports, government expenditure, investment and stock building are exogenous. Intermediate demand is endogenous. Consumption expenditure can be classified as either exogenous or endogenous.

[33] When consumption expenditure is taken to be exogenous, the multiplier simply identifies the change in activity generated in the economy by changes in intermediate demand for goods and services. The multiplier is called a Type I multiplier. It is made up of the direct effects of the initial change in exogenous demand plus the indirect

effects of the additional expenditure on intermediate goods and services. Where consumption demand is endogenous, and made to vary proportionately with wage income, the effects of induced consumption expenditure on activity is also included in the multiplier effect. This is called a Type II multiplier. It covers the direct and indirect impacts that are quantified in the Type I multiplier but adds the induced effect of additional consumption.

[34] In using I-O analysis to calculate backward multipliers the following assumptions are made:

- Constant-returns to scale, fixed coefficient production technology
- Constant coefficients in consumption (where Type II multipliers are calculated).
- No supply constraints

[35] *Constant-returns to scale, fixed coefficient production technology*: In calculating the upstream multipliers, it is assumed that all inputs into production in a particular sector change in strict proportion to the change in the output of that sector. Therefore if output increases by 10%, all inputs similarly increase by 10%. This implies constant returns to scale in production. It also implies that there is no substitution between inputs as output changes. This assumption is usually interpreted as implying that production is characterised by a fixed-coefficients technology. This is represented by an L shaped unit isoquant, which entails a zero elasticity of substitution between inputs. However, an alternative is that substitution is possible but input prices do not change, so that the cost minimising choice of technique does not vary as output varies (McGregor et al, 1996).

[36] *Constant coefficients in consumption*: Where induced consumption is incorporated into the multiplier values, in conventional models the consumption of all commodities changes in line with changes in wage income. Again, one can appeal to the lack of price and wage changes in an I-O model as some justification for this assumption.

[37] *No supply constraints*: In our view, this is the key assumption to the use of I-O upstream multipliers. There must be available labour and productive capacity to meet any increase in demand in any sector. Similarly there must be no key fixed natural resources which are presently fully utilised. Supply must therefore react passively to demand so that there is no crowding out of some demands by others and no changes in production techniques to economise on scarce resources or commodities.

[38] Essentially a Type II demand-driven I-O multiplier is a sophisticated Keynesian multiplier. It operates in an identical way but provides more sectoral disaggregation. Imports and intermediate demands are also better identified. It shares with the Keynesian multiplier the requirement that the supply-side of the economy plays a totally passive role. This might be appropriate in the short run for an economy with unemployment problems or for a regional economy in the long run where inter-regional migration and additional investment can relax labour market and capacity constraints. However, the application to the UK national economy should be thought of as more of a thought experiment than realistic modelling. The notion that the UK economy does not have supply constraints is clearly unrealistic.

2.4 The determination of relative multiplier values

[39] The multiplier value for any industry is, in principle, determined by all the interactions between firms and, where appropriate, consumers within the economy (Appendix 1). However, it is possible to make some generalisations concerning the relative size of multiplier values, usually based upon the cost characteristics of the industry receiving the initial injection.

[40] For any industry, the multiplier values will differ between different measures of activity. That is to say, the output multiplier value will, in general, differ from the employment, income and value-added multiplier values. Further, not only are the absolute values different, but even the rankings of industries by their multiplier values can differ using different activity measures. The reasons for such differences are outlined below, but in general they revolve around the cost structure of the industry receiving the initial injection.

[41] For any one activity measure, an industry's Type II multiplier will always be at least as large as the Type I multiplier. This is because the Type II multiplier captures more of the possible knock-on effects than does the Type I multiplier. Specifically, the Type I multiplier includes the indirect effects generated by the intermediate purchases made by the sector receiving the initial demand stimulus. However, the Type II multiplier also incorporates induced consumption effects generated by the change in wage income accompanying a change in a sector's activity.

[42] The Type I output multiplier for a particular sector is strongly dependent on the proportion of its gross output that is spent on domestically-produced intermediate inputs. Where this proportion is high, we expect the Type I output multiplier to be large. High proportionate intermediate purchases by a sector will be linked to low purchases of intermediate imports and a low ratio of value-added to gross output.

[43] For Type I calculations, the additional employment, income and value added produced by £1 million additional final demand to one sector will be influenced by two effects. One is the direct effect: the employment, income or value-added intensity of the initial sector itself. The second will be the indirect impact which should be correlated with the output multiplier value. However how will the corresponding multiplier values be calculated? We take the employment multiplier as an example, but the same logic holds for income and value added.

[44] Imagine that the ratio of direct employment to gross output of £1 million in the initial industry is e_i. Also label the additional employment generated, primarily in other industries, as a result of the Type I multiplier process is Δe^I_i. This value will be positively related to the value of the Type I output multiplier. The total employment-output multiplier, $M^I_{Q,E}$ is given by

$$M_{Q,E}^{I} = e_i + \Delta e_i^{I} \qquad (1)$$

[45] The Type I employment-output multiplier will be high therefore where both the output multiplier and the direct employment-output ratio are high.

[46] However, the conventional Type I employment multiplier, $M^I_{E,E}$ is defined as the total change in employment divided by the initial change in exogenous employment. If the initial increase in exogenous demand were £1 million, the corresponding increase in employment would be e_i. Therefore the employment multiplier is given as:

$$M_{E,E}^{I} = \frac{e_i + \Delta e_i^{I}}{e_i} = 1 + \frac{\Delta e_i^{I}}{e_i} \qquad (2)$$

[47] Equation (2) identifies a seeming paradox. Because the direct employment-output ratio, e_i, appears in the denominator of the second term on the right hand side of equation (2), *ceteris paribus*, the larger its value, the lower the value of $M^I_{E,E}$. This is reinforced by another factor. The value of Δe^I_i will, in general, be negatively related to the ratio of value-added to total output. However, this ratio will tend to be positively related to e_i Therefore both the higher e_i and the lower Δe^I_i will depress the value of $M^I_{E,E}$.

[48] Exactly the same form of argument applies to the Type I income and value-added multipliers. The absolute size of the indirect effects are related to the size of the sector's output multiplier, which tends to be negatively related to the sector's wage income-output and value added-output ratio. Similarly, where these effects are expressed as a ratio of the initial income or value added injection, the larger the size of the income-output and value added-output ratios, the lower the relative size of these changes and therefore the lower the relevant multiplier value. That is to say, if £1 million final demand injection leads to the same indirect increase in wage income, that sector which has the lower initial wage income injection, i.e. the lower wage income-output ratio, will have the higher income multiplier.

[49] There will, in general, be differences in the Type I employment, income and value added multiplier values for the same sector. In short, a high ratio of other value added to output depresses the value-added multiplier against the income and employment multipliers and a relatively high wage depresses the wage income multiplier against the employment multiplier.

[50] Type II multipliers are slightly different. These multipliers incorporate the impact of not only the additional intermediate demands but also the induced additional consumption expenditure. Here the value of a sector's output multiplier depends positively upon the ratio of the wages plus domestically supplied intermediate demand to gross output. Industries with low Type II output multipliers will have high imports and other value added (rents and profits payments) in proportion to their gross outputs.

[51] For the standard Type II employment, wage income and value-added multipliers a similar relationship applies as expressed in equation (2) for Type I multipliers. However, one consideration is important. In this case the value of the output multiplier should be positively, not negatively, related to the ratio of the sector's employment, income and value added intensity. However, it is still the case that a sector with a low employment-output ratio but a high wage will have, ceteris paribus, a high Type II employment ratio. On the other hand, a labour intensive sector with a relatively low wage is likely to have a low Type II employment ratio. What really matters in determining the Type II

employment multipliers is the absolute size of the average wage payment and domestically-supplied intermediate expenditures per worker.

2.5 Multiplier analysis of changes in output

[52] Typically demand-driven multiplier analysis is used to analyse the knock-on effects of changes in exogenous final demand. However, it can also be adjusted to predict changes associated with changes in the output of a sector, even though, in the demand driven I-O model, output is usually taken to be endogenous (Johnson and Kulshreshtah, 1982; Papadas and Dahl, 1999). The key point here is simply that if the final demand for a sector increases, then the output of that sector will, in general, increase by more than that amount. With Type I analysis, this is because the sector either directly or indirectly uses its own output as intermediate inputs. In Type II analysis there might also be a stimulus to the sector through induced consumption expenditure.

[53] The solution is simply that the initial final demand change needs to be somewhat less than the required change in the output of the sector. Technically the change in final demand for the output of sector i (ΔF_i) to produce and output change in sector i of ΔQ_i is given by

$$\Delta F_i = \frac{\Delta Q_i}{\alpha_{i,i}} \qquad (3)$$

[54] where $\alpha_{i,i}$ (≥ 1) is the ith diagonal element in the appropriate Leontief inverse. This general approach has been developed to use also where the output of one sector is fixed through supply constraints. Our hybrid treatment of the impact of landings uses a similar method.

2.6 Import substitution adjustments

[55] Within a demand-driven I-O model, the analysis of import substitution is relatively straightforward. It simply implies replacing the demands for domestic commodities by imports of the same commodity. Where these are final demands, such as government expenditure or investment, this is simply done by reducing the final demands for the appropriate domestic commodities by the corresponding amount. Where the relevant change in demand relates to the demand for the commodity as an intermediate good in the domestic production of some other commodity (or group of commodities) the procedure is a little more complex.

[56] In the intermediate good case, the adjustment needs to be made in the fixed production coefficient that links the intermediate demand for one commodity to the output in other sectors. If the degree of import substitution were, say, 50%, then this coefficient would be reduced by 50% in all the relevant sectors. Once these coefficients have been adjusted, the Leontief inverse is then generated. In essence, in this case the final demands will be the same, but the multiplier values will be reduced.

2.7 The notional shutting down of a complete sector

[57] In the demand-driven I-O approach, the complete closure of a particular sector is modelled as if all the domestic demands for that commodity were transferred to imports. There is no implied change in technology or tastes in so far as commodities are concerned, simply that what is recorded in the base data as being supplied by the domestic sector, now requires to be imported. The viability of other sectors is not threatened through breaking supply links, but the output of sectors directly or indirectly supplying the closed sectors will clearly be adversely affected. From the discussion in section 2.6 above, adjusting for increased imports typically requires changes both to the final demands for the commodity and the production coefficients, which, in principle, affects all the multiplier values.

[58] The impact of the complete closure of a sector is identified by calculating the total gross output, employment, income and value-added generated with the I-O system characterised by the new set of final demands and multiplier values, and subtract these from the original figures for these activity variables.

[59] Two notes of caution should be sounded about the estimates of the impact of the complete closure of the sector. The first is that these estimates cannot be taken to be a form of accounting. That is to say, each sector could be removed, independently, and the impact of removing that sector quantified as outlined above. If all these individual impacts were then summed, the total lost output and employment would be greater than the initial total output and employment. In that respect, this procedure cannot be seen simply as a form of accounting or attribution.

[60] A second problem is that the total measured affect will vary, depending on whether a Type I or Type II approach is taken to the calculation of the new activity variables. In this procedure, however, it is not necessarily the case that a Type II calculation will give a bigger result than a Type I one. It seems more reasonable to count consumption as endogenous, and, if so, a Type II approach would be preferred.

2.8 Forward, supply-driven, Ghoshian, or downstream multipliers

[61] The supply-driven, downstream multiplier, initially developed by Ghosh (1958) is less well known than the conventional demand-driven upstream variant. Its calculation involves the following procedures. First, the variables that are taken be exogenous are not, in this case, elements of final demand, but rather factor supplies specific to individual industries. That is to say, the stimulus to output initially comes from an exogenous change in the non-produced (natural) resources used by a particular industry. This increase in resource availability generates an increase in that industry's output. This initial increase in output is, in principle, independent of any change in demand. In this supply-driven story, it is the turn of demand to be the passive partner.

[62] The increase in the output of the industry receiving the initial, exogenous, supply stimulus is then distributed, either as intermediate supplies to other industries or to final demand. Where this change in output is allocated as inputs to other industries, the outputs of those industries are similarly increased, and so on. This expansion in other industries that, directly or indirectly, use the first industry's products as intermediate inputs is the multiplier effect. Where only intermediate supply is incorporated into the multiplier process, this is known as a Type I multiplier. If labour is treated as an intermediate input, an expansion in consumption leads to an increase in the supply of labour that is then allocated to industries as a productive input. This process is labelled as a Type II multiplier.

[63] In using supply-driven multipliers the following assumptions are made:

- Perfect substitution between inputs in production
- Fixed output coefficients
- General supply constraints – no demand constraints

[64] *Perfect substitution between inputs in production*: There are two key characteristics associated with the supply-side multiplier process. The first is the production function at the level of the industry. How do we calculate the change in output in a particular industry that accompanies a change in the use of one input in that industry? In the supply-side multiplier process, the change in output is simply equal to the change in the value of that input. For example, assume that the supply-driven stimulus to an industry is a doubling of the land input, and the payment to land rent in the industry is presently £10 million. The input is assumed to increase by £10 million (the rental rate is assumed to be unchanged) and the output of the industry is similarly assumed to increase by the same £10 million. There is assumed to be no change (at this point) in other inputs in the industry. That is to say, other inputs are neither increased (to complement the expansion in land) nor are they reduced (as land substitutes for them).

[65] These assumptions are in complete contrast to those made in the demand driven model. In the demand-driven model, inputs are used in fixed proportions so that the elasticity of substitution between inputs is zero. However, in the supply-driven multiplier the inputs can be interchanged so that the elasticity of substitution is implicitly taken to be infinity. In the demand-driven multipliers production is assumed to take place with fixed coefficients so that the unit isoquants are L-shaped. In the supply-driven multiplier model, the isoquants are assumed to be straight lines reflecting perfect substitution between different inputs. However, the situation is not quite as extreme as it sounds. For small changes in inputs, the supply side method is a linear approximation to standard economic theory on the assumption that inputs are paid their marginal products (Gruver, 1989). The arguments made here are exactly those made in the standard growth accounting procedures.

[66] *Fixed output coefficients*: The second procedure is a little more troublesome. The increase in the output of a particular industry is allocated as inputs to other industries and to final demand in the same proportion as the initial distribution of output from that sector. Therefore if 50% of the steel sector goes into the production of cars in the initial period, 50% of all additional steel is allocated to the production of cars. This is irrespective of the change in other inputs in car production or the demand for cars. In the demand-driven multiplier, the input coefficients for each industry are held constant. For the supply-driven model, the output coefficients are held constant.

[67] Again, within a strictly supply-constrained setting, the fixed output coefficients might be justified as being a linear approximation to maximising behaviour, relevant for small changes in the economy. It is appropriate to think about the supply-constrained economy as trying to maximise the value of its final demands. The output of each industry can contribute directly to the satisfaction of these demands or indirectly by being used as an intermediate good to increase the output of other commodities. If the initial I-O table reflects this type of maximising behaviour, the initial weights given to different activities equalise their marginal contribution to meeting this goal. Therefore for small changes in the economy a similar distribution of sectoral outputs across might also represent a linear approximation to the optimal behaviour. However, it has to be said that we are unaware of any work that clearly shows that this supposition is true. Further, even if these linear approximation arguments do hold, for large supply changes they will be inaccurate.

[68] *General supply constraints – no demand constraints*: The key element to understanding the supply-driven I-O multiplier is that it only applies in a fully supply-constrained setting. To reiterate, all resources must be fully employed and sector-specific non-produced resources are the ultimate exogenous variables. Relaxing these supply constraints allows expansion in output. In the Type I multipliers, if the initial exogenous change is an increase in resources in one sector, the increase in the output of that sector is simply the increase in earnings of those resources. Note that there would be no changes in employment associated with the initial or subsequent changes in output. It would not be possible for total employment to change as full employment is assumed from the start (remember we are dealing with a supply constrained system). Similarly, although the gross outputs of individual sectors will change, there is no additional value added generated in the multiplier process. In essence, the multiplier process simply funnels the initial increase in output that occurs in one sector towards other sectors so as to satisfy more effectively final demand.

[69] In Type II supply-constrained multipliers, employment is treated as though it were an additional industrial sector, so that in this case employment can vary with a supply-side shock. However, the employment changes in this case simply because labour inputs are now part of the way of delivering final demand (which now no longer includes household consumption). The easiest way of thinking about this is in the context of a slave economy – some of the additional output is allocated to breeding and maintaining more slaves. In a more democratic economy this objective could be generated via in-migration.

[70] A final issue that should be discussed is the endogenisation of imports in the supply-driven multiplier. As conventionally calculated, although an increase in resources will lead to an expansion in an economy's exports (as part of the increased output is allocated to exports as an element of final demand), there is no corresponding change in imports. It seems sensible for the economy to attempt to increase household consumption, public consumption (government expenditure) and future consumption (investment). But it is unclear why it should increase exports, if not to finance increased imports. Therefore the endogenisation of trade in a supply-driven model seems a logical extension. However, if this is done at fixed prices (adopting the small region assumption) the conventional supply-driven assumptions will not hold.

[71] It should be said that the realism of the supply-driven I-O analysis has been severely criticised by some in the literature. An example is Oosterhaven (1988).

2.9 An alternative interpretation of the supply-driven multiplier

[72] Dietzenbacher (1997) has argued that there is a more useful function for the supply-driven multiplier than to trace the impact of changes in value added quantities on the output of sectors. Rather this technique should be used to identify the effect of changes in the price of value added in one sector on the prices of the gross output of other sectors which use the first sector's output, directly or indirectly, as intermediate inputs into their own production. We make use of this insight here in considering the impact of an increase in efficiency, which effectively reduces the cost of sectoral value added.

2.10 Data issues

[73] Before discussing the comparability of demand- and supply-driven multiplier values, it will be useful to make some points about data. For the demand- and supply-driven multipliers to be accurate, the data in the I-O tables must accurately reflect the technology and output patterns for individual sectors for Type I multipliers and also the pattern of consumption behaviour for Type II multipliers.

[74] This implies accurate data collection but also that the economy should be in equilibrium in the base year. If the year were exceptional for some reason, then the data might not be a reliable source to use in subsequent years.

One particular concern is that in the Scottish 1998 tables there are a number of sectors with negative “other value added”. Such sectors are not covering their variable costs which implies data inaccuracy or serious industry disequilibrium. However, where superior information is available, production and purchasing coefficients can be changed to reflect that knowledge, though this has the disadvantage of implicitly unbalancing the I-O table as a set of accounts. Again we have had to adopt this procedure for both the Fish Catching and Fish Processing sectors here.

2.11 The consistency of demand- and supply-driven multipliers

[75] Where demand- and supply-driven multipliers are characterised as identifying upstream and downstream effects, it might be thought that both multipliers quantify the same kind of phenomenon and in fact could be combined to give some form of all embracing total impact. As should be clear from the separate accounts of both the multiplier formulations, this is false. The two multipliers measure the impact of different kinds of disturbance on economies facing quite different constraints. In choosing one or the other, the researcher makes a judgement about the kind of economy that he or she is investigating. For example, an expansion in sector-specific non-produced resources, which are the key exogenous variables in the supply-driven multiplier model, have no impact whatsoever in the demand-driven model, as sectors are assumed there to have excess capacity and no existing supply constraints.

[76] It might be thought that the nature of the industry under consideration should determine the kind of multiplier that is used. In particular, there have recently been a number of studies of fishing and forestry which have calculated supply-driven multipliers (Eiser and Roberts, 2002: Greig, 2000). These industries clearly experience natural resource constraints. However, the problem is that in the calculation of the standard I-O demand- and supply-driven multipliers, all sectors have to be facing the same constraints, and very extreme ones at that. Therefore just because fishing is supply constrained does not mean that the supply-driven multiplier is the appropriate one to use given that many other industries in the economy are not constrained in this way.

[77] The I-O models, whilst elegant and powerful, are limited in that they fail to deal with the implications of price change in the economy. A possible way forward for multi-sectoral modelling which can incorporate both supply and demand influences in a more sophisticated way than I-O multipliers is Computable General Equilibrium (CGE) modelling. See Greenaway et al (1993) for a good review.

2.12 Hybrid approach

[78] The actual approach that we have adopted in answering the questions posed in this report is a hybrid one. We have primarily built in supply links between fish landings and Fish Processing. We have assumed that a fixed proportion of the fish that is landed is processed and ultimately sold (with increased exports the sink demand). Therefore the landing of fish generates associated processing activity, almost as though these two sectors were a fully integrated industry. However, standard backward multipliers determine the subsequent impacts, so that in the other industries within the economy we assume a passive supply response.

Chapter 3: Modifications to the Scottish and UK I-O tables

[79] The analysis is based upon the 1998 Scottish Input-Output Tables (The Stationery Office, 2001b) and a set of Tables for the UK constructed from the 1998 Supply and Use Tables (The Stationery Office, 2001a). However, we needed:

- to adjust the Sea Fishing sectors in both the Scottish and UK tables
- to disaggregate the Sea Fishing sectors so as to separately identify Demersal, Shellfish and Pelagic fish
- to construct separate Fish Processing sectors, which required disaggregating the existing Fish and Fruit Processing sector in the Scottish and UK tables.

3.1 Adjustments to the Scottish I-O tables

3.1.1 Scottish Sea Fishing

[80] Table 3.1 presents the data on the top 10 largest intermediate purchases of the Scottish Sea Fishing sectors, as taken directly from the 1998 I-O table. The project steering group indicated that these purchases were inaccurate and not truly representative of the Sea Fishing sector, and requested that they be altered for the project. The main problem concerned purchases of fuel and oil (sector 35), which ought to form a higher proportion of intermediate purchases than they do in the tables.

Table 3.1: Top 10 Sea Fishing intermediate purchases from the 1998 Scottish I-O table

IOC	Sector	Intermediate Purchases (£m)	% of total int. purchases
97	Transport Services	27.63	19.37
78	Shipbuilding and Repair	26.31	18.44
26	Other Textiles	21.69	15.21
91	Retail Distribution	11.85	8.31
100.1	Banking	10.66	7.47
114	Other Business Services	8.49	5.95
35	Oil Process, Nuclear Fuel	5.81	4.07
90	Wholesale Distribution	5.10	3.57
120	Membership Organisations	3.63	2.54
48	Plastic Products	2.74	1.92

[81] Rather than change the entries and rebalance the table, thus creating more inaccuracies, it was decided that the Sea Fishing purchases would be altered and analysis would continue with an unbalanced table. The new columns were created using two sources of information:

- Breakdowns of Sea Fishing expenses and propensities to import for each fish type for Scotland and for the UK (provided by SEERAD and SFIA).

- A system for allocating these expenses into I-O categories (provided by the Scottish Executive).

[82] The expense breakdowns are shown below:

Table 3.2: Expenses breakdown for the Scottish Sea Fishing sector, 1998 (£ million)

	Demersal	Shellfish	Pelagic	Total
Gross Output	**209.5**	**86.2**	**103.8**	**399.5**
Inputs: Fishing				
Commission	9.5	2.2	4.6	16.3
Harbour Dues	8.0	1.5	2.2	11.7
Subscriptions and levies	1.6	0.3	0.8	2.8
Shore labour	5.1	0.2	0.5	5.8
Stores	0.3			0.3
Fuel and oil	17.2	8.6	10.0	35.8
Boxes	2.8	0.2	0.3	3.2
Ice	2.6	0.6		3.2
Crew travel	1.3	0.2	0.2	1.7
Food	5.2	2.1	2.5	9.8
Bait	2.0			2.0
Other expenses	4.3	1.2	4.8	10.3
Crew share	78.8	25.6	33.2	137.6
Total Fishing Inputs	**138.9**	**42.7**	**58.9**	**240.5**
Inputs: Vessel				
Insurance	9.1	2.0	4.7	15.8
Repairs	20.2	4.3	14.8	39.3
Gear	12.8	3.2	6.2	22.2
Hire and Maintenance	2.2	0.9	4.2	7.3
Other vessel owner Expenses	4.5	1.6	2.2	8.3
Total Vessel Inputs	**48.8**	**12.0**	**32.1**	**92.9**
Total Inputs	**187.7**	**54.6**	**91.0**	**333.4**
Gross Margin (excluding depreciation)	**21.8**	**31.6**	**12.8**	**66.2**

[83] The Scottish Executive has transformed these cost breakdowns into a format suitable for the I-O table by allocating each cost to a particular sector or combination of sectors. We have used these costs and the breakdown to create new Demersal, Shellfish, Pelagic and overall Sea Fishing sectors. The table below shows into which I-O sector each cost was allocated (and the share in each sector when the cost was split between several sectors).

[84] The top 10 intermediate purchases of the Scottish and UK Sea Fishing sectors (after deducting imports) using this method are shown in Table 3.4. Sector 35, which contains Fuel and Oil, is placed higher in these lists. Another notable difference between the purchases from the I-O and those above is the position of the Wholesale and Retail Distribution sectors (90 and 91); according to the industry sources Wholesale Distribution does not supply any inputs whatsoever, but these sectors are prominent on the Scottish I-O list. It is hoped that by creating the new columns of purchases the modelling results will be more accurate.

Table 3.3: Allocation of expenses to I-O sectors

Expense	I-O sector	Share
Commission	97	1.00
Harbour Dues	97	1.00
Subscriptions and Levies	120	1.00
Stores	26	1.00
Fuel and Oil	35	1.00
Boxes	48	1.00
Ice	19	1.00
Crew Travel	94	1.00
Food	8	0.37
	14	0.16
	17	0.32
	18.1	0.05
	18.2	0.05
	19	0.05
Bait and Other Running Costs	28	0.15
	30	0.04
	31	0.21
	33	0.02
	43	0.15
	44	0.04
	62	0.02
	85	0.02
	90	0.00
	91	0.33
	92	0.02
	95	0.00
	105	0.00
Insurance	101	1.00
Repairs	78	1.00
Gear	26	1.00
Hire and Maintenance	70	1.00
Other Vessel Owner Expenses	114	1.00

Notes: A description of the relevant I-O sectors is given in Appendix 3
Shore Labour Haulage is included in Value Added
Shares are rounded to two decimal places

Table 3.4: Top 10 Scottish Sea Fishing intermediate purchases after allocation of Sea Fishing expenses to I-O sectors

IOC	Sector	Intermediate Purchases (£m)	% age of total int. purchases
78	Shipbuilding and Repair	33.44	22.13
35	Oil Process, Nuclear Fuel	25.77	17.06
97	Transport Services	24.03	15.91
26	Other Textiles	21.36	14.14
114	Other Business Services	7.06	4.67
100.1	Banking	5.62	3.72
19	Soft Drinks	3.75	2.49
8	Meat Processing	3.60	2.39
91	Retail Distribution	3.54	2.34
48	Plastic Products	3.21	2.12

[85] The sales pattern of Sea Fishing is also required for the creation of forward multipliers. We retained the existing pattern of sales in the 1998 I-O table, only adjusting sales to Fish Processing (see below).

3.1.2 Fish Processing

[86] A major problem arose with regards the Fish Processing sector. In both the official 1998 Scottish and UK I-O tables, the Fish Processing sector is combined with Fruit Processing. Therefore the creation of separate Fish Processing sectors was required. We have adjusted the current 1998 sector values with data provided by the steering group to create new sectors that reflect the true linkages between fish catching and fish processing.

[87] In the 1998 Scottish I-O table, only 8% of Fish Processing's domestic purchases are from Sea Fishing. The 1998 figures also suggested that the Fish Processing sector utilised few imports of fish. This is in contrast to the information available from Seafish, which suggests that approximately 68% of Scottish Fish Processing inputs are fish. Further, in previous Scottish I-O tables a higher proportion of Fish Processing inputs came from Sea Fishing (intermediate fish purchases of the sector were 30% in 1992, 31% in 1993 and 35% in 1994. In 1996, however, they drop to 6% and are only 8% in 1998).

[88] The new sector's values were calculated using data from Seafish and from the "Financial Flows in the Scottish Sea Fisheries Industry" document prepared by SEERAD. Seafish estimates that total fish inputs to Fish Processing were £548.54m. Of these inputs, Seafish estimates £235.8m came from landings into Scotland and £312.74m were imported from abroad. To create a new Fish Processing I-O column we also required Fish Processing's purchases of Scottish landings only. Using information from SEERAD on the proportions of domestic and foreign landings into Scotland we split the £235.8m total purchases into £203.61m from Scottish landings and £32.19m from foreign landings.

[89] The new column was created by combining this information with the more accurate purchasing shares from the 1994 Scottish I-O table. The "Financial Flows in the Scottish Sea Fisheries Industry" document indicates total sales of the Scottish Fish Processing sector of £811.45m in 1998. Fixed entries in the column were inputs from domestic Sea Fishing (£203.61m) and imports (£344.93m). These imports were comprised of foreign landings of £32.19m and imports of £312.74m, and have been split equally between RUK and ROW in accordance with the 1994 table, leaving a total of £262.91m to be reallocated amongst the remaining intermediate sectors and primary inputs. This was achieved using the purchasing shares of the 1994 table. Finally, the Sea Fishing inputs of £203.61m had to be split between the three fish types, which was done using shares taken from the split in the 1998 I-O table made previously.

[90] Essentially we have created a completely new Scottish Fish Processing I-O sector. This provides a more realistic treatment of that sector. Under the new breakdown purchases from domestic (Scottish) Sea Fishing account for 61% of intermediate purchases and 25% of total costs. Total purchases of fish, including imports, account for 67.6% of total costs.

3.1.3 Employment in the Scottish and UK Sea Fishing sectors

[91] Employment had to be disaggregated between the three Sea Fishing sectors to create employment multipliers. However, there are various estimates of fishing employment. The Annual Business Inquiry estimates total employment but does not include self-employed, which is prevalent in Sea Fishing. The Labour Force Survey does include self-employed, but its estimates for 1998 were unreliable. It was decided that we would use the following Full Time Equivalent (FTE) employment figures, provided by the steering group. However, it must be noted that this produces employment estimates that are lower than the head count figures normally given by the government.

Table 3.5: Employment in the Scottish Sea Fishing sector

	Demersal	Shellfish	Pelagic
Scottish employment (FTEs)	3,015	3,732	418

3.2 Construction of, and adjustments to, the UK I-O tables

3.2.1 Construction of balanced industry-by-industry UK input-output tables

[92] Information on industry linkages between domestic sectors and outside of the UK was drawn from the 1998 I-O accounts compiled by the Office for National Statistics (ONS). The UK accounts included a table showing the purchases of all goods and services made by domestic industrial sectors; this was called the use table. A second table showed the purchases of all goods and services by UK final markets such as consumers' expenditure and exports.

[93] These two tables are adjusted to construct a 1998 UK balanced industry-by-industry Input-Output table. This forms the basis of the UK model. More details concerning its construction are given in Appendix 2. The relevant figures for employment were taken from the Annual Business Inquiry (ABI) for 1998.

3.2.2 Adjustments to the UK Sea Fishing sector

[94] Table 3.6 gives the intermediate domestic purchases from the Sea Fishing sector for the 1998 UK I-O table. Again fuel oil purchases seem low. However, for the UK table a more serious problem arose. The UK table proved to be inconsistent with the Scottish table in several respects. For example, total intermediate demand of the Sea Fishing sector in Scotland in 1998 was £142.6m – in the UK table it was £134.8m. It is clear that some adjustment must be made to the UK I-O Sea Fishing columns for the multiplier analysis. Essentially, the same form of adjustment and disaggregation has been applied to the UK tables as was applied to the Scottish tables.

Table 3.6: Top 10 Sea Fishing intermediate purchases from the 1998 UK I-O table

IOC	Sector	Intermediate Purchases (£m)	% age of total int. purchases
78	Shipbuilding and repair	39.91	29.61
101	Insurance and pension funds	25.30	18.77
119	Sewage and sanitary services	15.14	11.23
35	Coke ovens, refined petroleum & nuclear fuel	12.55	9.31
97	Ancillary transport services	10.14	7.52
26	Other textiles	6.84	5.07
114	Other business services	6.62	4.91
122	Other service activities	6.22	4.61
48	Plastic products	2.55	1.89
22	Textile weaving	1.00	0.74

Table 3.7: Expenses breakdown for the UK Sea Fishing sector, 1998 (£)

	Demersal	Shellfish	Pelagic	Total
Gross output	**372.2**	**175.4**	**113.8**	**661.4**
Inputs: Fishing				
Commission	16.2	6.9	5.0	28.2
Harbour dues	11.4	5.5	2.4	19.3
Subscriptions & levies	3.2	1.0	0.9	5.0
Shore labour	8.2	1.5	0.5	10.3
Fuel & oil	24.8	13.9	11.0	49.7
Boxes	5.5	0.5	0.3	6.2
Ice	4.3	0.8		5.1
Crew travel	2.8	2.7	0.2	5.7
Food & Stores	11.0	3.8	2.7	17.6
Other expenses	13.3	5.6	5.2	24.1
Bait	1.1	3.8		4.9
Crew share	132.7	57.5	36.4	226.6
Total Fishing Inputs	**234.5**	**103.6**	**64.6**	**402.7**
Inputs: Vessel				
Insurance	14.6	6.4	5.2	26.1
Repairs	24.7	12.9	16.3	53.9
Gear	13.6	10.8	6.8	31.2
Hire & maintenance	4.8	6.7	4.6	16.1
Other vessel owner expenses	7.4	5.4	2.4	15.2
Total Vessel Inputs	**65.2**	**42.2**	**35.2**	**142.5**
Total Inputs	**299.6**	**145.8**	**99.8**	**545.3**
Net Profit (exclude dep. & int.)	**72.6**	**29.6**	**14.0**	**116.1**

[95] We took the UK expenses breakdown from data supplied by SFIA and this is given in Table 3.7. These expenditures are then allocated to I-O sectors through the ratios presented in Table 3.3. The resulting breakdown of the top 10 intermediate purchases is given in Table 3.8.

Table 3.8: Top 10 UK Sea Fishing intermediate purchases after allocation of Sea Fishing expenses to I-O sectors

IOC	Sector	Intermediate Purchases (£m)	%age of total int. purchases
78	Shipbuilding and repair	45.85	16.32
97	Ancillary transport services	41.42	14.74
35	Coke ovens, refined petroleum & nuclear fuel	37.29	13.27
26	Other textiles	30.65	10.91
101	Insurance and pension funds	26.10	9.29
70	Electric motors and generators etc	16.05	5.71
114	Other business services	15.18	5.40
91	Retail distribution	9.53	3.39
8	Meat processing	6.34	2.25
48	Plastic products	6.24	2.22

3.2.3 UK Fish Processing

[96] Similarly to the Scottish Table, in order to separately identify Fish Processing, we decided to disaggregate the Fish and Fruit Processing sector into Fish Processing and Fruit Processing. This was achieved using the following information from the steering group: a total output of the Fish Processing sector of £2,200m, purchases of domestic fish of £358.8m and imports of fish of £1,128.4m. Again, we allocated the remaining purchases using the shares from the 1994 Scottish I-O table. This led to a new UK Fish Processing sector where purchases of

domestic fish are 50% of intermediate purchases and 16% of total costs, and total purchases of fish are 68% of total costs.

3.2.4 UK employment in Sea Fishing

[97] Again, data supplied by Seafish was used for UK employment in Sea Fishing.

Table 3.9: Employment in the UK Sea Fishing sectors

	Demersal	Shellfish	Pelagic
UK employment (FTEs)	6,120	9,759	449

[98] In conclusion, for the Sea Fishing and Fish Processing sectors there was a large disparity between the information in the I-O table and that provided to us by the steering group. Wherever possible, we have attempted to use the data provided by the Fishing authorities.

Chapter 4: The simulation results for Scotland and the UK

[99] In this chapter we present the results from a number of simulations based around the approaches outlined in Chapter 2. Generally this involves the calculation and use of demand- and supply-driven multipliers in an Input-Output framework for Scotland and the UK.

4.1 Demand-driven multiplier effects of £1m changes in Sea Fishing and Fish Processing final demands in Scotland and in the UK

[100] The multipliers reported in this section estimate the ultimate impact on the Scottish and UK economies of a change in final demand for Sea Fishing and Fish Processing output. These multipliers are all demand-driven and thus focus on the backward linkages of the Sea Fishing and Fish Processing sectors.

4.1.1 Output multipliers

[101] Tables 4.1 and 4.2 show Scottish and UK output multipliers and their rank relative to all other sectors in the economy (there are 127 other sectors in Scotland and 124 in the UK).

Table 4.1: Scottish backward output multipliers

	Type I	Rank	Type II	Rank
Demersal	1.68	29	2.23	17
Shellfish	147	65	1.90	62
Pelagic	1.63	36	2.12	32
Sea Fishing	**1.62**	**37**	**2.13**	**28**
Fish Processing	**1.66**	**32**	**1.98**	**46**

Table 4.2: UK backward output multipliers

	Type I	Rank	Type II	Rank
Demersal	1.77	79	3.42	53
Shellfish	1.88	45	3.54	29
Pelagic	1.88	44	3.53	32
Sea Fishing	**1.82**	**61**	**3.47**	**42**
Fish Processing	**1.62**	**111**	**2.52**	**122**

[102] Output multipliers express the total impact on output generated in the economy by a £1m increase in the final demand of a sector. A £1m increase in final demand will have three effects. The *direct effect* is the increase in domestic purchases by the sector experiencing the increase in final demand. This leads to the *indirect effect* as input suppliers increase their output and domestic purchases to meet the increased demand, and so on. Finally, the *induced effect* arises as the increased economic activity leads to an increase in the supply of labour and thus increased wage income and consumer spending.

[103] Type I multipliers include only the direct and indirect effects, and therefore the most important factor determining their value is the size of the sector's domestic purchases, i.e. its backward linkages in the economy. In Scotland, the Demersal sector has a higher proportion of domestic purchases than any of the other Sea Fishing sectors. This can be seen in Figure 4.1 which gives the proportion of each type of input into the Sea Fishing and Fish Processing sectors in Scotland. Therefore, the Demersal sector in Scotland has the highest output multiplier of the Sea Fishing sectors. Ignoring induced (consumption) effects; we can say that a £1m increase in Demersal

final demand will lead to a £1.68m increase in output in the Scottish economy. If we include induced effects, by using the Type II multiplier, the increase in Scottish output is £2.23m.

[104] By contrast, at the UK level, Figure 4.2 reveals that the Demersal sector has a lower level of domestic purchases than the other Sea Fishing sectors, resulting in the lowest output multiplier. The Shellfish and Pelagic sectors, with higher proportionate domestic purchases, both have Type I multipliers of 1.88 and Type II multipliers of 3.54 and 3.53 respectively. In Scotland the Fish Processing sector has a higher proportion of domestic purchases than Sea Fishing (most of these purchases coming from Sea Fishing) and therefore a higher output multiplier. In the UK the Fish Processing sector has lower proportionate domestic inputs and higher imports, and therefore the lowest output multipliers. With the exception of the Type I Fish Processing output multiplier value, the sizes of the output multipliers are larger in the UK than in Scotland. This is to be expected given that Scotland is a smaller economy with a higher degree of dependence on imports. Higher imports mean higher leakages from each round of the multiplier process and lower multiplier values.

Figure 4.1 - Proportion of each input type in Scotland

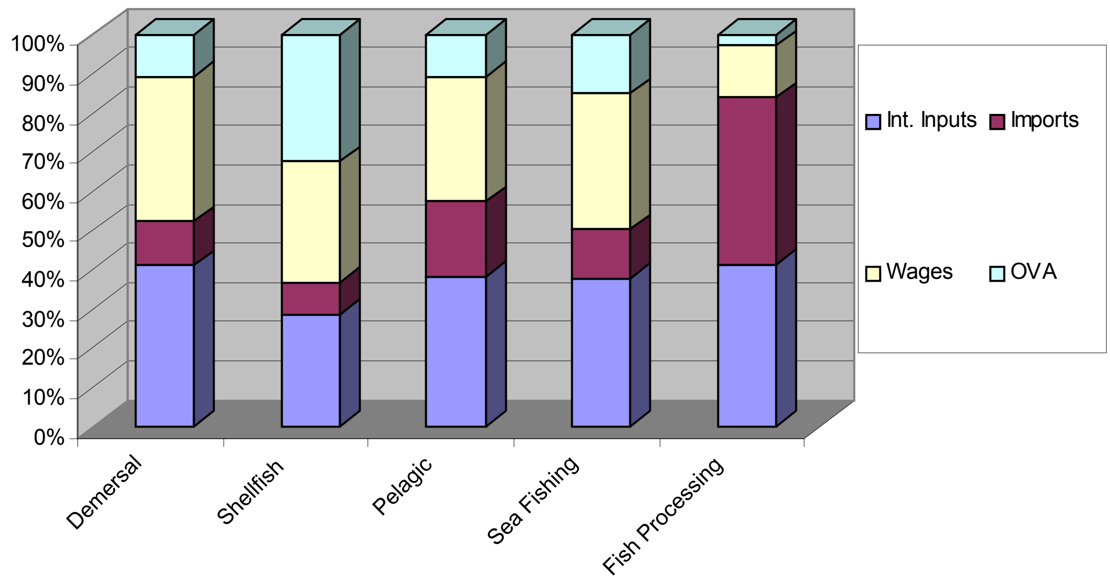
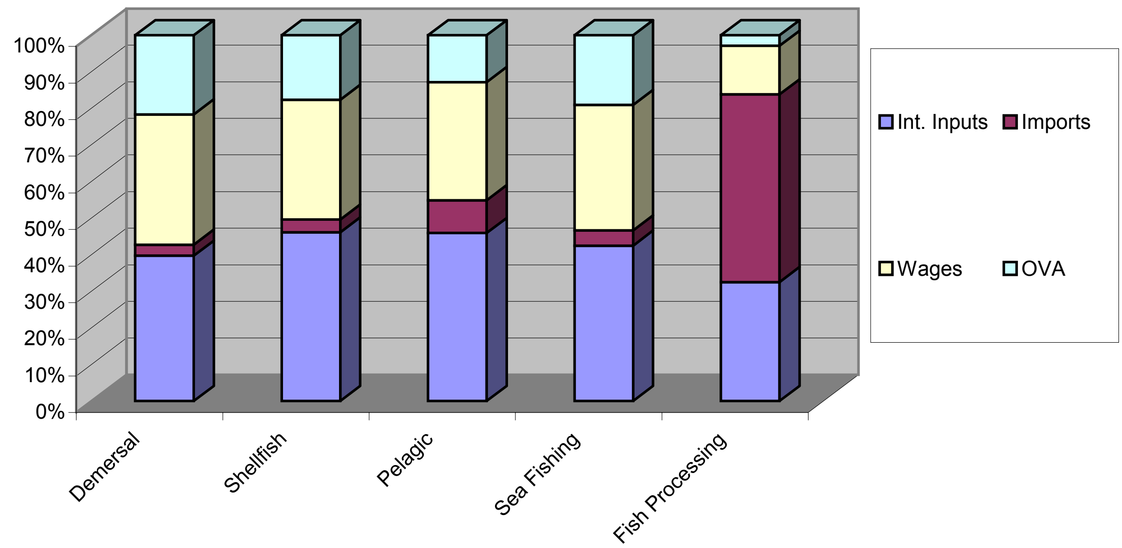


Figure 4.2 - Proportion of each input type in the UK



4.1.2 Employment multipliers

[105] The employment effects of increases in final demand and the standard demand-driven employment multipliers for Scotland and the UK are shown in Tables 4.3 and 4.4. The employment effects express the total increase in employment generated in the economy by a £1m increase in the final demand of a sector.

[106] The size of the *direct* employment effect is determined by the direct labour-intensity of the sector, that is to say the ratio of employment to gross output. If a sector is relatively labour-intensive then an increase in final demand of £1m will directly generate a relatively large amount of extra jobs in that sector. Indirect and induced effects on employment, analogous to those described previously, will then follow this direct effect.

Figure 4.3 - Inputs per employee in Scotland

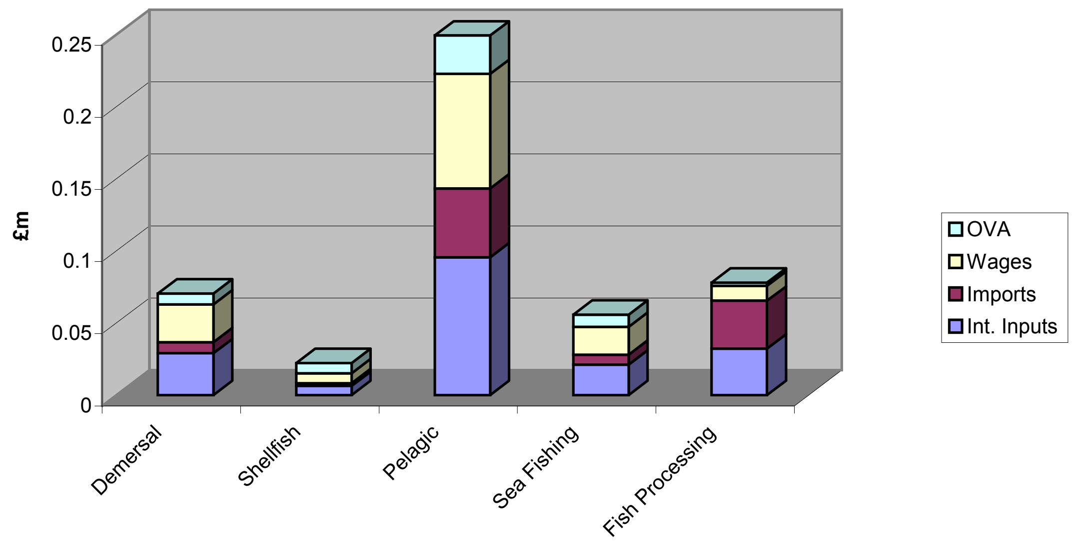


Figure 4.4 - Inputs per employee in the UK

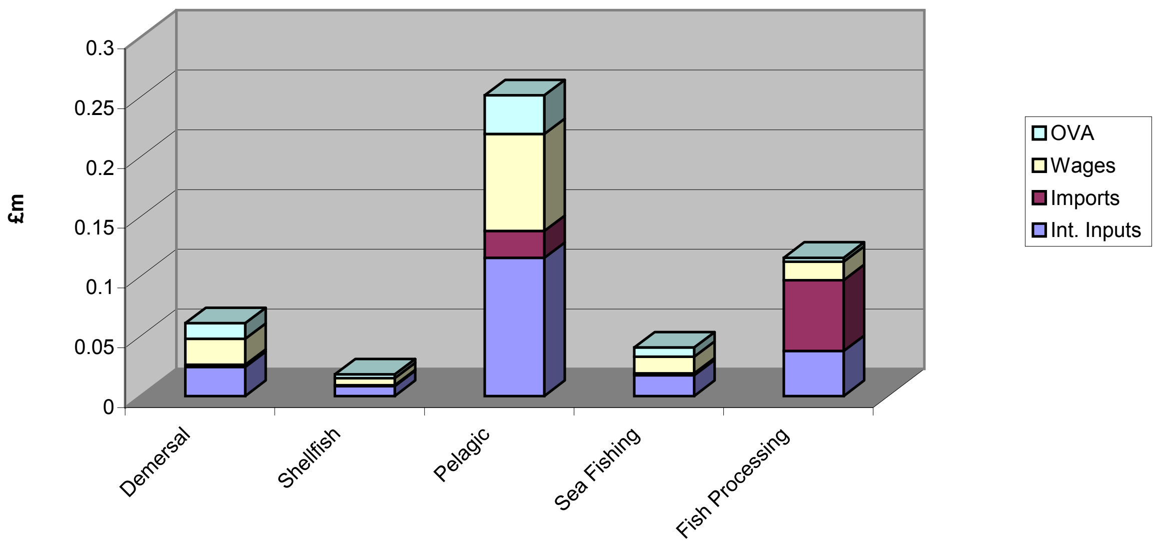


Table 4.3: Scottish employment multipliers

4.3(a) Scottish Type I employment multipliers

	Emp. Effect* Direct	Emp. Effect* Indirect	Employment Multiplier
Demersal	14.2	8.3	1.59
Shellfish	45.0	5.5	1.12
Pelagic	4.0	7.8	2.95
Sea Fishing	**17.9**	**7.6**	**1.42**
Fish Processing	**12.8**	**9.8**	**1.77**

4.3(b) Scottish Type II employment multipliers

	Emp. Effect* Direct	Emp. Effect* Indirect+Induced	Employment Multiplier
Demersal	14.20	15.6	2.10
Shellfish	45.0	11.1	1.25
Pelagic	4.0	14.3	4.56
Sea Fishing	**17.9**	**14.3**	**1.80**
Fish Processing	**12.8**	**14.1**	**2.10**

*effect per £1m increase in final demand

Table 4.4: UK employment multipliers

4.4(a) UK Type I employment multipliers

	Emp. Effect* Direct	Emp. Effect* Indirect	Employment Multiplier
Demersal	16.4	8.8	1.53
Shellfish	55.5	10.4	1.19
Pelagic	4.0	10.1	3.53
Sea Fishing	**24.7**	**9.4**	**1.38**
Fish Processing	**8.7**	**10.2**	**2.18**

4.4(b) UK Type II employment multipliers

	Emp. Effect* Direct	Emp. Effect* Indirect+Induced	Employment Multiplier
Demersal	16.4	29.9	2.82
Shellfish	55.5	31.8	1.57
Pelagic	4.0	31.1	8.82
Sea Fishing	**24.7**	**30.6**	**2.24**
Fish Processing	**8.7**	**21.7**	**3.51**

* effect per £1m increase in final demand

[107] Tables 4.3 and 4.4 reveal that there are wide variations in employment generation for £1 million increases in final demand amongst the Sea Fishing and Fish Processing sectors. For the fishing sectors, Shellfish has by far the largest employment effects in both Scotland and the UK. Including induced effects (Table 4.4), an increase in final demand for Shellfish of £1m will lead to 56 additional jobs in the Scottish economy and 87 in the UK economy.

[108] This may seem a strange result for Scotland, given that Table 4.1 indicates that the Scottish Shellfish sector has the lowest level of inter-industry linkages (as shown in its output multipliers). However, the high employment effect is explained by the fact that Shellfish is the most labour intensive of all the Sea Fishing and Fish Processing sectors. This is clear from studying Figures 4.3 and 4.4. These Figures show the total inputs per employee, broken down by input type, for each sector. However, from the accounting identities on which I-O tables are based, a sector's total inputs equal its total outputs. Therefore, those sectors showing low total inputs per employee have low output per employee and a corresponding high level of employment per unit of output. Inputs per worker are lower in the Shellfish sector than the other Sea Fishing and Fish Processing sectors. The Pelagic sector, on the other hand, has a relatively high output per employee and therefore has the lowest employment effect.

[109] The employment multipliers express the total increase in employment generated in the economy by one additional job in a sector. The Pelagic sector has the highest employment multipliers in both Scotland and the UK, and the Shellfish sector the lowest. This is a reversal of the results for employment effects but is expected: labour-intensive sectors tend to have high employment effects and low employment multipliers, especially if labour-intensity is combined with a low wage. Intuitively, this is because the creation of an additional job in a labour intensive sector will require a lower increase in final demand, and therefore will have a lesser effect on the economy, than the creation of an additional job in a capital-intensive sector. This is discussed in greater depth in Section 2.3.

[110] The Type I Demersal employment multiplier is larger in Scotland (1.59) than in the UK (1.53), even though the Type I output multiplier is lower in Scotland. This is probably due to the fact that the Demersal sector in Scotland is slightly less labour-intensive than in the UK (as shown in Figures 4.3 and 4.4). Although imports per employee are higher for the Demersal sector in Scotland than in the UK as a whole, the wage and intermediate inputs per employee are higher too. However, when induced effects are taken into account the UK Demersal sector has a higher employment multiplier (2.82 in the UK as opposed to 2.10 in Scotland).

4.1.3 Income and value added multipliers

[111] Income and value added multipliers for Scotland and the UK are shown in Tables 4.5 and 4.6.

Table 4.5: Scottish income and value added multipliers

	Type I		Type II	
	Income	Value Added	Income	Value Added
Demersal	1.49	1.54	1.84	2.11
Shellfish	1.38	1.27	1.71	1.60
Pelagic	1.53	1.56	1.90	2.12
Sea Fishing	**1.48**	**1.47**	**1.83**	**1.98**
Fish Processing	**2.42**	**2.74**	**2.99**	**3.72**

Table 4.6: UK income and value added multipliers

	Type I		Type II	
	Income	Value Added	Income	Value Added
Demersal	1.58	1.58	2.81	3.01
Shellfish	1.73	1.76	3.08	3.40
Pelagic	1.73	1.85	3.08	3.65
Sea Fishing	**1.64**	**1.66**	**2.92**	**3.20**
Fish Processing	**2.30**	**2.74**	**4.09**	**5.50**

[112] The income multipliers express the total increase in wage income generated in the economy by a £1m increase in wage income in a particular sector. The Fish Processing sector has the highest income multipliers for both Scotland and the UK, a result shared with the previous Sea Fishing I-O study (Greig, 2000). This is due to two factors – its comparatively higher level of inter-industry linkages (in Scotland) and its proportionately lower share of spending on wages and salaries. The multiplier values indicate that an increase in Scottish Fish Processing wage income of £1m will lead to a total increase of £2.99m wage income in the economy as a whole (including induced effects), with a similar effect of £4.09m in the UK.

[113] The value-added multipliers express the total increase in value added generated in the economy by an increase in value added in a particular sector of £1m. As with the income multipliers, the Fish Processing sector, with a lower proportionate level of value added than the Sea Fishing sectors, has the highest value added multipliers.

4.2 Multiplier effects of a £1m change in landings

4.2.1 Landings by "foreign" fleet

[114] First we consider the impact on the domestic economy of an additional £1m landings by "foreign" vessels. By "foreign" we simply mean non-domestic, so that for Scotland, "foreign" means the rest of the UK and the rest of the world: for the UK, "foreign" means the rest of the world. A change in foreign landings has two effects: a direct impact on the output of the Fish Processing sector, and a backwards impact on the sectors that supply Fish Processing.

[115] The direct impact of a £1m increase in foreign landings on Fish Processing output is £1.479m in both Scotland and in the UK. The derivation of these results is given in Appendix 3. The backward impact is found by adjusting this demand downwards to avoid including the indirect impact Fish Processing has on itself, and by producing new output and employment multipliers for the Fish Processing sector under the assumption that it does not purchase domestic fish. Creating these new multipliers is extremely important – in this section we are considering the impact of landings only, and ignoring the backwards link between Fish Processing and Sea Fishing.

[116] Table 4.7 shows that £1m foreign landings support £1.44m output in the Scottish economy and £2.00m output in the UK economy when indirect and induced (Type II) effects are included. In terms of employment these landings support 19 jobs in Scotland and 21 in the UK.

Table 4.7: Impact on the Scottish and UK economies of £1m foreign landings

	Scotland		UK	
	Output (£m)	Employment	Output (£m)	Employment
Type I	1.25	16.18	1.37	12.87
Type II	1.44	18.65	2.00	21.05

4.2.2 Landings by "domestic" fleet

[117] When considering the effect of £1m landings by domestic vessels, we simply take the effect of £1m landings by foreign vessels and add the additional effect caused by the purchases of the domestic boats. Therefore, the results for "domestic" landings will be larger than for "foreign" landings because with "domestic" landings we incorporate the backward links of the Sea Fishing sector with the domestic economy. This is achieved using the appropriate output multipliers from section 4.1.1. The results are shown in Tables 4.8 and 4.9 (where Sea Fishing is the aggregate catching sector).

[118] The output effects are similar regardless of which type of fish is analysed. In Table 4.8, the Type II output supported by £1m domestic landings in Scotland varies from £4.36m if the landings are Shellfish to £4.69m if they are Demersal. In the UK the Type II output supported varies from £5.43m (Demersal) to £5.55m (Shellfish). The reason for this reversal is that Demersal has the highest output multiplier in Scotland and Shellfish the lowest, but in the UK this is the exact opposite. The supported Type II employment ranges from 50 in Pelagic to 88 in Shellfish for Scotland, and from 56 in Pelagic to 108 in Shellfish for the UK. Shellfish landings support more employment because the sector is the most labour-intensive Sea Fishing sector: more workers are demanded for Shellfish landings than for the other fish types.

Table 4.8: Impact on the Scottish economy of £1m domestic landings

4.8(a) Type I results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	2.93	14.20	24.50
Shellfish	2.73	45.01	21.68
Pelagic	2.88	4.01	24.02
Sea Fishing	**2.87**	**17.94**	**23.79**

4.8(b) Type II results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	3.67	14.20	34.28
Shellfish	3.34	45.01	29.79
Pelagic	3.56	4.01	32.93
Sea Fishing	**3.57**	**17.94**	**33.00**

Table 4.9: Impact on the UK economy of £1m domestic landings

4.9(a) Type I results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	3.14	16.42	21.63
Shellfish	3.25	55.53	23.31
Pelagic	3.25	3.98	22.93
Sea Fishing	**3.18**	**24.69**	**22.30**

4.9(b) Type II results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	5.43	16.42	50.97
Shellfish	5.55	55.53	52.80
Pelagic	5.53	3.98	52.17
Sea Fishing	**5.48**	**24.69**	**51.66**

4.2.3 Landings by a composite fleet of "foreign" and "domestic" vessels

[119] In this section we analyse the output and employment supported by £1m landings by a composite of vessels, assuming that the proportion of "foreign" and "domestic" vessels is the same as it was in 1998. These results are very similar to the results for domestic vessels because, in general, domestic vessels made up the vast majority of landings in 1998. Therefore, the Sea Fishing multipliers are reduced only slightly and the reduction in Sea Fishing's backward links with the rest of the economy is relatively small.

[120] As before, the output effects are similar regardless of which type of fish is analysed. In Scotland the Type II output supported by £1m composite landings varies from £3.08m if the landings are Shellfish to £3.37m if they are Demersal. In the UK the Type II output supported varies from £4.90m (Pelagic) to £5.49m (Shellfish). The supported Type II employment for £1 million of composite landings ranges from 34 in Pelagic to 67 in Shellfish for Scotland, and from 50 in Pelagic to 107 in Shellfish for the UK.

Table 4.10: Impact on the Scottish economy of £1m composite landings

4.10(a) Type I results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	2.70	12.27	23.37
Shellfish	2.52	38.86	20.93
Pelagic	2.66	3.46	22.95
Sea Fishing	**2.65**	**15.49**	**22.75**

4.10(b) Type II results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	3.37	12.27	32.15
Shellfish	3.08	38.86	28.27
Pelagic	3.27	3.46	30.98
Sea Fishing	**3.28**	**15.49**	**31.04**

Table 4.11: Impact on the UK economy of £1m composite landings

4.11(a) Type I results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	2.88	14.01	20.35
Shellfish	3.22	54.65	23.15
Pelagic	2.91	3.27	21.14
Sea Fishing	**2.99**	**22.00**	**21.27**

4.11(b) Type II results

	Output (£m)	Employment At Sea	Employment Onshore
Demersal	4.92	14.01	46.59
Shellfish	5.49	54.65	52.30
Pelagic	4.90	3.27	46.65
Sea Fishing	**5.10**	**22.00**	**48.32**

4.3 Impact of the complete removal of Sea Fishing and Fish Processing

[121] This section considers the Type II impact on the domestic economy of completely removing the Sea Fishing and Fish Processing sectors. For this analysis it is assumed that the purchases of Sea Fishing output by other sectors in Scotland and the UK are replaced by imports, while those sectors which supply the Sea Fishing and Fish Processing sectors contract.

4.3.1 Removal of Sea Fishing only

[122] The impact on the Scottish and UK economies of removing their Sea Fishing sectors and replacing them with imports is shown in Tables 4.12 and 4.13. It is estimated that the Scottish Sea Fishing sectors support output, employment, income and value added amounting to £824.86m, 12,377 jobs, £244.45m and £379.21m respectively. In the UK the supported output, employment, income and value added is £2,095.95m, 35,016 jobs, £604.31m and £1,034.30m respectively. The higher impact of removal in the UK is due to two reasons: first, the Sea Fishing sector in the UK is larger so the direct impact is larger, and secondly, the Sea Fishing sectors have higher multiplier values in the UK than in Scotland.

Table 4.12: Impact on the Scottish economy of removal of the Sea Fishing sector

	Output (£m)	Employment Direct	Employment Indirect+Induced	Income (£m)	VA (£m)
Base level	137,973.59	7,166	1,835,458	38,254.62	60,356.78
New level	137,148.73	0	1,830,247	38,010.17	59,977.57
Difference	**824.86**	**7,166**	**5,211**	**244.45**	**379.21**

Table 4.13: Impact on the UK economy of removal of the Sea Fishing sector

	Output (£m)	Employment Direct	Employment Indirect+Induced	Income (£m)	VA (£m)
Base level	1,601,276.83	16,328	21,059,005	462,793.48	764,996.91
New level	1,599,180.87	0	21,040,316	462,189.17	763,962.61
Difference	**2,095.95**	**16,328**	**18,688**	**604.31**	**1,034.30**

4.3.2 Removal of both Sea Fishing and Fish Processing

[123] The Fish Processing sectors are larger than the Sea Fishing sectors and, as would be expected, removing these sectors reduces output, employment, income and value added by an even greater degree than when Sea Fishing alone is removed. The results are shown in Tables 4.14 and 4.15. It is estimated that Sea Fishing and Fish Processing support output, employment, income and value added in Scotland amounting to £1,885.54m, 26,110 jobs, £416.25m and £634.27m respectively. In the UK these sectors support £6,167.67m output, 77,791 jobs, £1,391.55m income and £2,290.58m value added.

Table 4.14: Impact on the Scottish economy of removal of the Sea Fishing and Fish Processing sectors

	Output (£m)	Employment Direct	Employment Indirect+Induced	Income (£m)	VA (£m)
Base level	137,973.59	17,553	1,825,071	38,254.62	60,356.78
New level	136,088.05	0	1,816,514	37,838.37	59,722.51
Difference	**1,885.54**	**17,553**	**8,557**	**416.25**	**634.27**

Table 4.15: Impact on the UK economy of removal of the Sea Fishing and Fish Processing sectors

	Output (£m)	Employment Direct	Employment Indirect+Induced	Income (£m)	VA (£m)
Base level	1,601,276.83	35,350	21,039,982	462,793.48	764,996.91
New level	1,595,109.16	0	20,997,541	461,401.93	762,706.33
Difference	**6,167.67**	**35,350**	**42,441**	**1,391.55**	**2,290.58**

4.4 Impact on the Scottish and UK economies of 25% and 50% changes in landings and in Fish Processing

[124] The impacts of 25% and 50% changes in landings ("foreign", "domestic" and "composite") and in Fish Processing on the Scottish and UK economies are shown in Tables 4.16 and 4.17.

Table 4.16: Impact on the Scottish economy of 25% and 50% changes in landings and in Fish Processing output

4.16(a) Results for a 25% change in landings into Scotland

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Foreign	13.99	0	181
Domestic	202.88	1,266	1,679
Composite	216.87	1,266	1,860
Type II			
Foreign	16.08	0	208
Domestic	252.11	1,266	2,329
Composite	268.19	1,266	2,537

4.16(b) Results for a 50% change in landings into Scotland

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Foreign	27.98	0	361
Domestic	405.76	2,532	3,358
Composite	433.74	2,532	3,720
Type II			
Foreign	32.16	0	416
Domestic	504.23	2,532	4,658
Composite	536.38	2,532	5,074

4.16(c) Results for 25% and 50% changes in Scottish Fish Processing output*

	25% Change		50% Change	
	Output (£m)	Employment	Output (£m)	Employment
Type I	320.99	4,364	641.97	8,728
Type II	382.66	5,178	765.33	10,356

*it is assumed that the increase in Fish Processing output is exported

Table 4.17: Impact on the UK economy of 25% and 50% changes in landings and in Fish Processing output

4.17(a) Results for a 25% change in landings into the UK

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Foreign	20.21	0	191
Domestic	385.30	2,987	2,698
Composite	405.50	2,987	2,889
Type II			
Foreign	29.65	0	312
Domestic	662.58	2,987	6,251
Composite	692.22	2,987	6,562

4.17(b) Results for a 50% change in landings into the UK

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Foreign	40.42	0	381
Domestic	770.60	5,974	5,396
Composite	811.01	5,974	5,777
Type II			
Foreign	59.31	0	623
Domestic	1,325.16	5,974	12,502
Composite	1,384.43	5,974	13,125

4.17(c) Results for 25% and 50% changes in UK Fish Processing output*

	25% Change		50% Change	
	Output (£m)	Employment	Output (£m)	Employment
Type I	848.03	9,868	1,696.06	19,737
Type II	1,316.34	15,872	2,632.68	31,745

*it is assumed that the increase in fish processing output is exported

4.4.1 Changes in landings

[125] The changes in landings were calculated using the impact of £1m landings in 1998 (from section 4.2) and total direct "foreign", "domestic" and "composite" landings in Scotland and in the UK in 1998. As Tables 4.16 and 4.17 show, the impact of changes in foreign landings are relatively small – for example, a 50% change in foreign (RUK and ROW) landings into Scotland, including induced effects, would change Scottish output and employment by £32.16m and 416 jobs respectively. This reflects the low level of direct foreign landings into Scotland in 1998, as compared to the domestic (Scottish) landings. Furthermore, foreign landings have a smaller backward impact on the domestic economy than domestic landings. For the UK the impact of a change in foreign landings is higher but still small. A 50% change generates (inclusive of indirect and induced effects) an increase in gross output of £59.31m and employment of 623.

[126] Changes in domestic and composite landings have very similar effects on the output and employment of the economy in both Scotland and the UK. For example, it is estimated that the Type II impacts of a 50% change in domestic landings in Scotland would be for Scottish output and employment to rise by £504.23m and 7,190 jobs respectively. In comparison, the 50% change in Scottish composite landings has an impact of £536.38m and 7,606 jobs.

[127] For the UK, the increase in activity generated by a 50% change in "composite" landings produces an increase in output of £1,384.47m and an employment change of 19,099. Nearly 70% of this additional employment is produced on shore, in the Fish Processing and other sectors affected indirectly through the expansion in landings.

4.4.2 Changes in Fish Processing

[128] The impacts of changes in the output of Fish Processing on the economy were calculated using Fish Processing output multipliers and employment effects. Using Type II multipliers, in Scotland a 50% change in Fish Processing output would lead to a total change in Scottish output of £765.33m and employment of 10,356 jobs. In the UK the impacts are predictably larger. The same proportionate change in Fish Processing output would lead to a change of £2,632.68m in UK output and 31,745 in UK employment. An interesting point is that there is a larger difference between Type I and Type II effects in the UK than in Scotland. The induced effects are clearly more important for the Fish Processing sector in the UK than in Scotland. Comparing the appropriate Scottish and UK multiplier values in Tables 4.1, 4.2, 4.3 and 4.4 backs this up.

4.5 Impact on the economy of 10% and 25% changes in Fish Processing's imports of fish

[129] The impacts on the economy of 10% and 25% changes in imports of raw fish to Fish Processing were calculated using information on Fish Processing's imports of fish in 1998 and its output multipliers and employment effects. It is assumed that the exogenous demands (exports, government etc.) for Fish Processing output will remain constant and that imported fish is a perfect substitute for domestic fish. Tables 4.18 and 4.19 show these impacts.

Table 4.18: Impact on the Scottish economy of 10% and 25% changes in imports of fish to Fish Processing

4.18(a) 10% change in imports

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Demersal	-31.70	-269	-157
Shellfish	-9.96	-304	-37
Pelagic	-14.35	-35	-69
Sea Fishing	**-55.91**	**-619**	**-262**
Type II			
Demersal	-42.17	-269	-296
Shellfish	-12.85	-304	-75
Pelagic	-18.65	-35	-126
Sea Fishing	**-73.51**	**-619**	**-495**

4.18(b) 25% change in imports

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Demersal	-79.24	-672	-394
Shellfish	-24.89	-761	-93
Pelagic	-35.88	-88	-173
Sea Fishing	**-139.79**	**-1,547**	**-656**
Type II			
Demersal	-105.43	-672	-739
Shellfish	-32.12	-761	-188
Pelagic	-46.63	-88	-314
Sea Fishing	**-183.79**	**-1,547**	**-1,237**

Table 4.19: Impact on the UK economy of 10% and 25% changes in imports of fish to Fish Processing

4.19(a) 10% increase in imports

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Demersal	-121.34	-1,125	-600
Shellfish	-70.40	-2,080	-391
Pelagic	-12.91	-27	-69
Sea Fishing	**-205.23**	**-2,786**	**-1,064**
Type II			
Demersal	-234.53	-1,125	-2,051
Shellfish	-132.71	-2,080	-1,189
Pelagic	-24.18	-27	-213
Sea Fishing	**-391.82**	**-2,786**	**-3,454**

4.19(b) 25% increase in imports

	Output (£m)	Employment Direct	Employment Indirect (+Induced)
Type I			
Demersal	-303.34	-2,813	-1,501
Shellfish	-176.01	-5,199	-977
Pelagic	-32.27	-68	-172
Sea Fishing	**-513.07**	**-6,964**	**-2,659**
Type II			
Demersal	-586.32	-2,813	-5,126
Shellfish	-331.78	-5,199	-2,973
Pelagic	-60.45	-68	-533
Sea Fishing	**-979.54**	**-6,964**	**-8,635**

[130] The size of the impact in the economy caused by replacing domestic purchases with imports depends on both the amount of purchases and the backward linkages of each fish type. The Fish Processing sector purchased more Demersal in 1998 than Shellfish or Pelagic, so the output effect is largest for changes in this sector's imports. However, in the UK the impact on employment is larger for Shellfish due its high labour-intensity. For Type II analysis, a 25% increase in Sea Fishing imports will produce a £183.79m impact on Scottish output and a 2,784 impact on Scottish employment. In the UK the equivalent impacts are £979.54 and 15,599 respectively.

4.6 Supply-driven multiplier effects

[131] The supply-driven I-O model multipliers are expressions of the change in gross output in the economy as a whole that accompanies a change in the value-added in one sector. In the demand-driven model, the multipliers can be calculated with consumption exogenous or endogenous, represented by Type I and Type II multiplier values. Similar possibilities apply in the supply-driven case. Labour supply can also either be exogenous or endogenous, with similar Type I and Type II labels. The assumptions that underpin this multiplier concept are discussed in Chapter 2, section 8. A number of health warnings should be issued here.

[132] The supply-driven multiplier applies to an economy that is severely supply constrained in all sectors. It is therefore totally inappropriate to add together demand-driven and supply-driven multiplier values. Where the demand-driven multiplier is appropriate to use, the supply-driven multiplier is completely inappropriate to use.

[133] In the supply-driven multiplier process, the fixed production coefficients that characterise the demand driven model are lost. It is therefore totally inaccurate to convert changes in output to changes in employment through using the base year employment-output coefficients.

[134] Further. the economic rationale for the assumptions made under the supply-driven multiplier have been extensively criticised (Oosterhaven, 1988).

Table 4.20: Scottish forward (supply-driven) output multipliers

	Demersal	Shellfish	Pelagic	Sea Fishing	Fish Processing
Type I	1.67	1.62	1.64	1.65	1.23
Type II	1.88	1.81	1.83	1.85	1.58

Table 4.21: UK forward (supply-driven) output multipliers

	Demersal	Shellfish	Pelagic	Sea Fishing	Fish Processing
Type I	2.15	2.16	1.89	2.12	1.50
Type II	4.70	4.74	4.01	4.64	4.66

[135] Tables 4.20 and 4.21 measure the extent to which the output of different forms of Sea Fishing and Fish Processing generate downstream effects by entering into the output of other sectors as intermediate inputs. As with demand-driven multiplier values, the Type II values will be greater than the Type I values because they incorporate labour as an intermediate input. Also we expect the UK values to be bigger than the Scottish values because we expect Scotland to be a more open economy with a bigger proportion of its output going to exports (rather than intermediate demand). These expectations are reflected in the results reported in the Tables.

4.7 Impact on the Scottish and UK economies of a 10% change in Sea Fishing labour efficiency

[136] An increase in labour efficiency in the Sea Fishing sector will reduce the cost of its output and therefore the price that it sells its product on to other sectors. If the reductions in costs in these sectors are similarly passed on in reduced prices, the costs to other sectors will also fall. The supply-driven multiplier can be used to identify these direct, indirect and induced price effects and measure how much costs will fall in aggregate and which sectors will

be most affected. Figures 4.5 to 4.8 show absolute and percentage reduction in costs experienced. As would be expected, Fish Processing is the only sector that experiences a sizeable percentage reduction in costs.

Figure 4.5 - Indirect Absolute Reduction in Total Costs Due to 10% Increase in Scottish Sea Fishing Labour Efficiency - Top 10 Ranked Sectors

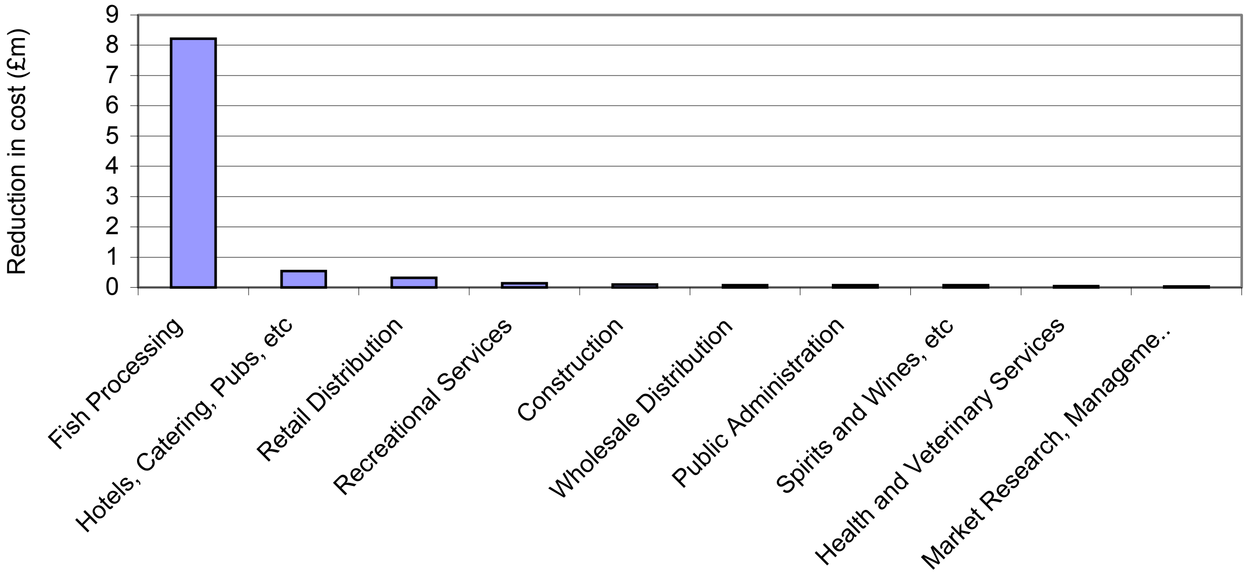


Figure 4.6 - Indirect Percentage Reduction in Total Costs Due to 10% Increase in Scottish Sea Fishing Labour Efficiency - Top 10 Ranked Sectors

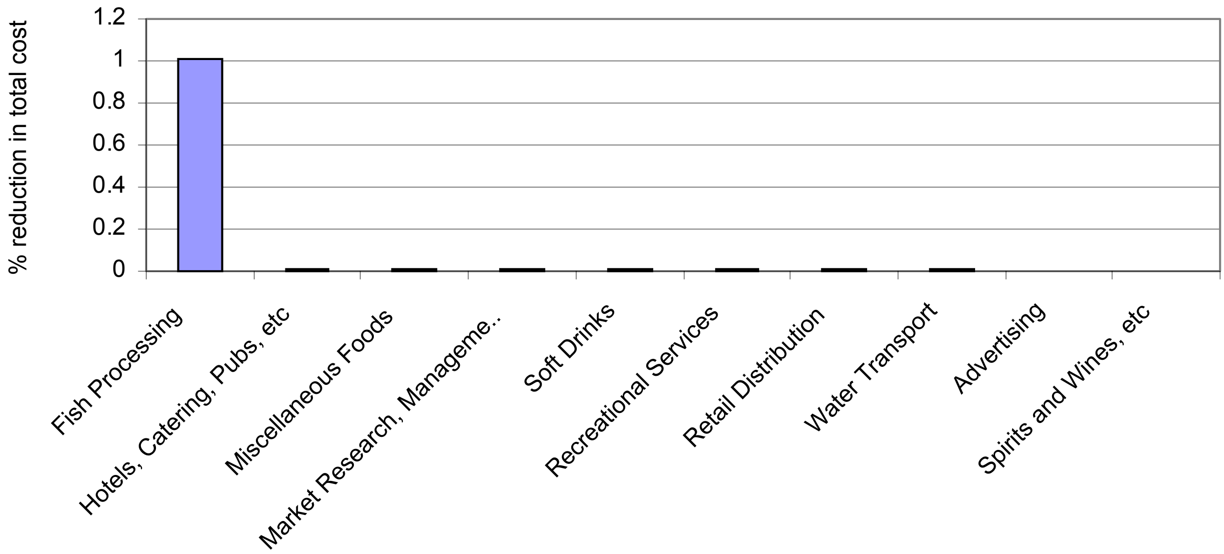


Figure 4.7 - Indirect Absolute Reduction in Total Costs Due to 10% Increase in UK Sea Fishing Labour Efficiency - Top 10 Ranked Sectors

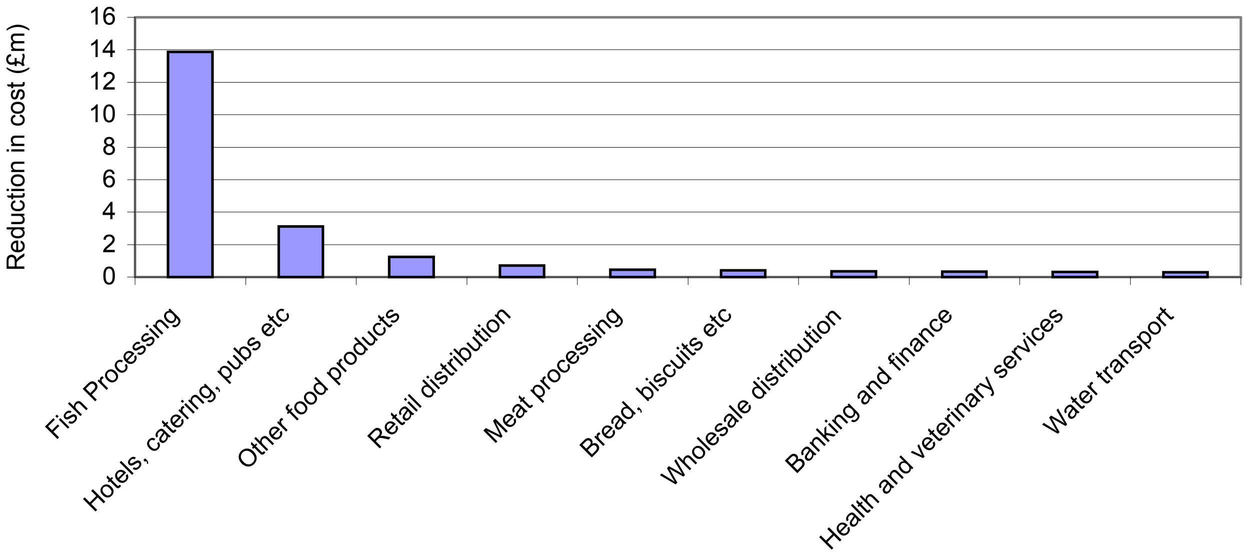
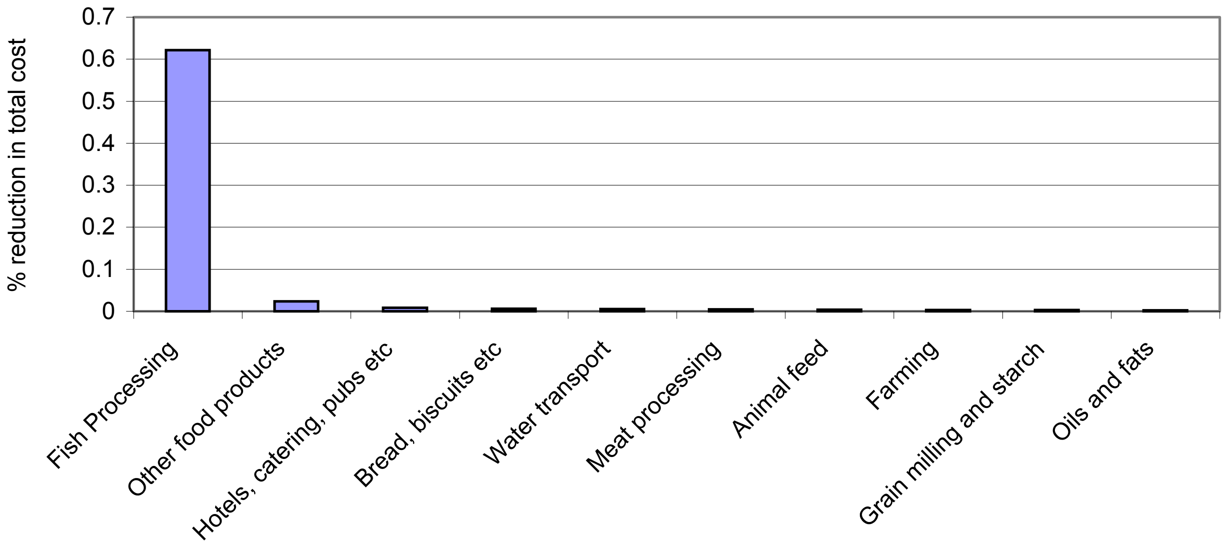


Figure 4.8 - Indirect Percentage Reduction in Total Costs Due to 10% Increase in UK Sea Fishing Labour Efficiency - Top 10 Ranked Sectors



Appendix 1: Multiplier Derivation

[137] A simplified standard I-O transaction matrix for an economy with n production sectors, and a vector of value added values and a final demand vector has the following form:

$$\begin{bmatrix} X & f & q \\ y^T & 0 & 0 \\ q^T & 0 & 0 \end{bmatrix}$$

where: X is the n × n matrix of intermediate sales and purchases where $x_{i,j}$ is the sales of sector i to sector j, f is the n × 1 final demand vector, q is the n × 1 gross output vector, and y^T is the 1 × n vector of value added inputs.

[138] All of these are conventionally expressed in value terms, and the following accounting identities hold.

$$Xi + f = q \quad \text{(A1.1)}$$

$$i^T X + y^T = q^T \quad \text{(A1.2)}$$

where i is an n × 1 vector of ones.

The demand driven multiplier

[139] If the elements x_{ij} of equation (A1.1) are replaced by $a_{ij}q_j$, where q_j is the output of industry j and $a_{ij} = \frac{x_{ij}}{q_j}$, the accounting identity (A1.1) can be replaced by:

$$Aq + f = q \quad \text{(A1.3)}$$

where A is an n × n matrix whose elements are a_{ij}.

[140] If Aq is subtracted from both sides of equation (A1.3), this produces:

$$f = q - Aq = (I - A)q \quad \text{(A1.4)}$$

where I is the n × n identity matrix..

[141] Post-multiplying both sides of equation (A1.4) by the inverse of the (I-A) matrix gives:

$$(I - A)^{-1} f = q \quad \text{(A1.5)}$$

The $(I-A)^{-1}$ is the Leontief inverse. This is used to calculate the vector of gross outputs, q, from the vector of final demands, f. Each element of the Leontief inverse, α_{ij}, measures the direct, indirect (and where appropriate induced) impact on sector i of a unit increase in the final demand for sector j. The sum of the elements of the jth column of the Leontief inverse is the output multiplier value for sector j.

The supply-driven multiplier

[142] If the elements x_{ij} of equation (A1.1) are replaced by $b_{ij}q_i$, where q_i is the output of industry i and $b_{ij} = \frac{x_{ij}}{q_i}$, the accounting identity (A1.1) can be replaced by

$$q^T B + y^T = q^T \quad \text{(A1.6)}$$

where B is an n × n matrix whose elements are b_{ij}.

[143] If $q^T B$ is subtracted from both sides of equation (A1.6), this produces:

$$y^T = q^T - q^T B = q^T (I - B) \quad \text{(A1.7)}$$

Post-multiplying both sides of equation (A1.7) by the inverse of the (I-B) matrix gives:

$$y^T (I - B)^{-1} = q^T \quad \text{(A1.8)}$$

[144] The $(I-B)^{-1}$ is the Ghoshian inverse. This is used to calculate the vector of gross outputs, q, from the vector of value added inputs y^T. Each element of the Ghoshian inverse, β_{ij}, measures the direct, indirect (and where appropriate

induced) impact on sector i of a unit increase in the value added of sector j. The sum of the elements of the ith row of the Ghoshian inverse is the Ghoshian output multiplier value for sector i.

Hybrid approach (Johnson and Kulshreshtah, 1982; Papadas and Dahl, 1999)

[145] To begin, assume that the first k sectors are output constrained. Equation (A1.1) is amended to:

$$\begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} \bar{q}_1 \\ q_2 \end{bmatrix} + \begin{bmatrix} f_1 \\ \bar{f}_2 \end{bmatrix} = \begin{bmatrix} \bar{q}_1 \\ q_2 \end{bmatrix} \qquad \text{(A1.9)}$$

where $\bar{q}_1$ is the k × 1 vector of constrained (exogenous) outputs, q_2 is the (n-k) × 1 vector of endogenous outputs, f_1 is the k × 1 vector of endogenous final demands and $\bar{f}_2$ is the (n-k) × 1 vector of exogenous final demands. A_{11} is a k × k matrix, A_{12} is a k × (n-k) matrix, A_{21} is an (n-k) × k matrix and $A_{22}$is an (n-k) × (n-k) matrix of input coefficients.

[146] From equation (A1.9) we get two equations:

$$A_{11}\bar{q}_1 + A_{12}q_2 + f_1 = \bar{q}_1 \qquad \text{(A1.10)}$$

$$A_{21}\bar{q}_1 + A_{22}q_2 + \bar{f}_2 = q_2 \qquad \text{(A1.11)}$$

[147] We can solve first for the endogenous outputs, that is the q_2 vector, using equation (A1.10). Subtracting $A_{22}q_2$ from both sides gives

$$A_{21}\bar{q}_1 + \bar{f}_2 = q_2 - A_{22}q_2 = \left[1 - A_{22}\right]q_2 \qquad \text{(A1.12)}$$

[148] Pre-multiplying both sides of (A1.12) by the inverse of the matrix $[1\text{-}A_{22}]$ produces the result:

$$\left[1 - A_{22}\right]^{-1}\left[A_{21}\bar{q}_1 + \bar{f}_2\right] = q_2 \qquad \text{(A1.13)}$$

[149] This value for the endogenous outputs can then be used to determine the endogenous final demands. Subtracting $A_{11}\bar{q}_1 + A_{12}q_2$ from both sides of equation (A1.10) generates:

$$f_1 = \bar{q}_1 - A_{11}\bar{q}_1 - A_{12}q_2 = \left[I - A_{11}\right]\bar{q}_1 - A_{12}q_2 \qquad \text{(A1.14)}$$

[150] Substituting equation (A1.13) into equation (A1.14) gives

$$f_1 = \left[I - A_{11}\right]\bar{q}_1 - A_{12}\left[1 - A_{22}\right]^{-1}\left[A_{21}\bar{q}_1 + \bar{f}_2\right] \qquad \text{(A1.15)}$$

[151] In this report, when we quantify the impact of landings we link landings to the output of both the Sea Fishing sector and the Fish Processing sectors. The details are presented in Appendix 2. Represent these two sectors as sectors 1 and 2 respectively and identify their outputs by appropriate superscripts ($\bar{q}_1^1, \bar{q}_1^2$). The relationship between exogenous landings and the exogenous outputs are then:

$$\begin{bmatrix} \bar{q}_1^1 \\ \bar{q}_1^2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ \lambda_2 & \lambda_2 & \lambda_2 \end{bmatrix} \begin{bmatrix} \bar{\ell}_D \\ \bar{\ell}_F \\ m \end{bmatrix} - \begin{bmatrix} \bar{k}_1 \\ 0 \end{bmatrix} \qquad \text{(A1.16)}$$

where $\bar{\ell}_D$ represents domestic landings of domestic vessels and $\bar{\ell}_F$ represents the domestic landings of foreign (non-domestic) vessels and m is the imports of raw fish into Fish Processing. $\bar{k}_1$ is the amount of the output of the domestic fleet landed in non-domestic ports and λ_2 the ratio of the output of the Fish Processing sector to the inputs of raw fish.

[152] Express equation (A1.16) as:

$$\bar{q}_1 = L\bar{\ell} - \bar{k} \qquad \text{(A1.17)}$$

where L is the 2 × 3 matrix of landing coefficients and $\bar{\ell}$ is the 3 × 1 vector of exogenous domestic landings and raw fish imports and $\bar{k}$ is the 3 × 1 constant vector. If equation (A1.17) is now substituted into equation (A1.13), the exogenous outputs are determined as

$$\left[1 - A_{22}\right]^{-1}\left[A_{21}\left[L\bar{\ell} - \bar{k}\right] + \bar{f}_2\right] = q_2 \qquad \text{(A1.18)}$$

[153] The endogenous final demands for Sea Fishing and Fish Processing can similarly be expressed as a function of the landings vector by substituting equation (A1.17) into equation (A1.15) producing

$$f_1 = \left[I - A_{11}\right]\left[L\bar{\ell} - \bar{k}\right] - A_{12}\left[1 - A_{22}\right]^{-1}\left[A_{21}\left[L\bar{\ell} - \bar{k}\right] + \bar{f}_2\right] \qquad \text{(A1.19)}$$

[154] In point of fact, the procedure adopted here is a little more complex than this in that the Sea Fishing sector is disaggregated by the three fish types, but the extension is straightforward.

Appendix 2: Additional details on the construction of the appropriately-disaggregated I-O Tables

Construction of balanced industry-by-industry UK Input-Output tables

[155] Information on industry linkages between domestic sectors and purchases from outwith the UK was drawn from the 1998 I-O accounts compiled by the Office for National Statistics (ONS). The UK accounts included a table showing the purchases of all goods and services made by domestic industrial sectors; this was called the use table. A second table showed the purchases of all goods and services by UK final markets such as consumers' expenditure and exports.

[156] To construct an I-O model the import content of the above purchases had to be removed to provide estimates of domestic purchases. This was undertaken for all domestic industrial sectors and all final demand markets except exports. Import penetration coefficients were calculated for all goods and services. The value of the coefficients was the ratio of total purchases of imports divided by total purchases for all goods and services. This is shown in equation (A2.1) below:

$$p_i = \frac{m_i}{x_i} \qquad \text{(A2.1)}$$

where: p_i is the import penetration coefficient for product i, m_i is the total domestic purchases of imports of product i, and x_i is the total domestic purchases of product i.

[157] By multiplying the final demand markets and use table by the vector of import penetration coefficients, a set of domestic final demand markets and use table can be estimated. This is shown in equations (A2.2) and (A2.3).

$$x_{ij} = \hat{p}_i s_{ij} \qquad \text{(A2.2)}$$

$$f_{ik} = \hat{p}_i t_{ik} \qquad \text{(A2.3)}$$

where: s_{ij} is the total purchases of products i by industrial sector j, x_{ij} is the domestic purchases of product i by industrial sector j, t_{ik} is the total purchases of product i by final demand markets k, and f_{ik} is the domestic purchases of product i by final demand market k.

[158] The resulting matrices x, f, and a set of purchases of primary inputs, including the separated imports, gave the domestic use table. To produce a table of industrial sector purchases from industries, the domestic use table needed to be multiplied by a make table. The make table shows the value of all the goods and services produced by each industrial sector. Unfortunately the 1998 UK make table was not made publicly available and therefore had to be estimated. Data for the share of a sector's principal product from total production within the sector was available. Information on secondary and by-products was not published.

[159] However a fully balanced industry-by-industry table for 1998 Scotland was available. Therefore UK non-principal production for each sector was distributed to secondary and bi-products on the same basis as for Scotland. This was reasonable as the non-estimated principal production for 104 of the 123 UK sectors accounted for 80% or more of total production.

[160] The domestic industry-by-industry table was calculated as shown in equations (A2.5) and (A2.6) below:

$$X_{ij} = m_{ji} x_{ij} \qquad \text{(A2.5)}$$

$$Y_{ik} = m_{ji} f_{ik} \qquad \text{(A2.6)}$$

where: m_{jii} is the proportion of product i produced by sector j, X_{ij} is the domestic purchases from industrial sector i by industrial sector j and Y_{ik} is the domestic purchases from industrial sector i by final demand market k.

[161] Matrices X, Y and the set of purchases of primary inputs provided the domestic industry by industry table. Although the table now provided the required inter-industry transactions it was not balanced. That is, the sum of

purchases by each sector (domestic and primary inputs purchases) did not equal the sum of sales by each sector (domestic and final demand market sales).

[162] A RAS procedure was applied to the matrices X_{ij} and Y_{ik}, the set of primary inputs including imports was assumed to be correct. The total sales for each sector were constrained to the value of total sectoral purchases. Then the total domestic purchases were constrained to the value of total sectoral purchases minus purchases of primary inputs. This iterative process was repeated until the difference between the RAS produced total sectoral sales and total sectoral purchases, from the original accounts, was less than 0.5% for all sectors.

Table A2.1: Description of I-O sectors to which Sea Fishing expenses are allocated

IO	SIC	Description
8	15.1	Production, processing and preserving of meat and meat products
14	15.81 - 15.82	Bread, rusks and biscuits; manufacture of pastry goods and cakes
17	15.85 - 15.89	Other food products (tea, coffee, condiments, soups, etc.)
18.1	15.91 - 15.95	Spirits and wines
18.2	15.96 - 15.97	Beers and ales
19	15.98	Production of mineral waters and soft drinks
26	17.52 – 17.54	Manufacture of rope, twine, net, nonwovens, narrow fabrics and other textiles
28	18	Wearing apparel (workwear, outerwear, underwear, etc.)
30	19.3	Footwear
31	20	Wood and wood products, except furniture (boxes, semi-finished wood products, etc.)
33	21.2	Articles of paper and paperboard (bags, cartons, stationery, etc.)
35	23	Coke oven products, mineral oil refining, other treatment of petroleum products (excluding petrochemicals manufacture)
43	24.4	Pharmaceuticals, medicinal chemicals and botanical products
44	24.5	Soap and detergents
48	25.2	Plastic products
62	29.1	Manufacture of engines, pumps, compressors, taps, valves and bearings
70	31.1 - 31.2	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus
78	35.1	Building and repairing of ships and boats
85	40.1	Production and distribution of electricity
90	51	Wholesale and commission trade, except of motor vehicles and motor cycles
91	52	Retail trade, except of motor vehicles and motor cycles, repair of personal goods
92	55	Hotels and restaurants
94	60.2 - 60.3	Other land transport (railways, coaches, taxis, etc.), transport via pipelines
95	61	Water transport
97	63	Cargo handling, storage and warehousing and other supporting transport activities
101	66	Life insurance, pension funding and non-life insurance
105	70.3	Real estate activities on a fee or contract basis
114	74.5 - 74.8	Other business services (employment agencies, security agencies, photographic studios, etc.)
120	91	Activities of membership organisations (professional and business organisations, trade unions, etc.)

Appendix 3: Details of the calculations in section 4

A3.1 Impact on economy-wide output and employment of £1m landings

[163] The impact of additional £1m landings on the economy will depend on whether the landings are made by foreign vessels, domestic vessels, or by a mix of the two. Landings by foreign vessels have an impact on the Fish Processing sector only, whereas landings by domestic vessels will have an additional backward impact caused by the vessels' purchases of domestic goods and services.

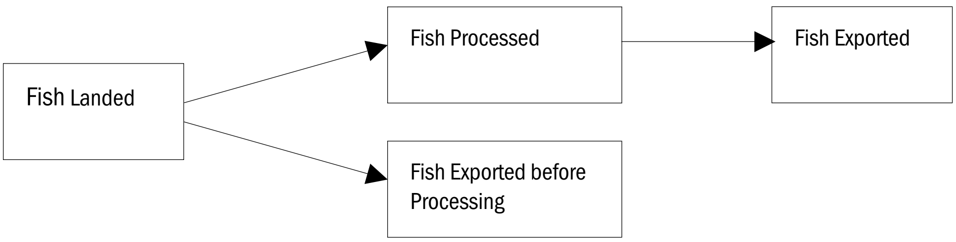
[164] From the "Financial Flows in the Scottish Sea Fisheries Industry" document and from information provided by the steering group, we have the following information:

Table A3.1: Fish inputs and sales of Scottish and UK Fish Processing sector (£m)

	Scotland	UK
Total fish inputs to the Fish Processing sector (£m)	548.54	1,487.20
Total sales of the Fish Processing sector (£m)	811.45	2,200.00

[165] Therefore, the ratio of fish inputs to total sales for the Fish Processing industry is 1.479 in both Scotland and the UK. Therefore, each £1m fish landed from a foreign boat leads to a total of £1.479m direct gross output in the Scottish and UK economies (because 811.45/548.54 = 1.479). For the purposes of this analysis we assume that:

- each type of fish leads to exactly the same amount of direct Fish Processing output (so that the results for foreign landings are presented for Sea Fishing alone and not for different types), and
- the Fish Processing sector is entirely supply-driven so that any additional landings are processed in the same proportions as in 1998 and then exported or displace imports:



[166] Using Scotland as an example, we can calculate the impact of £1m landings by a foreign vessel using the following formula:

(Amount Of Landings) * (Direct Output Effect) * (Fish Processing backward multiplier with zero purchases from Sea Fishing, adjusted for exports before processing)

[167] The Fish Processing multipliers with no purchases of fish were created by adjusting the appropriate column coefficients in the A-matrix downwards to zero. An additional £1m landings will increase the output of the Fish Processing sector by more than £1m due to indirect effects (purchases of the sector from itself). Therefore, the £1m landings figure had to be adjusted downwards before it could be used in the above formula to avoid double counting these indirect effects. This was achieved by dividing £1m by the total impact on the Fish Processing sector caused by a £1m increase in demand (the element in the Fish Processing row and column of the Leontief inverse).

[168] For example, the appropriate elements in the Scottish Leontief inverses are 1.051 (Type I) and 1.053 (Type II). Dividing £1m by £1.051m and by £1.053m means the necessary increases in landings are £0.951m and £0.950m. Using the Fish Processing backward output multipliers, with no purchases of fish and adjusted for landings after exports, of 0.891 (Type I) and 1.025 (Type II) we can find the total impacts on the Scottish economy of £1m landings by foreign vessels.

- Type I impact: 0.951 * 1.479 * 0.891 = 1.253
  £1.253m additional output
- Type II impact: 0.950 * 1.479 * 1.025 =1.440
  £1.440m additional output

[169] The impact on employment can also be calculated. This is achieved by multiplying each element in the Fish Processing column of the Leontief inverse by each sector's employment/output coefficient, summing over all sectors and multiplying again by 0.951 and 0.891 (for Type I) or 0.950 and 1.025 (for Type II).

[170] This extra activity is caused solely by the backward linkages of the Fish Processing sector. There is no additional impact caused by the Sea Fishing sector itself because the foreign vessel is assumed not to have any direct purchases in the domestic economy. However, if the £1m landings were by a domestic vessel, then there would be an additional impact caused by the purchases of that vessel. We can calculate the impact of £1m landings of each fish type by adding each type's multiplier effect, i.e. the extra backward linkages of the domestic vessels.

[171] To calculate the impact on output of £1m landings by a domestic vessel we take the impact of a foreign vessel (calculated above) and add the appropriate output multiplier:

$$\left(\left(\begin{array}{l}\text{Amount}\\ \text{Of}\\ \text{Landings}\end{array}\right) * \left(\begin{array}{l}\text{Direct}\\ \text{Output}\\ \text{Effect}\end{array}\right) * \left(\begin{array}{l}\text{Fish Processing backward multiplier with zero}\\ \text{purchases from Sea Fishing, adjusted for}\\ \text{exports before processing}\end{array}\right) \right) + \left(\begin{array}{l}\text{Fishing}\\ \text{Output}\\ \text{Multiplier}\end{array}\right)$$

[172] To calculate the employment effect we take the impact on employment of a foreign vessel and add the appropriate employment-output multiplier.

[173] We calculate the impact of composite landings by assuming that any composite landings will have the same proportion of domestic and foreign landings as in 1998. The steering group provided the following information:

Table A3.2: Composite landings information (£m)

	Scotland	UK		
	Aggregate	Demersal	Shellfish	Pelagic
Total fish purchases by the Processing sector from domestic landings only	203.61	217.9	119.1	21.8
Total fish purchases by the Processing sector from domestic plus foreign landings	235.80	255.3	121.0	26.5
Proportion of total landings that are domestic	0.863	0.854	0.984	0.823

[174] For example, we assume that, in Scotland, £0.863m of £1m landings of any fish type is by a Scottish vessel.

[175] The impact of composite landings on economy-wide output is calculated by multiplying the appropriate proportion by the standard output multiplier for each fish type and adding the impacts of the Fish Processing sector (with zero fish purchases):

$$\left(\left(\text{Amount of Landings}\right) * \left(\text{Direct Output Effect}\right) * \left(\text{Fish Processing backward multiplier with zero purchases from Sea Fishing, adjusted for exports before processing}\right) \right)$$

$$+ \left(\left(\text{Fishing Output Multiplier}\right) * \left(\text{Proportion of Domestic Vessels}\right) \right)$$

[176] To calculate the employment effect we take the employment generated by £1m landings by a foreign vessel and add the appropriate employment-output multiplier (again multiplied by the appropriate proportion).

A3.2 Impact on economy-wide output and employment of shutting down the entire Sea Fishing and Fish Processing sectors

[177] Removing an entire sector involves removing the sales and purchases of the sector, i.e. replacing the row and column entries in the I-O table with zeros. The output, income and employment generated *in the economy as a whole* without the sector can then be compared with the output, income and employment generated when the sector is included. We undertook this analysis using the Type II Leontief inverse.

A3.2.1 Sea Fishing sectors only

[178] Under this scenario the output of the fishing sectors are zero. We assume that all domestic purchases of fish are replaced by purchases of imported fish.

A3.2.2 Sea Fishing and Fish Processing sectors

[179] In this scenario the outputs of both sectors are zero. Output before and after removal of a sector is calculated by multiplying the Leontief inverse by the vector of final demands (consumer expenditure, government, exports, etc). We had to adjust the exports of Sea Fishing to account for its increased sales to Fish Processing that were imposed by the creation the new Fish Processing column. We have assumed that what are now sales of Sea Fishing to Fish Processing were previously Sea Fishing exports, and have therefore subtracted the additional sales

to Fish Processing from Sea Fishing exports. The new export figure was then used as part of the final demand of Sea Fishing in the calculation of output before removal.

A3.3 Impact on economy-wide output and employment of 25% and 50% changes in landings and in Fish Processing output

A3.3.1 Landings

[180] We already have information on the impact of £1m landings for different fish types and for different types of landings (foreign, domestic or composite). The total impact of landings on output or employment can be found by multiplying the £1m impact by the total value of landings. The changes in landings are analysed for the aggregate Sea Fishing sector only.

[181] For example, for foreign landings in Scotland, the Type I impact of £1m foreign landings on the output of the Scottish economy in 1998 was £1.25m, and the Type II impact £1.44m[1]. Total foreign landings in 1998 were £44.64m[2], so that the total Type I impact of these foreign landings on the Scottish economy was £55.95m, and the Type II impact £64.31m. The impact on Scottish output of a 25% change in foreign landings would therefore be £13.99m (Type I) and £16.08m (Type II). A 50% change would have an impact of £27.98m (Type I) and £32.16m (Type II).

[182] The impacts on employment of these landings are calculated by multiplying foreign landings by the Type I and Type II impacts on employment of £1m foreign landings.

A3.3.2 Fish Processing

[183] The impact of a change in the output of Fish Processing can be calculated by applying the Fish Processing multiplier to that change. For example, for Scotland we have a total output of the Scottish Fish Processing sector in 1998 of £811.45m[3], and backward output multipliers of 1.66 (Type I) and 1.98 (Type II). As before, it was necessary to adjust the size of the £1m landings downwards to avoid double counting the indirect and induced effects on the Fish Processing sector itself. Dividing £811.45m by the same elements of the Leontief inverses as before (1.051 for Type I, 1.052 for Type II), gives £771.96m (Type I) and £771.27m (Type II). Multiplying these adjusted total outputs by 0.25 and 0.5 and then applying the standard backward output multipliers of the Fish Processing sector provides the impact on the economy of 25% and 50% changes in Fish Processing output.

[184] The impact on employment can be derived by replacing Fish Processing's output multiplier by its employment-output multiplier in the above calculation.

A3.4 Impact on economy-wide output and employment of 10% and 25% changes in Fish Processing imports

[185] In these scenarios we assume that the Fish Processing sector increases its imports of fish by 10% and 25%, replacing domestic fish purchases. We split the additional imports amongst the three fish types using the proportions of domestically purchased fish (e.g. if Demersal purchases comprise 40% of the Scottish Fish Processing sector's purchases of domestic fish, then 40% of the increased imports will be Demersal). Again to maintain consistency we have used the steering group's estimates of Fish Processing imports.

[186] Firstly, we split Fish Processing imports into Demersal, Shellfish and Pelagic using the initial domestic purchasing shares of the Fish Processing sector. The impact on the economy arises through the reduction in domestic fish output, so we then take each type of fish's change in imports and multiply it by its output multiplier (for the impact on economy-wide output) and its employment-output multiplier (for the impact on economy-wide employment).

A3.5 Impact on economy-wide output and employment of a 10% increase in Sea Fishing labour productivity

[1] All figures in the report have been rounded to two decimal places.

[2] From "Financial Flows in the Scottish Sea Fisheries Industry".

[3] To maintain consistency with the landings simulations, we have used steering group's figures for Fish Processing output rather than the figures from the I-O table.

[187] A 10% increase in labour productivity was modelled by analysing the impact on other sectors in the economy of a 10% reduction in the expenditure on wages and salaries of the Sea Fishing sectors. The figures for Sea Fishing wages were taken from the newly created I-O columns (the data for which can be found in Tables 2.3A and 2.4A). We assume that the impact of this reduction in labour costs means that the Sea Fishing sectors can sell on their product at a lower price; therefore, the greatest impact in terms of a reduction in costs will be on those sectors that purchase from Sea Fishing. The reductions in total cost for each sector are found by multiplying the reduction in Sea Fishing labour costs by each element of the supply-driven Ghoshian inverse. This procedure follows Dietzenbacher (1997).

[188] We only present type I results because, in any Type II supply-side analysis, labour must be considered as an endogenous part of the model. Therefore, in Type II analysis an increase in labour efficiency cannot be considered as an exogenous shock to the model.

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