Economic Frameworks for policy-relevant analysis of the Software Sector in Scotland

Report on the design, compilation and implementation of a Software Satellite Account for Scotland and a Scottish Information Technology Labour Accounting Matrix

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Report to Scottish Enterprise

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Background:

This report is the outcome of a study undertaken for Scottish Enterprise, to explore the feasibility of constructing a Software Satellite Account for Scotland. The project was directed by Professor Iain McNicoll working with Ursula Kelly of the University of Strathclyde and ran from March – May 2003. The study was undertaken to assist Scottish Enterprise in the formulation of a new vision for the Scottish Software industry, by providing a new approach to ways of measuring the economic significance of the Scottish Software industry. The study is intended to be complementary to that undertaken for Scottish Enterprise by Mr Nigel Kay and Professor Andrew McGettrick *Scottish Software Game Plan – Some Fundamental Considerations Explored*.

Section One

Developing the pilot Software

Satellite Account for Scotland

Introduction

Measuring the economic role of the 'software sector' or the 'software industry'
continues to present significant challenges for statisticians and for policy-makers.

The Kay and McGettrick report highlighted some of the issues raised as a result of the
pace of technological development. Software is fast becoming an 'embedded' part of
many products and processes and previously clear distinctions between hardware and
software are in many cases becoming blurred. The fast-changing and increasingly
ubiquitous nature of software means that software-type activity cannot be captured
within a single Standard Industrial Classification (SIC) but permeates a very broad
range of SICs. A commonly accepted definition of 'the Software industry' has yet to
be developed. The OECD has commented that:

 " *From a statistical perspective, software raises issues that are at the heart of the
transformations associated with the growth of the information economy.*"[1]

These include difficulties in clearly identifying all software activity since the
production and development of software and software services is carried out across
many industries not formally identified as 'software' producers or suppliers.[2]

The definitional problems presented by software has led to a wide variance in
estimation processes across all OECD countries. The recently released *Report of the
OECD TaskForce on Software Measurement in the National Accounts* (March 2003)

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[1] *The Software Sector: A Statistical Profile for Selected OECD Countries* OECD 1998
[2] Such as accounting firms and management consultancy firms (Ibid)

makes a number of detailed proposals intended to harmonise ways of estimating 'software investment' in the National Accounts so that international comparisons can be made; there is increasing recognition that a common international interpretation of which products and services should be treated as 'software' needs to be developed.

Identifying and quantifying the Software Sector in Scotland also presents a number of challenges. However the growing significance of Software activity in Scotland makes it of policy importance to develop a credible and methodologically sound way be able to observe and quantify its economic impact and inter-relation with other industries. In particular, for policy-makers seeking to target investment to support software sector growth, a framework that can enable examination of the Software sector as an economic phenomenon, help to define its scope and significance and enable comparisons with other industries, is a crucial aid to decision-making.

This study therefore sought to create an economic statistical framework for evaluation of Software sector activity through the construction of a pilot Software Satellite Account for Scotland. The present study was necessarily partly a scoping exercise. It sought to:

- Investigate if the construction of an SSA was possible and develop the specifications of an SSA for Scotland
- To build a pilot SSA using relevant extant data,
- Identify the further data generation required for implementation of the fully specified SSA.
- To conduct some initial analyses using the pilot SSA

The project has succeeded in its aims of specification of an SSA framework for Scotland and the construction of an actual pilot SSA for Scotland, which in itself can be used for a wide range of analyses. A number of analyses using the pilot SSA have been conducted. These analyses provide 'real world' quantitative examples of at least some of the applications of a fully specified Scottish SSA based model and are intended to demonstrate and clarify both for stakeholders and for a more general audience what can be done with a full SSA. However in themselves the results are new and are of some policy-relevance in their own right as the authors are unaware of any previous thorough impact analysis of the sectors concerned having been undertaken in Scotland. The report also provides an indication of the next steps required for implementation of a fully specified SSA together with additional insights into further potential developments that could assist in the identification of the skills embodied in software sector activity in Scotland.

Satellite Accounting

Satellite Accounting is an internationally recognised methodological tool, described and legitimised by the United Nations in the System of National Accounts (SNA) 1993, for measuring phenomena which are of genuine policy interest but which do not fit very well into extant 'core' national accounting systems. Satellite Accounting is now being used in countries across the world to address the need to measure a wide range of policy-relevant economic activity that is not separately identified or disaggregated within their National Accounts. Examples of such applications include Environmental Satellite Accounts and Tourism Satellite Accounts. [3]

 A Satellite Accounting approach is particularly suitable to enable the study of a phenomenon such as the 'Software industry', since this method of Accounting is specifically designed to provide modes of analysis for complex phenomena which the conventional and traditional methods cannot encapsulate.

In its essence, a Software Satellite Account is an ancillary set of economic accounts, compatible with National Economic Accounts, which highlights and emphasises the software and software-related industries, thereby enabling the user to focus in on and analyse aspects of the 'Software sector' in the economy. [4]

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[3] The fast growing use of Satellite Accounting for measuring the economic role of Tourism is a case in point and the UN (working with the OECD, WTO and Eurostat) developed a key reference manual for this in 2001 the *Tourism Satellite Account: Recommended Methodological Framework.*. The first Tourism Satellite Account for Scotland has recently been developed by Professor McNicoll for the Scottish Executive, Visit Scotland and Scottish Enterprise.

[4] As far as the authors are aware, this is the first time that Satellite Accounting Techniques have been applied to the Software Sector, although there are examples of the application of Satellite Accounting to various other aspects of the 'information economy' (*Eg Methodological foundations of the Satellite Account of Information in the System of National Accounts* Jozef Olenski, Warsaw University and the National Bank of Poland 2001)

Development of the pilot Software Satellite Account

The development of the pilot Software Satellite Account for Scotland followed three fundamental principles:

- Conformity with international Satellite Accounting Standards

- Adaptability to Scotland's circumstances

- Feasibility of compilation for Scotland

It was constructed through both extending and reconfiguring the Scottish Input Output Tables, which are the most comprehensive sets of economic accounts for Scotland. The Input Output Tables are produced by the Scottish Executive and the most recent published tables are for 1999.[5]

Identifying the 'software industry' in Scotland

As has earlier been discussed, there are considerable difficulties associated with identifying software activity within the economy. The 1999 Scottish Input-Output Tables comprise 128 Industry sectors, which cover the totality of Scottish Economy However the 'software industry' is a complex phenomenon that encompasses a very broad range of industrial classifications and software sector activity will be subsumed within a wide range of industries. Currently there is no single specific definition or formal industrial classification of the 'software industry'.

To design an appropriate framework for the SSA therefore, the first steps were to identify which current Scottish industries may incorporate substantial software sector activity. Given the current complexities surrounding any definition of software sector activity, it is clear that a path had to be steered between too broad or too narrow an identification. Too narrow an identification (e.g. *only* including industries such as 'reproduction of computer software media' and 'software consultancy') runs the risk of considerable areas of 'software sector' activity being omitted. Conversely, too broad an identification (following the 'spirit' of the suggestion that software is now ubiquitous and is used, adapted or developed in almost every industry in one way or another) can end up making any definition of the 'software industry' thereby derived meaningless, since it will in effect comprise the whole economy.

'Core' software sector industries

The team therefore sought to be sensibly inclusive but at the same time fairly specific in the identification of industries that could comprise 'core' software sector activity to be highlighted within the SSA.

This was done by conducting 'keyword' searches of SIC classifications and other international schema, including NACE and ISIC, to identify industries that were likely to be software sector-related. (It should be remembered that SICs are compiled according to the primary activity of the industry in question and therefore any industry identified in this way must by definition be undertaking a considerable proportion of software type activity.) Independently conducted keyword searches produced a similar set of 'core' industries at 4 digit SIC level. The SIC codes for these industries were then mapped to the Scottish Input-Output Table classification of

industries. The SICs identified as 'core' and their mapping to I/O industries are shown

in Table1 below.

Table 1: Mapping of 'Core' Software Industries to the Scottish I/O classifications

Core Software Industry			Scottish I/O Table 1999	
Description	SIC 92	ISICRcv 3	SIC 92	Description
Reproduction of Computer Software Media	22.33	2230s	22	Printing and Publishing
Manufacture of Unrecorded Media	24.65	2429s	24.6	Other Chemical Products
Manufacturing of Computers and other ICT	30.02	3000	30	Office Machinery & Computers
Wholesale of Office Machinery & Computers	51.64	5150s	51	Wholesaling
Retail of Computers & Non-custom software	52.48/2	5239s	52	Retailing
Renting of Office Machinery incl computers	71.33	7123	71	Renting Machinery
Computer Services: Hardware consultancy	72.10	7210	72	Computer and Related Services
Computer Services: Software Consultancy	72.20	7220	72	Computer & Related Services
Computer Services: Data processing	72.30	7230	72	Computer & Related Services
Computer Services: DataBase Activities	72.40	7240	72	Computer & Related Activities
Computer Services: Computer Repair/Maintenance	72.50	7250	72	Computer & Related Activities
Computer Services nec	72.60	7290	72	Computer & Related Activities

'Software-linked' industries

The next step towards deciding which other industries should be highlighted within the SSA was to identify which 4-digit level SIC industries may have *close linkages* with the 'core' software industries in terms of inter-industry purchases and sales or which may comprise *some* software sector activity, although this may not be the primary activity of that SIC.

This is important, since the software sector does not exist in a vacuum, but will interact to a greater or lesser extent with other industries. Observing which other industries it interacts with most and least is important in identifying the degree of economic dependence and inter-dependence that may be involved, which is of key importance in assessing the sector's role in the Scottish economy.

The authors' expert judgment and knowledge of the Scottish economy was applied to further identify potential candidates as 'software-linked' industries. These industries were also mapped to the Scottish Input-Output table classifications of industries. The identified SICs and their mapping to Scottish I/O industries are outlined in Table 2 below.

Table 2: Mapping of 'Software-linked' Industries to Scottish I/O classifications

Software-linked Industries   **Scottish I/O Table 1999**

Description	SIC 92	ISICRcv 3	SIC92	Description
Manufacture of Paper Containers	21.21/2	2102p	21.2	Articles of Paper
Manufacture of Paper	21.23	2109s	21.2	Articles of Paper
Manufacture of Paper products nec	21.25	2109s	21.2	Articles of Paper
Publishing books and Journals	22.11-13	2211/12	22	Printing & Publishing
Publishing Sound recordings	22.14	2213	22	Printing & Publishing
Other Publishing	22.15	2219	22	Printing & Publishing
Printing	22.21-25	2221/2	22	Printing & Publishing
Manufacture of Office Machinery	30.01	3000	30	Office Machinery & Computing
Manufacture of TV,CD & Videos	32.20	3230	32.3	TV,CD & Videos
Manufacture of Toys and Games nec	36.50/2	3694p	36.4/5	Sport Equipment, Games, Toys
Agents specialising in the sale of goods nec	51.18	5110s	51	Wholesale
Other Wholesale	51.70	5190	51	Wholesale
Retail of Office Supplies	52.47	5239s	52	Retailing
Retail via mail order	52.61	5251	52	Retailing
Business/management consultancy	74.14	7414s	74.13/14 74.2	Business Consulting nec
Architect/Engineer/Technical Consultancy	74.20	7421	74.2/3	Technical Consultancy
Technical Testing & Analysis	74.30	7422	74.2/3	Technical Consultancy
Recruitment of Personnel	74.5	7491	74.5-8	Other Business Services
Education	80	80	80	Education*
Picture & Video Production	92.11	9211s	92	Recreation & Culture
Picture/Video Distribution	92.12	9211s	92	Recreation & Culture
Library & Archive Activities	92.51	9231	92	Recreation & Culture

The two completed mappings enabled the identification of the Input-Output industries that should be highlighted within the SSA.

Construction of the pilot SSA

The Scottish Software Satellite Account has been compiled as a purpose-designed 'extended Input-Output system' comprising 2 core matrices, the first of which is an 'internal satellite', the second is an 'external satellite'.

a) The inter-industry monetary flows matrix (an internal satellite)

b) An occupation by industry matrix (an external satellite).

Explaining the internal satellite: the inter-industry flows matrix

An 'internal satellite' extension is essentially the disaggregation and/or regrouping of pre-existing data already contained or subsumed within the basic Input-Output table. The most recent (1999) Scottish Input-Output tables contain transactions data for 128 separately identified industries and 11 'final' markets. The classifications of industries and markets follows recognised international conventions, notably the Standard Industrial Classification (SIC). For many analyses of the Scottish Economy this is sufficient. However, as earlier discussed, software sector activity does not confirm exactly, or in totality, to a number of specific classifications but is spread across a wide number of classifications.

Therefore the inter-industry monetary flows matrix in the pilot SSA has been developed as an internal satellite extension to the existing I/O tables. It separately identifies all of the I/O sectors that the team considered to include core software and software-linked activity and aggregates the other sectors of the economy so that it is possible to begin to 'zoom in' on software industry activity within the economy.

The inter-industry monetary flows matrix provides a complete picture of the monetary transactions for goods and services for the SSA base year of 1999, which reveals the relationship between the producers and consumers of products and services and the extent to which industries may be interdependent.

The separately identified I/O sector industries, which analysis suggests subsume some form of software sector or software-linked activity, are highlighted below.

Paper Products

Printing, Publishing

Other Chemical Products

Computers/office machinery

TV/Video

Sport,games,toys

Wholesaling

Retailing

Renting machinery

Computing Services

R &D

Other Business Consultancy

Technical Consultancy

Other Business Services

Education

Recreation

The remaining sectors in the inter-industry monetary flows matrix represent the 'rest of the economy' and have been aggregated as follows:

Primary

Extraction

Food,Drink & Tobacco

Textiles,clothing, footwear

Timber, Pulp, paper

Oil/Chemical Products

All other manufacturing

Utilities

Construction

Motor distribution

Post

Telecomms

Banking/Finance

All other services

It will be noted from the mapping of the identified 4-digit SICs to the I/O sector industries that there remains a fairly high degree of aggregation involved for the sectors under study.

The current make-up and disaggregation level of the Scottish Input-Output tables is to a large degree reflective of the industries which have been important to Scotland in the past – there is considerable disaggregation of manufacturing industries for example and very little disaggregation of new growth industries such as computing

services. [6]This factor currently limits the level of disaggregation possible within the pilot Software Satellite Account in terms of industries.

However the pilot SSA framework is constructed so that as and when the necessary data can be obtained at a more disaggregated level, this can be incorporated to create a fuller SSA. Details of the desirable incremental data and where further development could be usefully undertaken are summarised in Appendix 5.

Explaining the External Satellite: the occupation by industry matrix

The internal satellite matrix of the SSA details the operating sales and purchases made among the identified industries and between these industries and the rest of the economy. The principal outcomes of descriptive and modelled analyses are quantified in terms of industry gross outputs (which for most industries is approximately the same as the value of annual turnover). However, in many cases, "gross output" is not the activity measure of immediate policy relevance. For example 'numbers of people employed' is frequently a key policy variable. Therefore the second core component of the SSA is a purpose-designed 'external satellite matrix' of occupations by industry. This external satellite increases the scope of the SSA by introducing new data on variables and dimensions of interest which are not contained or subsumed within the I/O table and therefore could not be contained within an internal satellite.

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[6] This is an issue which is under discussion at the Scottish Economic Consultants' Advisory Group of the Scottish Executive, prompted by consideration of the knowledge economy, Tourism and other growth areas of the Scottish Economy.

The external occupation by industry satellite is compatible with the Input-Output table and with the internal inter-industry monetary flows satellite and is linked to it via suitably defined bridging coefficients. It enables analysis of the employment and occupations within the selected industries.

The Occupation by Industry matrix was purpose-designed with the same set of industries (core and software-related) industries being highlighted. The team were able to utilise their access to an extensive database of occupations by Scottish industry [7] and apply judgement on which occupations across the identified industries are most likely to be relevant to software activity as producers or users. These were separately identified and highlighted within the pilot SSA, with remaining occupations aggregated. The highlighted occupations are listed below at SOC 3-digit level, with the remaining occupations aggregated to SOC 1-digit level.

	126	Computer/systems managers
	179	Service sector managers
	191	Educ. Registrars
Other SOC 1		(Managers)
	212	Electrical Engineers
	213	Electronic Engineers
	214	Software Engineers
	216	Design/Develop Engineers
	218	Qual Control Engineers
	230	HE Teachers
	231	FE Teachers
	232	Educ. Inspectors

233 **Secondary Teachers**

234 **Primary Teachers**

235 **Special Teachers**

239 **Other Teachers**

270 **Librarians**

Other SOC 2   (Professionals)

302 **Electric/Electronic Technicians**

320 **Computer Analysts/Programmers**

330 **Air Traffic Controllers**

381 **Artist/Graphic Designer**

390 **Information Officers**

Other SOC 3   (Associate Professionals)

452 **Typist/Word Processor**

490 **Computer Operators**

Other SOC 4   (Secretarial/Clerical)

517 **Precision Instrument Makers**

526 **Computer Engineers**

Other SOC 5   (Craft & Related)

All SOC 6   (Personal & Protective Services)

All SOC 7   (Sales Occupations)

All SOC 8   (Plant/Machine Operatives)

All SOC 9   (Other)

The two core matrices being in place, the pilot SSA is complete as a set of integrated

economic accounts giving a snapshot of the Scottish economy in the chosen base year,

with software and software-related activity highlighted and brought to the fore.

Section Two

Preliminary Modelled Analyses using the pilot Scottish Software Satellite Account

Methodology

As noted previously, the Scottish Software Satellite Account (SSSA) is essentially a snapshot of the Scottish economy in the chosen base year, highlighting software and software- related elements of interest. As such, the accounts themselves can be used for various *descriptive* analyses relating, for example, to the absolute size of the "software sector" in terms of output, income or employment, and to its relative share of Scottish economic activity as a whole.

However, beyond description lies *modelling*, and it is possible to derive an economic model from the SSSA which very substantially increases the range and scope of analyses which can be undertaken to help to identify and quantify the "true" underlying economic significance of the software sector to the Scottish economy. In particular, the construction of an appropriately specified quantitative model allows:

(a) Detailed and comprehensive analyses of the "impact" of the software sector in the base year in terms of economic activity *generation*, including estimates of summary industry "multipliers" and measures of industry backward and forward linkages.

(b) Analyses for *other* than the base year involving scenario simulations relating to actual and/or putative developments in the software sector. In this mode, the model is being used for straight economic *forecasting*, or to assist in both ex ante and ex post *policy formulation and evaluation*. In all cases the model will provide estimates of "effects" which are economy-wide, detailed and internally-consistent.

The derivation of a model from the accounts involves the imposition of a particular economic theoretical vision (expressed in the form of behavioural and technical assumptions) and empirical estimation of the resulting required variables and parameters. The specific theoretical framework employed in this study is that encapsulated in the **Input-Output Model**. In the present context, the main advantages of the Input-Output (I/O) model include:

1. The basic I/O system has been in existence for over 50 years, and is now recognised internationally as a legitimate "standard" modelling framework for applied economic analysis. Indeed, the originator of I/O analysis (Wassily Leontief) won the Nobel Prize in economics for his pioneering efforts.

2. Since the early 1990's, the Scottish Executive has compiled the core annual Scottish national accounts in the form of Input-Output tables and has used I/O theory to produce estimates of Scottish industry output, income and employment multipliers. Given this official imprimatur, I/O is used extensively by academic and professional economists for a wide range of analyses of the Scottish economy and the outcome results are accepted as valid and relevant by public and private sector clients and the media.

3. Partly with points (1) and (2) in mind, the SSSA has been compiled as a purpose-designed "extended Input-Output system" comprising a core I/O table and a labour market satellite. Hence, an appropriate I/O model *can* be constructed from the base year SSSA, with the quantitative parameter and variable estimates ultimately being derived from official statistics.

In summary, while the I/O model is not the only one which could be derived from an SSSA, its theoretical and practical advantages in context strongly justify its use. [8]

A brief mathematical summary of the I/O framework used in the present study can be provided. Here, it is sufficient to note that the core I/O model is of the conventional "Type II" variety. In this context, Type II means that households are (technically) treated as equivalent to an industry, supplying labour services in return for employment income and demanding consumer products as inputs to produce labour. While this interpretation may seem a little forced, it is in fact the essential mechanism through which the important household income-expenditure knock-on effects are captured in the model. The bridge between the core I/O model and the labour market satellite is also conventional, and is made in terms of industry *employment-output coefficients* defined in terms of physical employment per unit of money output.

Finally, industry employment in each occupation is estimated by base year occupation shares coefficients.

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[8] It can be noted that empirical implementation of other models that are sometimes used for analyses of the Scottish economy (such as Keynesian regional multiplier or computable general equilibrium) would also require data from the SSSA accounts. Hence, quantification of the SSSA is not only of merit in its own right, but is an essential prerequisite for any subsequent modelling work.

The Base Year impact of defined pilot SSSA core software sectors.

As discussed in detail elsewhere in the report, the industry classification in the pilot SSSA is constrained to that available in the 1999 Scottish Input-Output tables, especially in terms of the maximum degree of disaggregation possible. It has also been noted that the 128 sector schema used in these tables is, in general, not sufficiently fine-grained to identify and quantify the majority of specific sectors defined as "core software" or "software related". Thus, it is not possible at present to undertake modelled analyses of the software sector at the levels of detail and accuracy ultimately desired (but noting this is an issue of data availability, not model specification).

However, there are two sectors in the existing pilot SSSA which conform, or come very close to conforming, to the requirement for inclusion as core software sectors. These are:

SIC 92 30 *Manufacture of office machinery and computers.* In a more detailed version of the SSSA, one might wish to define one component of this (SIC 30.02, manufacture of computers and ICT) as core software and the other (SIC 30.01, manufacture of office machinery) as software-linked, but clearly, virtually the entire industry is "software related" in the broadest sense.

SIC 92 72 *Computer and Related Service Activities.* In this case, there is no question that **all** of this industry would be defined as core software on any reasonable criteria.

The only issue is that greater disaggregation to at least 3-digit SIC level would be highly desirable in the context of the SSSA.

Hence, in the remainder of this section, results will be presented and discussed relating to the combined impact of SICs 30 and 72 on the Scottish economy in the base year of 1999 as estimated using the pilot SSSA model. In terms of the present report, there are three principal motivating factors for undertaking this exercise:

(i)   at a general level, it provides illustrative, but "real world", quantitative examples of at least some of the potential applications of a fully-specified SSSA based model.

(ii)   In terms of the specific case study, to the authors' knowledge no thorough impact analysis of what might loosely be described as the "entire Scottish computer industry" has been undertaken previously; hence the results obtained are new, and of some policy relevance in their own right.

(iii)   Again in terms of the specific case study, the results will provide some assistance in identifying where incremental resources for development of future versions of the SSSA could be most efficiently targeted (for example, in defining and identifying "software-linked" industries).

Before considering the detailed results, it is necessary to explain precisely what "impact" is being measured, since the concept employed here is a more comprehensive one than that generally utilised in such exercises. To be specific, the large majority of extant industry impact analyses in Scotland (including most of those of the authors) quantify the knock-on (or multiplier) effects arising from an industry's local *purchases* required to make its sales to specified *final markets*.

"Purchases" are all the operating expenditures on Scottish goods and services (including labour services) arising in the process of production, and "final markets" are those which are **not** other Scottish industries, which in the present context (and remembering households are treated as an "industry") are essentially government, investment, and interregional and international exports.

In short, the impact usually measured refers to the knock-on effects generated by an industry's local operating expenditures arising from its sales to particular markets. In the language of development economics, these are termed *backward linkage effects.* The archetypal industry envisaged in this scenario is one which purchases local commodities as inputs and exports 100% of its output.

It will be immediately obvious that this definition of impact is, at least *ab initio,* an excessively restrictive one when applied to the Scottish software, or ICT, industries, since a key characteristic of these sectors is that they do in fact *make significant proportions of their sales to other Scottish industries.* Hence, one would wish to specify an impact methodology which would allow that, at least in principle, knock-on effects on Scottish economic activity can arise from the software sector's local inter-industry sales as well as its inter-industry purchases. Indeed, such a specification becomes essential if (a) the scenario under analysis envisages that local purchasers are critically supply-dependent on the Scottish software sector; that is, that they cannot find readily available import substitutes [9] or (b) if the analysis is concerned with the transmission of technology/expertise embodied in the sales of Scottish software products to other local industries.

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[9] For a Scottish case study of this type, see McGregor and McNicoll *The Impact of Forestry on the Output of the UK and its member countries* Regional Studies Vol 26 No.1 1991

Multiplier impacts arising from local inter-industry sales are termed *forward linkage effects.* Hence, for the Scottish software sector the desired impact methodology will capture:

> Knock-on effects arising from local operating expenditures = backward linkage effects

And

> Knock-on effects arising from local sales to other industries = forward linkage effects

From which

> Total impact = backward linkage impact + forward linkage impact

Hypothetical Extraction

There are a number of different methods by which total impact as defined above can be measured, but one of the most intuitively appealing and technically elegant is that known as *hypothetical extraction.* Put simply, this method provides a quantitative answer to the following question:

" What would have been the base year levels of Scottish economic activity if industry X had not existed in Scotland in that year?"

Thus, the counterfactual scenario is the calculated base year in the *absence* of industry X, and the total impact of industry X is measured as the difference between simulated and actual base year activity levels.

The hypothetical extraction method requires more work on the part of the analyst, since the entire I/O model has to be re-calibrated and re-calculated for each specific

scenario; however, having done so, it provides one-pass estimates of the required total impact (i.e. backward+forward linkage effects) which are comprehensive and internally consistent, and, though not applied here, the method can be readily adapted to incorporate any critical supply dependencies required in the scenario under examination.

Given its merits in the present context, the hypothetical extraction method has been applied to the pilot SSSA model to calculate the impact on the Scottish economy in 1999 of the two software sectors described above as the quantified response to the following question:

" What would have been the levels of Scottish economic activity in 1999 if industries SIC 30 and SIC 72 did not exist in Scotland in that year?"

A summary of the key results by industry is given in Table 3 immediately below.

Table 3 The Total Impact of Specified Core Software Sectors on the Scottish Economy

in 1999: Industry results

SSSA Industry	Impact on:		Simulated/actual ratios
	Gross Output (£M)	Employment (FTE)	
Printing/Publishing	15.0	224	0.988
Office/computer Manufacture	6744.0	16476	0.0
Utilities	65.1	184	0.987
Motor Distribution	86.8	1464	0.968
Wholesaling	245.3	4079	0.939
Retailing	111.5	3253	0.979
Post	10.8	317	0.985
Telecommunications	32.8	217	0.984
Banking/Finance	114.0	874	0.988
Computer Services	1484.7	16730	0.0
R & D	8.3	192	0.972
Other business consultancy	47.3	703	0.919
Other business services	158.8	5983	0.926
All other industries	658.2	8691	
Whole economy	**9782.6**	**59387**	

Total Employment Income   1465.8

*Note: impact is measured as actual output/employment less simulated

output/employment.

The first results column of table 3 shows that the combined contribution of the

computer manufacture and computer services industries (henceforth "software sector"

for brevity) to Scottish gross output in 1999 was just under £9.8 billion. This

represented 6.9% of aggregate Scottish industrial output in that year. Of this, £8.23

billion was the output of the software sector itself and £1.55 billion was generated by

knock-on multiplier effects arising both from inter-industry purchases and sales

linkages and from household employment income-consumption interactions. [10] In

absolute terms, comparatively large output impacts were realised in individual service

sectors, including wholesaling, retailing, banking/finance and other business services.,

In fundamental terms, a *multiplier* is defined on the basis of:

$$\text{Multiplier} \quad = \text{outcome impact/ initial stimulus.}$$

Therefore, in the present study, it is appropriate to define a *total output impact*

multiplier for software as:

$$\text{Total gross output generated/software gross output}$$

with a calculated value of **1.189**. That is, every £1 million of software output activity

which actually took place in Scotland in 1999 generated another £189,000 of output in

other Scottish industries.

The second results column of table 3 shows the estimated 1999 impact of the software

sector on physical employment in Scottish industries. Employment here is quantified

in terms of *full-time equivalent jobs* (FTEs), and hence is a measure of physical

labour requirements rather than a head count of persons employed. On this basis, it

can be seen that software generated almost 59400 FTEs in Scotland in 1999,

representing 3.24% of total Scottish FTE employment in that year. Software's

smaller impact share of Scottish employment compared with gross output is largely

explicable in terms of particular *technological characteristics* of the software sector

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[10] The present scenario does not include any hypothesised critical-supply dependencies on the part of
Scottish industries purchasing from the local software sector. If however the absence of local software
sourcing meant that these industries had to curtail their own activities, then the measured impact of the
Scottish software sector would be (perhaps substantially) larger. For more discussion on this, and a
quantitative study of the Scottish forestry/timber industry, see McGregor and McNicoll (op.cit.)

itself. In particular, computer manufacturing was highly *non-labour intensive* compared to the Scottish average, and hence every £1million of computer manufacturing output generated relatively few direct (i.e. in computer manufacturing itself) FTE jobs. This can be clearly seen from the appropriate 1999 data as follows:

	Gross Output per FTE
Whole economy	£77382
Computer manufacture	£409325
Computer services	£88745

Of the total FTE jobs generated, 33206 were in the software sector itself and 26181 were in other Scottish industries. Thus, the *total impact employment multiplier* for software was **1.788.** That is, for every 100 FTE jobs in the software sector itself, multiplier effects created an additional 78.8 FTEs in other Scottish industries. Software was relatively "efficient" in generating multiplier employment because a significant proportion of the knock-on effect was realised in industries (especially service industries) which *were* relatively labour-intensive.[11]

The final column of table 3 shows the ratios of simulated outcomes to actual values for those industries and groups of industries separately identified. Unity minus these values gives what can be termed *sectoral software dependency ratios.* Clearly, at the

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[11] It can be seen from the bottom of table 3 that the software sector generated over £1.46 billion of employment income for Scottish households, representing 3.61% of total 1999 employment income i.e. slightly higher than its physical employment impact share.

relatively high degree of aggregation of the **rest** of the Scottish economy in table 3, it would not be expected that the degree of dependency on any individual sector such as software would be uniformly high, and indeed in table 3 most of the dependency ratios are of the order of 1-2%; however, even here three sectors stand out: wholesaling, other business consultancy and other business services, with dependency ratios of 6.1%, 8.1% and 7.4% respectively. The latter two in particular might be indicative of some "clustering" effects with the software sector, but in any event these preliminary results suggest that any future developmental resources for the SSSA could usefully be employed, inter alia, in exploring and explaining the nature and extent of these interactions in more detail at a more disaggregate level.

While Table 3 assesses software impacts in terms of *industries,* Table 4 below provides the equivalent results from this scenario run of the pilot SSSA model in terms of *occupations.*

Table 4: The Impact of Specified Core Software Sectors on the Scottish Economy in

1999: Occupational Results

Occupation		FTE Impact on:			Simulated/ Actual Ratio
SOC	Description	Direct	Knock - On	Total	
126	Computer/Systems Manager	1737	45	1782	0.728
179	Service Sector Managers	0	921	921	0.974
191	Education Registrars	0	5	5	0.995
OTHER SOC 1	Managers	4583	3327	7910	0.962
212	Electrical Engineers	141	13	154	0.911
213	Electronic Engineers	223	21	245	0.884
214	Software Engineers	4011	40	4052	0.386
216	Design/Development Engineers	389	44	433	0.927
218	Quality Control Engineers	472	16	488	0.824
23	All Teachers	0	398	398	0.996
270	Librarians	0	6	6	0.995
OTHER SOC 2	Professional	976	953	1929	0.978
302	Electrical/Electronic Technicians	0	11	11	0.992
320	Computer analysts/programmers	3391	97	3488	0.718
330	Air Traffic Controllers	0	2	2	0.991
381	Artist/Graphics designer	0	101	101	0.984
390	Information Officers	0	25	25	0.986
OTHER SOC 3	Associate Professional	1862	1783	3654	0.976
452	Typist/Word Processors	0	13	13	0.994
490	Computer Operators	1150	203	1352	0.868
OTHER SOC 4	Secretarial and Clerical	2773	4188	6961	0.972
517	Precision Instrument Makers	0	13	13	0.994
526	Computer Engineers	1373	10	1383	0.485
OTHER SOC 5	Craft & Related	1332	1994	3326	0.985
ALL SOC 6	Personal & Protective Services	166	2951	3117	0.985
ALL SOC 7	Sales Occupations	555	3277	3832	0.973
ALL SOC 8	Plant/Machine Operatives	7600	2123	9722	0.947
ALL SOC 9	Other	472	3435	3907	0.980

It can be seen that much, but not all, of the direct impact of the core software sector was in occupations which were explicitly "computer" or "software" related; notably computer/systems managers, software engineers, computer analysts/programmers, computer operators and computer engineers. In absolute terms, the sector also employed relatively large numbers of other managers (SOC 1), associate professionals (SOC 3), administrative/clerical staff (SOC 4) and manufacturing plant/machine operatives (SOC 8). Given that the multiplier effects of the software sector were realised across the range of Scottish industries, its knock-on impact on occupational employment was similarly diverse, tending to reflect the labour technology utilised in Scotland as a whole rather than sector- specific employment characteristics. For example, the relatively large number of sales staff/assistants (SOC 7) generated was attributable (in large part) to the income-consumption multiplier impact on the retail sector, in which these workers were relatively concentrated.[12] As can be seen from the final column of table 4, more than 5% of total 1999 Scottish occupational employment was generated (direct plus knock-on) by the software sector in the following SOCs:

SOC126, SOC212, SOC213, SOC214, SOC216, SOC218, SOC320, SOC490, SOC526, SOC8.

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[12] This discussion briefly illustrates the way in which any outcome result obtained from a run of the SSSA model can be explicitly and quantitatively traced back through each link in the chain of interactions and interdependencies to the originating stimulus. Thus there is no need to treat the SSSA model as a "black box"; on the contrary, many of the more policy-relevant results are likely to come from explicit examination of the *impact path*.

Of these, SOC 8 is an obvious candidate for further disaggregation in any future developmental work. Conversely, the impact of the software sector on a number of occupations separately identified in table 4 (for example, SOC 191, SOC 232, SOC 330) is revealed to have been very small in both absolute terms and as a percentage of base year totals, and hence these can considered as candidates for re-integration into broader SOC categories in future versions of the SSSA.

Finally in this section on impact analysis, Table 5 below summarises some of the aspects of the **embodied labour technology characteristics** of the software sector and its knock-on effects in the base year in comparison with those for Scotland as a whole. Specifically, relative to Scotland as whole, the entries in Table 5 give *occupation specialisation ratios* for computer manufacturing and computer services separately, and for the multiplier employment impact of these two industries combined. Each specialisation ratio is defined as:

(Software employment in that SOC/total software employment)/(Scottish employment in that SOC/total Scottish employment)

A ratio value greater than unity implies that software is relatively specialised in that occupational group compared to Scotland as a whole, and conversely a value of less than unity implies that software is relatively unspecialised in that SOC.

At a general level, Table 5 reveals that the SOC-level specialisation ratios for SIC 30 are significantly different from those in SOC 72, an indication of differences in the embodied labour characteristics of production (which is perhaps unsurprising, given that one is a manufacturing, and the other a service, industry.). In more detail, SIC 30 was highly specialised in SOC 8 (plant and machine operatives), moderately

specialised in SOC 3 (associate professionals), and relatively unspecialised in all other occupational groups. Previous work on "embodied skills" in Scotland [13] indicates that this broad pattern is typically found in manufacturing activities involving primarily assembly-type operations. SIC 72 was highly specialised in SOCs 1, 2 and 3 (management, professional and associate professional), and unspecialised in all other SOCs. This specialisation pattern is indicative of a *skilled-labour intensive* service industry. Finally, it can be noted that the outcome specialisation ratios of the knock-on effects reflect both (a) the pattern of actual domestic purchasing/selling linkages of SICs 30 plus 72 combined, and (b) the occupational structure of employment in Scotland as a whole as the impact is diffused through successive rounds of the multiplier process. As discussed in footnote 12, the separate contributions of each of these various effects can be identified in more detailed analysis.

The pilot SSSA does not contain a mapping from occupations to qualifications such as NVQ or SVQ, but previous work by the authors in this area [14] suggests that the following can be reasonably inferred from the results in Table 5:

(1) The average NVQ level in SIC 30 was *less* than that in Scotland as a whole in the base year.

(2) The average NVQ level in SIC 72 was *greater* than that in Scotland as a whole.

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[13] See, for example, Alexander & McNicoll *Skilled Content of Scotland's Trade* Scottish Economic Bulletin No.54, Alexander, Foley & McNicoll *Scotland's Trade in Skills* FAI Quarterly Economic Commentary December 1996 and McNicoll, Kelly, Marsh & McLay *Defining and identifying the Knowledge Economy in Scotland* University of Strathclyde Publishing 2002
[14] McNicoll, Kelly, Marsh & McLay *(Ibid)*

(3) The average NVQ level of the knock-on impact was *similar* to that of Scotland as whole.

Table 5: Software Occupational Specialisation Ratios in the Base Year

SOC	Specialisation Ratios For:		Knock-on (SIC 30 +72)
	SIC 30	**SIC 72**	
1 Managers and Administrators	0.81	1.97	1.20
2 Professional Occupations	0.86	2.49	0.51
3 Associate Professional & Technical	1.10	2.18	0.80
4 Clerical & Secretarial	0.95	0.70	1.22
6 Personal & Protective Services	0.09	0.01	0.99
7 Sales Occupations	0.32	0.11	1.62
8 Plant & Machine Operatives	4.27	0.34	0.81
9 Other Occupations	0.19	0.08	1.25

Section 3

Concluding Remarks

Concluding remarks

At its inception it was envisaged that this project would essentially be a scoping study, drawing on extant methodological and applied experience to propose a framework for the development of a Software Satellite Account for Scotland and to assess the feasibility of constructing a SSA from existing data sources as well as indicating the key areas where incremental data collection would be necessary.

The project has succeeded in developing an SSA framework for Scotland and constructing an actual pilot SSSA which can be used for description and analysis of software sector activities, revealing previously unobserved aspects of the inter-industry relationships of this complex phenomenon.

The authors have gone further to use the pilot SSSA as the base to derive an economic Input-Output model and conduct a number of relatively sophisticated analyses examining the impact of selected parts of Scotland's core 'Software' industry, looking at SIC 30 (Manufacture of office machinery and computers) and SIC 72 (Computer and Related Service Activities). The results derived are of potential policy-relevance in themselves but also exemplify some of the uses to which the SSSA framework can be put.

For example, the analyses revealed that the specified core Scottish Software sectors under examination played a significant contribution to the Scottish economy, making up 6.9% of aggregate Scottish industrial output in 1999. Every 100 jobs within the specified sectors generated an additional 78.8 FTEs in other Scottish industries. Some preliminary evidence of clustering activity was revealed, with relatively high

'software sector dependency ratios' being observed for wholesaling, other business consultancy and other business services. Examination of the degree of occupational specialisation within the specified Software sector industries also revealed a very different pattern between SIC 30 and SIC 72, reflecting the differences between essentially assembly-type manufacturing and skilled labour-intensive services.

In the course of constructing the pilot SSSA it became clear where further developmental work would be beneficial. In particular it was identified where a greater degree of disaggregation of industry classifications for both 'core' software and 'software-linked' industries is desirable. This is an issue of data availability and not model specification. Incorporation of additional industry data would enable the full-scale implementation of an SSSA that is sufficiently 'fine-grained' for substantive policy –relevant analysis, forecasting and scenario simulation. A summary of the further data required and developmental work that could be usefully undertaken is included in Appendix 5.

Additionally, in the course of SSSA construction and consideration of the issues arising from both the Kay and McGettrick report and from informal discussions with Scottish Enterprise on matters of key policy interest in relation to software and skills, a further innovative application was developed.   This is the *Scottish Information Technology Labour Accounting Matrix* (SITLAM), the first such application to be developed for Scotland. SITLAM has been included in Appendix 4, with description and analyses using SITLAM contained in Appendix 3. SITLAM has been developed as a *complementary* framework to the SSSA and begins to address the issue of how to measure the pathways by which knowledge permeates throughout the economy –

which can help in locating and tracking the spread of IT and 'software' skills throughout the Scottish economy. To the best of the authors' knowledge this is the first development of such a framework anywhere in the world. The authors consider the SITLAM to be very worthwhile examining in the context of this report, but it should be pointed out as a new and innovative concept the authors would wish to spend further time in its development, testing and validation. It is essentially being presented as an addendum to the main report in order to shed additional light on the topic under discussion and to suggest an area where further investigation could prove fruitful.