Regional input-output analysis and agriculture

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Résumé – L'intérêt du modèle input-output pour analyser les performances d'une agriculture régionale est désormais reconnu. En effet, cette technique permet de prendre en compte la spécialisation du secteur et son intégration croissante dans l'économie globale grâce au calcul des multiplicateurs économiques régionaux, d'une part, et de ceux qui relient l'économie d'une région donnée à l'économie nationale, de l'autre. Dans cet article, les auteurs examinent les apports et les limites du modèle input-output régional et de ses prolongements récents que sont la matrice de comptabilité sociale et le modèle d'équilibre général calculable. L'estimation des coefficients régionaux fait l'objet d'une analyse détaillée ; en effet, le coût – en temps et en ressources diverses – des enquêtes sur lesquels ils sont basés limite sérieusement l'obtention de coefficients permettant une évaluation fiable des effets multiplicateurs régionaux. Le reste de l'article est consacré à la construction d'un modèle input-output de l'économie du Pays de Galles, centré sur l'agriculture et les secteurs qui lui sont liés. Il est utilisé pour analyser la diversification des sources de revenu des ménages agricoles, selon deux modalités susceptibles d'améliorer le caractère durable de l'agriculture galloise d'un point de vue social et environnemental. Dans un premier exemple, on compare l'intérêt de la restauration de forêts anciennes non entretenues dépendant d'exploitations agricoles et de nouvelles plantations. C'est la reprise progressive de la gestion et de l'entretien des forêts caduques actuellement abandonnées qui procure l'amélioration la plus sensible du revenu rural au Pays de Galles, alors que l'accent mis aujourd'hui sur les nouvelles plantations est moins justifié du point de vue du revenu et des emplois qu'elle génère. Le deuxième thème concerne l'agriculture biologique. On compare la réduction de la demande d'intrants à l'accroissement de l'utilisation locale des produits qu'elle génère et on évalue l'effet probable de son développement graduel sur l'économie des régions rurales galloises. Des simulations prenant en compte des degrés croissants de conversion de systèmes conventionnels à l'agriculture biologique montrent que cette évolution conduirait à de faibles baisses du revenu et de l'emploi, même si elle concernait des zones assez étendues. De plus, les aménités fournies par l'agrobiologie en ce qui concerne la qualité de l'environnement et la baisse de la production justifient tout à fait de lui apporter un soutien. Ces exemples montrent l'intérêt des techniques input-output pour l'analyse de nombre de questions concernant la politique agricole et le développement rural, et en particulier lorsque des problèmes économiques, sociaux et d'environnement sont en cause.

Mots-clés :
modèle input-output, agriculture régionale, Pays de Galles

Regional input-output analysis and agriculture

Summary – *This article examines the use of the input-output approach in the understanding and analysis of the role of agriculture in regional economies. Though this work is more or less equally divided between regional analysis in industrialised and developing countries, the focus is on the former. The constraints and opportunities offered by the technique are considered, together with extensions such as Social Accounts and CGE modelling. Some of the potential of the technique is illustrated by recent work related to agriculture and rural development in the regional economy of Wales.*

Key-words:
input-output analysis, regional economy, Wales

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REGIONAL approaches to economic modelling have arisen out of an awareness of the special characteristics of sub-national areas that can be obscured when looking at a nation as a whole. Serious socio-economic problems within a region (such as rural or urban deprivation and poverty) can be completely overlooked at the national level of an apparently healthy economy. Consequently, whilst geographic, economic linguistic or cultural criteria used to define regions can have important implications for the end results[1] the choice of methodological tool used to analyse regional economic performance can also be influential. There are a number of reasons for the differences between regions and the nations which they make up, but of these one can be isolated as particular economic relevance: openness, or the degree to which trade flows across regional boundaries are possible, or facilitated by economic structure. Since flows of goods and services across regional borders are rarely measured accurately, economic analysis is often severely hampered.

This article discusses regional economic modelling techniques and their application to agricultural and broader, rural questions; it will illustrate these by examining several research projects that use Wales as a case study. Input-output analysis is a form of modelling that has proved particularly popular in regional studies, and in recent years the basic technique has been extended and developed (Dewhurst *et al.,* 1990). Despite some limitations, the analytic abilities of this tool can provide valuable insights into the workings of a regional economy (and also, within an inter-regional context, its place within the national or supra-national economy) in ways which are beyond the scope of other approaches. This derives from an ability to represent relationships between industries, through which their implied structural interdependencies can be examined. In this context, exploration of the relationship between the agricultural industry and rural economies has especially proved useful. The fairly radical changes that the farming community have faced and are continuing to face are due to factors beyond mere shifts in agricultural policies; political rethinking on the environment, social and regional funding have had far reaching effects.

Division of national economies into regions for the purpose of calculation of economic aggregates is a relatively recent. Bendavid (1974) asserted that "thinking regional" requires features to be distinguished between the economy of a sub national region from that of a nation. Key

[1] Economic features contribute to regional identity and increasingly, cultural and linguistic differences are being given more recognition. This is recognised in the Maastricht Treaty, Article 128 which states that *"The Community shall contribute to the flowering of the cultures of the Member States, while respecting their national and regional diversity and at the same time bringing the common cultural heritage to the fore"*, Nelson and Pollard, (1992).

among these are a greater degree of specialisation and openness, a closer proximity to trading partners and competitors, and an inability to "close" the region at will. The impact of trade and changes in economic factors is greatly magnified for a region, such that knock-on effects and leakages will be greater.

The aim of this article is to examine the benefits and problems associated with input-output analysis within the regional context. The first section provides a theoretical overview, including an examination of debates regarding realism and applicability of input-output models within this rural regional context. This critique is followed by a review of recent related literature. Because this is of considerable volume of work, only representative examples have been chosen to demonstrate the model's range and flexibility. The final part of the article illustrates these two areas of discussion through current research on the Welsh rural economy, which suffers from many of the characteristic socio-economic problems of the countryside. A significant dependence on agriculture makes it susceptible to changes in the CAP, but a range of historical and cultural factors impede structural adjustment. Regional policy interacts with agricultural policy at this level in confronting the social problems of outward migration, housing, low incomes and a generally ageing population.

A CRITICAL OVERVIEW OF THE INPUT-OUTPUT MODEL

Several flaws in input-output modelling have been the subjects of considerable discussion. Though space for a review is limited here, Hewings and Jensen (1988) have commented that: *"...while ... input-output models have become an accepted part of the arsenal of analytical techniques, there is a strong suspicion that many analysts have a higher level of the model's limitations than they have of its utility"*. The flexibility of the framework provides information not only on output, but also on the use of inputs and the indirect or secondary effects of change in outputs. Hence where there is interest in the indirect effects of industrial activity either on the environment, or other primary inputs themselves such as employment or energy use, techniques based on the input-output approach can be useful. The ability to estimate various multipliers provides policy-makers with an accessible perspective on employment and income creation, and permits an extensive investigation into the direct and indirect effects of agricultural policy measures and proposed changes to them. This article is not concerned purely with the role of input-output in agriculture, however, since regional policy is having an increasingly important influence in rural areas as well.

Other kinds of multipliers can be derived from alternative approaches to modelling rural economies: most notably economic base multipliers (Conway, 1991) and those derived from a Keynesian aggregate income approach to regional economies (Ashcroft *et al.*, 1988). Both of these approaches have problems[(2)] which those based on an input-output model can overcome, particularly through their ability to measure the upward and downward linkages that are a particular feature of the agricultural sector. A regional accounting system provides the basis for the model from which input-output multipliers are derived. Transactions and flows are allocated by sector, allowing the calculation of an average input-output ratio. This specifies the input use of one sector in terms of the output from a supplying sector. The matrix multiplier can trace the impact of a change in the output of one industry, in terms of the effect that it will have on all other industries, subject to certain limiting assumptions. The realism of these assumptions have been discussed by, for example, Midmore (1993); Conway (1991); Bourque (1987); Richardson (1985); Pyatt and Round (1979) in a social accounting matrix context; and Harrigan *et al.* (1991) in relation to computable general equilibrium analysis. This discussion, focused the rigidity of input-output coefficients and the consequence of this for accuracy, is summarised below; however, besides the importance or otherwise of realism, a number of other criticisms of regional input-output analysis have been articulated. For the sake of brevity, only the most serious of these issues will be considered here. They are the high costs that can be involved in preparing a regional table; the time involved in constructing tables; and the absence of a framework for resolving distributional issues.

To estimate the effect of any change in final demand, it has to be assumed that production technology is of fixed proportions, that this relationship is constant over the forecasting period and that there are no constraints on productive capacity. However, coefficients will vary over time because of a) relative price changes; b) changes in the nature of

[(2)] Economic base multipliers assume that whilst income and employment in a region rely heavily on an exporting, 'basic' sector; the region's needs themselves are served by the non-basic, service sector. Several problems arise from this simple division, since no account can be made for difference in characteristics between industries. It is impossible to determine the source of changes in final demand, and increases in demand have varying effects among the basic industries themselves. The Keynesian regional income-expenditure model is identical to its national counterpart, except the variables involved refer to regional aggregates. The model focuses attention on changes in the marginal propensity to consume locally produced goods, which are highly dependent on the size of the region (smaller regions will import more) and also the range of goods and services produced internally. This approach, although it can be elaborately defined in relation to the impact of particular investment projects, is of limited interest to policy-makers since it lacks detail of the diverse impact of changes in different industrial sectors. It may also underestimate the magnitude of regional/local multipliers, as suggested by Moore *et al.* (1985).

product themselves; c) technological change; and, d) economies of scale. It can be argued that these assumptions are not that unrealistic, especially when viewing the sector as a whole, and industrial activity in general terms. Nevertheless, agriculture is a special case, since it is an industry made up of many producers, each with a range of potential alternative outputs. The response to changes in demand may be unequal, as different groups of producers with different resource endowments may react differently to expansion or contraction of demand. Because it is the marginal, rather than the average input-output relationship that governs response to changes in demand, output multipliers will tend to overstate the impact of a policy change. Efficiency varies among producers, and so the income and employment effects of a unit change in demand are also likely to be asymmetric with relation to an expansion or a contraction. Substitution between *outputs* may also occur so that land use can switch relatively rapidly between activities; for example, one of the principal effects of milk quotas was to divert resources into other forms of livestock production. Finally, technical change in the agricultural sector has been both rapid and well diffused; as technological change in general causes a decline in the proportion of intermediate inputs used in production, this provides additional reasons for coefficients to vary from year to year. Estimating regional, rather than national, coefficients give rise to further problems, because not only must technical coefficients be determined but also allocated between local supplies, and imports: this latter fraction is much less stable than one determined principally by production structures.

The collection of data by survey methods is expensive, and even then accuracy can be compromised due to the *"hiding of information, lies, inadequate training of observers, poor question design, the difficulty of mass observations, definition and classification problems, instrumental error, passage of time and error-compensating processes"* Jensen (1980,140). To overcome this problem, non-survey techniques relying on secondary data sources have been developed. However, these mostly rely on the assumption that regional production functions are identical to those at national level. Conversion of national into regional coefficients can be done in a number of ways, by using regional weights, RAS methods, location quotients (simple and cross-industry), commodity balances or regional purchase coefficients (see Richardson, 1985, for a full description). There is also the possibility of hybrid models. Richardson described these as combining survey and non-survey methods in *"a middle way in the choice of method... a crucial next step in regional I-O research... (and) a more effective and balanced compromise between the present extremes of cheap but possibly unreliable non-survey methods and prohibitive surveys"* (Richardson, 1972, 129-130). Hewings (1977) provides one example of a hybrid model by using coefficients from another, similar region on the premise that any regional coefficient is far better than a national one. Another general example is the GRIT (Generation of Regional Input-Output Tables) approach, a true hybrid devised by Jensen *et al.* (1973) and developed by West (1981). GRIT analysis also uses national tables as its foundation, with the initial coefficients being calculated by the methods mentioned above such as location quotients. Efforts can then be concentrated on obtaining superior survey data to insert in particular matrix cells where the initial non-survey estimate suggests are important.

The GRIT procedure thus allows considerable time-saving in the construction of reasonable estimates of regional input-output tables, the second major difficulty which affects the accuracy of modelling and forecasting based on this technique. Until this year, the most recent Welsh regional input-output table available referred to 1968, but did not appear in published form until 1977 (Ireson and Jarvis, 1977). Existing (if limited) evidence confirms the *a priori* view that the accuracy of multipliers diminishes with the passage of time. For example, Midmore (1993) determined the average loss of accuracy over time (in terms of per cent root mean square error) in employment multipliers for milk production, based on a regional input-output table, as 4.2% in the year after that to which the table related, 6.3% two years after, 8.1% three years after, and 9.5% four years after.

One final deficiency of input-output models, which is of particular relevance in regional applications to agriculture, concerns distributional issues. Conventionally, the household sector has been treated as a single, aggregated sector of the final demand column, despite growing evidence of the importance of household interactions compared with inter-industry transactions (e.g. Hewings, 1986, Batey, 1990). Thus, household income from employment appears as an extra row and household consumption propensities as an extra column. By treating households as an additional "industrial" sector, important linkages both between household groups themselves and between the household sector and the rest of the economy are masked. Social accounting matrices (SAMs) were developed by Stone during the 1960s for the "Programme for Growth" project (Stone *et al.*, 1962) and later used by others such as Pyatt and Roe, 1977 in Sri Lanka to investigate issues such as income distribution and employment. While used mainly in the developing countries, SAMs have been applied to industrial economies, not only at national level (for example, the United States; see Adelman and Robinson, 1986) but right down through various levels of regional disaggregation to that of a single village (Adelman, Taylor and Vogel, 1988). The possibilities for modelling households are extensive, since they can be classified by a variety of characteristics (especially with the availability of primary data sources such as the Population Census and the Family Expenditure Survey). Keuning and de Ruijter (1988, 88) summarise these as asset ownership; location; size and composition; characteristics of the head or main earner (distinguishing e.g. main employment status, main occupation, main branch of industry, educational attainment, age, sex, main language, race (tribal), kinship, religion and political affiliation); household/non-profit institution. It is therefore possible to compare and contrast groups to examine demand or consumption patterns, or more commonly impacts on income distribution, such as Bell and Hazell (1980), Cohen (1988) and Adelman, Taylor and Vogel (1988).

CGE models, based on the SAM system, provide a coherent approach which models both price and volume changes simultaneously, and releases the modelling approach from the constraint of the fixed coefficient assumption. For example Haggblade *et al.* (1993) examine the effect of endogenous price sensitivity in a comparison of alternative methods of estimating agricultural growth multipliers. Their model, which allows for upward sloping supply curves for non-tradeables and for substitution between inputs (see also Ingene and Yu, 1991), suggests that input-output methods overstate the magnitude of growth multipliers by a factor of between 10 per cent and 25 per cent. The volume of data required (much of which relates to trade flows and is of dubious accuracy), however, limits the use of CGEs for purely regional purposes. There are further, considerable problems associated with the calibration of coefficients, as an alternative to their probabilistic estimation. Consequently, CGE models tend to deal with highly aggregated industrial sectors and are mostly associated with efficiency questions and neo-classical welfare analysis, for example analysing the effect of the GATT agreement (Kilkenny and Robinson, 1990). They are more extensively used in developing countries to determine the impact of alternative development strategies on the regional structure of production or distribution of income (Adelman and Robinson, 1986; Claret and Roumasett, 1986; Howitt 1986; Coxhead and Warr, 1991).

RECENT DEVELOPMENTS IN RURAL INPUT-OUTPUT METHODOLOGY

The aim of this section is to examine some of the more recent work that has been done in the field of rural input-output analysis. Many of these examples improve and extend standard techniques in order to overcome some of the problems highlighted in the preceding section. These problems include the static nature of the input and output coefficients, the inclusion of induced (Type II) effects as well as the standard indirect (Type I) effects, and the development of regional modelling.

Standard input-output model coefficients are estimated using an average figure of the quantity of input required to produce one unit of output. It has been suggested that if the coefficient were instead estimated by means of regression techniques, the stochastic variation of each coefficient could also be measured. This idea was originally developed to overcome the further difficulty of allocating input use to various enterprises from whole farm data. Errington (1987) built on an earlier attempt of Tyler (1969) to use multiple regression techniques to estimate the proportion of whole farm input used by each separate enterprise. Each of the inputs is made the dependent variable for multiple regression, with output by enterprise as dependent variables. However, this technique can also give rise to insignificant or even negative coefficients, probably caused by multi-collinearity (see also Midmore, 1991, who developed a ridge regression method of estimation for this problem, and Moxey and Tiffin, 1994 who applied Bayesian methods). This problem is also illustrated in some recent work from Wales, which is summarised in the next section.

Traditional input-output tables represent flows between industrial sectors in terms of the money value of output, yet it is possible to estimate the impact of changes on other resources, for example the quantity of employment, energy and environmental variables. Either this can be done simply by translating the estimates of output from each sector into energy use / employment use per sector, or by constructing a separate input-output table that measures the flows of other resources themselves. Gould and Kulshreshtha"s (1986) analysis of structural change in the Saskatchewan economy does this by modelling flows of energy between separate sectors. Their study separated changes due to fluctuations in final demand from technological change, as well as dividing technological change into market share and input structure effects.

The standard input-output model takes into account only Type I effects. Changes in household demand are aggregated with other final demands and made exogenous. However, changes that are experienced in (for example) the agricultural sector will affect household income of farmers, farm workers and others, and therefore demand for consumption goods, which in turn will have knock-on effects. It is possible to incorporate the households as an endogenous part of the system and also measure Type II effects – i.e. direct, indirect and induced changes which occur as a result of demand changes – thus creating a more "closed" input-output model (Bulmer-Thomas, 1982; Pyatt and Roe, 1977; Roberts, 1992). Thus, by incorporating households into use matrices, it is then possible to disaggregate them into different groups (by income or other socio-economic stratification) if spending and purchasing patterns for each group can be established. Making behavioural assumptions about each group allows estimation of the effect of changes in the system on household purchasing power and its subsequent consequences.

Batey *et al.* (1987) have demonstrated how, in a specifically rural region, the results of economic impact analysis may be influenced by the choice of household disaggregation scheme. Using data from the Greater Cork region in the Irish Republic, impacts were examined using four model types. The simplest form of model treated households exogenously, to produce multipliers showing direct and indirect effects only. The second model included Type II multipliers, enlarging the input-output model by incorporating an extra row and column to represent households, and endogenised them in the system of accounts to show direct, indirect and intensivity (normally termed *induced*) effects. However, this assumed a linear and homogenous consumption function for each household and the same pattern of unemployment and migration; the third model divided households into indigenous and employed immigrants (producing multipliers showing direct, indirect and extensive, or out of area, effects). The fourth model went one stage further and disaggregated households to represent the redistributive elements of income change as well, explicitly modelling the propensities to consume of unemployed workers including the indigenous unemployed (and producing multipliers that include direct, indirect, extensive and redistributive effects). They concluded that the largest component of induced impact resulted from extensive income, i.e. that from immigrants though the intensive and redistributive income effects more or less cancelled each other out. Employment impact, however, showed a clear gradation of effects; extensive effects were largest, but were modified substantially by redistributive effects.

Round (1989) explored the decomposition of input-output and economy-wide multipliers in a regional setting. Using flows between two regions and the rest of the world, the methods for decomposing multipliers were set out in a straightforward, comprehensible way. Turning finally and more specifically to regional and inter-regional models we find a different range of problems that have been tackled by a large number of authors. Regional input-output tables (and variations) have been created in order to examine the consequences of a certain economic event in detail. These enable the effects of changes in the economy to be examined at a more local level. We noted earlier that regional data can either be collected to compile the tables, or alternatively, national tables can be adjusted by mechanical methods. Both options can cause problems. To compile tables from survey data, there are immense data requirements; some that are either difficult to obtain, or simply not available. The inaccuracies involved in mechanical adjustment are well known, if often ignored (Round, 1983, has provided critical insights; see also Richardson, 1972, for a methodological review). Therefore, the path frequently taken in creating a regional table is first to adjust the table mechanically, then enhance the resulting coefficients with such survey data as is available.

The Aberdeen School of Agriculture has devoted considerable effort to developing regional input-output tables; for example, Johns and Leat (1987) developed an input-output model of the Grampian Region in Scotland using the GRIT technique to generate the regional input-output coefficients. Their implementation combined the application of Simple Location Quotients (a measure of the relative importance of each industry regionally compared with its national importance), and Cross Industry Location Quotients (a measure of the relative sizes of selling and purchasing industries, to determine whether the selling industry will be able to provide enough goods to the purchasing industry in that region) with survey data. Output, income and employment multipliers, both Type I and Type II were calculated for 34 industrial sectors. The results indicated that the effect of increasing output in any one sector had the greatest impact on incomes and employment in the service sector and the lowest on the food industries. However, when indirect effects were examined, the reverse was true. This highlights the importance of examining the relative size of the direct and indirect coefficients, as well as their ratio(3). For example, the multipliers for the slaughtering sector are very large, yet this sector is relatively unimportant in terms of absolute values of output and employment. The Grampian study was extended by Leat and Chalmers (1991), providing further disaggregation of the agricultural industry into 8 separate sectors by using multiple regression procedures on farm survey data (see above). They concluded that with every job lost on the farm, approximately one off-farm job would be placed at risk; although their model was specifically for the Grampian Region, this conclusion was similar to that obtained from a model of countryside change constructed for England and Wales (Harvey *et al.*, 1986). They highlight two sources of concern which limit the effectiveness of the modelling approach; that the assumptions of constant input-output relationships when examining large scale changes in agricultural and food production are dubious; and that the model functions more accurately for contractions of industry than expansion. The latter was ascribed to the readiness of businesses to shed labour in times of difficulties, but a reluctance to take on new staff in times of expansion.

A recent study in Canada (Gilchrist and St Louis, 1994) explored the effect of diversification policies on a small region - Saskatchewan, assuming that the diversification would improve the performance of the economy by making it less sensitive to outside shocks. The implications of policy alternatives were tested by examining the mean and variance of regional income to obtain partial policy rankings, on the assumption that appropriate criteria are locally increases in expected regional incomes and decreases in the variance of regional income.

Inter-regional models examine the flows of goods and services between different regions as well as outside the regional system to the rest of the world. Richardson (1972) describes the compilation of such models. More recently, Gould (1986) has studied the impacts of Prairie Branch Line Rehabilitation. Four regions were specifically defined by this study – Manitoba, Alberta, Saskatchewan, and "other Canada", and data was collected to represent not only transactions between these regions, but also the level of international and interregional trade for each commodity. This model

(3) This point is discussed by Mattas & Shrestha, 1990. They suggest a new approach – that of input-output elasticities, which incorporate both the multiplier effects and the relative size of the economics sectors.

allowed total impact of the project to be estimated, and contributed to the information used to complete a cost benefit analysis study.

RECENT APPLICATIONS OF INPUT-OUTPUT ANALYSIS IN RURAL WALES

A series of regional studies have been carried out using the input-output methodology, each of which examines certain aspects of agriculture at the Welsh (regional) level, or at the mid Wales (sub-regional) level. In sequential order, the first set of studies placed inter-industry linkage analysis, based on input-output methods, at the centre of a study of pluriactivity and the Rural Economy in the Less Favoured Areas of Wales (Bateman *et al.*, 1993). This was itself part of a wider study that examined changing farm economies in Europe. Other ongoing research employs a SAM, with disaggregated agriculture and household accounts to examine the flows of public support to the rural area of mid Wales[(4)]. The importance of public support to this area to maintain the farming industry and therefore the local economy has given rise to growing concern about the targeting of not just public money, but all forms of direct and indirect support. The research aims to identify the flows from these sources (EU, national and local government and other public agencies) and measure the impacts of changes in each on the distribution income within and between farming and non-farming households. In this section, however, we concentrate on results from the study of farm pluriactivity in Wales.

The study examined current farm involvement in non-farm economic activity, its potential to offset agricultural income losses and the capacity for such processes to be assisted through government policy. Two enterprises, farm woodland management and organic farming, were suggested as developments in pluriactivity that could offer contributions to improvement in farm household income. Input-output analysis was then used to simulate the impact of these activities on the rural economy. The simulations were based on previously constructed input-output tables that underlie the Welsh Input-Output Disaggregated Agriculture Model (WIODAM), described in detail in Bateman *et al.* (1993).

[(4)] *Mid Wales* is taken to be that area covered by the Development Board for Rural Wales and includes the three districts of Powys (Brecknock, Montgomeryshire and Radnor), Ceredigion in Dyfed and Meirionnydd in Gwynedd. This is an area distinct from *Rural Wales*, which has been identified as an EU Objective 5b Area and extends over most of the three counties of Dyfed, Powys and Gwynedd, together with parts of Clwyd.

Farm Woodland as a Pluriactivity Enterprise

Most policy incentives in Britain are concentrated on the establishment of new woodlands and, given current cost and expected harvest values, there has been a concentration on exotic conifer species. However, in environmental terms these are far less ecologically valuable than existing semi-natural woodlands, predominantly broadleaf. These have become neglected, and are decaying as a result of over-maturity and grazing of the understorey as farming has become more specialised, although until fairly recently they were managed productively for commercial purposes (see, for example, Jones, 1927). Revived management of these areas would improve the supply of good quality timber and, hence, the potential for rural manufacturing activities (Psaltopoulos and Thomson, 1993, found strong backward linkages of wood-processing industries in the regional economy of Grampian). The aim of the study was to provide a comparison between the total (direct and indirect) income and employment effects of conifer plantations on farms and revived management of existing, neglected semi-natural broadleaf farm woodlands.

The steps involved in developing this simulation were complex, and can only be described in outline here. For more detail, see Bateman *et al.* (1993). In the case of conifer establishment, the existing area and age structure of this type of forestry on farms was determined, in order to estimate likely future harvesting and replanting rates[(5)]. Together with information on historic rates of new planting, likely patterns of total new plantings and harvesting were established. These represent (a) a scenario in which policies provide support similar to current levels, and consequently the rate of decline in new plantings continues; and (b) a scenario in which incentives are improved, to re-establish the historic rate of past new planting. There is no alternative but to assume that, over the lifetime of the simulation, both establishment and harvesting technology remain constant. Estimates of average costs, based on coniferous woodland activity reported from the survey of farms mentioned above and other representative sources of data (Dolan and Russell, 1987; Nix, 1986, 1991). These were used to project forward the total costs of this type of farm forestry as if it were a single enterprise. The returns were based on projected harvesting rates and assumptions about real prices; these were either constant, or declining or rising by 1 per cent per annum. Thus three demand assumptions were developed, together with two supply assumptions, providing six scenarios in total.

One of the major difficulties in incorporating forestry activities into an input-output model is that the link between major establishment ac-

[(5)] In Britain, felling licences are required for any major timber harvesting, and it has become customary to issue such licences only on condition that replanting takes place.

tivities and their subsequent benefits is a very long one. Output depends on plantings or management activities of past decades (see Thomson and Psaltopoulos, 1994 for further discussion of this point). One method adopted by the compilers of the 1979 Scottish input-output table (Industry Department for Scotland, 1983) was to divide forestry activities into two, planting and harvesting. However, there are difficulties with this, notably that:

• in the case of planting, inputs are used up without any "visible" output: though a notional increase in the value of land can be attributed to gross capital formation, the valuation techniques for this are unreliable, especially as the market mechanism is subject to considerable intervention;

• in the case of harvesting, not all of the inputs are accounted for, though of course it may be argued that the discounted establishment costs were in any case negligible;

• most importantly, the input-output method allows the analysis of industries as if they were whole systems, regardless of the circumstances facing individual enterprises, so that the long-run balance between inputs and outputs can be evaluated.

For these reasons, the farm forestry options have been incorporated into the input-output model as single sectors, utilising the long-term ratios between activity and other sectors. The average flows implied by this conjecture have been subtracted from the overall flows into the forestry and fishing sector. For each scenario, long run input-output coefficients were then calculated, relating total costs and returns over a 40-year forward projection. These, inserted into the base matrix of direct coefficients for the regional economy of Wales, provided the basis for derivation of output, income and employment multipliers.

In the case of existing, recovered semi-natural broadleaf woodlands, the procedures have been different in some respects. The rate of extended scope of management of currently neglected resource was based on two assumptions. These are: (a) the historic rate of recovery through the activities of the state-funded organisation, *Coed Cymru*, whose role is exclusively dedicated to this activity, approximately 1,000 hectares each year; and (b) the organisationís proposed rate of recovery, approximately 3,000 hectares each year. Standard costs of management are not available from published sources. These costs vary considerably, due to the small size and contrasting terrain of such areas, often residuals of larger woodland areas that did not prove suitable for conversion to pasture. A series of case studies therefore provided the necessary average cost and output data. Assumptions concerning returns followed the same pattern as for the conifer establishment simulations, adding a further six scenarios for comparison. However, under the assumption of a more rapid rate of new management, most of the potential would be exhausted in the first 10 years of the simulation. Hence costs would rise to a peak and then decline rapidly thereafter, but supplies of better quality timber would become available earlier and more consistently throughout the entire period in question. In a manner similar the conifer establishment simulations, long run input-output coefficients were calculated and inserted into inserted into the base matrix of direct coefficients to derive of output, income and employment multipliers.

These are shown in Tables 1-3. In terms of the effects of any of these scenarios on total gross output, at least under the assumption of stable prices, the largest effects occur from the "gradualist" approach to the improved management of existing broadleaf farm woodlands, the least from a policy of accelerated management. In between are the two conifer establishment options. If, on average, prices fall then the plantation options exert the greatest effect on gross output, for a given increase. If prices rise, then the two plantation options provide much lower knock-on effects. However, output effects are probably less interesting than those occurring with respect to incomes and employment. The overwhelming impression from Table 2 is that here is much less variation within these than in the output multipliers, and the relationship between each policy option for each price assumption is constant. Accelerated management of existing broadleaf woodland, per unit of income generated, creates the greatest overall effect on incomes; this is followed, in order of magnitude, by the gradualist approach and then the two conifer plantation policy options. Table 3 shows the job creation multiplier effects. In contrast to the other types of multiplier, in this instance the conifer options provide considerably greater knock-on effect, except if prices rise on average in the long term. It is interesting to note that, from farm conifer plantation activity, employment effects are on average greater if the recent rate of planting decline continues. The increase in employment associated with the accelerated programme of management of existing woodlands is lowest of all. Of course, it should be borne in mind that these are long-run averages, and that the accelerated programme of management of existing farm broadleaf woodlands would create more jobs than other options during the initial 10-year phase, during which the majority of woodland areas were drawn into the scheme.

Table 1.
Long-run Average Output Multipliers, Farm Forestry, Wales

	Price Assumptions		
	Stable	Falling	Rising
Farm Forestry Conifer Plantations			
Continuing average recent rate of planting	1.424	2.202	1.143
Continuing average recent rate of planting decline	1.412	2.161	1.140
Existing Woodlands Management			
Rate of new management: ± 1,000 ha per annum	1.456	1.635	1.853
Rate of new management: ± 3,000 ha per annum	1.191	1.483	1.154

Table 2.
Long-run Average Income Multipliers, Farm Forestry, Wales

	Price Assumptions		
	Stable	Falling	Rising
Farm Forestry Conifer Plantations			
Continuing average recent rate of planting	1.255	1.253	1.254
Continuing average recent rate of planting decline	1.254	1.252	1.253
Existing Woodlands Management			
Rate of new management: ± 1,000 ha per annum	1.272	1.271	1.272
Rate of new management: ± 3,000 ha per annum	1.280	1.278	1.281

Table 3.
Long-run Average Employment Multipliers, Farm forestry, Wales

	Price Assumptions		
	Stable	Falling	Rising
Farm Forestry Conifer Plantations			
Continuing average recent rate of planting	1.339	1.679	1.169
Continuing average recent rate of planting decline	1.357	1.716	1.185
Existing Woodlands Management			
Rate of new management: ± 1,000 ha per annum	1.225	1.255	1.544
Rate of new management: ± 3,000 ha per annum	1.066	1.125	1.075

These input-output multipliers may be interpreted as indicating the long-run ratio between the direct impact of various approaches to farm forestry to their wider impacts on the rural economy. Consequently, they are not directly comparable either with the short-term multipliers calculated for agricultural sectors in the same study (see following section), or with the (rather weaker) backward linkages derived by Psaltopoulos and Thomson (1993). Obviously these are important, given the harvest cycle involved in forestry. However, it is perhaps also useful to provide a summary of the simulation from which the multiplier relationships have been derived. This allows the absolute magnitude of the incomes and employment created in each scenario to be compared. Table 4 provides these details, showing annual averages over the same period for each scenario. Greater levels of income generation will be achieved if a gradualist policy of bringing farm woodlands into management is pursued; incidentally, these will also be more stable. Conversely, more jobs will be created in the medium term if the accelerated programme is attempted. This does not suggest, however, that the establishment of new woodlands on farms should be discontinued, merely that greater priority should be given to the recovery of existing neglected woodland. This is because the area of semi-natural ancient woodlands which exists is finite; judicious planting, especially where it extends adjacent to existing areas, can improve the quality of this environmental resource. Also, there is the possibility of a shortage of softwood in the early decades of the coming century, and if that is to be met partly from domestic resources, then considerable areas will need to be planted up in coming years.

Table 4. Annual Averages of Total Income and Employment Effect, Conifer Plantation compared with Existing Management, Wales 1992-2032

Income Effects (£m1991)	Price Assumptions		
	Stable	Falling	Rising
Farm Forestry Conifer Plantations			
Continuing average recent rate of planting	0.780	0.884	0.468
Continuing average recent rate of planting decline	0.779	0.820	0.651
Existing Woodlands Management			
Rate of new management: ± 1,000 ha per annum	1.749	1.747	1.748
Rate of new management: ± 3,000 ha per annum	0.515	0.514	0.515

Employment Effects (No. of Jobs)	Price Assumptions		
	Stable	Falling	Rising
Farm Forestry Conifer Plantations			
Continuing average recent rate of planting	32	43	26
Continuing average recent rate of planting decline	35	45	30
Existing Woodlands Management			
Rate of new management: ± 1,000 ha per annum	147	150	185
Rate of new management: ± 3,000 ha per annum	154	162	155

Organic Farming as a Pluriactive Enterprise

The inclusion of organic farming as a pluriactive enterprise may seem initially seem at odds since it is an alternative farming system rather than an alternative source of income. Nevertheless, the study set out three hypotheses concerning the role of organic farming in the farm business, the farm household and the rural economy, to test the its validity of its inclusion. The hypotheses were:

- that organic farmers have different (higher/lower) levels of income from comparable conventional farmers;
- that organic farming is likely to have a marketing and processing pattern that differs from conventional farming;
- that organic farming would have a different pattern of inputs (including labour) from conventional farming, and therefore different implications for the rural economy.

The first two hypotheses were tested using a regional subsection of previous national surveys of organic farming to examine the level of income and the pattern of activity in organic farm households. The analysis drew heavily on Murphy's (1992) investigation of the extent of organic farming in Great Britain, using data respecting the 78 farms in Wales. For the third hypothesis, input-output coefficients were identified that were appropriate to organic farming and which were then used to modify WIODAM. Briefly, it was concluded that organic farming was a viable form of pluriactivity and of particular interest to Wales, with potential for a number of farm types and sizes, based on a small but relatively well established presence in British farming. With respect to its direct impact on the rural economy (in terms of on-farm employment) it offers some advantages over conventional farming, such as improved marketing and processing opportunities.

The study investigated the relative indirect impact of two aspects of an increased uptake of organic farming in Wales. Organic farming reduces purchased inputs, such as fertilisers and chemicals, which will in turn reduce the overall level of economic activity; however, this could be offset by the increased employment opportunities in marketing, processing and packaging. Input-output multipliers were used to determine the relative magnitude of each effect. As a preliminary, both the value of organic agriculture's output in Wales and its cost structures needed to be estimated in order to modify WIODAM's use and make matrices. Data from the Murphy study was used to fulfil both these requirements. Allocation of variable costs to enterprises was based on this survey gross margin data, but the allocation of fixed costs required further work. The regression technique described earlier in this article was applied and some serious problems due to multi-collinearity between predictors were overcome by use of ridge regression estimators to provide satisfactory estimates. In other cases they proved intractable, and conventional coefficients had to be "borrowed" instead.

Direct input-output coefficients were then calculated, and multiplied the estimates of organic enterprise output. These flows were deducted from the inputs to the conventional agricultural enterprises; in addition, the outputs of organic agriculture sold to processing industries and final consumers were entered on the final matrix, together with corresponding deductions made to the sales of conventional agriculture. Output, income and employment multipliers were calculated from the resultant matrix. A major source of potential inaccuracy was due to the relative age (from six years prior to the study) of the base input-output matrix. While this is a common problem in input-output analysis, the matrices can easily be updated when more recent information becomes available. The multiplier relationships that were derived are shown in Table 5.

Clearly, no generalisations can be made concerning relationships between conventional and organic multipliers: some were similar; others were significantly different. For example, for cereals, the differences are fairly slight, but the conventional output and income multipliers were higher, whereas for pasture and forage crops, the organic income multipliers were much higher than their conventional counterparts, though the reverse was the case for the employment multipliers.

Table 5. Input-Output Multipliers for Welsh Organic and Conventional Agriculture

	Output		*Income*		*Employment*	
	Organic	Conventional	Organic	Conventional	Organic	Conventional
Cereals	1.02	1.06	1.02	1.11	1.12	1.06
Pasture & Forage Crops	1.22	1.47	4.26	1.88	1.16	2.12
Other Crops	1.13	1.03	1.29	1.04	1.17	1.04
Milk	1.80	1.79	2.46	2.12	2.96	2.29
Cattle	1.66	1.52	2.64	2.03	1.90	2.86
Sheep	1.60	2.07	1.51	2.21	2.44	2.57
Pigs	2.28	2.63	4.89	4.30	13.70	4.26
Other Livestock	1.35	1.34	4.13	3.29	2.36	2.69

These multipliers should be used with caution, given the current and future states of organic farming in Wales. If significant changes involving dairying and livestock converting to organic production were to occur, the result would be fairly complex. A series of calculations were made to estimate the total effect of a switch of 0.5 per cent of production from conventional livestock to organic production methods. First the income effect resulting from a loss in conventional income for each of the livestock enterprises (milk, cattle and sheep) was calculated, then the gain in income for each of the organic enterprises, and finally the impact on the incomes of the processing sectors (milk processing and slaughtering). A 0.5 per cent reduction resulted in a very small total impact of a loss of income, £0.37 million.

These conclusions highlight two issues: the economic viability of organic farming; and its potential contribution in fulfilling environmental and social objectives. The study argues that there is a strong case for financial support to organic farmers. In the context of pluriactivity, the study concluded that firstly, the direct impact of organic farming on the rural economy (in terms of on-farm employment) offered advantages over conventional farming. Secondly, the knock-on effects of organic farming suggested that any possible disadvantages in terms of lower input use were offset by benefits in terms of additional local processing.

CONCLUSION

In this article we have attempted to show the potential range of innovative approaches that input-output techniques provide to cope with contemporary policy issues related to agriculture and rural regional economies. In particular we hope to have demonstrated how a number of intersecting concerns that are environmental, social and economic in nature can be handled within this context.

There are, of course, a number of difficulties and constraints. Obtaining accurate descriptions of input-output flows can be costly and time-consuming, even if they only need extending to cope with the circumstances of the evaluation in question. For instance, to construct an extra set of input-output relationships for organic agriculture took almost as much time as the original group of input-output coefficients from which they were being distinguished. Yet there are good reasons for developing compromise approaches in which part of regional tables are mechanically derived, since some flows are more important than others in terms of their contribution to table accuracy. Equally, even if acceptably accurate tables can be constructed, there is good reason to suspect that regional (and inter-regional) flows, and the behavioural relationships assumed from them, are not as stable as those described in national tables: analysts need to take on board the consequences of using out-of-date coefficients. Despite these concerns, it is clear that the versatility and unique potential of input-output techniques will ensure their continued application to problems related to agriculture and the rural economy in the foreseeable future.

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