

THE NORTHERN IRELAND REGIONAL ECONOMETRIC MODEL[†]

Clifford W. Jefferson

Macroeconometric modelling of regional economies is in its infancy. While national models have been in widespread use in industrialised countries for many years, it is only comparatively recently that econometric models have been constructed for regions. National models with the national expenditure format have developed around a substantial body of economic theory together with the relevant national income statistics. The development of regional econometric models has been hindered by the relatively unsophisticated body of regional economic theory and the limited availability and quality of regional data. This paper outlines in general terms the structure of the Northern Ireland model. It follows the format of the more recent regional econometric models in the USA and is intended primarily for medium-term forecasting.

Interest in regional modelling was stimulated by Klein (1969), who considered two different systems of regional models for the economy as a whole: first, a complete set of interlocking regional models from which national magnitudes would be obtained as the sum of the corresponding variables over all the regions, and secondly, a set of independent regional models linked to a national model and not interacting with one another. While the former "bottom up" approach has considerable theoretical interest in that it allows regional development to interact and feed back into the national performance, the latter "top down" approach, where a single regional model is designed to operate as a satellite to an existing national model, offers the more practical approach for modelling the single region. It is much less demanding on the data, permits greater flexibility in modelling the individual region and can be built in association with existing national models.

Klein advocated the single region "top down" approach as the way forward in regional modelling but surprisingly recommended that the models should take the national expenditure format using exogenous variables predicted from national models. Unfortunately the national expenditure format normally cannot be estimated because of the inadequacy of most regional accounts. For example, reliable time series on consumer expenditure and regional trade seldom exist. Instead regional accounts have tended to concentrate on output and income for which data can be more readily obtained. Gross regional output (GRO) is obtained by summing value added over its component sectors and gross regional income (GRI) by adding factor payments and transfers to residents of the region:

$$\text{GRO} = \sum X_i \neq \text{GRI} = \sum F_j$$

where X_i is the output of sector i and F_j is the factor payment or transfer of type j .

Regional output and income may differ substantially because of the "openness" of a region. Portions of factor payments may be paid to non-residents of the region, e.g., the profits of multiregional firms, and residents may receive national transfer payments in the form of pensions or welfare payments.

The major step forward in finding a format of fairly general applicability which could be used on the satellite principle came in the Philadelphia model (Glickman, 1971). Glickman adopted a modified export-base approach in that he accepted that part of the economy is regarded as "basic" and driven by export demand while output in the remainder of the economy is induced by local expenditure. The innovation was that the

[†] Work on a medium-term forecasting system based on the Northern Ireland regional econometric model is currently being supported by funds from the Social Science Research Council (Northern Ireland Panel).

format of the model attempted to describe the detailed structural relationships through which the export base/induced mechanism works. For forecasting, the model was linked as a satellite to the Wharton EFU Model (Evans and Klein, 1968) taking predicted values of national variables as exogenous. The importance of the "Glickman" format lies in the fact that it explains and utilizes variables which are likely to be available in most regions, namely output, income and employment. The general applicability of the format was quickly recognised and during the mid and late 1970s a large number of models of this type were constructed and are at present operating for forecasting and simulation in states and cities in the USA.¹

The Northern Ireland Model

The first version of the Northern Ireland model, published in Jefferson (1978), followed the basic "Glickman" format but modified to suit the characteristics of a region of the United Kingdom. It is a demand based model which is designed to operate as a satellite to the Cambridge Econometrics Ltd. Multisectoral Dynamic Model (MDM) of the United Kingdom economy.

The core of the model structure is contained in six essential blocks; output, employment, labour force and unemployment, earnings, personal income and transfer payments. Once the level of output, employment and personal income has been determined in these blocks, other non—essential blocks can be driven by the model. The differentiated regional economic base approach has been implicitly used to classify the regional economy into four fundamental sectors: (i) export based; (ii) induced by local expenditure; (iii) financed by public expenditure; and (iv) agriculture. The export based sector, i.e., manufacturing, is taken to be primarily a function of United Kingdom demand. The induced sector, which includes the public utilities, transport and communication, distributive trades, miscellaneous private services, privately financed construction, and mining and quarrying, is regarded as primarily a function of local expenditure. The public financed sector, the second basic sector in the model, includes public administration, health and education services and publicly financed construction, and is driven by public expenditure. The agricultural sector is important in the Northern Ireland economy but because it is complex and requires specialized modelling in a somewhat different area of interest, it has been treated as exogenous in the model.

The essential structural relationships in a highly aggregated version of the Northern Ireland model are shown in Figure 1. Endogenous variables are shown in rectangular boxes and exogenous variables are shown in circles. Arrows indicate causal relationships and lines without arrows indicate content of a major variable.

Manufacturing output (QM) is principally a function of national demand proxied by United Kingdom output in manufacturing² (QMUK), i.e.,

$$QM = f(QMUK, QM_{.1}) \quad (1)$$

Output in the induced sector (QS) is assumed to be produced in response to local demand and this is proxied by personal disposable income (PDY) in the absence of reliable series of consumer expenditure, i.e.,

$$QS = f(PDY) \quad (2)$$

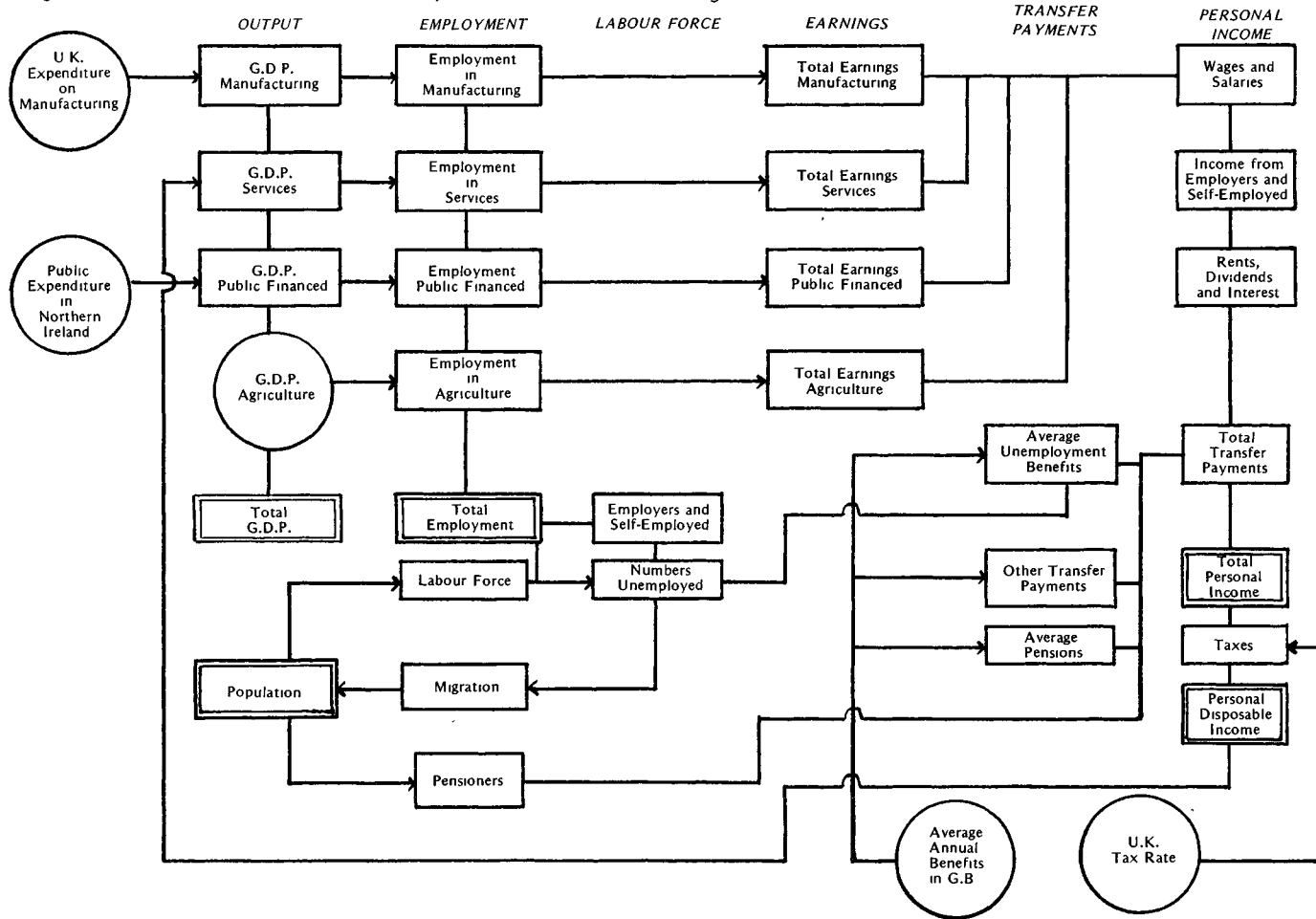
Output in the public financed sector (QP), the second basic sector, is taken as a direct function of public expenditure in Northern Ireland (PEX), i.e.,

$$QP = f(PEX) \quad (3)$$

With output in agriculture (QA) taken as exogenous, gross regional product (Q) is the sum of the output in the four sectors, i.e.,

$$Q = QM + QS + QP + QA \quad (4)$$

Figure 1: The Main Structural Relationships in the Northern Ireland Regional Econometric Model



Employment in each of the three private sectors (E_i) was to be modelled on the basis of simple inverse production functions of the form:

$$E_i = f(Q_i, K_i, t) \quad (5a)$$

where K_i is capital stock and t is "time", a proxy for productivity. However it was only possible to obtain estimates of capital stock in the manufacturing sector and here the variables proved to be non significant. Along with employment in the public sector, where the inclusion of capital stock in the employment demand equation would be inappropriate because of the method of calculation of output,³ the employment equations have the form:

$$E_i = f(Q_i, t) \quad (5b)$$

Total employment is obtained by summing over the four sectors, i.e.,

$$\sum_{i=1}^4 E_i \quad (6)$$

It can be argued that average wages in the region are a function of average national wages ($AWUK_i$) and local labour market conditions. If the latter is proxied by the level of unemployment (UK) average annual wages in each sector (AW_i) in the region can be modelled as:

$$AW_i = f(AWUK_i, UE) \quad (7)$$

In the public sector, regional wages are taken as a function of national wages only.

Total wages and salaries (TW) is obtained by summing wages in each sector. Thus the total wages identity is:

$$TW = \sum_{i=1}^4 E_i \times AW_i \quad (8)$$

The other components of personal income (PY) i.e., income from self-employment (YSE); rent, dividends and interest (RDI) and transfer payments (TP), are modelled separately and summed,

$$PY = TW + YSE + RDI + TP \quad (9)$$

Personal taxes are deducted from personal income to obtain personal disposable income (PDY),

$$PDY = PY - TX \quad (10)$$

Personal disposable income is the principal determinant of local expenditure and is used as the proxy for it to drive the induced sector of the model.

In the simplified stylized version of the model presented in Figure 1 unemployment is determined as a result of labour market flows. The level of migration (M_t) is influenced by the level of unemployment (UE_t),

$$M_t = f(UE_t \text{ et al.}) \quad (11)$$

Population (POP_t) is a function of migration and natural change (NC_t), and the labour force (LF) is a function of the population of working age and activity rates (AR). Thus:

$$POP_t = POP_{t-1} + M_t + NC_t \quad (12)$$

and

$$LF = f(POP_t, AR) \quad (13)$$

Unemployment is determined as the residual between the working population, and employees and self-employed persons (SE) giving:

$$UE = LF - E - SE \quad (14)$$

In common with other regional models it has not proved possible to adequately model unemployment and population in this way⁴ and it has been necessary to resort to an ad hoc approach of relating changes in unemployment (ΔUE_t) to changes in employment (ΔE) and to change unemployment in the UK ($\Delta UEUK_t$) i.e.,

$$\Delta UE_t = f(\Delta E, \Delta UEUK_t) \quad (15)$$

$$UE_t = UE_{t-1} + \Delta UE_t \quad (16)$$

This formulation provides a reasonably good fit for unemployment over the sample period but is clearly not very satisfactory for medium term forecasting. Work is in hand on a non-econometric approach to forecast labour supply on the basis of given assumptions. This will be combined with model forecasts of employment and self-employment to estimate unemployment.

The most recent version of the model follows the format in Figure 1 but at a more disaggregated level and it contains an additional block on consumers' expenditure. It has 48 stochastic equations and 25 identities and has been estimated from annual data for the period 1959 to 1979. The simple export-base approach has been modified in the light of information on destinations of sales from the Census of Production and output flows data from the rather outdated input-output model for Northern Ireland (Moffett, 1973). Thus the output of industrial orders in manufacturing and services is modelled according to the principal sources of demand for their products. Equations in the recursive parts of the model have been estimated by OLS. In equations where the possibility of simultaneous equation bias is present the method of Two Stage Least Squares with Principal Components has been used.⁵

Medium Term Forecasting

The Northern Ireland model has been constructed principally for medium term forecasting. In it the two basic driving forces are UK demand for manufactures and Northern Ireland public expenditures. All the predictions of the UK variables which are exogenous to the Northern Ireland model are taken from the Cambridge Econometrics Ltd. (MDM) model of the UK economy.⁶ This multisectoral dynamic model combines the traditional macroeconomic forecasting model explaining the major economic time series with the industry type based on the Leontief input-output system. It is claimed that the importance of this type of model for medium and long term forecasting lies in its ability to incorporate changes in the industrial structure into its forecasts. Forecasts of public expenditure in Northern Ireland are given in the White Papers on the Governments' expenditure Plans. There is sufficient detail to provide estimates of the several categories of public expenditure needed to drive this second major basic sector of the model. The system is operational and medium term forecasts have already been produced.⁷

As with all existing regional econometric models the Northern Ireland model can be criticised as a medium term forecasting technique in several fairly obvious ways. The small number of sample observations on which the model is based together with the problem of missing data series on important variables, has resulted in a number of very simple equations. Some important relationships are clearly misspecified, no doubt with resulting biased coefficient estimates. This is a situation which is ripe for the presence of multicollinearity and autocorrelation.

In addition to these econometric problems there are some obvious economic shortcomings. The model is demand based and does not take account of the supply side conditions. It does not cope well with structural change. This can be particularly important for forecasting in the medium term in a regional economy like Northern Ireland where the whole thrust of regional development policy has been to improve the industrial structure and in the current climate of massive recession is likely to be even more crucial.

Clearly one would like to know to what extent the effects of structural change are incorporated in the demand based equations and how far ahead one can forecast before structural change invalidates the use of the equations estimated from the sample period. Work is proceeding on a non econometric approach which can be used to incorporate a quantitative measure of structural change into the existing forecasting model.

As discussed above, it has been necessary to resort to an ad hoc relationship for estimating unemployment because no satisfactory equations could be estimated to model the supply side of the labour market. The problem here is two-fold; first, the inferior quality of the annual estimates of net migration and, secondly, the desired approach of calculating unemployment as the residual between two large variables, labour supply and civil employment can result in large errors in the unemployment estimates. In addition, outward migration increased enormously in the mid-1970s due to the civil disturbances and this influence is not easily modelled. For medium term forecasting, in addition to using the ad hoc unemployment equations it will be necessary to provide a check by estimating labour supply by traditional methods, using different assumptions about migration and activity rates and thus estimate unemployment as the residual between labour force and jobs.

Medium term forecasting with the Northern Ireland regional econometric model is not without problems but then neither is any other technique for regional forecasting. These problems arise mainly as a result of data limitations but also from inadequate economic theory. They are common to virtually all regional econometric models and because of them, it is not possible to build regional forecasting models of comparable quality to national models. However regional econometric models have been designed to utilize what is available and as such provide the forecaster with a technique which is potentially superior to the other main regional forecasting techniques such as export-base or input-output models. These are early days in the construction and use of regional econometric models and no doubt as their use becomes more widespread they will develop and improve. Wider use on a regular basis for forecasting and analysis should improve the techniques of regional modelling and forecasting and develop the data base.

Current work on the Northern Ireland model is directed towards providing a medium term forecasting service on a regular basis over the next few years. Most forecasters adjust their forecasts in the light of informed opinion. It is intended that medium term forecasts for the Northern Ireland economy will be based on the model projections but modified in the light of informed opinion canvassed at regular working seminars.

FOOTNOTES

1. For a general survey of regional econometric models see Glickman (1977). Other useful discussions can be found in Klein and Glickman (1977) and Knapp, et al., (1978).
2. The Census of Production suggests that nearly 70 per cent of manufacturing output is sold directly outside Northern Ireland, mostly in Great Britain. Of the remainder, a substantial proportion is used as intermediate inputs in the same exporting industries. The above formulation may be regarded as attempting to take account of the effects of the Industrial Development Programme by accepting the "pressure of demand" theory such as suggested by Moore and Rhodes (1976).
3. Throughout the sample period and until quite recently, GDP in the public sector was calculated without including any contribution from capital.
4. Most researchers in other regions have had similar problems with modelling the labour supply side in this fashion. See for example, the Temptress III model for Scotland (Lythe, et al., 1981), where after trying other formulations they decided to follow the approach used in the Northern Ireland model.
5. The method used is that due to Klein (1969).
6. For a discussion of the (MDM) model see Barker et al., (1980).
7. See for example, Fairclough and Jefferson (1980).

REFERENCES

- BARKER, T.S., V. BOROOAH, R. Van der PLOEG, and R.A. WINTERS, 1980. "The Cambridge Multisectoral Dynamic Model: An Instrument for National Economic Policy Analysis," *Journal of Policy Modelling*, Vol. 2, pp.319–384.
- EVANS, M.K., and L.R. KLEIN, 1968. "The Wharton Economic Forecasting Model," Economics Research Unit, University of Pennsylvania.
- FAIRCLOUGH, I., and C.W. JEFFERSON, 1980. "The Northern Ireland Economy 1978–84: A Medium Term Forecast Made in June 1980," Occasional Paper No. 15, Department of Economics, Queen's University, Belfast.
- GLICKMAN, N.I., 1971. "An Econometric Forecasting Model of the Philadelphia Region," *Journal of Regional Science*, Vol. 11, No. 1.
- GLICKMAN, N.I., 1977. *Econometric Analysis of Regional Systems*, London: Academic Press Inc (London) Ltd.
- JEFFERSON, C.W., 1978. "A Regional Econometric Model of the Northern Ireland Economy," *Scottish Journal of Political Economy*, Vol. 25, No. 3.
- KLEIN, L.R., 1969a. "The Specification of Regional Econometric Models," Papers of the Regional Science Association, Vol. 23.
- KLEIN, L.R., 1969b. "Estimation of Interdependent Systems in Macroeconometrics," *Econometrics*, Vol. 37, pp.171–192.
- KLEIN, L.R., and N.J. GLICKMAN, 1977. "Econometric Model Building at the Regional Level," *Regional Science and Urban Economics*, Vol. 37, pp.3–23.
- KNAPP, J.L., T.W. FIELDS, and R.J. JEROME, 1978. "A Survey of State and Regional Econometric Models," Taylor Murphy Institute, University of Virginia, Charlottesville, Virginia.
- LYTHE, C., J. DEWHURST, S. PARILLO, M. COX, and R. GAUSDEN, 1981. "Temptress III," Department of Economics, University of Dundee, (May).
- MOFFETT, W., 1973. "An Input–Output Model of the Northern Ireland Economy," Ph.D. Thesis, Department of Economics, Queen's University, Belfast.
- MOORE, B.C., and J. RHODES, 1976. "Regional Economic Policy and the Movement of Manufacturing Firms to Development Areas," *Econometrics*, Vol. 43, pp.17–31.