The Economic and Social Review, Vol. 20, No. 3, April, 1989, pp. 267-273

Growth, Migration and Causality: A Comment on Tests for Macroeconomic Feedback from Large-scale Migration Based on the Irish Experience, 1948-87

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I INTRODUCTION

It has long been assumed that a low rate of economic activity has been a direct cause of emigration in the Irish context. However, primarily because no empirical research into the reverse proposition has been undertaken, there is no concensus over what effect net migration has had on economic activity or whether it has had any effect at all. Theoretically, it is not clear whether emigration has an adverse or positive impact on economic activity. It must be determined whether those who emigrate lower or raise the average level of productivity. If those who emigrate have productivity levels below the average level (i.e., are unemployed or dependent), then it is likely that GNP *per capita* will rise after they leave. On the other hand, if those who emigrate have productivity levels above the average level, it is likely that GNP *per capita* will fall.

Walsh (1989) provides an important empirical foundation in this regard by employing Sims' (1972) causality tests in an attempt to determine whether emigration has had any impact on Irish economic activity. Walsh finds that changes in the level of economic activity have an influence on emigration but can provide no strong evidence that emigration has any impact on GNP *per capita*. In an effort to test the robustness of this result, this paper employs the Vector Autoregression (VAR) methodology pioneered by Sims (1980) and alternative causality tests suggested by Granger (1969).

*I would like to thank Gabriel Fagan and the editor for assistance with technical matters and helpful comments. The usual disclaimer applies.

In Granger's (1969) sense, a time series $\{X_t\}$ is said to cause another time series $\{Y_t\}$ if forecasts of future Y can be improved using present and past X given present and past Y. In the sense defined by Sims (1972) X is said to cause Y if present X is correlated with future Y, given present and past Y. Kohn (1981) provides an elementary proof that the Granger and Sims definitions are equivalent while Hosoya (1977) and Florens and Mouchart (1982) provide more exotic proofs of the same proposition. A comparison of the Granger causality test results with the Sims causality test results found by Walsh is therefore justified especially as the results from both sets of tests should be the same asymtotically.

The plan of this paper is as follows. In Section II, a description of the general procedure used by Sims (1972) and Walsh (1989) to test for causality is provided along with some of the problems that may be encountered in employing this procedure. In Section III, a description of the vector autoregression methodology is presented along with the Granger-causality tests obtained from a VAR using Walsh's (1989) dataset. In Section IV, the impulse response functions generated from this VAR are provided. Finally, in Section V, a summary and some concluding remarks are presented.

II SIMS' CAUSALITY TESTS AND CAUSALITY PRESERVING FILTERS

A general procedure for testing for causality as employed by Walsh (1989) and of which the procedure outlined in Sims (1972) is a derivative, is outlined in Pierce and Haugh (1977). In the Sims' procedure, estimated or prechosen (see Sims (1972)) univariate linear filters are used to generate whitened series (U, V) that preserve the causal relationship between the original series (X, Y). In order to determine whether X Sims causes Y, current U is regressed on leads and lags of V and the significance of the coefficients on the leading values of V are tested. If they are found to be significant, U is said to Sims cause V and because the linear filters are causality preserving, X is said to Sims cause Y.

Pierce and Haugh mention an alternative one-sided regression approach provided by Granger (1973)[1] where U_t is regressed on present and lagged V_t and *vice versa*. The relevant test for Granger-causality is to test for the joint significance of the coefficients on the lagged values of U_t and V_t.

A number of problems may be encountered when employing the Sims procedure. If inappropriate filters are employed and there is significant serial correlation left in the whitened series it may spill over into the residuals from

1. Granger, C.W.J., 1973. "Causality, Model Building and Control: Some Comments", unpublished manuscript presented at the IFAC.IFORS International Conference on Dynamic Modelling and Control (University of Warwick, Coventry).

the Sims' test regression. If this occurs, although the least squares estimates of the coefficients on the leads will be consistent, bias will occur in the estimates of their variances. Very often this bias is downward resulting in inflated t- and F-statistics and R^2 values (see Granger and Newbold (1974)). Therefore, if the prechosen filter leaves substantial serial correlation in the filtered series, it is possible that causality may be believed to have been found where it does not exist. Feige and Pearce (1979) have shown that using different filters on the same dataset can generate contradictory causality test results.

A further problem in this procedure is that the outcome of the causality testing is quite sensitive to the choice of lag structure (see Thornton and Batten (1985)). This problem is also encountered when joint significance testing in a VAR is performed as dicussed in the next section. Also, a serious disadvantage of the Sims' procedure in small samples is the loss of observations that results when a variable is regressed on the leads of another variable. This will suppress information that may have had an important influence on the summary statistics of the model.

Using the filtered series and the same lag structure used by Walsh (1989) the one-sided test suggested by Granger (1973) as discussed above was performed. The results of these regressions[2] do not differ too much from Walsh (1989) in that they suggest that there is stronger evidence that GNP causes NMR than the reverse proposition. With lags 3 and 4, there is evidence of unidirectional causality with evidence of GNP causing NMR at the 5 per cent and 10 per cent significant levels respectively using filters 1b and 2. However, the use of filters 1a and 2 does not give significant evidence of causality in either direction illustrating sensitivity of the results to the filtering used.

III VECTOR AUTOREGRESSION AND GRANGER CAUSALITY TESTS

A more direct method of determining the causal relationship between variables is suggested in Granger (1969). This involves regressing X on its own past and that of Y which is essentially the employment of a Vector Autoregression (VAR) model, the properties of which were later investigated by Sims (1980). The possibility that Y Granger causes X can be examined directly by testing whether the coefficients of lagged Y are zero. The lagged dependent variables in the VAR equations take out that part of X and Y that can be explained by their own pasts and in a sense perform a similar operation to the filtering procedure for the Sims' test. The causality testing procedure is simply to test the joint significance of the coefficients on lagged values of the independent variables.

2. The summary statistics of these regression equations are available from the author on request.

The main caution with the approach is to ensure that an appropriate lag-length is chosen so that the residuals of the VAR equations are white noise and the spurious regression phenomenon is avoided. This usually involves an extensive search of the lag space. In the present study, the tools used to determine the lag-length of the NMR-GNP VAR were likelihood ratio tests and Box-Ljung Q-tests. It was found that a lag-length of four seems to be appropriate. The summary statistics of this specification are presented in Table 1 below.

Table 1: *The Summary Statistics of the NMR-GNP VAR (Estimated over 1952-1987)*

Dependent Variable	*F-test* for the significance of lagged independent variable*	*Box-Ljung Q-statistic* for serial autocorrelation*	$\bar{R}^2$
NMR	F(4,27) = 2.520 (0.064)	Q(18) = 11.878 (0.853)	0.834
GNP	F(4,27) = 3.372 (0.023)	Q(18) = 15.365 (0.637)	0.299

*Significance levels for test statistics are in parentheses.

The F-statistics are the tests for causality and suggest that there is indeed significant evidence of feedback. The hypothesis that GNP does not cause NMR is rejected at the 10 per cent level while the hypothesis that NMR does not cause GNP is rejected at the 5 per cent level. Therefore the evidence that NMR causes GNP is stronger than the evidence that GNP causes NMR, contrary to Walsh's (1989) finding.

For purposes of comparison, this VAR was estimated over sample periods that correspond directly with those used in the Sims' test performed by Walsh (1989). The results were fairly similar to those of Walsh, suggesting that through the filtering and loss of observations from the leads, some important information was suppressed.

IV IMPULSE RESPONSE FUNCTIONS

The impulse response functions trace out the moving average representation of the Vector Autogressive model and provide a complete description of the dynamic structure of the model. They are derived by subjecting the model to one-time shocks which must be typical shocks (i.e., have occurred in the past) to avoid the Lucas critique. To consider the effects of a change in one variable in isolation, the errors are orthogonalised through a causal ordering of the relationship between NMR and GNP (see Hakkio and Morris (1984) or Flynn (1986) for discussion). The convention of using the F-tests to determine the causal ranking of NMR and GNP was adhered to although it is easy to verify that the reverse causal ranking does not give rise to very different impulse response functions. The causal ranking therefore adopted in this model was NMR first and GNP second.

Figure 1 below illustrates the response of GNP *per capita* to a one-time net outflow of 0.1 per cent of the population (i.e., a 10 per cent increase in emigration over the 1987 level). Also, the response of the NMR to a 1 per cent increase in GNP *per capita* is tracked out. The response of GNP *per capita* has two distinctive characteristics. Over the first five-year period there is a net decrease in GNP *per capita* of about 0.7 per cent if there is a once-off increase in emigration of about 3,000. This suggests that those who have emigrated in the past have had productivity levels above the average. Over the second five-year period, GNP *per capita* increases by about 0.6 per cent, almost offsetting the decline in the earlier period. An interpretation that may be put on this is that after highly productive workers emigrate, they begin to be replaced by workers with lower productivity levels that make increments to their human-capital endowments over time.

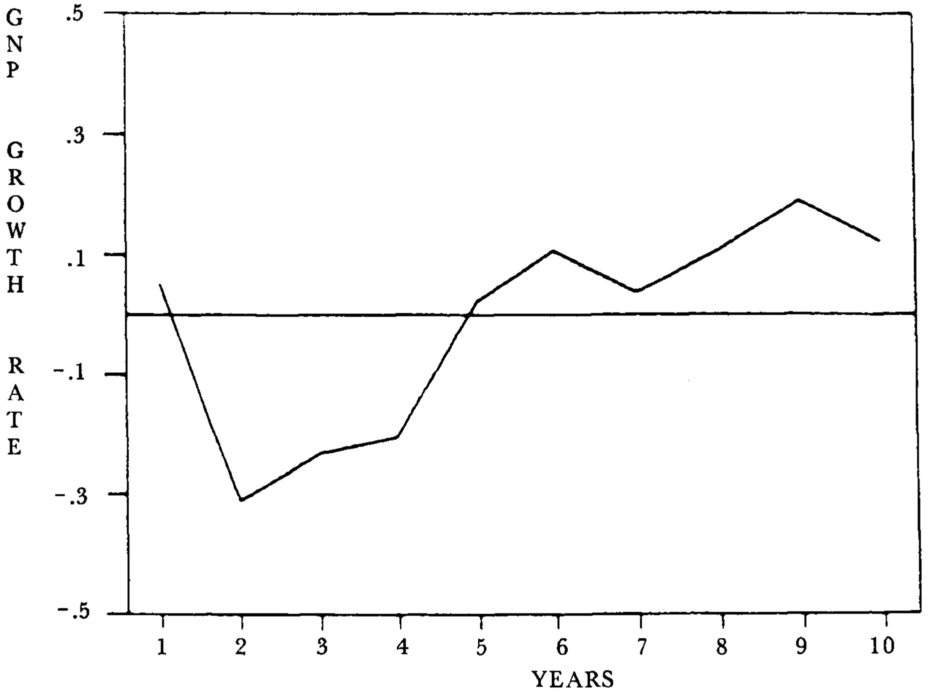
The response of the NMR to a one-time 1 per cent increase in GNP *per capita* has an almost sustained effect. Over a ten-year period in the absence of any other disturbances, a 1 per cent increase in GNP *per capita* in the first year results in a cumulative inflow of about 0.3 per cent of the population which would correspond to an inflow of about 9,000 people. This result is consistent with the theory that a poor economic performance is a sustained direct cause of emigration from Ireland.

V SUMMARY AND CONCLUSIONS

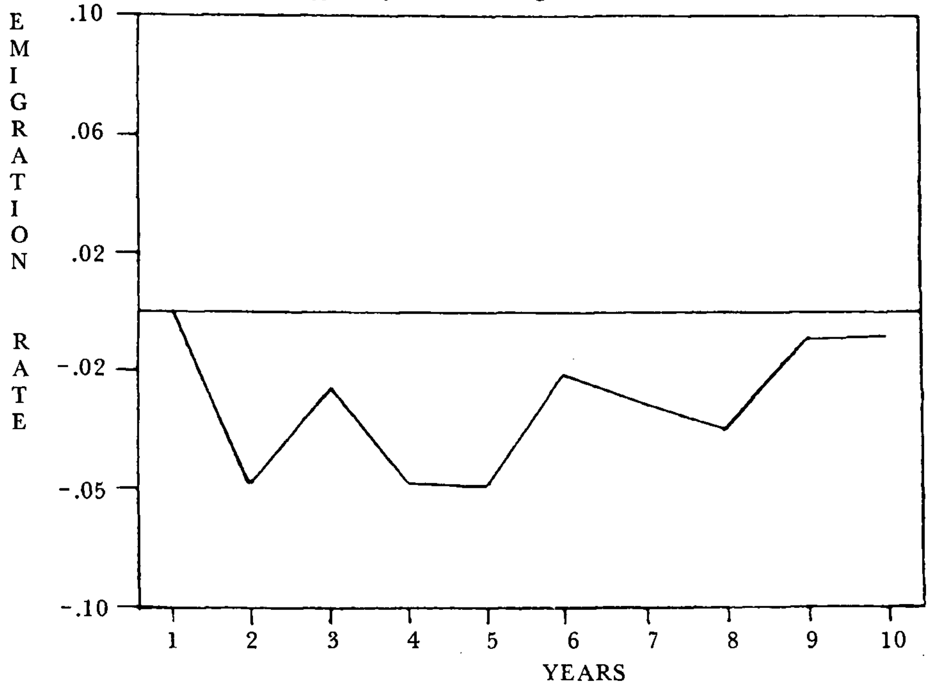
Using the VAR methodology, this paper finds that GNP *per capita* causes NMR as does Walsh (1989) but also finds that there is evidence of feedback from NMR to GNP in contradiction to Walsh. The results find evidence in favour of the so-called "brain-drain" theory, i.e., that those who emigrate from Ireland are highly productive. The difference to Walsh's results may lie in the causality testing procedures. It is possible that the Sims' tests performed by Walsh have inappropriate lead-lengths as the filtering used suggests a different lag-structure to that in the VAR. Also, the Sims' test involves loss of observations and degrees of freedom from the filtering and specification of lead-length which can have a crucial effect on small sample results. This outlines the advantage of the VAR which does not lose as many degrees of freedom and has a greater ease of implementation than the Sims' test.

Figure 1: *Impulse Response Functions of GNP and Emigration*

Effect of Emigration on GNP



Effect of GNP on Emigration



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