THE MACROECONOMIC IMPACTS OF FOREIGN DIRECT INVESTMENT: THE SCOTTISH CASE

by

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A thesis submitted in fulfilment
of the requirements for the
Degree of Doctor of Philosophy.
Department of Political Economy,
University of Glasgow, April 1985.

DEDICATION

To my mother and father.

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ACKNOWLEDGEMENTS

Although ultimately I bear responsibility for this thesis I am indebted to numerous people and institutions who contributed to the final outcome.

Firstly I wish to record my appreciation for the conscientious guidance and unfailing encouragement of my supervisor John Foster.

Secondly I am indebted to David Bell formerly of the Fraser of Allander Insitute now University of Warwick for invaluable econometric advice and supervision during a period of study leave by John Foster.

Special thanks must go to Tony Gloyne for those very beneficial chats at quite eccentric hours and for many helpful editorial comments.

Next I wish to express my gratitude to Carmen Sanjines Orejuela for her great help in proof reading the thesis, to Valerie McNish for providing the flow chart/graphics and to Sheena Bryson for bracing herself up to the task of typing, what was at times a quite difficult text.

I am also grateful to the Dundee Scottish Economic Modelling Group, the Fraser of Allander Institute and the Scottish Office for the provision of unpublished data series; and to the University of Glasgow and the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom for the scholarships.

Last but by no means least I would like to thank Dora Scholarios for her tremendous moral support and for most unselfishly sacrificing what should have been time spent together so that this thesis could be completed.

ABSTRACT

A two sector multi-equation macro-econonometric model of Scottish manufacturing industry was constructed and distinctive characteristics of the home and foreign sectors explored. In addition dynamic simulations were carried out to elucidate the policy implications of alternative scenarios.

ABBREVIATIONS

ACC	The product of Scottish manufacturing output and Scottish capacity utilization in manufacturing.
C.E.S.	Constant elasticity of substitution.
d	Difference operator.
Δ	Difference operator.
DEM	Scottish domestic demand. e.g. DEM = SCONK + SHIMK + SFIMK + STINMK + PAGSK.
dln	Approximates the percentage rate of change or rate of growth of a variable. e.g. $dlnX = lnX - lnX(-1)$.
DSEMG	Dundee Scottish Economic Modelling Group.
D.W.	Durbin-Watson test statistic.
d^2	Second difference.
FDI	Foreign direct investment.
GDFCF	Gross domestic fixed capital formation.
IDC	Industrial Development Certificate.
IER	U.K. index of exchange rates, relative to the U.S. dollar, 1975 = 100.
INC	Scottish personal disposable income net of the real wage bill in Scottish manufacturing.
I/O	Input - Output.
JVE	Output argument weighted by the price of

	U.K. investment goods/expected rates of return. e.g. JVE = WPUK x SIOP/PIGUK (UKR x IER)
ln	Natural logarithm.
PAGSK	Public authority government spending.
OLS	Ordinary least squares.
PFI	Private foreign investment.
PIGUK	Price of U.K. investment goods.
RAT(-1)	Index of U.K. to European rates of return lagged one year.
RDG	Regional development grants.
REP	Regional employment premium.
SAS	Scottish Abstract of Statistics.
SCOMER	Scottish manufacturing establishments record.
SCONK	Scottish consumer expenditure.
SCUIK	Scottish manufacturing capacity utilization index.
SDA	Special development area.
SEB	Scottish Economic Bulletin.
SFEM	Scottish foreign manufacturing employment.
SFIOP	Index of Scottish foreign manufacturing output.
SFIMK	Scottish foreign manufacturing investment.

SHEM	Scottish home manufacturing employment.
SHIMK	Scottish home manufacturing investment.
SHIOP	Index of Scottish home manufacturing output.
SIMFOR	SIMulation model of FOReign investment.
SIOP	Index of Scottish total manufacturing output 1975 = 100.
STEM	Total manufacturing employment in Scotland.
STINMK	Scottish total non-manufacturing investment.
TREND	Time trend, which attempts to proxy technological change.
TWSMK	Scottish manufacturing real wage bill.
TWUKMK	U.K. manufacturing real wage bill, net of the Scottish manufacturing wage bill.
UKR	Long term U.K. corporate bond rate.
WPUK	Index of wholesale prices in the U.K., 1975 = 100.
WXV	Proxy measure of world demand (export volume index), 1975 = 100.

INTRODUCTION

The identification and evaluation of the overall impacts of foreign direct investment on a host economy/region are prerequisites for informed policy prescription. However in practice these tasks pose quite complicated analytical and technical problems. In the vast majority of applied studies these difficulties tend to be reflected in the form of vague and inconclusive results. It is precisely these problems of identification and evaluation which this thesis will address. The purpose of the thesis is hence two fold. The first aspect concerns the development of an applied empirical methodology with which to analyze the structure and net overall impacts of the foreign sector in a host economy/region. The second objective is the application of the above methodology to a specific case, in this particular instance Scotland. It is hoped that the methods employed herein will also have relevance to other country/region studies which have similar characteristics to Scotland. It follows that the perceived contribution of the thesis is two fold. The first aspect is in the methodological analysis of foreign investment in that the proposed method will enable formerly unanswered questions to be addressed. The second contribution lies in the provision of specific answers in the context of Scotland.

The proposed method of analysis will be via a two sector (home/foreign) macro-econometric model of Scottish manufacturing industry. As in most modelling exercises, the approach must by necessity be pragmatic in nature, given the theoretical and empirical limitations imposed by the data. The overall model is comprised of three main blocks of equations, namely manufacturing output, employment and investment, all of which emphasize demand side as opposed to supply side influences. The specification and estimation of the single equations in this context not only enables the determinants of foreign/home output, employment and investment to be ascertained but simultaneously allows the quantitative differences between sectors, in the form of fixed parameter estimates to be identified. Once the above has been achieved the estimated blocks of equations will be assembled into a multi-equation system for simulation purposes. It is further argued that the results which are obtained from the single and multi-equation exercises can to a large extent only be found in a study of this type and it is these results which are the most important from a policy maker's perspective. The type of information which emerges from an exercise of this type includes: dynamic response elasticities, multiplier-type effects, export propensities, macro-linkages and long-run net effects of the foreign sector in output, employment and investment.

CHAPTER I

LITERATURE REVIEW

Introduction

The following literature review has the primary objective of providing both a theoretical and an empirical backdrop to the debate on the costs and benefits of foreign direct investment (FDI) on a host economy, with an emphasis on methodology. The choice of neo-classical static general equilibrium theory for purposes of the review is not out of any great predisposition for the tenets of this theory but merely reflects the surprising lack of what is usually termed the Keynesian alternative.

The selection of the Scottish case as an example of the applied work in the field was made for two reasons. The first is that the studies on the Scottish economy can be viewed as a proxy case for the issues and methods covered in the empirical literature as a whole.[1] As such they provide good examples of the gap which exists between the highly structured theoretical work and the much more descriptive empirical work. The second reason becomes apparent when one considers that the purpose of this thesis is the development of an empirical methodology with which to analyse the structure and the impacts of the foreign sector at the regional level with special reference to Scotland. As the Scottish case has been chosen for application of this methodology it is clearly necessary to become familiar with the existing work, both to avoid duplication and as a means of assessing the relative strengths and weaknesses of existing studies. Given the esoteric nature of the neo-classical literature, and at the opposite extreme, the highly unstructured nature of the applied literature, it is hoped that the review will demonstrate the great need for an empirical methodology. It will be argued that it is necessary to develop such a methodology from a mixture of eclectic a priori theorizing and specification search in order to properly evaluate the overall macro impacts of FDI on a host economy/region.

The Classical View on FDI

It is only in the last few decades that the arguments for and against FDI for the recipient country have come into prominence. Crudely put, the central classical notion was that, as a result of FDI, everyone gained i.e. the investing country, the recipient country and the world economy at large. The key theoretical justifications employed were the static law of comparative advantage and instantaneous adjustment in the terms of trade. The basic mechanism through which the theory operated was rate of return differentials between countries. Internationally mobile capital was supposed to flow from the capital rich country where it had low marginal productivity, to the capital scarce country which had a high marginal return to capital. The host country benefited to the extent that the productivity of investment income created was greater than that which the foreign investor took out in the form of profits, royalties, etc. On the other hand the investing country benefited to the extent that the rate of return on its foreign investment exceeded the rate of return on its domestic investment. Lastly, the world economy gained via increased world output, due to the opportunity cost associated with no foreign investment.

The MacDougall Analysis

The first explicit theoretical analysis on the costs and benefits of FDI was the classic work of MacDougall[2] who employed a static long-run framework which operated in a one sector (tradeables), two factor (capital and labour), two country world. The analysis starts out with what he described as a list of drastic assumptions to be relaxed in turn so as to view their implication for the theory. He initially assumed the following:

1. Full employment.
2. No taxation.
3. The size of the labour force is independent of the stock of foreign capital.
4. The stock of host owned capital is independent of the stock of foreign capital.
5. No external economies.

6. Constant returns to scale.

7. Perfect competition.

8. Foreign investment has no effects on the terms of trade.

As stated above, the model is set very much in the classical tradition with the host gaining by increased productivity of the complementary factor, as capital stock increases. By relaxing certain assumptions MacDougall was able to look at the level and distribution of gains from FDI between countries. For example, the host could simply increase its gain from FDI by raising the tax on foreign profits which, in turn, led to consideration of international tax differentials on profits and capital exports which obviously had implications for the rate of return on capital, i.e. the capital export tax affecting the absolute level of foreign investment and the profit tax influencing the distribution of gain between investing and recipient country.

MacDougall concluded that the host's share of the gain from FDI could be increased by higher tax revenue out of foreign profits, external economies, domestic firms absorption of know-how and, finally, economies of scale. It is interesting to note that MacDougall did not drop the assumption of full employment and this convention is adhered to by an overwhelming majority of authors in this area.

The Optimal Tax on FDI

Following MacDougall and developing along the lines of affecting the absolute level of foreign direct investment are a number of studies concerned with what the literature terms the optimal tax on foreign investment, the most notable of these being the early work of Kemp[3] and Jones[4].

Kemp's contribution lies in the connection he made between international capital flows and the terms of trade. In essence, he relaxed MacDougall's assumption that foreign investment has no effect on the terms of trade and opened up the way for the integration of tax policy on international capital flows (the optimal tax) and trade policy (the optimal tariff). A situation now arises where international capital flows are dependent on rate of return differentials, which are affected by profit taxes, tax differentials on capital exports and tariff differentials. Kemp & Jones operated in a neo-Heckscher-Ohlin type of world with the following set of assumptions:

1. Two countries, two factors (capital and labour), and two commodities.
2. Both factors are in fixed supply.
3. Net savings equal zero.
4. Perfectly competitive product and factor markets.
5. Technology is allowed to differ between countries.

6. Capital is homogenous, perfectly durable and smoothly substitutable for labour.
7. Perfect information, i.e. all parties are well informed about world trading and investment opportunities.
8. Full employment is always ensured.
9. Imposition of a tariff does not encounter retaliation by the foreign country.
10. Constant returns to scale with strictly concave production functions that satisfy the Inada condition, i.e. for each country the marginal product of each factor in each industry approaches 0 to ∞ as the ratio of this factor to the other approaches ∞ to 0 respectively.
11. The host's consumption of commodity one and commodity two is always positive.
12. The host exports commodity two which is labour intensive relative to commodity one.
13. Throughout the world neither commodity is an inferior good.

Given the above assumptions, what Kemp and Jones attempted to do, under some additional qualifying assumptions on the types of specialization in each country, was to derive analytical expressions for the level and sign of the optimal duty on international trade and the optimal tax on foreign capital. The main cases which will be reviewed here are the situations where at least one of the two countries is completely specialized in the production of one of the two commodities, while the other country produces either one or both of the two commodities. The case where both countries are incompletely specialized cannot be appropriately handled in this framework and will be discussed later in the review.[5] A more precise representation of the neo-classical approach in this context which allows the lines of causation to be made explicit can be represented as follows:

Let C_1 and C_2 represent the host country's consumption level of commodity 1 and commodity 2 respectively. The Social Welfare Function is defined as $U(C_1, C_2)$.

$$C_1 = X_1 (p, K^*) - r^*_1 (p^*, K^*) + p^* Z^*_2 (p^*, K^*) \qquad (1)$$

$$C_2 = X_2 (p, K^*) - Z^*_2 (p^*, K^*) \qquad (2)$$

Where,

K^* = the net flow of capital services flowing from the foreign to host country.

p^* = the domestic relative price of commodity two in terms of commodity one for producers in the foreign country.

p = the domestic relative price of commodity two in terms of commodity one for producers in the host country.

$X_1 (p, K^*)$ is the host country's output level of commodity one.

$X_2 (p, K^*)$ is the host country's output level of commodity two.

$Z^*_2 (p^*, K^*)$ is the foreign import level of the second commodity.

$r^*_1 (p^*, K^*)$ is the real foreign rental rate of capital in terms of the first commodity.

The Social Welfare Function is strictly quasi-concave with $U_1 = \partial U / \partial C_1 > 0$ and $U_2 = \partial U / \partial C_2 > 0$.

If the host is incompletely specialized

$$X_{11} = \partial X_1 / \partial p < 0 < \partial X_2 / \partial p = X_{21}$$

and by the Rybczynski Theorem.

$$X_{12} = \partial X_1 / \partial K^* > 0 > \partial X_2 / \partial K^* = X_{22}$$

Along any offer curve of the foreign country $Z^*_{21} = \partial Z^*_2 / \partial p^* < 0$ and if the foreign country is incompletely specialized $Z^*_{22} = \partial Z^*_2 / \partial K^* < 0$, but $Z^*_{22} \lesseqgtr 0$ as $K^* \lesseqgtr 0$ if foreign specialization is complete. By the Stopler-Samuelson Theorem, with incomplete specialization in the foreign country $r^*_{11} = \partial r^*_1 / \partial p^* < 0$ and $r^*_{12} = \partial r^*_1 / \partial K^* = 0$ but if the foreign country is completely specialized $r^*_{11} = 0 < r^*_{12}$ by the law of diminishing marginal returns.

The objective of host government according to the neo-classicists was to maximise $U(C_1, C_2)$ by choosing p,

p^* and K^* subject to C_1 and C_2 as well as taking account of the degree of specialization in the foreign country. From the first order conditions of the social welfare maximization function, results are derived which are further manipulated to yield expressions for the optimal value and sign of the international trade tax and foreign investment tax. Given first best optimization (i.e. when the value of the duty and capital tax can be altered simultaneously) Kemp's well known first best package is to apply a positive duty and a positive tax under both assumptions of specialization. Jones extended Kemp's work by looking at the second best package of policies under the assumption of partial optimization. Case one is where the duty on international trade is assumed to be zero (say by commercial agreement) while the host is free to alter the tax on foreign capital flows. The second is simply a reversal of the above where the optimal tax is now set at zero. Jones concluded that for case 1 when both countries are completely specialized the optimal tax should be positive; the same conclusion applying for the case where one country is incompletely specialized. In case 2 Jones concluded for both types of specialization that the tariff imposed should be positive.

Further work directly along these lines was carried out by Gehrels[6] who considered the Jones partial optimization cases but under the initial assumption that in case 1 the tariff does not equal zero and in case 2 the tax does not equal zero. He concluded that relative to the full optimization scenario the sign of the optimal duty is positive and should be greater than the first best level. This same finding applies to the sign and level of the optimal tax.

A more recent work squarely in the Kemp-Jones tradition, i.e. the two commodity, two factor framework, is that of Brecher[7]. He argued that the second best package of policies suggested by Jones is actually the third best. He concluded that under partial optimization the duty or tax must be complemented with a tax (subsidy) in consumption or production. Further details of Gehrels and Brecher will not be discussed since in the subsequent literature, the type of model that they have pursued has been surpassed in several important respects by other variations which take into account the concepts of non-tradeable goods and sector specific capital.[8] The implications for the Heckscher-Ohlin type model as a result of the Caves analysis were:

1. Perfect mobility of one type of specific capital will lead to complete factor price equalization across countries, assuming identical production functions between countries and that the two commodities are traded without any natural or artificial barrier.

2. If all commodities and specific factors are perfectly mobile internationally, then the number of equations displaying international price equality becomes greater than necessary to yield international factor price equalization. Thus, it is likely that at least one country will be completely specialized with one type of specific capital entirely absent from that country.
3. Movement of one type of specific capital from one country to another will produce an incentive for the other type of capital to move in the other direction.
4. In the specific capital type model tariff protection of the capital intensive industry will cause an increase in the real wage provided that specific capital of the protected industry is perfectly mobile internationally and the country concerned is a small country. Whereas in the Heckscher-Ohlin model tariff protection leads to a decrease in the real wage.

According to the literature, the need for a framework which incorporated the sector specific assumption was that under the assumption of incomplete specialization for both countries the traditional Kemp-Jones model produced either inconsistent or indeterminate results. The problem with the traditional approach in this light was that the terms of trade were determinate and unaffected by changes in exogenous demand. This results in the rental rate on capital being independent of changes in demand and therefore adjustments to changes in income between countries take place via capital movements rather than through changes in the terms of trade. Further, even the above consistency disappears when both countries are too small to bring about a change in the world terms of trade and, therefore, the international allocation of capital becomes indeterminate.

Because of the above problem, an alternative was sought in the general equilibrium, sector specific, type model.[9] Some of the basic results of the general equilibrium model with specific factors are now presented since they are helpful in understanding subsequent work.

1. Given constant product and commodity prices, an increase in the supply of a factor always lowers the reward to that factor.
2. Via the Stopler-Samuelson theorem an increase in the relative price of a commodity will increase the real reward (in terms of both goods) of the factor used relatively intensively by that commodity and lead to a fall in the real reward of the other factor used relatively intensively by

the other commodity.

3. At constant commodity prices via the Rybczynski theorem an increase in the supply of one factor will increase the output of the commodity using the expanding factor relatively intensively and decrease the output of the other commodity.

However, one of the caveats of the sector specific approach, as stated by Amano, is that "there is a clear limitation to a theory based on specific factors which does not analyze the mechanism that determines their supplies".[10] Hence specific factors are viewed as primarily a short-run phenomenon, where the length of the period is dependent on the degree of shiftability of the factors concerned. A specific example of the use of the above model, with the additional distinction between traded and non-traded goods, is given by Burgess.[11] He looked specifically at the issues of returns to domestic factors and challenged the notion produced by the traditional models of both the MacDougall and Kemp-Jones variety that an influx of foreign capital will raise real wages and lower the return to domestic capital.

Capital stock in the Burgess model is assumed to be sector specific and the labour force moves freely to equilibriate wage rates between sectors. Further, the foreign investor is a supplier of an industry specific package of capital services and demands renumeration for his services in units of traded goods with output prices now endogenous to the model given a non-traded goods sector. Now that the equilibrium in the non-traded goods market has to be considered, Burgess concluded that the issue of income distribution becomes an empirical one versus a purely analytical one. The relative welfare between capital and labour is now dependent on the elasticities of substitution between capital and labour in each sector and the elasticities of substitution between traded and non-traded goods in consumption. Burgess stated that, "the immediate impact of foreign investment at unchanged output prices is to shift the labour force from non-tradeables to tradeables and thereby raise real wages and lower real return to both types of capital. The subsequent increase in the relative price of non-traded goods will initiate a reverse shift of the labour force which will raise the return to capital in the non-traded goods sector and lower the return to capital in the traded goods sector. The effect on the real wage depends on the extent to which the wage increase falls short of the price increase of non-tradeables, and the extent to which the labour force wishes to consume non-tradeables. Labour is more likely to be adversely affected by the price adjustment whenever the wage increase is small relative to the increase in the price of non-tradeables, while the share of wage income spent on non-tradeables is large".[12]

Further reconsideration of the early Kemp-Jones work (specifically the optimal tax) is taken up by Dei[13] under the scenarios of generic and specific capital and a non-traded goods sector. Given the assumption that both countries are incompletely specialized he concluded that it is the instability of the non-traded sector which brings about the following unorthodox results:

1. An increase in the tax rate encouraged capital exports of the host country.
2. A capital influx into the host raised the real rental rate of capital in that country.
3. That it is optimal to subsidize the income from international investment.

However, it must be pointed out that, under the assumption of complete specialization for both countries, Kemp's original assertions are revived and when specific capital is considered, the sign on the optimum tax is ambiguous.

Finally, one study worth considering in this selective review is that of Das.[14] The feature of this article which is most relevant is his single country model in the spirit of Burgess in which he presented a simple theoretical analysis of foreign investment in the presence of unemployment. He assumed that capital is specific in each sector, unemployment in each sector is due to wage rigidity, labour is mobile between sectors and foreign investment occurs only in the traded sector.

He wanted to examine the effects on overall employment and employment in each of the respective sectors as a result of an exogeneous increase in FDI. The main mechanism by which foreign investment affects the different economic variables in the system is via its impact on the relative price of non-traded goods. Das concluded that the net employment result is largely an empirical question. The model showed how the exogeneous flow of FDI increased employment in the non-traded sector, and why the results for employment in the traded sector and overall employment were ambiguous.

Finishing this theoretical review with the work of Das is appropriate, since his message is the need for an empirical evaluation of foreign investment. Even within the restrictions of a general equilibrium framework, which requires a much greater number of assumptions to generate what are often a very small number of quite simple conclusions, the importance of applied work is recognized. However, acknowledging the need for empirical analysis on the subject does not invalidate the need for a theoretical base, but raises the question of identifying the most appropriate theoretical set of premises from which a researcher should operate.

It is argued here that the neo-classical assumptions used to evaluate the impact of FDI, namely the existence of full employment and the predominance of the relative price mechanism in restoring equilibrium, are unduly restrictive and irrelevant. As seen from the preceeding selective review of the literature, the conclusions of the theory are somewhat removed from what policy makers seem to be after when allowing foreign capital to enter their country, i.e. short-term increases in output and employment and, more importantly, long-term gains in potential and actual output. Under the assumptions of the majority of neo-classical writers, the impact issue is merely one of distribution of the gains from foreign investment between investing and borrowing countries and further, the distribution of that gain or loss between factors within a country.

Probably the best evidence which supports the spirit of the above argument on the irrelevance of neo-classical work in this context is that the empirical literature on costs and benefits in FDI does not display a great deal of dependence on the assumptions of neo-classical theory. This view is best summed up by the following statement from empirical researchers in the field: "the theoretical work on the assessment of gains and losses from foreign investment is largely undeveloped, remains at a high level of abstraction and is ambiguous in its predictions".[15] Ironically this can be viewed as an advantage or disadvantage. On the one hand, as strength in that these empirical studies are not operating under the constraining assumptions just mentioned. Hence, they are free from the conclusions which follow. On the other hand the disadvantage of the lack of an explicit methodological base is that there is no framework in which to comment on the longer term impacts of FDI on a host economy.[16]

Scottish Empirical Studies on FDI

Given that the neo-classical theory on the subject is generally viewed as largely inappropriate, it is the purpose of the remaining section of this review to show the way in which this is reflected in the empirical studies on Scotland. In addition, this shows the extent to which the lack of an explicit methodological framework provides a constraint on these studies' ability to ascertain, not only structural differences between the home and foreign sector, but further [illegible] some of the longer term macro questions on the relative impacts of FDI. Before launching into the methodological issue as it relates to this representative group of empirical studies, it is worth mentioning a wide variety of studies which are indirectly related to FDI in Scotland but will not be reviewed here.

These studies have to do with evaluating the impact of U.K. regional policy.[17] Their relevance lies in the fact that FDI in Scotland is generally viewed as more or less a product of regional policy incentives in the U.K., regional policy being the vehicle which is supposed to encourage migrant firms to move to the less developed areas of the U.K..[18] Most of these studies, however, are irrelevant for the purposes of the present study mainly because they do not distinguish between English firms and foreign firms (in the context of this study, foreign meaning any non-U.K. firm).[19] A subset of these studies which does genuinely distinguish between foreign and indigenous firms are the so-called firm movement studies.[20] These studies attempt to evaluate the comparative impact of indigenous and foreign firm movement as a result of regional policy. Here again a problem arises in so far as these studies emphasize the relative importance of various policy instruments in stimulating firm movement without addressing the question of what happens once these firms arrive in Scotland. In contrast, the present study is more concerned with ascertaining the structure and the impacts of the foreign sector once it has been established rather than with the relative determinants of its movement, as related to regional policy.[21]

What ensues is a review of the Scottish studies which are more directly related to the question of analyzing the impact of FDI proper. The methodological drawback with the vast majority of these studies is precisely one of the main problems to which this thesis addresses itself (i.e. in devising an empirical macro-methodology which enables the alternative situation to foreign investment to be examined in a quantitative manner).[22] It must be emphasised that this problem with the empirical literature in general does not invalidate its findings or insights (in a short-term context) which are mainly at the micro level[23]. However what is argued here is that this search for a broader macro-type methodology for analyzing foreign investment impacts, will provide a reference point for the medium to long-term, that can be used by those working at the micro level. The two approaches are essentially complementary and it is argued here that the lack of a more macro-type approach prohibits explicit consideration of the opportunity costs of FDI. Hence the inability of these micro studies to make more definite statements on the overall impacts of FDI in Scotland.

This problem of accounting for opportunity costs is readily acknowledged in the literature. For instance Dunning stated that a methodological issue "which is particularly troublesome to research workers, and which policy makers are too often apt to ignore, is the problem of evaluating the effects of FDI net of those effects that would have occurred if the resources used by the investing companies had been differently deployed".[24]

On foreign investment in Scotland Lythe & Majmudar argued, "thus while the importance of U.S. investment in terms of employment gains cannot be denied there are wider issues involved. The central issue is what would have happened in the absence of U.S. foreign investment".[25]

Hood & Young stated that, "by whatever framework the benefits and costs of foreign investment are analyzed, one of the central issues is the postulation as to what might have happened in the economy in the absence of that investment. In effect such benefit/cost exercises require a benchmark, although in application to foreign investment they can scarcely even be given one".[26] It will hopefully be shown in this thesis that in fact a benchmark can be provided.

The general climate of opinion on FDI in Scotland as regards short and long-run effects is best summed up by McDermott "unless it can be demonstrated that long-term damage to the Scottish economy has resulted from this, it would be difficult to argue for any change to the policies which have encouraged such investment".[27]

Further examples of the type of statements that the micro studies allow the researcher to make as regards overall impacts are provided in Hood & Young's review of the costs and benefits literature on FDI in Scotland.[28] All too often Hood & Young are halted by the logic of their approach in addressing the question of the overall net outcome of FDI. Again it is argued here that this type of question is best handled within an aggregate framework. Bearing in mind that it would be beneficial to be able to get to grips with the longer term impact questions on FDI and, assuming for the moment that this can best be handled with a macro type approach,[29] it is deemed worthwhile to engage in a brief selective review of the short-term findings of the Scottish studies on the impact of FDI.

The pioneering study on foreign investment in Scotland was by Forsyth[30] whose work takes into account a wide variety of issues concerning the extent, impact and implications of FDI in Scotland. Some of his main conclusions are as follows:[31]

1. That the U.S. sector performed better than indigenous firms in terms of growth, profitability and labour productivity.
2. That U.S. firms as a whole used more advanced methods than did indigenous firms.
3. That labour relations were better in indigenous firms.
4. That the growth of U.K. and European markets induced U.S. firms to locate in Britain and that regional policy invoked U.S. firms to locate in Scotland.
5. That the short-term impact of FDI was clearly employment and output creating due to the vast quantity of under utilized resources in the Scottish economy.
6. That diffusion of technological and managerial know-how from the foreign to the indigenous sector was minimal.
7. That the foreign sector exhibited a low degree of integration with indigenous industry, manifested

in poorly developed inter-industry and inter-firm linkages.

Besides the above conclusions, which were mainly gleaned via the survey method, Forsyth's study is novel relative to the other Scottish studies which follow, in that he attempted (albeit in a somewhat crude fashion) to examine alternatives to FDI. He made use of static short-run regional multiplier analysis and reported a range of possibilities for employment in 1969. His overall conclusion from this exercise was that U.S. investment had positive employment impacts (after adjustment of the more extreme alternatives, i.e. that all of the investment by the U.S. sector would have been replaced by the indigenous sector). In this case Forsyth argued, "the cost of replacing the U.S. owned sector would have been considerable and would have placed a heavy burden on the central government"[32]. Hence it would have been an extremely unlikely scenario.

Further work on the motives and methods of foreign firms entering Scotland can be found in Hood & Young[33], which lends some additional support to the notion that regional policy is effective in attracting foreign firms to Scotland. They argued, "it would appear that the establishment of a U.S. firm's initial European operation in Scotland was related more to intra-U.K. locational influences than to a strategy of establishing a highly developed European forward base designed to provide a locus of control for future plants".[34]

As far as European companies are concerned Hood & Young concluded in another article that the main method of entry is via acquisition.[35] They argued that it is the ready made nature of the plant with its established markets and existing commercial arrangements which the European firms found to be most important. As to whether this method of operation bestows net costs or benefits to the Scottish economy, Hood & Young concluded that "while there are no a priori reasons to conclude that loss will ensue from foreign takeover, there is as yet little evidence of the infusion of new management, technology or products into Scottish companies acquired by continental European parents. In fairness this is a relatively recent phenomenon, but it is one on which an open verdict would have to be returned as there is all still to prove in terms of Scottish benefit".[36]

The next debate which seems to have received a lot of attention in the Scottish literature is the external control or branch factory type argument. Firn[37] discussed three major drawbacks to a high degree of external control.

1. That there is a tendency for greater capital intensity over time, therefore a propensity for less employment potential in the long-run.

2. That there is a tendency for the emergence of a branch factory economy which not only cancels out the advantages of inter-firm and inter-industry linkages, but further that the indigenous sector's growth prospects are hampered in the long-run.
3. It fosters a dependent attitude on the part of the host and hence dampens entrepreneurial drive.

The other argument often bandied about on the costs of external control is that it tends to exaggerate the deflationary tendencies of the economy in which it is located.[38] Along the lines of the analogy that when Detroit catches a cold, Scotland comes down with pneumonia.

Empirical work on the branch factory argument for the Scottish case, was carried out by Hood & Young.[39] They defined branch plant as including all manufacturing branches and subsidiaries whose locus of ultimate control lies with the parent company in America. Control is inferred if:

1. 50% or more of the voting stock is owned by residents of the U.S.A. or
2. 25% or more of the voting stock is concentrated in the hands of a single holder or organised group of holders in the U.S.A. or

3. The Scottish firms are foreign branches of U.S. companies or
4. The Scottish firms are proprietorships or partnerships owned by Americans.

They examined two functional areas of activity where the potential loss of autonomy is greatest, i.e. research and development (R & D) and marketing. They use these as proxy indicators of the authority and decision making potential delegated to local management. From the data which they derive by way of a survey, they come to the conclusion that the majority of U.S. firms in Scotland either undertake no R & D/ marketing, or the functions delegated to them are not particularly meaningful.

However, while acknowledging this particular cost of FDI to Scotland Hood & Young note the paradox involved with this argument: "While the involvement of multinationals or the development of a host economy invariably involves a loss of economic independence, and is therefore to be regarded as a cost, the exact nature of the loss depends on what would have happened in the absence of foreign direct investment. The level of U.K. interdependence is such that much of the alternative employment creation would probaly have been externally controlled in any event".[40]

Finally, another study along the lines of the above which explicitly examines the purchasing and sales linkages between the foreign and home sectors for the electronics industry is by McDermott.[41] He set out to test the following five hypotheses.

1. That the foreign sector should stimulate the generation of indigenous enterprise via diffusion of technology, skills and creation of local market opportunities.

   This premis could not be rejected outright, but he could not find many new Scottish firms which owed their existence to the foreign sector.

2. That the presence of the foreign sector would be reflected in the parallel development of related indigenous enterprise.

   This hypothesis was also not rejected and he found that home firms grew at similar rates as foreign firms. It also seems to lend support to the argument that the foreign sector was not crowding out local competition.

3a. That the foreign company should be no more complex in organizational terms than a local company with similar proportions of technical and managerial staff.

3b. That foreign and home firms should have similarly structured environments.

   Here it was found that significant

differences did exist between level of organization and employment structure between home and foreign firms.

4. That strong linkages will emerge between the foreign subsidiary and the local industrial infrastructure.

   This hypothesis was rejected, i.e. strong linkages were not pronounced. The dependence found was asymetric in that the foreign sector was more important for the local sector and not vice versa.

5. That there will be local firms which have reduced their dependence on the foreign sector and will establish external market contacts.

   From his evidence he could neither reject nor not reject this hypothesis.

Summary

The preceding selective review of neo-classical theory and the applied Scottish studies, on the impacts of FDI, has been presented in order to illustrate the methodological gap which exists between the highly structured theory and the more descriptive applied work. It has been argued that by looking at the work of MacDougall through Das, the limiting assumptions of full employment and the predominance of the relative price mechanism obscure the most important issues in which the host economy is presumably interested, i.e. both short and long-run gains in output and employment. The matters of greater significance from the neo-classical perspective inevitably reduce to the problems of income distribution. Furthermore, it was argued that the irrelevance of neo-classical assumptions has contributed to a situation in which applied work in the field is conspicuously devoid of theoretical content. This lack of theoretical base is in evidence in nearly all of the Scottish work. This in turn leads to a situation in which it is not possible to empirically analyze the overall net impacts of FDI. Given the object of the thesis this is clearly unacceptable and therefore leads to a detailed discussion of quantitative macro-oriented approaches in Chapter II with a view to bridging the gap between theory and practice and providing a practical means of evaluating the structural differences between the sectors as well as the net overall impacts of FDI.

NOTES: CHAPTER I

1. Scotland, when viewed as an economic region vs. an independent economic entity, is unique in that it has no independent price system, no explicit balance of payments, no unique Scottish currency etc. However, this does not invalidate the point that Scotland, the "economic region", is subject to the same economic realities (of having a limited supply of resources available to satisfy its citizens demands) as an independent nation state. It is argued here that these realities tend to be reflected in the empirical literature on FDI in Scotland (with the notable exception of balance of payment type studies) and hence, for the purposes of this review and this thesis, nothing is lost by not drawing on the vast quantities of applied literature in this area.

2. See Mac Dougall, G. D. A. 'The Benefits and Costs of Private Investments from Abroad: A Theoretical Approach', Economic Record, Vol 36 (1960), pp. 13-35.

3. See Kemp, M. C. 'The Gain from International Trade and Investment: A Neo-Heckscher-Ohlin Approach', American Economic Review, Vol. 56 (Sept. 1966), pp. 788-809.

4. See Jones, R. W. 'International Capital Movements and the Theory of Tariffs and Trade', Quarterly Journal of Economics, Vol. 81, No. 1 (Feb. 1967), pp. 1-38.

5. For a good discussion of the inconsistencies and ambiguities produced by the Kemp-Jones model in this respect, see Das, S.P. and Lee, S. D. 'On the Theory of International Trade with Capital Mobility', International Economic Review, Vol. 20 No. 1 (Feb. 1979), pp. 119-132.

6. See Gehrels, F. 'Optimal Restriction on Foreign Trade and Investment', American Economic Review, Vol. 61 (1971), pp. 117-159.

7. Brecher, R. A. 'Second Best Policy for International Trade and Investment', Journal of International Economics, Vol. 14 (1983), pp. 313-320.

8. The pioneering work on sector specific capital (which basically means that capital can be mobile internationally within the same industry, but is not mobile domestically) was carried out by Caves, R. E. 'International Cooperations: The Industrial Economics of Foreign Investment', Economica, Vol. 38 (Feb. 1971), pp. 1-27.

9. A good mathematical exposition of this model can be found in Amano, A. 'Specific Factors, Comparative Advantage and

International Investment', Economica, Vol. 44 (1977), pp. 131-144.

10. Ibid., p. 131.

11. See Burgess, D. F. 'On the Distributional Effects of Foreign Direct Investment', International Economic Review, Vol. 19, No. 3 (Oct. 1978), pp. 647-664.

12. Ibid., p. 653.

13. See Dei, F. 'Non-traded Goods and Optimal Foreign Investments', Journal of International Economics, Vol. 9 (1979), pp. 527-538.

14. Das, S.P. 'Effects of Foreign Investment in the Presence of Unemployment', Journal of International Economics, Vol. 11 (1981), pp. 249-257.

15. See Hood, N. and Young, S. Multinationals in Retreat: The Scottish Experience (Edinburgh: Edinburgh University Press, 1982), p. 12.

16. This point will be explored further, later in this Chapter and in Chapter II.

17. For a very comprehensive review of the studies in this vein refer to Schofield, J. A. 'Macro Evaluations of the Impact of Regional Policy in Britain: A Review of Recent Research', Urban Studies, Vol. 16 (1979), pp. 251-271. For a more Scottish specific view see the following: Moore, B. and Rhodes, J. 'Regional Policy and the Scottish Economy', Scottish Journal of Political Economy, Vol. 21 (1974), pp. 215-236; Begg, H. M., Lythe, C. M. and MacDonald, D. H. 'The Impact of Regional Policy on Investment in Manufacturing Industry, Scotland 1960-71', Urban Studies, Vol. 13 (1976), pp. 171-179. Begg, H. M. and Lythe, C. M. 'Regional Policy 1960-1971 and the Performance of the Scottish Economy', Regional Studies, Vol. 11 (1977), pp. 373-381 and Majmudar, M. 'Government and the Scottish Economic Performance: 1954-1978', Scottish Journal of Political Economy, Vol 30 (1983), pp. 153-169.

18. For a review of the major changes in U.K. regional policy and the instruments used, refer to Schofield, J. A. op.cit., pp. 270-271. See also Ashcroft, B. K. 'The Scottish Region and the Regions of Scotland' in Ingham, K. P. O. and Love, J. (Ed.) Understanding the Scottish Economy (Oxford: Martin Robertson, 1983), pp. 178-179 Further, for the institutional details of U.K. policy stance on inward investment, which is essentially an open door policy, see Brech, M. and Sharp, M. Inward Investment: Policy options for the United Kingdom

(Chatham House Papers: Routledge & Kegan Paul, 1984), pp. 2-25.

19. For conceptual reasons it is hard to really classify England as foreign when compared with a genuine foreign company whose home base is not in the U.K. (although there is a cultural argument for doing this). The reason being that Scottish firms and English firms are highly integrated within the U.K. market, in their technological infra-structure, in the same exchange rate system, government taxation system and under U.K. policy in general. Thus it would be difficult to postulate that there is an a priori difference between Scottish and English firms and, therefore, one would expect that their relative impacts on the Scottish economy would not differ significantly. Furthermore, the available data do not include English figures to the ranks of foreign data hence, for the purpose of this study, England is not viewed as foreign to Scotland.

20. A relatively recent article in this area which briefly reviews the other main work on foreign and indigenous firm movement is by Ashcroft, B. K. and Ingham, K. P. D. 'The Comparative Impact of U.K. Regional Policy on Foreign and Indigenous Firm Movements', Applied Economics, Vol. 14 (1982), pp. 81-100.

21. See Chapter VI for detailed consideration of the determinants of FDI in Scotland. Further discussion takes place there on the relative strengths and weaknesses of viewing the determinants of FDI in Scotland as part and parcel of regional policy narrowly defined.

22. The advantages and disadvantages of this type of exercise are examined in further detail in Chapter II.

23. Indeed quite a significant amount of information is discernable at the micro level which cannot be picked up in a macro type study. Certainly a lot of very useful information is lost in aggregation and it is not argued here that the micro studies should be replaced by the macro ones, but merely that the lack of a macro approach can severely limit the usefulness of the micro studies over time.

24. See Dunning, J. H. International Production and the Multinational Enterprise (London: George Allen & Unwin, 1981), p. 36.

25. Lythe, C. and Majmudar, M. The Renaissance of the Scottish Economy (London: George Allen & Unwin, 1982), p. 154.

26. See Hood, N. and Young, S. (1982), op.cit., p. 14.

27. See McDermott, P. J. 'Multinational Manufacturing Firms and Regional Development: External Control in Scottish Electronics Industry', _Scottish Journal of Political Economy_, Vol. 26 (1979), p. 303.

28. See Hood, N. and Young, S. (1982), _op.cit._, pp. 12-29.

29. The advantages and disadvantages of applying a framework which takes into account interrelationships versus a more partial approach are discussed in Chapter II.

30. See Forsyth, D. J. _U.S. Investment in Scotland_ (Prager, 1972).

31. Qualifications and the problems associated with these conclusions are covered by Forsyth. It is only intended at present to give a taste of the types of issues covered and the methods used to analyse them.

32. See Forsyth, D. J. (1972), _ibid._, pp. 105-106.

33. See Hood, N. and Young, S. 'The Geographical Expansion of U.S. Firms in Western Europe: Some Survey Evidence', _Journal of Common Market Studies_, Vol. 14, No. 3 (1976), pp. 223-234.

34. _Ibid._, p. 234.

35. See Hood, N. and Young, S. 'Foreign Direct Investment in Scotland: The European Dimension', _Scottish Journal of Political Economy_, Vol. 28, No. 2 (June 1981), pp. 165-185.

36. See Hood and Young (1982), _op.cit._, p. 22.

37. See Firn, J. 'External Control and Regional Development: the Case of Scotland', _Environment and Planning_, Vol. 7 (1975), pp. 393-414.

38. See Parsons, G. F. 'The Giant Manufacturing Corporations and Balanced Regional Growth', _Area_, Vol. 4 (1972), pp. 99-103.

39. See Hood, N. and Young, S. 'U.S. Investment in Scotland - Aspects of the Branch Factory Syndrome', _Scottish Journal of Political Economy_ Vol. 23, No. 3, (Nov. 1976), pp. 279-94.

40. See Hood, N. and Young, S. (1982), _op.cit._, p. 25.

41. McDermott, P. J. (1979), _op.cit._, pp. 287-306.

CHAPTER II

EMPIRICAL METHODOLOGY

Introduction

The purpose of Chapter II is to advance the methodological argument by elaborating on the need for an approach which is capable of accounting for the opportunity cost associated with the presence of foreign investment. Once this has been completed, a summary of the main effects of FDI is presented along with the criteria for more narrowly defining the effects which will be analyzed in greater detail. It should then be apparent that the most appropriate empirical methodology for analyzing the net overall effects of FDI is one which is quantitative and macroeconomic in nature. The discussion then moves into assessing the respective merits of three different macro methods used at the regional level (i.e. economic base, input/output and econometric models). The macro econometric approach is chosen as the most appropriate for purposes of the thesis. The ensuing analysis then looks at criticisms of the econometric approach from both the national/regional macro econometric perspectives and is followed by a discussion of the attempts made to accomodate these criticisms within the context of the thesis.

The opportunity cost of FDI

As pointed out in Chapter I a very important and complicated analytical problem is that of assessing the opportunity costs associated with foreign capital. For example, to state that a certain amount of income and employment are a result of FDI is ambiguous and depends on whether an absolute or relative criterion is applied. Bos et al.[1] in a study which attempted to construct an empirical methodology of the impacts of private foreign investment (PFI) on developing countries stated, "It should be noted that in the last paragraph we used the words 'income generated through PFI' and not 'income due to PFI'. A distinction between these two expressions is needed because it is questionable whether evidence presented on income generated through PFI, even if the data are fully correct, is acceptable as evidence of income due to PFI. This latter would only be appropriate if the productivity of factors of production employed in PFI would have had a zero productivity in the absence of PFI. In other words it would require that all labour and capital (and perhaps land) used in the PFI sector would have been idle in the absence of PFI. If this is not the case the opportunity cost of factors of production employed in the PFI sector have to be deducted from the value added generated in the PFI sector in order to obtain the contribution made to GNP".[2]

From the above it can be seen that the central issue from the researcher's point of view is to be to devise some way of getting to grips with the question of what might have happened in the absence of FDI. In general there are five obvious alternatives to FDI:

1. Raising capital and other resources domestically.
2. Borrowing from abroad.
3. A combination of 1 and 2.
4. Importing the finished product.
5. Not carrying out the investment.

Once the alternative situation has been determined, it can be deducted from the actual outcome in order to arrive at net FDI. This would seem to necessitate a quantitative approach since measurement is implied, which could very well take place at the micro (by means of social cost-benefit analysis)[3] as well as the macro level.[4]

The Impact of FDI on a Host Economy/Region

Given the above, the prerequisites for a study of this type are:

1. A clearly defined notion of the ways in which FDI can advance or detract from a country's welfare.
2. Ways in which to deal explicitly with the alternatives to FDI.
3. Data on FDI in the host country.

The following list outlines some of the most important effects of FDI on the host economy.[5]

- <u>On the positive side</u>

1. The direct contribution to GDP in the form of wages, salaries, taxes etc. as a result of increased employment and investment.
2. Additions to the capital stock, which increase actual and potential output of the economy.
3. Spin-offs to the local economy from the technological and managerial expertise of the foreign sector or, in other words, demonstration effects.
4. Sales and purchasing linkages between the foreign sector and indigenous enterprise. The hope here is that the linkages between sectors will not only force the home sector to become more efficient through increased competition but also to call new domestic firms into existence.
5. The balance of payments effects are anticipated whereby the foreign sector will not only bring capital into the country but also stimulate exports.

- <u>On the negative side</u>

1. The direct contribution to GDP can be altered and the gains diminished if price distortions occur in the product/factor markets which can lead to a misallocation and, hence, inefficient use of resources. Further ways in which the gain to GNP could be eroded is by transfer pricing, high expatriation of profits, dividends, royalties, etc. and also by the depletion of natural resources.
2. Under the assumption of full employment of capital and labour, any capital or labour used by the foreign sector which could have been more productively used by the home sector is a cost to the economy. This also applies even under the assumption of less than full employment, at the disaggregated sub-sectoral level.
3. As far as local spin-offs, the external control argument suggests that the branch economy (assuming that little in the way of linkages have occurred) will become technologically dependent on the foreign sector and hence innovative efforts will be stifled.

4. The converse of establishing local linkages and promoting growth is that the foreign sector will outcompete local enterprises and monopolize their operations.
5. The balance of payments contribution could equally be eroded by capital outflows and a greater propensity to import than to export.

The preceding summary of possible effects covers the main questions to which the applied economist should address his efforts. They are largely socio-economic, measurable, and verifiable effects which do not explicitly take into account political and cultural questions. This is an obvious drawback to the quantitative macroeconomic approach, although each discipline inevitably has its limitations; and in this respect it is suggested that the more non-economic questions be left to the political scientist, sociologist, anthropologist, etc.

As suggested by the appraisal of the limitations of neo-classical theory, and the applied literature on FDI in Scotland, what is necessary in order to evaluate the net impact of FDI on a host economy is explicit consideration of the alternative situation to FDI. It is argued that since measurement is implied, it is best to employ a quantitative framework. Furthermore, since the aim of this study is to evaluate the overall impacts of FDI, it would seem more appropriate to look at the total volume of FDI via a macroeconomic framework rather than try to infer upwards from a case study project type approach. The general advantage in the case of an appropriate macro approach is that it can deal systematically with a much greater degree of simultaneity and can provide answers to some of the longer term questions regarding the foreign sectors' impacts on the host economy.

Regional Macroeconomic Methodologies

It should be clear at this point that this thesis is concerned with developing an applied macroeconomic methodology, for evaluating the impacts of manufacturing FDI in a host economy/region, in this case Scotland. It is probably appropriate, at this point, to review the types of quantitative macro methods that have been applied at the regional level and comment on their associated costs and benefits.

A. Economic Base

One of the first statistical models employed in regional research is the well known economic base model formulated by Hoyt.[6] The theory is quite simple and postulates that the local economy can be divided into two sectors according to the location of the market for its goods. These are commonly referred to as the basic goods sector (where the market destination is outside the region) and the non-basic or service goods sector (whose market outlet is within the region). The basic assumptions are: (i) that regional growth is dependent on the growth of the export or basic goods sector; (ii) that an increase in production of basic goods calls forth an increase in the production of non-basic goods and, (iii) that there is a stable relationship between basic and non-basic goods. One further convention worth noting is that local economic activity or output is usually proxied by employment and income data. An example of a simple multiplier formulation, using employment as a proxy for local economic activity, can be set out as follows:

D = the percentage rate of change.

E_t = total employment.

E_b = basic goods sector.

E_{nb} = non-basic goods sector.

S = marginal propensity to consume (MPC) locally.

k = simple multiplier.

Consider the identity

$$DE_t = DE_b + DE_{nb} \qquad (3)$$

The marginal propensity to consume (MPC) is taken as

$$S = DE_{nb}/DE_t \qquad (4)$$

with the usual simple static multiplier of

$$K = 1/1-S \qquad (5)$$

Substituting (4) into (5) yields

$$K = 1 + DE_{nb}/DE_b \quad 7 \tag{6}$$

The usual route taken by the regional analyst is to make projections of E_b and then apply the multiplier to obtain total employment projections.

The obvious problems (typically cited in the literature) for a simple model of this type are:

1. The suitability of income or employment as a proxy for output changes.
2. The conceptual problem of identifying which sectors are basic and which are non-basic. (The main methods include simple arbitrary classification, use of a location quotient, the minimum requirements technique and the survey (interview) technique).
3. The inability of the model to take into account dynamic behaviour.
4. The suitability of the assumption of a stable basic to non-basic goods ratio.

The weakness of the economic base approach is best summarized by Glickman: "Economic base analysis provides an expeditious method of forecasting regional economic growth: the theory of urban growth is simple and the data requirements are minimal. The resulting information flow, however, is limited to forecasts for the basic and service sectors. In addition, conceptual and technical procedures, such as the questionable stability of the basic/service ratio and improper identification of sectors, detract from the accuracy of the forecasts".[8]

It is not necessary in the context of this thesis to explore in further detail the disadvantages of the economic base approach since the technique (although macroeconomic in nature) is basically a crude forecasting tool, totally inappropriate for a study of this type. This is because this thesis is concerned with the structure of the environment in which foreign investment operates. It is seeking to establish the structural differences between the home and foreign sectors in a region (Scotland) so as to facilitate the analysis of alternative policies. The simple ex-ante nature of the economic base static forecast would not allow for this more sophisticated type of analysis (ex-post policy analysis and forecasting) to be carried out.

B. Input-Output

A second type of national and regional analysis which is applied at the macro level and has the considerable advantage of being able to operate at a highly disaggregated sectoral level is input-output (I/O) analysis. One of the main advantages of this technique is that it takes a very detailed look at the interrelationships and linkages which exist in an economy.[9]

The basic idea of I/O analysis is that each industry in the economy is dependent on every other industry. For instance, the output of industry 1 is the input for industry 2 and the output of industry 2 is the input for industry 3 etc. Given that the economy is open and static the following identity holds.

$$X_i = \sum_{k=1}^{s} X_{ik} + Y_i \qquad i, k = 1, 2 \ldots s \qquad (7)$$

where, X_i = the total output in industry i.

X_{ik} = the quantity of industry i's output absorbed in the production of k's output (intermediate demand).

Y_i = amount of industry i's output absorbed by final demand (C + I + G + (X-M)).

C = consumption.

I = investment.

G = government spending.

X = exports.

M = imports.

The usual assumptions made in this type of analysis are:

1. That each commodity group is produced by a unique producing industry.
2. No external economies or diseconomies of scale.

3. That there is a unique observable production process which does not take substitution of inputs into account.

The above assumption of a fixed parametric relationship between inputs and outputs yields

$$X_{ik} = a_{ik} X_k \qquad (8)$$

Where a_{ik} is the production coefficient specifying the quantity of i needed to produce one unit of k, with X_k being the output of industry k. Therefore

$$X_i = \sum_{k=1}^{s} a_{ik} X_k + Y_i \qquad (9)$$

The above system of linear equations (s) can be solved for the output of industry (X_i) if the level and distribution of final demand across sectors is known.

The same type of input-outut structure under two separate guises is used at the regional level.[10] They are the "square version" typified by highly aggregated final demand and the "dog leg" version which has a much greater level of disaggregation in final demand. An example of a typical regional model of either variety is

$$rX_i = \sum_{r=1}^{s} r X_{ik} + rY_i \qquad (10)$$

$$rX_{ik} = ra_{ik} rX_k \qquad (11)$$

$$rX_i = \sum_{k=1}^{s} ra_{ik}\ rX_k + rY_i \qquad (12)$$

where r is a region and all other variables are defined as above. The distinguishing factor between the two regional approaches lies in the specifiction of Y_i.

The I/O model is extensively used in impact and multiplier analysis and there is no shortage of studies at the regional or national level along these lines.[11] There are however some well recognised disadvantages of the approach such as

1. The results that emerge are essentially cross sectional and hence any sort of dynamic analysis is precluded.
2. The assumption of constant production coefficients precludes the ability of the technique to take into acccount economies or diseconomies, innovation, technological change, etc.
3. The static impact multipliers are only valid in so far as the assumption of fixed structure holds.

These disadvantages are further compounded by the great difficulty in identifying foreign/home distinctions and accordingly the I/O approach was not felt appropriate for the purposes of this study.[12]

C. Regional Econometric

Next, is a brief discussion of regional econometric models. It is only intended at this point to provide an overview of the main characteristics of regional models and their perceived advantages for this study. Further theoretical and empirical details will be presented in the appropriate chapters.[13]

The seminal article on regional modelling was by Klein.[14] Klein's model is analogous to satellite industry models which utilize the top-down vs. bottom-up approach. The main characteristic of the regional top-down approach is the heavy dependence on its national counterpart. This type of regional model is essentially integrated with and driven by a national model, i.e. a one way interface is constructed in which the regional model uses as inputs, exogeneous variables which are generated by a national model. As far as feedback is concerned, the national variables can induce change in the region but not vice versa. On the other hand, the bottom-up approach, while conceptually more realistic in that it accounts for the interdependent nature of relationships between region and nation (by aggregating regional models to form the national model), is unfortunately practically and technically more difficult to construct due to severe data limitations at the regional versus the national level.[15]

Klein further suggested that regional models should adopt the standard Keynesian income-expenditure framework

$$GRP = C + I + G + (X - M) \quad (13)$$

where, GRP = gross regional product.

However, subsequent examination of the statistics typically available at the regional level suggested that this approach was severely constrained due to the lack of regional trade data.[16] Accordingly the typical regional model is built around regional income or output.

Further characteristics which most regional models embody are:

1. Use of annual data, which to a large extent determines theoretical complexity.
2. Relatively few observations, which limits the complexity of dynamic specification due to the constraint on statistical degrees of freedom.
3. Relatively few series of sufficient length, which leads to the situation where the specified relationships are of a bivariate, recursive nature.
4. Structural dependence on national models (top-down approach), in other words, the absence of a strong degree of independence as an internally generated system.

The usual applications of an econometric model espoused in the literature are for analysis, forecasting, simulation and control. Even within the context of the limitations mentioned above, regional econometric models can to a greater versus a lesser extent perform these functions and hence it is argued that this type of method is the most appropriate for the purposes of this thesis. Obviously the more dynamic, the greater the reliance on economic theory, the greater the independence from national models and the more simultaneous, the better, since these qualities are usually assumed to produce a much better approximation of reality.[17] In the context of the present study, the major advantage of this framework relative to the economic base and I/O approaches is that its range of analysis is capable of embodying a relatively long period of time. Hence it will be able to capture the effects of key economic variables in a dynamic long-run context.

This thesis argues that the economy (Scotland in particular) can be split into two sectors (home & foreign) so as to identify structural differences and further to ascertain what effects these different structures have on selected key economic aggregates. The results will not only be valuable in a model context, where the relationships are brought together is a combined simultaneous and recursive fashion, but are also important in a single equation context. Having said this it must be remembered that a multi-equation model can take on different static or dynamic properties of its own. It is often the case that some of the richness and complexity of the single equation model has to be sacrificed in an overall modelling context. For instance Pindyck and Rubinfeld argue that when ". . . individual regression equations, which may fit the historical data very well, are combined to form a simulataneous-equation model, simulation results may bear little resemblance to reality. The difficulty arises because the construction of a simulation model often involves understanding the dynamic structure of the system that results when individual equations are combined and thus may not be a straight forward process".[18]

However, leaving this point aside for the moment, it is argued that not only does one get the multi-equation advantages of building a model of this sort, but also the single equation advantages. By way of elaboration, on the single equation front, relative elasticities between sectors can be ascertained, multipliers can be implied, and forecasting performed.[19] Further, the results of the single equation tests are not only useful in that they are indicative of broad macroeconomic trends but they also can suggest further lines of micro and macro research.

In terms of the complete model constructed, the main advantage of the econometric approach is that it provides a quantitative framework which takes into account complex dynamic interrelationships which can be used not only for forecasting (ex-ante and ex-post) but more importantly for policy simulation and control. In other words, this framework enables the counter factual situation to be hypothesized. As has been mentioned on numerous occasions thus far, this particular ability is crucial in determining the overall short-term and long-term impacts of net FDI.

However, before further discussion can take place as regards the specific types of modelling to be carried out, some attention must be directed towards current criticisms of the econometric approach.[20]

The Lucas Critique of Quantitative Policy Evaluation

This critique strikes at the very heart of traditional econometric analysis and in particular on the assumption of fixed or stable parameters and their implications for alternative situation type analysis. He argued that the features of econometric models which lead to the short-term success in econometric forecasting are totally unrelated to quantitative policy evaluation. Furthermore, that policy simulations can provide no useful information as to the actual consequences of alternative economic policies.

His basic argument is best summarized in his own words, " . . . given that the structure of an econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models".[21] This argument rests on the assumption that economic agents alter significantly their behaviour to various policy shocks and hence the traditional assumptions as to the fixed nature of the functional relationships between the dependent and independent variables and parametric stability are invalid.

On the assumption that the above criticisms are valid, it follows that the traditional fixed parameter model is not a valid way of performing policy evaluation. Lucas thus finally comes to the conclusion that "the only scientific quantitative policy evaluations available to use are comparisons of the consequences of alternative policy rules".[22] The reasoning behind this thesis is as follows:

1. The optimal decisions of economic agents are not analyzed under the assumption of an arbitrary sequence of future shocks, but rather under the assumption that policies and other disturbances are viewed as a stochastically distributed function of the state of the system

   with $X_t = g(Y_t, a_t, n_t)$ (14)

where,

g is a known function.

a_t is a vector of fixed parameters.

n_t is a vector of disturbances.

$$Y_{t+1} = f\ (Y_t,\ X_t,\ b(a_t),\ u_t), \qquad (15)$$

where the vector of behavioural parameters (b) vary systematically with the parameters (a_t) governing policy and other shocks.

2. The econometric problem is to estimate $b(a_t)$.
3. (a_t) must follow a preannounced pattern via a set of policy rules.

The problem with this approach from an econometric viewpoint is that if (a_t) does not follow a preannounced pattern then it will only become known to agents in a gradual manner and hence will initially be unstable and econometrically unpredictable. Furthermore, the only way econometric estimation can take place within this framework is via the generation of data that has resulted from applying a policy rule. Hence the business of quantitative policy evalution is reduced to the application of various rules and, in an ad hoc manner, to a comparison of outcomes.

One of the problems with the Lucas critique is that it takes quite a purist view of the way in which econometric estimation is supposedly performed. His argument assumes that there is not what Klein calls the 'man-model' interaction. In other words, no reestimation is performed in order to take into account exogeneous changes which deviate drastically from the norm. However, not many practitioners of econometrics actually take the pure stance that Lucas would like to attribute to them. Klein argues, "typical forecast exercises adjust models so as to align their performance with initial conditions, last minute fragmentary information, and external (non-sample) information about events to come. This is an efficient use of models. The main reactions are kept intact for policy analysis after adjustments have been made. Applicationsin this form, judged particularly by the forecast record, have been superior to pure model applications or pure human judgement applications. I would assert that man-model forecasts are better than either purist forecast".[23]

Further problems with the critique are even more ironical when one considers the argument that it is supposedly the breakdown of Keynesian theory and empirical method which produced errors in the forcasting of inflation and unemployment in the mid-nineteen seventies. Mistaken or not (which certainly the custodians of these various econometric models would not acknowledge to the degree that their critics claim), it can be argued that traditional econometric models at least are capable of quantifing the errors that go along with their forecasts.

This in turn leads to the respecification, reestimation and the reevaluation process. In contrast the theoretical argument of Lucas has no empirical justification and, furthermore, these types of models can not be placed nearly under the same empirical scrutiny as those of the traditional approach.

Further support for the traditional econometric approach is given by Klein when he states that: "to argue that expectations are functions of policy instruments in such a way that the effects of changes in these instruments are nullified by decision-makers' revised action - seems to me to be a contrived argument to show that macroeconomic policy is futile. It has no independent empirical justification".[24]

As to the Lucas criticism of the assumption of fixed parameters, Klein responds that, "It can be agreed that the variable parameter model generalizes the fixed parameter model, but, as with many generalisations, it gives less specific results; and again I would repeat that there is no empirical basis for making the parameters functions of the policy instruments, let alone making them very particular functions".[25]

Another sceptic on the insights of the rational expectation approach is Sims[26] who argues that "A policy action is better portrayed as implementation of a fixed or slowly changing rule. I also argue that explicit identification of expectation-formation mechanisms is not necessary for policy analysis, concluding that the rational expectation critique of econometric policy analysis is a cautionary footnote to such analysis rather than a deep objection to its foundations. From this perspective, the conventional use of econometric models to aid in policy choice is neither self contradictory nor meaningless".[27]

Given all of the above reservations to the Lucas critique it will be assumed that the econometric analysis which follows in later chapters is proceeding on fairly safe methodological grounds and that the Lucas critique should be viewed as more of a general statistical argument as it relates to varying parameter models. This statistical point, without of course all of the rational expectation assumptions which follow, can be taken on board or not at the discretion of the researcher depending on the nature of the problem being analyzed.[28]

Having decided that the most appropriate method for the purposes of this thesis will be a traditional macro-econometric approach albeit with a regional slant, what follows is a brief discussion of the specification issues involved with a model of this type. This discussion not only has general econometric significance but it is particularly relevant for econometric modelling at the regional level.

Dynamic specification, Auto Correlation and the Error Corrections Model[29]

As mentioned earlier in this Chapter, one of the main difficulties with modelling at the regional level is that available data usually consists of a small number of observations, (usually annual data), which hampers the ability of the model to take on complex dynamic forms.[30] Another major problem as regards the specification issue which the time series analysts Granger and Newbold[31] have pointed out, is the problem of spurious relationships in economic data. Granger and Newbold argue that one typically finds a very high serial correlation between adjacent values in economic time series and point out the well known consequences of auto correlation:

1. Inefficient estimates of regression coefficients (i.e. smaller standard errors).
2. Suboptimal forecasts.
3. Invalid significance tests on the regression coefficients (i.e. it leads to high 't' values and high R^2's which are misleading since the existence of serial correlation has violated one of the assumption of classical regression analysis e.g. [E $(e_i, e_j) = 0$ for $i \neq j$]).

Simulation experiments carried out on economic data in 'levels' lead them to conclude that, " . . . it will be the rule rather than the exception to find spurious relationships. It is also clear that a high value for R^2 or $\bar{R}^2$, combined with a low value of d, is no indication of a true relationship".[32] The obvious implication of the above findings is that the equation is misspecified and a procedure they suggest which is capable of coping with this problem is to take first differences of all the variables that appear to be highly correlated.

The Granger and Newbold criticism has been taken on board by econometricians, and one particular example of the response to it has been the work of Hendry et al.[33] Their work goes a long way towards saving the classical foundations of regression analysis and is classified as a contribution to dynamic specification in econometrics which has further implications for how economic theory is used in applied work. The approach uses the differencing procedure, but of a somewhat different form than that suggested by Granger & Newbold, in that not all variables are differenced, only those which pertain to the short-run dynamics of the equation while the variables which refer to long-run economic theory are entered in levels. Further, the differencing procedure is an approximation to the percentage rate of change of the variable (i.e. dln of the variable). This procedure has an advantage over a straight percentage change in that it preserves the overall linearity of the equation.

The error correction type model is basically a way in which to dynamically specify a relationship, while simultaneously using economic theory to limit the class of models. In other words, it is a way in which economic theory surrounding the steady state solution of the model can be incorporated into an equation which has short-run dynamic implications. The interpretation from control theory is that Y_t (dependent variable) is adjusted from Y_{t-1} as a linear function of changes in Z_t (derivate control) and the feedback from previous disequilibrium. So the equilibrium solution when Y = Z (i.e. actual = desired) provides a convenient way of implementing long-run economic theory in dynamic models based on control principles. The justification for the use of levels (proportional control) is that the size of the difference between actual and desired (i.e. the steady state equilibrium) can be analyzed as well as the rate of growth (dln) at which the steady state solution is approached (via derivative control).

Again the idea of examining this model and the reason for its proposed implementation in this study is that it not only helps with the specification problem as stated by Granger and Newbold, (which is acute in most regional models) but it also allows the introduction of short-run dynamics and long-run economic theory into equation specifications, two items which are rare indeed in most regional models.

A brief exposition of the theoretical model now follows:

Consider the model

$$\ln Y_t = a + b\ln Y_{t-1} + c\ln X_t + e\ln X_{t-1} + u_t \qquad (16)$$

where,

a is a constant term

$|b| < 1$

In the steady state, assume X_t grows at a rate g_x and the relationships between X and Y is

$$Y = kX^v \text{ or } \ln Y = \ln k + v\ln X \qquad (17)$$

with $g_y = d\ln Y_t$ or

$g_y = vg_x$, where v = elasticity of Y with respect to X

Now (16) will be rearranged to look at the steady state solution implied by the particular dynamic specification.

$$d\ln Y_t = a + (b - 1)\ln Y_{t-1} + c d\ln X_t + (c + e)\ln X_{t-1} + u_t \qquad (18)$$

Further rearrangement will yield

$$d\ln Y_t = a + c d\ln X_t + (b-1) * \left[\ln Y_{t-1} - \frac{c + e}{1 - b}\ln X_{t-1}\right] + u_t \qquad (19)$$

In the steady state there is a linear relationship between lnY and lnX. This can be seen in the term in square brackets. This term is known as the error correction mechanism. It starts to work when the observations begin to deviate from the long-run steady state growth path. For example say Y_t starts to grow at a faster rate than is consistent with the steady state solution. This could occur if there was a series of abnormally large random disturbances or because of the systematic effect of a third variable, not appearing in the relationship. When Y_{t-1} is moving above its long-run growth path the sign of the term in the square brackets becomes positive. However since (b - 1) is negative, the result of

$$[\ln Y_{t-1} - \frac{c + e}{1 - b} \ln X_{t-1}]$$ being negative is to drive Y_t

back towards its long-run growth path.

Summary

The aim of this Chapter has been to set the methodological stage in terms of the theoretical and empirical work which follow. The main points which were made are:

1. This study will attempt to suggest an empirical method for evaluating the overall net effects of FDI.
2. Given (1), the choice of framework must be a macroeconomic one.

3. Since an aggregate method is required it is deemed appropriate that an econometric approach be used.

4. Given (3), an attempt has been made to accomodate current criticisms of this approach.

Having established the above, this study now proposes to use the suggested empirical methods in a specification search for the best fitting relationships as they pertain to the analysis of foreign investment in the Scottish case. The search for the most appropriate theoretical form will take place in the relevant national and regional literature. Relevance is largely determined by data availability, as in any applied exercise. It must be emphasised that what ensues is not a search for or an attempt to construct a general theory on the impacts of foreign investment. Rather existing methods and theories will be applied in such a manner which hopefully will shed new light on the important problem of evaluating the impacts of FDI on a host economy. In the following Chapter regional manufacturing output determination will be discussed.

NOTES: CHAPTER II

1. Bos, H. C., Saunders, M. and Secchi, C. Private Foreign Investment in Developing Countries. A Quantitative Study on the Evalaution of Macro-econometric Effects (Boston: Reidel, 1974) is the only study in the general empirical literature which makes an explicit effort at devising a method for macro level analysis.

2. Ibid., p. 19.

3. For the classic text on this subject, refer to Little, I. M. D. and Mirrlees, J. A. Project Appraisal and Planning for Developing Countries (London: Heinemann, 1974).

4. The purpose of this thesis is not to look at the impact of FDI at the project level, but to look at the overall volume of FDI and its resulting impacts. So, again, by way of reiteration of Chapter I, the micro and macro approaches to FDI should be viewed essentially as complementary approaches.

5. It must be noted that at the macro level under the assumption of less than full employment of capital and labour, any net addition to capital due to FDI which produces employment should be classified as a benefit. In these circumstances there is no question of a net loss occurring as a result of FDI, unless of course there is some reason for assigning an extremely large value to the costs associated with cultural and political disadvantages.

6. Hoyt, H. One Hundred Years of Land Values in Chicago, (University of Chicago Press, 1933). See also Glickman, N. J. Evaluation and Analysis of Regional Systems: Explorations in Model Building and Policy Analysis (New York: Academic Press, 1977), pp. 13-73 for a guide to the basics of this approach.

7. $K = 1/1-S$

$$= 1/1-(DE_{nb}/DE_t)$$

$$= 1/DE_b/DE_t$$

$$= DE_t/DE_b \quad \text{or} \quad 1 + DE_{nb}/DE_b$$

8. Ibid., Glickman (1977), p. 27.

9. The pioneering work was by Leontieff, W. The Structure of the American Economy, 1919-1939 (New York: Oxford

University Press, 1951).

10. In the case of Scotland see the work of Scottish Council, IBM (U.K.) and the Fraser of Allander Institute, Strathclyde University, e.g. McGilvray, J. 'Construction of the 1973 Input/Output Tables for Scotland: A Summary of Experience', The Fraser of Allander Institute Discussion Paper 20 (1981).

11. In the context of this thesis, no attempt has been made to review these studies or look at them in greater depth. As will become evident shortly, input/output analysis as such has not been the method adopted for this thesis. Refer to Glickman, op.cit., (1977) for further details and references on these impact studies.

12. Another type of I/O model at the national and the regional level is one which uses a combination of an econometric and I/O approaches. For an example of its application at the U.K. level see Barker, T. S. (Ed.) Economic Structure and Policy with Application to the British Economy (London: Chapman and Hall, 1976). For an example of its application at the regional level, see Bell, D. et. al. 'The Development of a Medium Term Model for Scotland I: Projections to 1984'. The Fraser of Allander Institute Research Monograph Number 10 (1982), pp. 1-65. However, an exercise based on the I/O-econometric approach would be extremely labour intensive and far beyond the practical scope of a Ph.D. dissertation.

13. See Chapters III through V for a theoretical and empirical discussion of the regional output, investment, employment and consumption functions. The econometric problems of evaluation and model simulation are in Chapters VI and VII respectively.

14. See Klein, L. R. 'The Specification of Regional Econometric Models', Papers of the Regional Science Association, No. 23 (1969), pp. 105-115.

15. For an operational example of this approach see Courbis, R. 'The Regina Model: A Regional-National Model for French Planning', Regional Science and Urban Economics, Vol. 9 (1979), pp. 117-139.

16. See Glickman, N. J. "Son of the 'Specification of Regional Econometric Models'", Papers of the Regional Science Association, Vol. 32 (1974), pp. 155-177.

17. Hopefully discussion of dynamic specification in this Chapter and the methods by which regional modelling is approached in the ensuing Chapters will show how these "good" qualities are to a greater versus a lesser extent

embedded in the Scottish model (hereafter known as SIMFOR which is short hand notation for SIMulation model of FOReign investment).

18. See Pindyck, R. S. and Rubenfeld, D. L. Econometric Models and Economic Forecasts (McGraw-Hill, 1981), p. 335.

19. See Chapters III through V for a detailed discussion of the single equation results of the SIMFOR model.

20. See Lucas, R.E. Studies in Business Cycle Theory (Oxford: Basil Blackwell, 1981), pp. 104-130.

21. Ibid., p. 126.

22. Ibid., pp. 125-126.

23. See Klein, L. R. Econometric Models of Guides for Decision Making The Charles C. Moskowitz memorial Lectures: No. 22 (New York: New York University, 1981).

24. Ibid., pp. 37-38.

25. Ibid, p. 38.

26. Sims, C. A. 'Policy Analysis with Econometric Models', Brookings Papers on Economic Activity, Vol 1 (1982), pp. 107-152.

27. Ibid., p. 108.

28. Choice of the varying parameter technique for the purposes of this thesis,whilst considered, was not chosen as a method of analysis. At this point in the development of these models, their application seems to be of greater significance in models which are of a time series rather than econometric nature. As usual the information that can be gleaned from a time series approach is mainly useful for forecasting and not the detailed type of counter-factual analysis which takes place in a standard econometric type framework.

29. Actually the first person to advocate the use of error correction type models at the regional level was D. Bell. See for example Bell, D. (1982) op.cit., and Bell, D. Regional Econometric Modelling with Special Reference to Scotland, Ph.D. Dissertation, University of Strathclyde (July 1984).

30. The usual lag limit with annual data, depending on the number of observations, is one to two years.

31. See Granger, C. W. T. and Newbold, D. 'Spurious

Regressions in Econometrics', _Journal of Econometrics_, Vol. 21 (1974), pp. 111-120. See p. 111 for an example of the types of results which are reported.

32. _Ibid_., p. 117.

33. See Hendry, D. F. 'Predictive Failure and Econometric Modelling in Macroeconomics: The Transactions Demand for Money' in Ormerod, P. (Ed.) _Economic Modelling_, (Heinemann, 1979). See also Davidson, J. E. H., Hendry, D. F. Srba, F. and Yeo, S. 'Econometric Modelling of the Aggregate Time-Series Relationship between Consumer's Expenditure and Income in the United Kingdom', _Economic Journal_, Vol. 88 (1978), pp. 661-692.

CHAPTER III

REGIONAL OUTPUT DETERMINATION: THE SCOTTISH CASE

Introduction

Following on from Chapters I and II, the next three Chapters concentrate on the empirical backbone of the thesis. As indicated in the earlier Chapters, the methodological approach will be econometric, with particular emphasis being placed on the Hendry error correction type specification.

The overall model consists of three blocks of equations, namely manufacturing output, investment and employment.[1] Each of these blocks is further broken down into what are described hereafter as the home and the foreign sectors.[2] As stated earlier the aim of the modelling exercise is not only to explain the determinants of home and foreign behaviour in an individual equation sense for each of the three blocks but, in addition, to assemble them in a dynamic multi-equation system.[3]

In Chapter III the theoretical and empirical arguments as pertains to block I (i.e. manufacturing output determination at the regional level) are discussed and developed. Chapters IV and V will follow in the same vein with the development of the manufacturing investment and employment equations respectively.

The mechanics of the present Chapter are as follows:

Firstly, there is a discussion as to which accounting framework the model should adopt, e.g. an expenditure, income or output approach. Secondly there is a brief review of the theoretical issues, assumptions and implications of regional output equations, i.e. supply type specifications and demand oriented equations. This is followed by econometric estimation of the parameters of the respective home and foreign functions. Finally, there is a discussion of estimation problems/techniques and an interpretation of the econometric results.

Accounting Framework

The first problem to be tackled in the context of using a macro modelling approach is that of choosing which proxy measure of national income is to be used. National income as an indicator of aggregate social welfare is defined as the money value of all goods and services becoming available to the nation from economic activity. In practice, there are three distinct ways of arriving at this measure based upon income, output and expenditure and, in principle, they should all be equal.

In Scotland, for instance, the income estimates of GDP are based on the factor income approach which breaks down the total income of its residents/territory (which are derived directly from the current production of goods and services) into four broad categories. These are income from employment, income from self-employment, gross trading profits and surpluses and rents with a factor adjustment for stock appreciation.[4] Although Scotland is fairly well endowed with these data, as most regions seem to be, the problem in the context of this thesis with trying to build a model around an identity of this type is that the preferred industrial disaggregation does not exist. Specifically, the data does not include a category for the manufacturing sector and neither is there any distinction between income accruing from home and foreign residents. Hence, the income method will not be used or explained in any greater detail.[5]

Another method of deriving GDP is the well known expenditure method which sums together all the expenditure on goods and services that become available to a nation. This involves the addition of government consumption/ investment and private consumption/investment which yields gross domestic expenditure at market prices, when adjustments are made for stock changes. This figure is then added to exports net of imports to give GDP at market prices. To achieve a figure comparable to the income and output estimates the net result of taxes minus subsidies must then be added.

The problem in the Scottish case as with nearly all regional accounts, is that a full set of expenditure statistics is not available due to the lack of international and especially inter-regional trade data. The explanation for this lack of inter-regional data is given by Lythe and Majimudar in the following terms: "... cross-border flows of purchases of goods and services and of payments for factor services are usually not measured for regions of a country, because there is no institutional need to measure them for customs and excise purposes, and so regional balance of payment accounts cannot be constructed".[6]

It must be noted however, that even though the expenditure figures do not represent total demand in Scotland, they do represent a complete statement of domestic demand in that total imports are implicitly accounted for in the consumption, investment or capital formation figures as well as in the government consumption data.[7] The above mentioned data deficiency at the regional level is the major obstacle which precludes the construction of a macro-model around the standard Keynesian income-expenditure formulation. As mentioned in Chapter II, this framework was suggested by Klein in his pioneering regional modelling article,[8] but the realities concerning data availability were later illustrated by Glickman. In this respect he stated that, "Klein admittedly took little account of the availability of data when specifying his model".[9] He further stated that "Data for major segments of the expenditure side of that set of accounts are missing; it is rare to find regional time series for consumption, exports, imports or non-manufacturing investments".[10] Hence, this method will not be used in the modelling exercise.

The final way in which GDP is valued is via the output based method. It is defined as the sum of value added of all productive activities in the economy, where value added is equal to the selling price of goods and services net of the costs of material inputs. The idea is that output should be valued at factor cost, i.e. at the cost of production, free from the distortion of indirect taxes or subsidies. Each value is only counted once so that the sum of output should be equal to the sum of income generated as a result of making that output. This means that each part of the value of output represents an income to whoever provides the resources to produce that output, or that each income is earned out of some contribution to the value of output.[11] GDP valued in this manner is in fact the method which the vast majority of regional modellers have chosen, due not only to the fact that the data is available but also to the fact that this data enables a much greater level of disaggregated analysis to take place.

The analysis which follows will proceed in the spirit of the output approach, albeit in a more narrowly defined manner in that it is the determinants of manufacturing output as opposed to total output which will be examined. Hence, the search for the most appropriate a priori theoretical form for the home and foreign manufacturing output functions, will naturally draw on the literature which emphasizes the manufacturing sector vs. non-manufacturing and the service sectors.

Having made the decision to model around output, further choices have to be made as to whether the model will emphasize demand determined or supply determined type specifications. Although both specifications have been widely discussed in the literature, their respective merits for purposes of this thesis must be established.

Supply Oriented Regional Output Specifications

Relatively recently some attention has been directed towards the supply side of output determination at the regional level. Proponents of this type of specification argue in favour of what is basically a production function type approach, in which the availability and price of factors are the major constraints in determining output. Naturally, as with most neo-classical type formulations, perfect competition in product and factor markets is assumed along with the associated dominance of the price mechanism. It is further assumed that there is full employment of factor inputs and hence the long-run equilibrium position of output is maintained via free movement of relative factor prices.

Essentially the neo-classical view is that the long-run level of output is predetermined and differences between actual and potential output are adjusted by changes in relative prices. Starting from a position of long-run equilibrium of output and full employment of all factors, (assuming constant potential output and that factor switching can not occur),[12] the typical scenario which a model of this type produces is the following: The price of the factor used relatively intensively in the production of that output will increase followed by an eventual increase in the price of the product to compensate for the rise in the factor's reward. Finally, this will cause a fall in the demand for output back to its long-run equilibrium level due to its now inflated price.

An example of a more supply side orientated approach at the regional level is provided in an article by Crow[13] who argued for explicit introduction of factor demand theory and location theory. He builds on the work of Savitt[14] and employed a translog cost function as the source for his factor demand equations. A simplified version of his model reads as follows:

The translog cost function incorporating capital and labour can be written as

$$\ln(PxX) = \ln a + b\ln X + c\ln Pk + e\ln Pl + 1/2\, fkk\, (\ln Pk) + fkl(\ln Pk \ln Pl) \quad (20)$$

where,

ln = natural log.

P_x = the price of total output.

P_k = the price of capital.

P_l = the price of labour.

X = actual output.

Output is treated as if it were in long-run equilibrium but since the cost minimizing adjustment for capital and labour does not take place instantaneously, equilibrium output (X^*) does not equal actual output (X). Thus, the factor demand equations in the form of cost minimizing output shares can be derived:

$$PkK/PxX^* = (a_k + b_{kk} \ln P_k + b_{kl} \ln P_l) \qquad (21)$$

The above equation is then renormalized to yield the equilibrium level of output

$$X^* = PkK/P_x (a_k + b_{kk} \ln P_k + b_{kl} \ln P_l)^{-1} \qquad (22)$$

Thus, from equation (22) it is clear that equilibrium output is a function of the quantity of capital stock and factor prices. In Crow's model it is also assumed that capital stock is predetermined outwith the factor demand system and, furthermore, that output and factor inputs adjust to capital stock.

It is via this application of factor demand theory that Crow is able to introduce location theory into equilibrium output determination. For instance, in his model it is no longer the case that capital formation is determined by output, but rather that output is determined by capital formation which is in turn determined outwith the factor demand system by location theoretic elements, i.e. factors which affect the price of factor supplies such as transportation costs, regional policy, economies and diseconomies of agglomeration, etc. The above account, albeit simplified, reveals the basic logic of the supply side approach.

Another work which placed emphasis on supply side behaviour was that of Courbis.[15] In this model regional production is not only demand driven but also takes into account supply side effects by considering the level of regional capital stock. He classified industries into two categories, namely demand located industry (e.g. building and tertiary production) and non restricted or footloose industry (e.g. manufacturing industry).

As in the Crow model, Courbis attempts to capture the presumed cost minimizing nature of footloose industry by postulating that regional manufacturing output is dependent on regional capital stock which in turn is dependent on regional factor prices. Again, as with Crow, this view is in line with conventional wisdom as regards the role of regional policy in affecting regional factor prices so as to induce migrant firms to locate in the region. These supply side approaches are intuitively appealing in that they view firms as cost minimizing producers, and may have some relevance to this thesis in so far as the multinational enterprise is usually viewed as having the resources available to search for low cost locations. It is argued here, however, that it is incorrect to try and place so great an emphasis on locational influences since once a footloose enterprise locates in a region, it is most likely that demand factors will be the primary determinant of output. It is further argued that the proposed way in which locational elements are to be incorporated (i.e. factor demand theory) is grossly irrelevant to the conditions that exist in most economic regions.

The problems in trying to incorporate factor demand theory for the Scottish case, which could act as a good proxy for other regions, are as follows: The first objection pertains to the endogenous treatment of prices in the regional context. Scotland in fact does not have its own internal price system (i.e. it is part of a common currency area and cannot embark on regional devaluations) and furthermore, the value of Scottish main economic indicators are only approximately 10% of the corresponding U.K. values. Hence any changes in the demand and supply of factors in Scotland dœs not have any great perceivable effect on U.K. prices at least in the short to medium-term.

In addition, Scotland suffers from chronic under-employment of labour and underutilization of capital. One does not have to look very far to find the appropriate documentation, e.g. tables 1-3 (Appendix 4) contain time series for unemployment and capacity utilization in Scottish manufacturing together with migration figures which combined with the unemployment figures reflect the lack of employment opportunities in Scotland. It is much more likely then that exogenous changes in demand will produce greater employment and/or utilization of factors versus the price clearing full employment scenarios offered by neo-classical theory.

It is argued therefore that Scotland should be treated as a price taker with an infinitely elastic aggregate manufacturing supply curve (for at least the short and medium-term) with output being demand determined in both the home and foreign sectors. It is further argued that while locational factors may have some relevance to the foreign sector, it is better to try to pick them up in the foreign investment function, since once the foreign firm is located, it should be demand factors which determine output.

Having decided that demand orientated theoretical forms are more appropriate to regional output determination in general and for Scotland in particular, it would seem appropriate to review the various demand type functions available in the literature.

Demand Oriented Regional Output Specifications

Given that manufacturing output is to be modelled with a demand type approach, the first problem is to ascertain, not only the source of demand, but also how to measure that demand. As regards the sources of demand for any economic region, logically there are three: world demand, rest of nation demand and demand from the region itself. In other words, Scottish manufacturing output whether it is from the home or foreign sector can be sold in Scotland, to the rest of the world or the rest of the U.K.. The conventional approach is to simply model regional output as a function of its corresponding national counterpart (taken as a proxy measure for national demand) and hence only account for one source of demand. The rationale for this being that in most regions probably the greatest percentage of output does indeed go to the rest of the country, and further, associated statistical problems of multicollinearity, and that of finding the appropriate measures of demand are often obstacles for entering all three sources. Besides trying to capture demand factors, the typical regional output specification also attempts to capture supply side influences, of course without the aid of factor demand theory, via a relative cost type variables e.g. relative capital or labour costs between regions.

One of the first regional growth specifications to incorporate the demand driven satellite type approach was by F. Bell[16] who used something of a modified economic base approach that placed heavy emphasis on the role of regional exports in economic growth. He postulated that

$$X_t = a + bGNP_t + u_t \quad (23)$$

where,

X_t is export income of the region.

GNP_t is taken to represent extra-regional markets and the actions of the national government.

u_t is the random error term.

This rather simple formulation provided the impetus and logic for a number of output specifications following in the literature in which it is postulated that the regional economy is driven by the national economy and that regional business cycles are more or less in phase with national behaviour.

Another demand type example is the model of Adams et. al.[17] which postulated that regional output was a function of national output and the relative cost of labour between the nation and region.

$$\ln Xm = a + b\ln X_{us} + c\ln(C_m/C_{us}) + u_t \quad (24)$$

where,

ln is the natural logarithm.

Xm is manufacturing output in Mississippi.

X_{us} is manufacturing output in the U.S..

C_m/C_{us} is the ratio of unit labour costs in Mississippi to unit labour costs in the U.S..

Although examples of this type of specification abound, the following examples only relate to the U.K.. Jefferson's model of Northern Ireland[18] hypothesises that regional output is again a function of national output, although in this case regional output is a distributed lag function of U.K. output:

$$RQ = a + (b/1 - cL) * O \qquad (25)$$

where,

RQ is output in Northern Ireland.

Q is output in the U.K..

L is the lag operator.

Jefferson carried out experiments on the regional competitiveness variable, i.e. relative labour costs between the region and nation, but no statistical significance was found.[19]

Lythe's et al. model of the Scottish economy[20] applied a slightly different version of regional output specification, in that a priori information was used from the Scottish input-output table to distinguish local from export related industries. The export industries' output was related to its corresponding national counterpart and Scottish destined output to relevant local variables.

Finally D. Bell's model of Scottish manufacturing output[21] postulated that regional output was a function of national and local measures of demand:

$$A(L)qr = B(L)qn + C(L)ul \qquad (26)$$

where,

A(L), B(L) and C(L) are polynomials in the lag operator.

qr is regional output.

qn is national output.

ul is local unemployment which is taken as a proxy of local demand.

Even though the above separate specifications have taken different functional forms, have included (or not included) different measures of local demand, have used different sources of a priori information on classifying export and local industry etc., they all have regional output as a function of national output, with national output being taken as a proxy for external demand (presumably both the U.K. and rest of the world). The problem with this type of specification, especially in the context of this thesis,is that it does not include much Scottish specific behaviour as regards regional output determination. In other words, Scotland is viewed implicitly as simply a scaled down U.K., with little in the way of Scottish peculiar effects working their way into regional manufacturing output determination.

The output specifications depicted above come closer to a class of time series or ex-ante forecasting equations. The relationships between variables are more of correlation and not necessarily causation. Although this type of output specification is valid for forecasting exercises, it is not really useful for the particular type of econometric work which is proposed here. Another problem with modelling output in the above manner, is that the local demand source is often suppressed by the statistical strength of the regional/national relationship. In the context of SIMFOR, the problem is that the above models do not place enough emphasis on an internally generated system.

It would be desirable to drive the Scottish model, not only from "external" exogenous variables, but more importantly from local exogenous variables, when simulating foreign investment impacts. It must be recognized that FDI not only affects demand, but is also part of Scottish domestic demand, i.e. consumption + home investment + foreign investment + government spending + non-manufacturing investment. Hence one of the more important and interesting exercises would be to change certain exogenous variables which affect FDI in Scotland and then ascertain their resulting absolute and relative impacts on selected Scottish aggregates. The problem with arguing that Scottish foreign output in this case is dependent solely on U.K. foreign output is not only that it fails to take into account the peculiarities in Scottish foreign output determination but, more importantly, it does not account for the fact that foreign investment is part of Scottish demand which means that its associated multiplier impacts cannot be explicitly analyzed. The point is that, it is this component of Scottish demand (i.e. foreign investment) which is of primary relevance to the thesis and hence any model of manufacturing output which is to account for it, must include an argument for Scottish demand.

Given that it is this particular component of Scottish demand which is of primary concern, and that the output specifications reviewed above cannot cope with an explicit Scottish demand argument, it seems more fruitful to pursue a specification along the lines suggested by Kelly[22] who tried to forge a link between the final demand expenditure aggregates and regional output determination in Scotland. The idea here is that by explicitly modelling expenditure aggregates, the door can be opened to further modelling of the various components within the domestic aggregate expenditure (final demand) identity. Kelly in fact does not take things this far, but he seems to be the first to try to make this connection.

Kelly's approach was basically to distinguish between three sources of final demand for Scottish output: local Scottish demand, rest of the U.K. demand and world demand. He used information from the Scottish and U.K. input-output tables to construct a weighted index which reflected the distribution of output between these final demand categories, after taking into account intermediate demand. Scottish demand was taken as the summation of Scottish consumer expenditure, gross fixed capital formation in Scotland and Scottish public authorities' current expenditure. World demand was proxied by an export volume index and U.K. demand again by the summation of consumption, investment and current government spending.

The basic form of his specification was as follows:

$$Qm = a + bT + C_W [(\bar{d}_O + \bar{e}_O) WTVI] + F_S [\sum_{i=1}^{3} \bar{d}_1 XS_i]$$

$$+ g_W [\sum_{i=1}^{3} \bar{e}_1 XU_i] + u_t \qquad (27)$$

where,

- Qm is Scotish manufacturing output.
- T is a time trend to proxy technological change.
- WTVI is the world demand proxy (world trade volume index).
- XS_i is final demand in Scotland (C + I + G).
- XU_i is final demand in rest of the U.K. (C + I + G).
- $\sum_{i=1}^{3}$ represents the three components of the final demand aggregate (e.g. C = 1, I = 2, G = 3).
- a, b, Cw, F_S and g_W are the parameters to be estimated.

$\bar{d}_o$ is the proportion of Scottish net output flowing ultimately to world trade (but excluding that part flowing via intermediate demand from the rest of the U.K.).

$\bar{e}_o$ is the proportion of Scottish net output flowing ultimately to world trade via intermediate demand from the rest of the U.K.

$\bar{d}_1$ is the proportion of Scottish net output flowing ultimately to Scottish domestic final demand category XS_i (i = 1, 2, 3).

$\bar{e}_1$ is the proportion of Scottish net output flowing ultimately to U.K. domestic final demand category XU_i (i = 1, 2, 3).

This specification is quite interesting and it obviously comes closer to the type of specification that will be necessary for this thesis in that, once Scottish demand is captured, further modelling of Scottish demand components can proceed at a more detailed level. However it has drawbacks on both the theoretical and empirical fronts.

The first problem at the theoretical level pertains to the assumption of the fixed input-output weights over time. The information associated with $\bar{d}_o$, $\bar{e}_o$, $\bar{d}_1$ and $\bar{e}_1$ is obtained from a cross section and has the obvious limitation that the fixed weights take no account of the shifts which occur over time in the proportion of output destined to the different final demand categories. This information in fact becomes redundant in the type of dynamic specification proposed in Chapter II in that the first differencing process will yield zeros for the value of input-output derived constants. Hence this particular drawback will not be carried forward into present output modelling.

A more serious problem with a specification of this more complex type, whether with the use of a priori weighting factors or not, is the statistical problem of multicollinearity. This was in fact pointed out by Kelly when he stated, "Having described the format used to present the results, a general cautionary note on the subject of multicollinearity is necessary ...". He goes on to say "It was natural to expect a fairly high degree of multicollinearity between independent final demand variables used in estimation, and, while this does not affect the overall goodness of fit of the estimated equations, it tends to lead to rather large variances for the related coefficient estimators because of the problem of separating out and identifying the effects of different independent variables. Consequently it can be expected that the estimated coefficients C_w, F_s, g_w are rather imprecise and unreliable".[23]

It is precisely this problem of imprecise and unreliable coefficients, that will have to be avoided in

SIMFOR or any model which proposes to be structurally or econometrically oriented and which ultimately aims to produce valid simulations of alternative scenerios. This validity is of course based to a large degree on the overall reliability of the structural parameters or coefficients.[24]

Alternative Specification of Regional Output

What follows is a suggested alternative theoretical form to regional output determination, which will not only capture foreign investment effects but which will, it is hoped, withstand the empirical single equation validation process (i.e. be well specified as reflected in overall equation and individual coefficient tests of significance, tests for multicollinearity, auto-correlation, heteroscedasticity, correlation, etc.).

It should be clear at this point that, in order to examine the foreign investment which is part of Scottish demand, it is necessary to explicitly account for this demand in regional output determination. Scottish demand is defined as,

$$DEM = SCONK + STIK + PAGSK \qquad (28)$$

where SCONK is Scottish consumption, STIK is Scottish total investment and PAGSK is public authority government spending in Scotland. Further STIK is defined as,

STIK = STIMK + STINMK (29)

where STIMK is total manufacturing investment in Scotland and STINMK is total non-manufacturing investment in Scotland. Finally STIMK is defined as

STIMK = SHIMK + SFIMK (30)

where SHIMK is home manufacturing investment in Scotland and SFIMK is foreign manufacturing investment in Scotland.

The idea is that the emphasis should be placed on Scottish demand so that the behaviour of the foreign sector can be ascertained and compared with the behaviour of the home sector as regards relative elasticities, impact multipliers, long-run multipliers, etc.

It is next argued that it is theoretically possible to explicitly model local demand (Scottish) in a regional output function which can implicitly take into account the rest of the U.K. demand, hence there is no need to enter both sources of demand explicitly; this being the cause of the mutlicollinearity problem noted by Kelly.

The basic argument is that besides Scottish specific information, the rest of the U.K. influence is already subsumed within most of the Scottish data (i.e. in both dependent and independent variables). For instance the case of Scottish demand will now be examined in further detail. The ratio of DEM/RUKD (where RUKD = rest of U.K. demand), is presented as a time series in Appendix 5, table

4). Not surprisingly this ratio does not exhibit any great fluctuations, confirming the view that, as a first approximation, the relative levels of demand in Scotland c.f. the rest of the U.K. are reasonably stable. It can also be seen that the arithmetic mean is approximately 10% and that the ratio fluctuates around this mean. Given that a regression of dlnDEM and dlnRUKD produces an R^2 of .29, it can be deduced that there are peculiarities in the Scottish economy which are separate and distinct from the rest of U.K. influence. Hence it will be argued that the mean ratio of DEM/RUKD remains reasonably stable and further that fluctuations about the mean represent that part of DEM which is Scottish specific.

Given the above argument, Scottish demand could be represented as follows:

let,

ISD	be identical Scottish demand i.e. that part of Scottish demand which is influenced solely by the rest of the U.K. behaviour.
PSD	be peculiar Scottish demand i.e. that part of Scottish demand which is influenced solely by peculiar Scottish factors.
X_{Ruk}, Y_{Ruk}	be a set of independent variables in the rest of the U.K.

X_s, Y_s be a set of independent variables in Scotland.

DEM be Scottish demand.

RUKD be the rest of U.K. demand.

where,

$$DEM = ISD + PSD \quad (31)$$

$$ISD = DEM/RUKD\ f(X_{uk}, Y_{uk}) \quad (32)$$

$$PSD = g(X_s, Y_s) \quad (33)$$

substituting (32) and (33) into (31) yields

$$DEM = [DEM/RUKD\ f(X_{uk}, Y_{uk}) + g\ (X_s, Y_s)] \quad (34)$$

The perceived advantage of viewing Scottish data in this particular way is that it encompasses both rest of U.K. and Scottish specific influence, hence more information is added to the model which should result in greater reliability of parameter estimates. This is clearly superior to viewing Scottish variables as only a function of rest of U.K. variables when the Scottish data does exist, since simply using rest of U.K. variables would be net of Scottish specific information. Furthermore, an additional advantage of this approach (which will be shown empirically) is that rates of change of Scottish variables allow mainly Scottish peculiar factors to be highlighted, i.e. the first order differencing procedure nets out a lot of the rest of U.K. influence.

The above argument concerning 'levels' and 'differences' in Scottish demand can in fact be substantiated to a large degree by intuitive empirical testing in the context of a Scottish regional output function. First it is necessary to:

1) Identify and estimate the best home and foreign output functions given the application of the Hendry type error correction specification, under the assumption that the Scottish demand argument is valid.
2) Given [1], to experiment by entering the rest of U.K. demand variables (in differences and levels) explicitly into the equation, to see the resulting change on Scottish coefficients. If in fact the Scottish demand argument as set out above is valid then the entry of the difference in rest of U.K. demand should not change the value of the corresponding Scottish coefficient, and the entry of the level of rest of U.K. demand should cause multicollinearity.

Given, that the best empirical forms of the Scottish output functions (total, home and foreign) are:[25]

dlnSIOP = f(C, lnSIOP(-i), dlnDEM, lnDEM(-i), dlnWXV) (35)

dlnSHIOP = f(C, lnSHIOP(-i), dlnDEM, lnDEM(-i), dlnWXV) (36)

$$dlnSFIOP = f(C, lnSFIOP(-i), dlnDEM, lnDEM(-i), dlnWXV) \qquad (37)$$

where,

SIOP is total net manufacturing in Scotland.

SHIOP is home net manufacturing output in Scotland.

SFIOP is foreign net manufacturing output in Scotland.

WXV represents world demand.[26]

The above argument for Scottish output (whether total, home or foreign) is basically saying that the growth of this output is a function of a logged lagged level of itself, the growth in Scottish demand, the logged lagged level of Scottish demand (which contains both rest of the U.K. influences and peculiar Scottish influences) and finally growth of world demand. It can be seen that this specification is in the mould of the Hendry error correction model (Chapter II), in that both rates of change and levels of the relevant variable are included in the equation. Again, the rates of change determine the function's short-term dynamics and the levels are entered to determine the long-run properties of the equation.

Empirical Results

It is desirable that the specification chosen violates as few of the assumptions of classical regression as possible. For instance, in the simple multiple regression model where

$$Y_i = B_1 + B_2 X_{2i} + B_3 X_{3i} + \dots B_k X_{ki} + u_i \qquad (38)$$

1. The B_k's are non-stochastic.
2. No exact linear relationship exists between two or more of the independent variables.
3. The error term (u_i) has a zero expected value and a constant variance for all observations
4. The errors corresponding to different observations are uncorrelated.
5. The error variance is normally distributed.

Applying ordinary least squares (OLS) to the estimation of regional outputs, yields the following "best" results.[27]

1) <u>Home output function</u>

dlnSHIOP = f(C, lnSHIOP(-1), dlnDEM, lnDEM(-1), dlnWXV) (39)

Var.	Coeff.	S.E.	t	R^2,	$\bar{R}^2$	D.W.	F.
C	-3.11	0.87	-3.54	.84			
lnSHIOP(-1)	-0.59	0.14	-4.08		.79	2.3	
dlnDEM	1.22	0.24	5.07				
lnDEM(-1)	0.62	0.15	3.88				15.3
dlnWXV	0.42	0.08	4.92				

(Estimation period is 1961-1977)

The 't' tests of significance for individual coefficients, are all significant at the 1% level. The 'F' test for overall equation significance is also statistically significant. Hence the null hypothesis that all the regression coefficients are equal to each other and in turn are equal to zero can be rejected. The $\bar{R}^2$ is very good considering that when modelling differences it is much more difficult to get a good test statistic on this measure of association. There are no implausable signs on the coefficients and therefore this indicator of multicollinearity seems to be satisfactory. Heteroscedasticity is not usually a problem in economic time series since deflating the series and taking logarithms normally eliminates this problem. Although the Durbin Watson (D.W.) statistic is slightly higher than desirable, (i.e. a value of 2.0 indicating no auto correlation) the value of 2.3 is in the indeterminate range and after examination of the residuals there does not seem to be a problem.[28] Hence further respecification using alternative functional forms, different dynamics, different right hand side arguments and so on was not deemed necessary.

2. <u>Foreign output function</u>

dlnSFIOP = (C, lnSFIOP(-1), dlnDEM, lnDEM(-1), dlnWXV) (40)

Var.	Coeff.	S.E.	t	R^2,	$\bar{R}^2$	D.W.	F.
C	-8.85	5.47	-1.61	.72			
lnSFIOP(-1)	-0.30	0.15	-1.93		.61	1.94	
dlnDEM	1.34	0.61	2.18				
lnDEM(-1)	1.06	0.64	1.64				7.1
dlnWXV	0.60	0.18	3.28				

(Estimation period is 1961 - 1977)

Again, as was the case with home output, this foreign output function looks reasonable given the battery of single equation tests available. The 'F' statistic is significant, the D.W. reflects a fairly accurate equation specification with no serial correlation present; all the 't' tests are significant at the 1% level (with the exception of lnDEM(-1) and C which are significant at the 5% level) and finally the $\bar{R}^2$ is quite acceptable for a difference equation.

These two equations are in fact the best results obtained from a very extensive and exhaustive specification search. The implicit assumption is that the Scottish demand argument presented earlier is valid. Hence the Scottish demand variables that are entered in rates of change and levels, have the interpretation that the rate of change in Scottish demand closely approximates mainly Scottish peculiar behaviour and, in turn, determines the short-term properties of the equation. The level of Scottish demand again is interpreted as encompassing the rest of the U.K. and Scottish peculiar behaviour.

Given these results, which will be interpreted shortly, further experimentation can lend some intuitive empirical support to the Scottish demand argument. One experiment involved simply entering various combinations of the level of Scottish and rest of U.K. demand variables in the output equations. Inevitably, multicollinearity seems to occur as reflected in implausible signs, high R^2's, low 't's for individual coefficients, high standard errors for individual coefficients, etc. This is not surprising, since this is what Kelly found and confirms the view that U.K. influences are at work in the Scottish data. In fact a regression of DEM on RUKD yields an $R^2 = .97$

A more revealing experiment is to examine the value of the rate of change in Scottish demand when its corresponding U.K. argument is entered in the equation instead of the rate of change in world demand. The world demand variable is dropped since a collinear relationship between dlnWXV and dlnRUKD was detected. If in fact the rate of change in Scottish demand (dlnDEM) is picking up mainly Scottish elements, then its coefficient value should remain relatively the same when dlnWXV is dropped and dlnRUKD is added. The results of this test in fact did not change the coefficient on dlnDEM to any great extent. In case 1 with dlnWXV the coefficient value is 1.22 and in case 2 with dlnRUKD the value is 1.27 suggesting not only that this parameter value is fairly robust, but further that in the case of home output there is a high degree of independence between dlnDEM and dlnRUKD since the usual signs of multicollinearity did not show up. The same result was found on a similar test in the foreign output function. The coefficient value on dlnDEM of 1.40 again is not significantly different from the previous value of 1.34. As before, the message is that there is a large degree of independence between the growth of Scottish demand and the growth of U.K. demand, confirming the view that it is mainly peculiar Scottish demand which is being witnessed. In fact a simple regression of dlnDEM on dlnRUKD yields an R^2 of .29. Hence, it is argued that the home and foreign output specifications represent to a greater versus a lesser degree, additional information which is accounting for peculiarly Scottish phenomena and further that the above two equations pass the usual single equation validation criterion. They will therefore be used in the SIMFOR multi-equation exercise in Chapters VI and VII.

Next, is a brief discussion of some of the more significant differences between the home and foreign output functions. Again their estimated parameters are:

$$dlnSHIOP = -3.11 - 0.59 lnSHIOP(-1) + 1.22 dlnDEM + 0.62 lnDEM(-1) + 0.42 dlnWXV \quad (41)$$

$$dlnSFIOP = -8.85 + -0.30 lnSFIOP(-1) + 1.34 dlnDEM + 1.06 lnDEM(-1) + 0.60 dlnWXV \quad (42)$$

The long-run parameters implied by these specifications are

$$lnSHIOP = 1.05 lnDEM \quad (43)$$

$$lnSFIOP = 3.53 lnDEM \quad (44)$$

The lagged level of the dependent variable in this formulation, does not have the standard partial adjustment interpretation, common to equations which are estimated in levels. It has to be remembered that the dependent variables are in rates of change and that a 1% increase in the value of the lagged dependent variable means that the growth rate of the dependent variable will be smaller in the next period. These lags, in particular, are added to the equation to help determine its long-run steady state properties. For example, in the long-run, all the rates of change drop out of the equation and the lagged dependent variables are taken to the left hand side e.g.

$$0.59 lnSHIOP = 0.62 lnDEM \quad (45)$$

$$0.30 lnSFIOP = 1.06 lnDEM \quad (46)$$

Hence the logic for the way in which (43) and (44) above are derived.

Equations (41) and (42) have the following interpretations.

1. A 1% change in the growth of Scottish demand (dlnDEM) produces a 1.22% change in the growth of home output and a 1.34% change in the growth of foreign output. These coefficients can be interpreted as dynamic growth elasticities, and it seems that in the short-run, both the home and foreign sectors, have greater than a unit elastic response in growth terms to a change in the growth of Scottish demand. The foreign sector is slightly more elastic, but the difference does not seem to be significant.
2. As regards world demand, a 1% change in the growth of world demand (dlnWXV) produces a .42% change in the growth of home output and a .60% change in the growth of foreign output. Both these sectors dynamic growth elasticities of responsiveness are less than unity i.e. relatively inelastic.
3. The most interesting difference between the home and foreign sector is the highly elastic nature of the foreign sector's reponse to a 1% change in Scottish demand (3.53%) as opposed to the home sector's unit elastic response of (1.05%).

The short-run response of the home and foreign sector in [1] above seem reasonable, although it is hard to know what to expect or how to interpret the values of coefficients on variables which are entered to determine short-run dynamic properties. The fact that the coefficient values are greater than unity suggests that Scottish peculiar growth is less than that of the growth of the rest of the U.K. and further that, while the rate of change of Scottish demand does highlight Scottish peculiar factors, there is inevitably a certain amount of U.K. behaviour which is picked up. Essentially these coefficients are what the data suggest and economic theory does not have much to offer on the subject.

As regards [2] above, i.e. the growth in world demand (dlnWXV), again it is difficult to really know what coefficient value to expect. However, having said this, what the values seem to suggest is that relative to Scottish demand, world demand does not elicit a very elastic output response in either home or foreign sector. This could be explained by the fact that Scottish market information is more ready to hand and that both the home and foreign sector in Scotland are more rest of U.K. orientated than rest of the world oriented as regards external markets. Finally, it could be the nature of the data for world demand (in that it may not be a good proxy), which explains why the short-run Scottish demand and world demand elasticities are not closer.[29]

Number [3] above is the most interesting result and implies that in the long-run the foreign sector responds much faster to changes in Scottish demand than does the home sector.

This greater overall sensitivity to demand whether on the up or downside may be explained by the following considerations:

1. That to some extent Scottish demand growth might be less than the rest of the U.K. demand growth (reflected by the fact that both the home and foreign coefficients are greater than unity). While this explanation might be able to account for a certain amount of the difference between unity and the value of the demand coefficient in foreign output, it certainly does not explain away the largest part of the discrepancy. This statement is considered valid since it has been shown earlier that Scottish c.f. rest of U.K. demand levels are relatively stable, even though the growth of Scottish and rest of U.K. demand are not synchronous. Hence, it should not be expected that their relative growth rates would differ to the extent implied above.

   Therefore the high coefficient value on demand in the foreign output equation probably suggests that in the long-run, the foreign sector is relatively freer from supply side constraints. The advantage of having a powerful parent company in this instance would be the economies bestowed at nearly zero marginal costs in the form of new research and development, new product specifications, retooling, etc. This latter point would in fact be obscured in a function which did not disaggregate the sectors (e.g. the coefficient of demand in a total output equation was 1.3), which would have led to a conclusion more along the lines of the argument in the above paragraph.

2. That there are different levels of industrial concentration in the two sectors. The foreign sector for example, has a greater concentration in the high technology electronics type industry, whereas the home sector traditionally has a greater concentration in heavy engineering industry. It is argued here that the lag response time of production, to changes in demand would be much slower in the traditional industries vs. the high technology electronics industry.
3. It could also reflect the fact that foreign companies have located abroad for the very purpose of filling the demand for its products. It is often argued that one of the main reasons for foreign firms locating in the U.K./Scotland is to have proximity to the market, so that they could more easily respond to demand changes.[30]
4. It might also be argued that the foreign sector is more efficient in forecasting demand changes and hence, is better poised to take advantage or respond to market changes.

The above explanations are merely offered as plausible hypotheses concerning the differences between the long-run home and foreign output elasticities, with respect to changes in demand. These could naturally be tested more rigorously at the micro level. However, it must be remembered that SIMFOR is concerned with the quantification of the structural parameters and the overall net contribution of the foreign and the home sectors. Therefore it is felt that attention should be focussed on the fact that quite distinct parametric differences are in evidence, and not on the specification and testing of the exact nature of the reasons for these differences. It is in fact these parameter estimates which will be the key to the multi-equation simulation experiments which follow in Chapters VI and VII.

Summary

The preceding Chapter has been concerned with the theoretical and empirical issues pertaining to manufacturing output determination at the regional level; with emphasis on the specification and estimation of the most appropriate home and foreign manufacturing output functions for Scotland. A demand orientated approach was opted for and an attempt was made to forge links between final demand expenditure aggregates and manufacturing output. Statistically significant results were obtained which were consistent with a priori theoretical and intuitive expectations. These results in essence enabled the differences between the home and foreign sector to be highlighted and quantified. Hence, the first step towards the eventual goal of simulating the overall net impact of

FDI on Scotland (especially in output, employment and investment) has been taken.

Chapter IV follows next with the development of the theoretical and empirical arguments for the home and foreign investment functions in Scottish manufacturing.

NOTES: CHAPTER III

1. These categories were chosen since they can normally be regarded as the most important areas of concern from the host country's perspective, and further they satisfy the empirical criteria set out in Chapter II, i.e. verifiable, quantifiable and socio-economic. These three so-called "impact categories" not only satisfy the data availability criteria for Scotland, but are also available in general for most economic regions. Therefore, not only will the model which is developed herein have obvious relevance to Scotland, but it is also hoped that it will have more general relevance to other country study work on FDI.

2. To arrive at this distinction the foreign value for the particular data series concerned was simply subtracted from the total value of the series to obtain the home figure. Therefore the identity that home + foreign = total will always hold.

3. A model flow chart which graphically depicts the entire model's interrelationships is presented in Appendix 1. It will be more useful and make greater sense when all the blocks have been developed and assembled for simulation in Chapters VI/VII.

4. For further discussion on the distinction between residents and territorial income, see Lythe, C. and Majmudar, M. *The Renaissance of the Scottish Economy*, (London: George Allen & Unwin, 1982), pp. 19-21; for further details on the sources and methods of Scottish GDP (income method), see Lythe and Majmudar, *ibid*., p. 195.

5. This method has been used quite successfully in other regional modelling exercises. However, the models were not exclusively concerned with foreign investment. e.g. see Latham, W. R., Lewis, K. A. and Landon, J. H. 'Regional Econometric Models: Specification and Simulation of a Quarterly Alternative for Small Regions', *Journal of Regional Science*, Vol. 19, No. 1 (1979), pp. 1-13.

6. See Lythe and Majmudar, *op.cit*., p. 21.

7. See Lythe and Majmudar, *ibid*., pp.31-37 for a time series summary of Scottish domestic demand and p. 196 for sources and methods of the data comprising domestic demand.

8. See Klein, L. R. 'The Specification of Regional

Econometric Models', Papers of the Regional Science Association, No. 23 (1969), pp. 105-115.

9. See Glickman, N. J. "Son of 'The Specification of Regional Econometric Models'", Papers of the Regional Science Association, Vol. 32 (1974), pp. 155-177.

10. See Glickman, N. J., ibid., p. 156.

11. See Lythe and Majmudar op.cit., pp. 26-29 for a time series summary of Scottish output and p. 195 for sources and methods.

12. These are not necessary assumptions of the analysis, but have only been made to simplify the example.

13. See Crow, R. T. 'Output Determination and Investment Specification in Macroeconometric Models of Open Regions', Regional Science and Urban Economics, Vol. 9 (1979), pp. 145-158.

14. See Savitt, J. H. Electric Energy Useage and Regional Economic Development, Electric Power Research Institute (Palo Alto, California, 1976).

15. See Courbis, R. 'Measuring Effects of French Regional Policy by Means of a Regional National Model', Regional Science and Urban Economics Vol. 12 (1982), pp. 59-79.

16. See Bell, F. 'An Economic Forecasting Model for a Region', Journal of Regional Science, Vol. 7, No. 2 (1967), p. 109-127.

17. See Adams, F. G., Brooking, C. G. and Glickman, N. J. 'On the Specification and Simulation of a Regional Econometric Model: A Model of Mississippi'. The Review of Economics and Statistics, Vol. 57 (1975), pp. 286-298.

18. See Jefferson, C. W. 'A Regional Econometric Model of the Northern Ireland Economy' Scottish Journal of Political Economy, Vol. 25, No. 3 (Nov. 1978), pp. 253-272.

19. See Bell, D. Regional Econometric Modelling with Special Reference to Scotland, Ph.D. Dissertation, University of Strathclyde (July 1984) for a formal argument of the inappropriateness of the regional competitiveness variable in the U.K. content. His basic conclusions were:

   a. That relative earnings do not necessarily accurately reflect relative wage costs, given the fixed costs of employment.

b. That although labour costs predominate in total costs of production, they do not necessarily determine the competitiveness of the product. This is due to the fact that in the U.K. pay bargaining structures tend to result in a uniformity of labour costs across regions. Therefore total unit costs differentials will depend more on the cost of non-labour inputs.

c. That consumers make their decisions on the purchase of output at the delivery point and not at the production point. The costs that occur between producer and seller include: transport, insurance, indirect taxes, dealer's margins, etc.

d. That it must be taken into account that non-price factors can influence the relative attractiveness of goods from other regions (e.g. marketing and advertising).

20. See Lythe, C., Dewhurst, J., Parrillo, S., Cox, M., Gausden, R. 'Temptress III', Report to the Social Science Research Council, Dept. of Economics, University of Dundee (May 1981).

21. See Bell, D., op.cit.

22. See Kelly, C. M. 'Scottish Output in Sub-Sectors of Manufacturing Industry, Modelling in Relation to Expenditure Aggregates', ESU Discussion Paper No. 7, Scottish Office (Edinburgh, 1980), pp. 1-57.

23. Ibid., pp. 22-23.

24. There are certainly many more properties which determine the reliability of a macro-model's simulations besides decent single equation fits, for example, historical tracking performance, model stability, ex-post forecasting ability, and ex-ante forecasting ability, all which will be discussed in Chapter VI.

25. In fact after rigorous specification search this general form was found to be the most appropriate. Reporting the results of all these tests (which can be made available on request) would be a rather tedious task and hence only the results used for further analysis are reported.

26. Please note, that a full list of variable names as pertain to SIMFOR can be found in Appendix 2, 'Abbreviations, Variable Names, Identities and Definitional Relationships in SIMFOR'. Further, the actual definitions, sources and methods used to obtain

the data for estimation purposes can be found in Appendix 3, 'Data used in SIMFOR'.

27. The whole model will in the first instance be estimated by the ordinary least squares (OLS) procedure. In Chapter VI, two stage least squares and principle components of instrumental variables will be discussed.

28. Refer to Appendix 4 for the actual, fitted and residual plots not only for the output equations but also for all the equations which will eventually be estimated for the simulation experiments in Chapters VI and VII.

29. Note that the specification search did not bear out that the level of WXV should be entered in the equation. This seems to suggest that long-term demand from the rest of the world is met by increasing either both capital and labour utilization or alternatively (especially in the foreign sector case) by moving plant to the source of demand. Both explanations seem reasonable since world demand is relatively unstable, which is further compounded by the volatility of exchange rates. As regards, moving to the source of demand, it is in fact often argued that U.S. plants in particular, come to the U.K./Scotland as a base for further physical expansion into Europe. This argument is put forward by Hood, N. and Young, S. in 'European Development Strategies of U.S. owned Manufacturing Companies located in Scotland', Report Prepared for the Scottish Economic Planning Department (Edinburgh, 1980), pp. 1-100.

30. Specific tests of this hypothesis are carried out in Chapter IV.

CHAPTER IV

REGIONAL INVESTMENT DETERMINATION: THE SCOTTISH CASE

Introduction

The purpose of Chapter IV is to develop further the theoretical and empirical arguments as pertains to the home and foreign investment functions. As mentioned in Chapter III, an explicit attempt will be made to enter supply side or cost type variables in the foreign investment function, while aggregate demand (albeit indirectly) will again be the primary determinant of home and foreign investment. This Chapter is broken down as follows: First there is a brief review of the investment functions typically applied at the regional level. This is followed by a discussion of the most appropriate specifications for the home and foreign sectors. Finally the operational empirical forms of the equations are presented along with the various tests performed and interpretation of the results.

Regional Investment Functions

A wide variety of investment functions have been applied at the regional level (e.g. simple accelerator models, profit models, interest rate models, etc.) and, whether of the Keyensian or neo-classical variety, the vast majority seem to assume, either implicitly or explicitly, that investment is a derived demand with output being demand determined.[1] This is consistent with the usual price taker assumption in regional output specifications and hence any attempt to take cost factors into account, whether in the output or investment functions, occurs in a somewhat ad hoc manner without explicit supply constraints.

As regards accelerator type models (i.e. those which emphasize the role of output) the first to be applied at the regional level was by F. Bell.[2] His basic argument was that the desired stock of capital in a region is a log-linear function of regional output and the level of technology.

$$K^*_t = f(V_1)^m_t \ (1 + p)^{-i} \qquad (47)$$

where,

- K^*_t is the desired long-run equilibrium capital stock in the current period.
- $(V_1)_t$ is total received income and is comprised of local service and export income.
- $(V_2)_t$ is total produced income or the output of the factors of production located in the region.
- i is the time trend, to proxy technical progress.
- m denotes the manufacturing sector.

Although $(V_2)_t$ should have been entered in the above relationship, Bell assumed $(V_2)_t$ to be a constant fraction (p) of $(V_1)_t$, (and performed the above substitution) thus allowing disaggregation into manufacturing and non-manufacturing investment, the ultimate purpose of this specification. He also assumed that the percentage increase in capital stock during the year is a fixed proportion (g) of the percentage gap between the desired (K^*) and actual capital stock (K).

$$K_t/K_{t-1} = (K^*_t/K_{t-1})^g \quad (0 < g < 1) \tag{48}$$

Substituting (47) into (48) and rearranging yielded

$$K_t/K_{t-1} \doteq f^g(V_1)_t^{gm} \ (1 + gp)^{-i} K^{-g}_{t-1} \tag{49}$$

By using this form and by distinguishing between export and local income Bell postulated that manufacturing investment was dependent on export income and that non-manufacturing investment was a function of local service income.

$$(K_t/K_{t-1})^m = f^g + (X_t)^{gm} \ (1 + gp)^{-i} \ (K_{t-1})^{-gm} \tag{50}$$

$$(K_t/K_{t-1})^{nm} = f^{'g'} + (S_t)^{g'nm} \ (1 + g'p')^{-i} \ (K_{t-1})^{-gnm} \tag{51}$$

where,

X_t is export income.

nm denotes the non-manufacturing sector.

S_t is local income.

Investigations were also carried out on interest rate variables in an attempt to apply supply side adjustments, although no significance was found.

The specification thus emphasised the growth in regional output or income as the determinant of the derived demand for the regional factor (capital). While quite a lot of regional behaviour is captured by this function, in that regional output and capital stock are employed, it must be noted that regional output in the manufacturing sector is simply a function of national output, hence local factors are not emphasised to the extent necessary in SIMFOR.

Another accelerator type model which placed even less emphasis on regional structure was that of Guccione and Gillen[3]. They postulated that regional investment (Ir) was a function of the change in national output (ΔGNP) and regional investment lagged two periods:

$$Ir = a + b\Delta GNP + cIr(-1) + eIr(-2) \qquad (52)$$

The only variables which were regional specific included the lagged endogenous variables, which would obviously account for a good fit, but were of limited relevance in ascertaining regional behaviour.

Glickman[4] provided yet another example of an output dependent specification. He attempted not only to take factor costs into account but he also tried to emphasise regional variables:

$$I_r = f[(iL - iS), GRO, RMO(-1), RKS(-1)] \tag{53}$$

where,

I_r	is regional manufacturing investment.
iL	is a long-term interest rate.
iS	is a short-term interest rate.
GRO	is gross regional output.
RMO(-1)	is lagged regional manufacturing output.
RKS(-1)	is lagged regional capital stock.

Again, however, regional output was simply taken as a function of its national counterpart.

Following Bell's attempt at modelling regional investment were a series of studies which tried to pick up regional behaviour by using regionally generated profits as a major explanatory variable. For instance, L'Esperance et al.[5] argued that total manufacturing investment can be broken down into investment in structures (IS) and investment in machinery (IM). IS was taken to be a function of IM and the national interest rate on corporate bonds (ICB):

$$IS = a + bIM - cICB \tag{54}$$

IM was assumed to be a linear function of profits or internally generated funds in manufacturing (IGF), a lag of IGF and a lagged value of itself (IM_{-1}):

$$IM = e + fIGF_{-1} + gIGF_{-1} + hIM_{-1} \quad (55)$$

Further IGF was endogenized and was equal to a function of the rate of change and the level of gross regional product in manufacturing (ΔRPM and RPM respectively):

$$IGF = h + i\Delta RPM + jRPM \quad (56)$$

The IGF variable was simply a scaled down version of national profit type income plus capital consumption allowance for manufacturing:

$$IGF = RI_r/RI_n\ (PTI_n + CCA_n) \quad (57)$$

where,

RI is the rate of return on capital.

r is the subscript for a region.

n is the subscript for the nation.

PTI is profit type income.

CCA is the capital consumption allowance.

Again, as with the Bell specification, the profit type equation for IM allowed for cost or supply factors to influence investment determination in that revenues minus costs yielded profits. The profits variable is however endogenized so that the growth of income or output, (which is determined by demand) remained as the primary driving force. In essence, the simple accelerator is implicit and is embedded in the profits function. As usual the growth of output was determined explicitly by national variables.

Crow[6] provided yet another version of the regional profits type investment function, and argued "non-residential fixed investment is taken as a function of gross private product less the private wage bill, lagged one year. This variable was intended to capture the influence of profits as an expectational variable as well as the ability to finance new investment".[7]

A slightly different regional investment function which emphasised profits was that attributable to Engle.[8] He attempted to pick up locational influences and hypothesized that is was the supply of factors which determined the potential income of the economy. Regional manufacturing investment in his model was a linear function of the ratio of profits between the region and alternative location/(s) and the total supply of investment goods:

$$I^m = b_o + b_1 \, r^m/r^* + b_2 \, I^{us} \qquad (58)$$

where,

I^m is manufacturing investment in the region.

r^m is the marginal value product (MVP) of regional manufacturing investment.

r^* is the rate of return elsewhere, taken to be either the MVP is the single-most profitable alternative in the nation or the average MVP in the nation as a whole.

I^{us} is manufacturing investment in the U.S..

The model is basically trying to capture the behaviour of the footloose investor who surveys a number of alternative locations and ultimately invests in the one which offers the highest profit opportunities. The relative profits ratio could obviously be a promising avenue to pursue in the foreign investment equation. However, as used in the above study, it has serious shortcomings in that it totally neglected product demand and further the national supply of factors proxy is not very illuminating as regards regional structure. This national proxy variable again placed this type of specification more into the mould of an ex-ante forecasting equation.[9]

A more recent example of a regional manufacturing investment function which emphasized the role of national variables and which can be interpreted as more of a forecasting equation is that of Lythe et al.[10] They postulated that investment in Scottish manufacturing (SIM) was a function of its U.K. counterpart (UIM) and an index of Scottish North Sea Oil activity (SOIL):

$$SIM = aUIM + bSOIL \qquad (59)$$

They argued, "we would justify this type of specification by postulating that Scottish investment responds to much the same stimuli as U.K. investment but in fact our adoption of this form was very much _faute de mieux_."[11]

The only real opposition to the preceeding types of investment specifications was (as in the case with regional manufacturing output) provided by Crow.[12] He argued that none of the above specification types, "account for the possibility that output itself might be determined to a large degree by the available stock of capital and labour - the supply side - rather than by a specialized aggregate demand for the product of a particular region".[13]

He basically argued for an investment specification which would emphasize interregional competitiveness or relative factor costs and spatial elements such as transportation costs, agglomeration economies, etc. The suggested forms were either to develop an ad-hoc linear or log-linear equation in which regional investment was specified as a share of national investment. Investment in this case was regarded as a problem of qualitative choice which could be represented by a logit model where regional investment was taken as a probability function of investing in one region versus another . Crow argued that this may be illustrated by assuming that at the micro level a firm has a value function for the allocation of investment of the form

$$V(I_{gr}) = \exp(b_o + b_1 P_{gr} + b_2 AS_{gr} + b_3 AM_{gr} + b_4 X^*_{gr} + b_5 T_r + b_6 R_r \; b_7 S_{gr} + b_8 Q_{gr}) \qquad (60)$$

where,

Subscript r denotes the region.

I_{gr} is regional investment.

P_{gr} is a measure of before tax profit rate.

AS_{gr} is the accessibility to input supply, and can be represented as:

$$AS_{gr} = \sum_j (\sum_h X_{hj} \, a_{hg})/(A_{rj} \, C_g)$$

X_{hj} is the value of production in industry h in region j.

a_{hg} is a national input-output coefficient indicating the input of h per unit output g.

A_{rj} is a measure of the impedence in the transportation network between regions r and j.

C_g is a parameter to be determined.

AM_{gr} denotes accessibility to output markets, it uses a_{gh} vs. a_{hg}.

X^*_{gr} is output capacity, and is used as a proxy for the economies of agglomeration and concentration.

Tr denotes regional taxes.

R_{gr} denotes land prices.

S_{gr} denotes special traits about regional factors not covered by other terms, (e.g. productivity differentials in the local work force, energy costs etc.).

Q_{gr} denotes amenities specific to the region.

An aggregate spatial allocation logit function which is analogous to the micro value function was expressed as

$$\ln(I_{gr}/I_{gn}) = b_o + b_1(P_{gr}/P_{gn}-P_{gr}) + b_2(AS_{gr}/AS_{gn}-AS_{gr}) + b_3(AM_{gr}/AM_{gn}-AM_{gr}) + b_4(X^*_{gr}/X^*_{gn} - X^*_{gr}) + b_5(T_r/T_n-T_r) + b_6(R_r/R_n-R_r) + b_7(S_{gr}/S_{gn}-S_{gr}) + b_8(Q_{gr}/Q_{gn}-Q_{gr}) \quad (61)$$

There is no objection to the types of location specific or relative costs variables which Crow was trying to integrate into his investment specification. It is however the deeper objection to the determination of regional capacity (X^*_{gr}) as outlined in Chapter III which makes the whole hearted adoption of his approach a non event in the context of SIMFOR or, for that matter, any regional model which acknowledges the current realities of excess factor supplies.

It is therefore argued that the investment specifications for the home and the foreign sectors should proceed in the spirit of the equations in the pre-Crow review and that supply side arguments are to be simply applied in an ad hoc manner when it is deemed necessary.

Home Investment Determination

Given the above, it was determined that the simple accelerator model would best depict the behaviour of the home sector in SIMFOR.[14] As is typical for a specification of this type, two questions will be considered in the investment process.

1. What determines the desired level of capital stock? Defined as,

$$K_t = K_{t-1} - D_t + I^G_t \tag{62}$$

where,

K_t is the current level of capital stock.
D_t is capital consumption.
I^G_t is gross investment.

2. What determines the rate at which investment is to proceed to achieve desired capital stock K^*_t?

The formulation suggested here will not explicitly take factor prices into account. In other words, investment will respond to changes in output and not to the price of capital or labour.[15] This is consistent with the assumption of endogenous prices at the U.K. level in the output function and no constraints on supply in the short and medium-term. Hence there is no explicit production function constraint from which to derive the investment specification. This yields the fixed coefficient model which employs the following identities:

$$I^n_t = K_t - K_{t-1} = I^G_t - D_t \quad (63)$$

$$I^G_t = K_t - K_{t-1} + D_t \quad (64)$$

where,

I^n_t is net investment.

The explicit assumptions of the model are that

$$Q_t = aK^*_t \quad (65)$$

$$K^*_t = bQ_t, \text{ where } b = 1/a \quad (66)$$

$$D_t = gK_{t-1} \quad (67)$$

In other words that output Q_t is a constant proportion of desired capital stock K^*_t and vice versa. Further that capital consumption is proportional to preexisting capital stock. Substituting equations (65) and (67) back into (62) and rearranging yields

$$I^G_t = bQ_t - b(1-g)\, Q_{t-1} \quad (68)$$

The assumption in the case of equation (62) is that desired capital stock K^*_t is actually achieved or, in other words, that instantaneous adjustment has occurred between actual and desired levels of capital stock. In order to account for the situations in which $K_t \neq K^*_t$, a partial adjustment mechanism is usually postulated of the following form:

$$K_t - K_{t-1} = e\,(K^*_t - K_{t-1}) \quad (0 < e < 1) \tag{69}$$

This can be reexpressed in terms of K_t and actual observed variables

$$K_t = e(bQ_t) + (1-e)\,K_{t-1} \tag{70}$$

Therefore,

$$K_t - K_{t-1} = eb\,(Q_t - Q_{t-1}) + (1-e)\,(K_{t-1} - K_{t-2}) \tag{71}$$

Substituting this result into equation (64) yields

$$I^n_t + D_t = eb\,(Q_t - Q_{t-1}) + eD_t + (1-e)\,(K_{t-1} - K_{t-2}) + (1-e)\,D_{t-1} \tag{72}$$

where, $D_t = b(1-g)\,Q_{t-1}$

which finally yields,

$$I^G_t = ebQ_t - eb\,(1-g)\,Q_{t-1} + (1-e)\,I^G_{t-1} \tag{73}$$

Hence the expression for investment is in terms of the change in output and a lagged dependent variable in investment. This is in essence the argument which is applied to the home investment function, although there are further modifications and adjustments to account for the error corrections mechanism.[16]

Foreign Investment Determination

The purpose of the foreign investment function in the context of SIMFOR is not only to try and capture some of the influences which initially attract foreign investment to Scotland, but also to attempt to incorporate a mechanism which enables subsequent behaviour to be ascertained (e.g. cost of capital, cost of investment goods, expected rates of return, relative costs, etc.) There are three basic questions relevant to FDI in Scotland:

1. What factors determine foreign investment in Scotland and the rest of the U.K.?
2. Given the intention of investing in the U.K., what factors result in some investment going to Scotland?
3. Once set up in Scotland, what are the factors which determine continued capital formation in Scotland?

Given these objectives it was deemed to be more appropriate to draw guidance from the literature on domestic capital formation and location theory rather than trade theory and the so-called eclectic theory of international production.[17] The latter places more emphasis on industrial/organisation theory and seeks to explain in a general manner, the determinants of the quantity and composition of international production. Obviously the specification for SIMFOR is much narrower in that it is one particular geographical location which is of primary concern.

Before development of the theoretical specification for foreign investment, it may be illuminating to present a brief summary of some of the main determinants of FDI usually cited in the literature.

1. <u>Market Considerations</u>

a. Size and/or growth of the market.
b. Export base for neighbouring markets.
c. Maintenance of market share.
d. Matching of competitors' investment in the market.

2. <u>Cost Factors</u>

a. Lower labour costs.
b. Availability of raw materials.
c. Availability of skilled labour.
d. Availability of capital/technology.
e. Lower transport and production costs.
f. Financial incentives and tax structure.
g. Stability of foreign exchange.

3. Barriers to Trade

a. Circumvention of tariffs, quotas, etc.

b. Preference of local customers for local products.

4. Investment Climate

a. Political stability.

b. Familiarity with language, culture, etc.

c. General government attitudes, reflected in exchange regulations, limitations on ownership, etc.

The items mentioned under investment climate are essentially qualitative in nature and will not explicitly be taken into account in the foreign investment equation. However this does not diminish their importance in FDI determination, in fact they all seem to be quite favourable in the Scotland/rest of the U.K. context. Hence, while not directly accounted for, they can be viewed as important contributory factors.[18]

As regards the barriers to trade, it is often argued that Britain's membership to the EEC could have acted as a stimulus to foreign investors who wanted access to European markets. Besides the technical problem of testing this hypothesis in the context of SIMFOR,[19] the chances are that, even if it could be tested, it would prove to be troublesome (reflected by the usual signs of multicollinearity) due to the overpowering influence of market growth in Scotland/rest of the U.K. Hood & Young for instance in a study which looked at the geographical expansion of U.S. firms in Western Europe,[20] stated, "The data on the shifts in producion location do suggest at least some 'EEC effect', although the much faster growth rates within the EEC countries must have also been a major factor".[21]

Given the arguments against including [3] and [4] in the equation it was decided that emphasis should be placed on market considerations, cost factors and rates of return. In fact as noted in Chapter I, these are to a large extent the factors which Forsyth, Hood and Young found to be significant in the Scottish context. The way in which these variables enter the equation will essentially be in an ad hoc manner in that they are not derived in a formal manner from standard economic theory.

As regards market size and growth, it is argued that these factors can be captured by the level of Scottish manufacturing output (which implicitly includes rest of U.K. influences) and by the growth in Scottish manufacturing output respectively. This is where the emphasis on domestic capital formation theory comes into play. It is argued that the adoption of an accelerator type model with additional arguments for the cost of capital and/or rates of return on capital would not only capture the foreign firms' initial reason for investing, but also its subsequent behaviour. It is further argued that these proxy market variables have to be modified in some way in order to allow more supply oriented factors to be taken into account.[22] For instance, a cost of capital formulation of the Jorgenson variety could be attempted.[23] The main difference between the simple accelerator and the standard Jorgenson model[24], as developed in the literature, is the relationship between desired capital stock (K^*) and output (Q_t). As stated earlier, in the simple accelerator model, there is a fixed proportional relationship between K^* and Q_t with no explicit production function constraint. In the Jorgenson model the optimal level of capital stock is determined from the assumed Cobb-Douglas production function as proportional to the market value of physical product divided by the implicit price of capital services.

The desired capital stock may be represented as:

$$K^*_t = aP_t\ Q_t/C^*_t \tag{74}$$

where,

- P_t is the product price.
- a is a constant from the Cobb-Douglas production function measuring the elasticity of output with respect to capital.
- C^*_t is the flow price of capital which in turn is usually taken as a function of the income tax rate, tax allowance on depreciation, tax allowance

on interest payments and tax allowance on capital gains/losses. In other words, C^*_t incorporates the effects of relative prices, which Jorgenson showed to have the same effect on desired capital stock as does output.

Although it has been suggested that this type of equation could be adopted for foreign investment, it is not intended to use the expression derived from the theory proper.

The obvious limitation with the specification as depicted is that imposed by the Cobb-Douglas production function itself, the inappropriateness of which has already been aired in Chapter III (output block). In order to maintain consistency between foreign output and investment determination, it is assumed that there is a relationship of the form $K^*_t = bQ_t$ in the foreign sector with $Q_t = aK^*_t$. However, the form of C^*_t attempted in this function is not derived from neo-classical supply side premises. Its proposed adoption in an essentially ad hoc manner is so that demand side effects can be tempered by supply side or cost factors.[25] In essence, it is an output or demand argument weighted by the cost of capital. In 'level' terms it could have the interpretation that manufacturing output or proxy market size has an obvious influence on whether foreign invetment is located in Scotland/rest of U.K., as well as being one of the factors which determines continued investment. However, not only must the market exist in order to stimulate continued investment but further, the cost of capital weighting means that it must be economical to do so.

An alternative modification to the output arguments outlined above, besides the user cost of capital formulation, would be an argument in terms of the expected rate of return on the foreign investment. On an a priori basis it seems plausible to argue that foreign investors (assuming that most of their borrowing occurs on U.K. captial markets, that a U.K. rate of interest can be taken as a world rate,[26] and that there is not a shortage of funds in U.K. capital markets) look to both the exchange rate and the U.K. rate of interest as guides to the U.K. rate of return. This rate is essentially a real rate in so far as that expected inflation is accounted for in the exchange rate, i.e. as expected inflation increases the exchange rate depreciates. The argument is that if foreign investors expect inflation to be increasing in the U.K. then there would be an incentive to borrow and invest in Scotland/rest of the U.K. since the expected depreciation of sterling would in effect bestow a capital gain on a liability. In other words, in terms of the foreign investors' home currency, he would be repaying loans at a lower price than was contracted (prior to depreciation). Further incentives for investing in the U.K. resulting from exchange rate depreciation would be to keep up the sales of what would be now expensive U.K. imports, plus the prospect of selling cheaper exports from Scotland/rest of the U.K..

It is also argued that, in addition to the above arguments, location type variables such as relative rates of interest, labour costs, profits, etc. be tried on the right hand side of this equation. Now that the general theoretical forms of the home and foreign investment functions have been set out, the operational empirical specifications will be presented along with results and interpretation.

Empirical Results

A. Home Investment

As argued in the last section, the most appropriate theoretical specification for the home sector is the simple accelerator model,[27] where

$$SHIMK = f[dlnSIOP, SHIMK(-1)] \qquad (75)$$

As with the output equations, the home manufacturing investment equations will be estimated in differences and levels, to facilitate incorporation of the Hendry estimation method. Various dynamics have been experimented with on both the rate of change and level variables. Although economic theory does not say much about short-term economic dynamics, the suggestion of

ΔSIOP where SHIMK is in levels, could also be taken to suggest that Δ^2 SIOP be employed when SHIMK is estimated in terms of ΔSHIMK. This is in fact the term which proved to be most significant. The higher derivative is slightly more subtle and is interpreted as the rate of change in the growth of output. Two separate expressions for the accelerator were tried.[28] The first was simply,

$$d^2 lnSIOP = dlnSIOP - dlnSIOP(-1) \quad (76)$$

where,

$$dlnSIOP = lnSIOP - lnSIOP(-1)$$

the other is,

$$d^2 lnFLEXACC = dlnFLEXACC - dlnFLEXACC(-1) \quad (77)$$

where,

$$dlnFLEXACC = lnFLEXACC - lnFLEXACC(-1)$$ and,

$$FLEXACC = (SIOP * SCUIK)$$

(SCUIK) is the index of Scottish capacity utilisation.

This agumented flexible accelerator mechanism has also been used in the National Institute Model[29] and seeks to provide an important element of cyclical behaviour in the economy. The result of applying this additional weighting was that the coefficient on the accelerator term decreased and better individual coefficient and overall equation fits, in terms of significance tests, were achieved.

The following results were derived from the equations which embodied the best (OLS) fits after exhaustive testing, for different functional forms, dynamics and arguments on the right hand side. Firstly, the results for the home manufacturing investment equation for the simple accelerator model were:

$$dlnSHIMK = a + blnSHIMK(-2) + cd^2lnSIOP + elnSIOP \qquad (78)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	3.09	1.33	2.32	.58			
lnSHIMK(-2)	-0.81	0.20	-3.48		.48	2.7	5.68
d^2lnSIOP	1.00	4.56	1.78				
lnSIOP	0.34	0.21	1.62				

(Estimation period is 1963-1978)

$$dlnSHIMK = a + blnSHIMK(-2) + cd^2lnFLEXACC + elnFLEXACC \qquad (79)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	1.23	0.59	2.07	.60			
lnSHIMK(-2)	-0.75	0.19	-3.88		.50	2.8	6.03
d^2lnFLEXACC	0.57	1.30	1.85				
lnFLEXACC	0.34	0.20	1.79				

(Estimation period is 1963-1978)

The problem with both of these results was the high D.W. statistic which could reflect <u>dynamic misspecification</u>, i.e. the omission of important varibles, wrong functional forms or incorrect dynamics, over differencing (in other words the variables which were taken as growth rates or rates of change of the growth rate should not have been differenced) or finally, negative serial correlation.

If in fact it was the latter, then it has been shown by Hendry and Mizon[30] that this can be corrected by applying one of the standard serial correlation correction procedures, e.g. Cochrane Orcutt, Hildreth Lu, the Beach and McKinnon maximum likelihood method, etc. They have developed a test which is able to ascertain whether the conditions exist which would warrant a serial correlation correction. This test is based on the common root restriction and can be summarized as follows:

Consider,

$$Y_t = B_1 Y_{t-1} + yo\ X_t + y1\ X_{t-1} + u_t \qquad (80)$$

If, $L^n Y_t = Y_{t-n}$ then equation (80) can be rewritten as

$Y_t = B_1 LY_t + yo\ X_t + y1\ LX_t + u_t$, rearranging in terms of Y_t yields

$$(1-B_1 L)\ Y_t = (yo + y1\ L)\ X_t + u_t \qquad (81)$$

If $y_1 = -B_1\ yo$ (which is called the common root restriction)

then,

$$(1-B_1\ L)\ Y_t = yo\ (1-B_1 L)\ X_t + u_t \qquad (82)$$

The terms involving Y_t and X_t have a common factor, i.e. $(1- B_1L)$, dividing through by this term yields

$$Y_t = yo\ X_t + u_t / (1- B_1L) \tag{83}$$

which is equivalent to

$$Y_t = B_1 Y_{t-1} + u_t \tag{84}$$

Thus Y_t in equation (83) has been generated by a first order auto-regressive process, and it would be valid to correct for serial correlation by one of the standard procedures mentioned above.

The problem in terms of this thesis, in employing the test for the common root restriction was that it is only asymptotically valid; which therefore precluded formal testing of the small samples in SIMFOR. Accordingly, a certain amount of intuitive reasoning had to be applied.

The problem of overdifferencing manifests itself in residual autocorrelation in the error term which, prior to differencing, had been random white noise. This problem can be eliminated by respecifying the relationship in levels, i.e. without differencing. In the case of SHIMK it was found that the poor D.W. persisted, hence it was concluded that overdifferencing was not the cause of serial correlation. Furthermore, tests were carried out on functional form, lags, etc., which yielded insignificant results. In other words, respecification did not help, which suggested that the equation was not too badly specified (given the theoretical and empirical limitations imposed by the data).[31]

Given the above, it was decided to correct for negative serial correlation, via the Beach and McKinnon maximum likelihood method which estimates a value of rho(p) and transforms a simple equation of the form

$$Y_t = a + bX_t + u_t, \tag{85}$$

where,

$$u_t = pu_{t-1} + v_t$$

to,

$$Yfit(t) = a(1-p) + [X(t) - p * X(t-1)] * b + p * y(t-1) \tag{86}$$

or

$$Yfit(t) - p * y(t-1) = a(1-p) + [X(t) - p * X(t-1)] * b \tag{87}$$

The corrected results are as follows:

$$dlnSHIMK = f(C, lnSHIMK(-2), d^2lnSIOP, lnSIOP) \tag{88}$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	3.42	0.94	3.6	.70			
lnSHIMK(-2)	-0.85	0.15	-5.3		.63	2.1	9.6
d^2lnSIOP	1.00	0.53	1.8				
lnSIOP	0.33	0.15	2.0				

(Estimation period is 1963-1978)

dlnSHIMK = f(C,lnSHIMK(-2), d^2lnFLEXACC, lnFLEXACC) (89)

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	1.70	1.32	1.28	.75			
lnSHIMK(-2)	0.82	0.13	-5.97		.69	2.1	12.3
d^2lnFLEXACC	0.60	0.26	2.26				
lnFLEXACC	0.33	0.14	2.40				

(Estimation period is 1963-1978)

As can be seen from the corrected results, the accelerator formulation weighted by capacity utilization provides a slightly better fit as regards individual coefficients and overall equation measures of significance.

A note of interest is the value of d^2lnSIOP of 1.00 and d^2lnFLEXACC of 0.60. The smaller value of d^2lnFLEXACC seems to be picking up increased utilization of capital before new capital expenditure occurs in the short-run. In other words, spare capacity will be utilized more intensively before new capacity is created. The long-run coefficients resulting from the above equations are

lnSHIMK = 2.57lnSIOP (90)

lnSHIMK = 2.48lnFLEXACC (91)

The values of 2.48 for lnFLEXACC is nearly the same as the unweighted accelerator model which seems to suggest that there is no excess capacity in the long-run. In other words that the under and over capacity situations have netted out over time. The short-run coefficients on d^2lnSIOP and d^2lnFLEXACC can be interpreted as dynamic elasticities and their less than unit and unit values seem to suggest that there are lags inherent in the investment process. In the long-run, however, actual and desired are equal and the elasticies of lnSHIMK with respect to changes in lnSIOP and lnFLEXACC are fairly high. The capacity utilisation accelerator has in fact been the form chosen for the overall modelling exercise.

B. Foreign Investment

Following are the foreign investment results, which again are the best from specification search. As mentioned earlier in this Chapter, the theoretical forms which will be attempted first are the output arguments weighted for the cost of capital and/or the long-run expected rates of return on capital. The cost of capital formulation was similar to that of Boatwright and Renton,[32] although it did not prove to be statistically significant. The best results in the case of foreign investment were gained from the following rate of return type arguments:

JVE = [(WPUK x SIOP)/PIGUK] x Z

where,

Z = (UKRxIER)

JVE	is the proxy market type variable weighted by the cost of U.K. investment goods and expected long-run rates of return on investment.
WPUK	is wholesale prices in the U.K..
SIOP	is total manufacturing output in Scotland.
PIGUK	is the price of investment goods in the U.K..
UKR	is the nominal long-term U.K. rate of interest.
IER	is an index of U.K./U.S. exchange rates.

Experiments with this variable in the foreign investment equation initially yielded the following "best" set of results:

<u>Case 1</u> dlnJV = dln[(SIOP x WPUK)/PIGUK]

In the simplest form this variable is attempting to proxy market growth as the growth of output in Scotland weighted by the cost of U.K. investment goods, with U.K. output being implicit. The inclusion of the weighting element not only allows market factors to be considered, but further, it allows consideration of the feasibility of the investment in terms of the cost of U.K. investment goods.

In this case the results are

$$dlnSFIMK = a + blnSFIMK(-1) + cdlnJV + elnJV \quad (92)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-6.5	3.20	-2.02	.37			
lnSFIMK(-1)	-0.47	0.17	-2.70		.22	1.3	2.4
dlnJV	0.30	1.10	0.27				
lnJV	1.80	0.80	2.23				

(Estimation period is 1962-1978)

The insignificant individual equation and overall equation coefficients, low $\bar{R}^2$ and D.W. suggest that there are other factors which need to be employed in explaining the location and growth of FDI in Scotland.

A possible adjustment to the above argument is the expected rate of return argument outlined in the last section:

$$JVE = [(WPUK \times SIOP/PIGUK) \times (UKR \times IER)]$$

$$dlnSFIMK = a + blnSFIMK(-1) + dlnJVE + elnJVE \quad (93)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-7.67	2.83	-2.7	.58		1.56	5.63
lnSFIMK(-1)	-0.61	0.22	-2.7		.48		
dlnJVE	0.75	0.29	2.5				
lnJVE	0.86	0.37	2.7				

(Estimation period is 1962-1978)

These results are the "best" when considering the weighted output argument.

A further line of argument frequently cited as having significance in the case of foreign investors locating in Scotland concerns regional policy. It is argued that government efforts at reducing the costs of capital, labour, buildings, etc. in the relatively disadvantaged regions is one of the primary determinants of the location and/or relocation of foreign investment in/to Scotland.[33] Although it was hoped that some sort of argument for the regional development grant (RDG) could be worked into the user cost of capital formulation, the argument for the cost of capital proved to be insignificant. Besides, the system of implementing these grants precludes this type of statistical analysis i.e. these grants usually represent up to 25% of the value of investment once the investment has occurred. Hence, inclusion of a term of this type would only have amounted to a convenient way of getting a better fit while saying nothing about causation since it is essentially an autoregressive statement arguing that foreign investment is some function of itself. The problem with the inclusion of Industrial Development Certificates (IDC's) and the creation of Special Development Areas (SDA's) as dummies presented the same technical problem mentioned for the EEC variable.

In fact, it could be further argued that, even if these variables could be worked validly into the equation, the strength of the demand variable would outweigh them or that multicollinearity would certainly exist between IDC control and Scottish demand in so far as IDC control is largely a function of demand conditions in the rest of the U.K. (especially the South East).

Schofield[34] seems to support this point when he recognised the need to analyze the relevant macro-aggregates directly and also the need to treat the level of demand as an independent variable. Arguing from the same perspective, Lythe[35] stated "that it is misleading to focus so much attention in terms of method and evalution on narrowly defined "special" regional policy".[36]

One final argument to be employed in the foreign investment function, as set out in the earlier theoretical discussion was the search for any relevant location type variables. The variable which proved to be significant in the case of FDI in Scotland was the ratio of U.K. to European rates of return on investment (RAT1). In other words, when an investor surveys locations, he will not only consider market size/growth, cost of investment goods and local rate of return factors but also the rate of return in competing locations.[37]

The final results for the foreign manufacturing investment equations are

$$dlnSFIMK = f\ [(C,\ lnSFIMK(-1),\ dlnJVE,\ lnJVE,\ lnRAT1(-1)] \quad (94)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-7.75	-2.74	-2.82	.61			
lnSFIMK(-1)	-0.57	0.61	-2.61		.48	2.0	4.78
dlnJVE	0.50	0.39	1.65				
lnJVE	0.81	0.28	2.87				
lnRAT1(-1)	0.57	0.43	1.31				

(Estimation period is 1962-1978)

Although some significance was lost on the dlnJVE variable and lnRAT1(-1) is not significant even at the 5% level, it was felt that this cost was more than offset by the value of 2.0 on the D.W. statistic. Again, as was the case with the home investment function, this phenomenon is particularly difficult to model given the dynamic constraints and the inability to quantify what could be important missing arguments, e.g. regional policy, investors attitudes, host government attitudes, etc.. Given these difficulties it is felt that the above equation is satisfactory. In fact, later experimentation in Chapter VI will show that, when embedded in the model, this equation replicates historical data quite accurately.

The long-run coefficients suggested by this equation are

$$\text{lnSFIMK} = 1.42\,\text{lnJVE} + 1.00\,\text{lnRAT1} \qquad (95)$$

In other words, the long-run elasticity of lnSFIMK with respect to a 1% change in the level of the weighted output argument is 1.42% or relatively elastic, and is a unit elastic response in the case of a 1% change in the ratio of U.K. in European profits.

As with the output block, significant empirical differences in the behaviour of the home and foreign sectors are in evidence. However, in the case of investment, quite separate functional forms have been used for each sector, mainly to account for supply side or more cost oriented factors. In the output block each sector's uniqueness was displayed in a more subtle manner via different parameter values for the same right hand side arguments of the same functional form. Again, as with the output block, the important point is that significant results have been found and the distinct character of each sector has been quantified. It remains yet to be seen just how these relative sectoral differences translate themselves in an overall model structure as regards the welfare of the Scottish economy.

Summary

This Chapter has been concerned with the theoretical and empirical issues as they relate to home and foreign investment determination in Scotland. A modified simple accelerator model with an argument for capacity utilization was opted for in the case of home investment. It was again argued as was the case with output that at the aggregate level, given excess factor supplies, demand would be a major driving factor of economic activity. By way of substantiating this hypothesis empirically, alternative arguments for interest rates (cost of capital), profits, and relative profits were tested. All of these proved to be insignificant, whereas the accelerator model seemed to fit the data reasonably well. While noting the importance of output (taken as a proxy for market size and the change in output as a proxy for market growth) in the foreign sector, it was argued that supply side or more cost oriented elements should be considered as well. In this function several variables were suggested such as cost of capital, cost of investment goods, expected rate of return in the U.K., influence of Britain's accession to the EEC., relative profits, relative wages costs, and regional policy measures such as R.E.P., R.D.G. and I.D.C. control. The results which formally proved signficant included an output argument weighted by the price of U.K. investment goods and expected rates of return in the U.K. as well as term for relative U.K. to European profits. Given that the functions for output and investment have now been developed, the arguments for employment and SIMFOR's link equations will be developed in Chapter V before moving on to model solution and simulation in Chapters VI and VII.

NOTES: CHAPTER IV

1. As was the case with the output equations, there seems to be no previous modelling work done at the regional level on the home and foreign distinction. This finding also applies to the employment equations.

2. See Bell, F. W. 'An Econometric Forecasting Model for a Region', Journal of Regional Science, Vol. 7, No. 2 (1967), pp. 104-127.

3. See Guccione, A. and Gillen, W. J. 'A Simple Disaggregation of a Neoclassical Investment Function', Journal of Regional Science, Vol. 12, No. 2 (1972), pp. 279-294.

4. See Glickman, N. J. "Son of 'The Specification of Regional Econometric Models'", Papers of the Regional Science Association, Vol. 32 (1974), pp. 155-177.

5. See L'Esperance, W. L., Nestel, G. and Fromm, D. 'Gross State Product and an Econometric Model of a State', American Statistical Association Journal, Vol. 64 (1969), pp.787-807.

6. See Crow, R. T. 'A Nationally Linked Regional Econometric Model', Journal of Regional Science, Vol. 13, No. 2 (1973), pp. 187-204.

7. Ibid., p. 189.

8. See Engle, R. F. 'A Disequilibrium Model of Regional Investment', Journal of Regional Science, Vol. 14, No. 3 (1974), pp. 367-376.

9. As mentioned in Chapter III, while an equation of this type may be valid in forecasting exercises, it has been deemed inappropriate for SIMFOR, since the ultimate aim is counter-factual alternative situation type analysis.

10. Lythe, C., Dewhurst, J., Parrillo, S., Cox, M., Gausden, R. 'Temptress III' Report to the Social Science Research Council, Department of Economics, University of Dundee (May 1981), pp. 1-41.

11. Ibid., p.12.

12. See Crow, R. T. 'Output Determination and Investment Specification in Macroeconometric Models of Open Regions', Regional Science and Urban Economics, Vol. 9 (1979), pp. 141-158.

13. *Ibid.*, p. 143.

14. Preliminary trials were carried out for profits variables, relative profits variables and interest rate variables however no significance was found. Hence they were omitted from theoretical consideration.

15. It could theoretically be argued in the case of home investment that regional policy (i.e. subsidies to capital and labour) does play some role in investment determination. This not only applies to Scottish firms that may have invested in other regions but also to migrant English firms, which are defined in SIMFOR as home firms. However, the inclusion of regional policy type variables proved to be a very difficult task. This was due to data and specification problems, both of which will be discussed in greater detail in the foreign investment function.

16. These will be pursued when presenting the results, i.e. after the theoretical discussion of foreign investment.

17. For further details and references of the eclectic theory of international investment refer to Dunning, J. H. *International Production and the Multinational Enterprise*, (London: George Allen and Unwin, 1981), pp. 1-439.

18. This favourable U.K. investment climate was mentioned in Chapter I with further reference to Brech, M. and Sharp, M. *Inward Investment: Policy Options for the United Kingdom*, (Chatham House Papers: Routledge & Kegan Paul, 1983).

19. The first problem is obviously that of finding a suitable proxy for Britain joining the EEC. Given that this is extremely difficult to quantify, the standard approach is to use a dummy variable. The problem in the context of SIMFOR which uses rates of change for the dependent variable, is that the usual 0, 1 dummy variable formulation would make no sense unless it was an on/off policy action.

20. See Hood, N. and Young, S. 'The Geographical Expansion of U.S. Firms in Western Europe: Some Survey Evidence', *Journal of Common Market Studies*, Vol. 14, No. 3 (1976), pp. 223-234.

21. *Ibid.*, p. 235.

22. It is argued in the case of FDI that the more footloose nature of the enterprise enables it to have a much greater degree of flexibility relative to a home firm in 'shopping around' for the 'best' location considering

both supply and demand factors.

23. For an example of a foreign investment function of this type, see Boatwright, B. D. and Renton, G. A. 'An Analysis of United Kingdom Inflows and Outflows of Direct Foreign Investment', The Review of Economics and Statistics, Vol. 57 (1975), pp. 478-486.

24. See Jorgenson, D. W. 'Capital Theory and Investment Behaviour', American Economic Review, Papers and Proceedings, Vol. 53 (1963), pp. 247-59.

25. Initial experimentation with the competing simple accelerator formulations yielded negative results for the foreign investment function which supports the a priori view that supply side or cost factors may be more important in the foreign sector. After repeated trials with various dynamics on both the rate of change and level variables in the simple accelerator formulations, the best results which could be gained are as follows:

$$\underset{(-3.3)}{dlnSFIMK = -5.5} - \underset{(-4.4)}{0.58 lnSFIMK(-1)} + \underset{(0.96)}{0.71 d^2 lnSIOP} + \underset{(3.71)}{1.71 lnSIOP}$$

The problem in this case, as expected, is the insignificant 't' statistic on the output term.

$d^2lnSIOP = dlnSIOP - dlnSIOP(-1)$ and,

$dlnSIOP = lnSIOP - lnSIOP(-1)$

The same problem occurs when a modified flexible accelerator formation is employed, i.e. where the output term is weighted by capacity utilization in Scotland. The idea with this variable is to try and capture cyclical variations in investment. The result is

$$\underset{(-3.07)}{dlnSFIMK = -9.6} - \underset{(-3.82)}{0.39 lnSFIMK(-2)} + \underset{(0.81)}{0.34 d^2 lnFLEXACC} + \underset{(3.28)}{1.16\ lnFLEXACC}$$

where,

$d^2lnFLEXACC = dlnFLEXACC - dlnFLEXACC(-1)$

dlnFLEXACC = lnFLEXACC - lnFLEXACC(-1)

lnFLEXACC = ln(SIOP x SCUIK)

Again, the insignificant 't' is evidenced in the output term. Given these results, it was decided that an argument for the cost of capital and/or the rate of return on capital would be a more appropriate theoretical form.

26. Separate experiments on relative U.S. to U.K. interest rates yielded negative results, which suggested that it was safe to assume that the U.K. rate did in fact proxy an international rate.

27. As a means of empirically validating this hypothesis extensive tests were performed on competing hypotheses, e.g. short-term and long-term interest rates, profits variables, stocks and works in progress (as a proxy of cyclical behaviour). These were attempted under a variety of fuctional forms, dynamic specifications, etc., but none proved to be significant. Since reporting all of these results would be rather tedious, they are not contained herein. (They can however be obtained on request).

28. Refer to Appendix 2 for variable names, and Appendix 3 for varible definitions, sources and methods.

29. See National Institute of Economic and Social Research, 'Listing of the Interim NIESR Model IV', Discussion Paper No. 28 (1974).

30. See Hendry, D. F. and Mizon, G. E. 'Serial Correlation as a Convenient Simplification, not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England', The Economic Journal, Vol. 88 (Sept. 1978), pp. 549-563.

31. The problem in this case is that the small number of observations severely limits the complexity of the dynamics. In fact, the dynamics are not nearly as exacting as they could be, given the complexity of the process they are trying to capture. However, within the limits of the data, it was decided that these were the "best" dynamics available and hence it is assumed that the bad D.W. does in fact reflect negative serial correlation.

32. See Boatwright and Renton, op.cit., pp. 485-586.

33. For a relatively recent study on migrant firms which includes a brief review of other firm movement studies in

relation to regional policy, see Ashcroft, B. K. and Ingham, K. P. D. 'The Comparative Impact of U.K. Regional Policy on Foreign and Indigenous Firm Movements', Applied Economics, Vol. 14 (1982), pp. 81-100. The general view of these studies was that regional development grants (RDG), industrial development certificates (IDC) and the creation of SDA's special development areas in 1967 were the variables which had the greatest significance in explaining firm movement. The view that capital grants (especially the RDG) have been effective in attracting FDI was also found to be the case in the Forsyth and Hood and Young studies reviewed in Chapter I.

34. See Schofield, J. A. 'Macro Evaluations of the Impact of Regional Policy in Britain: A Review of Recent Research', Urban Studies, Vol. 16 (1979), pp. 251-271.

35. See Lythe, C. and Majmudar, M. 'The Renaissance of the Scottish Economy' (London: George Allen & Unwin, 1982), pp. 1-224.

36. Ibid., p. 129.

37. Experiments were also conducted on relative U.S./U.K. rates of return and U.S./U.K. labour costs, although none proved to be significant.

CHAPTER V

REGIONAL EMPLOYMENT DETERMINATION: THE SCOTTISH CASE

Introduction

The purpose of Chapter V is to develop the employment block together with link equations of consumption and the manufacturing wage bill for subsequent integration within SIMFOR. The Chapter is broken down as follows. First there is a selective review of employment demand equations typically used in regional modelling exercises. This is followed by a statement of the theoretical assumptions of the most appropriate specifications for the home and foreign sectors in SIMFOR. Next is the presentation of the empirical results of the employment demand equations. Finally, a brief discussion on the development and estimation of the consumption and wage bill link equations is presented along with their results.

Regional Employment Demand Functions

Stated simply regional employment demand functions seem to come in two distinct varieties: those which are derived from a production function constraint and those using the inverted production function approach. In the case of the former either the estimated production function coefficients are used in the demand for labour relationship or the suggested derivation is estimated itself. These equations contain arguments in terms of output and the real wage or output weighted by the real wage. It could be said that this approach emphasizes the cost of labour as being one of the major determinants of the demand for labour.

In the case of the latter, which is more short to medium-term in character, greater emphasis is placed on the role of demand. The usual assumptions are that wages are fixed and that commodity prices are rigid due to market imperfections. Hence increases/decreases in demand in the short to medium-term lead to changes in output (brought about by either increasing/decreasing labour/capital utilization or changes in the stock of employment) and not to price changes in the product and factor markets.

A. Cost Oriented Employment Demand Functions

An example of a more cost orientated type of equation is provided by F. Bell.[1] He started with a Cobb-Douglas production function with shift parameters representing neutral technological progress:

$$Q(1) = A(1 + r)^{t} K^{h} L^{1-h} \qquad (96)$$

where,

r is the rate of neutral technological change.

h is the capital production elasticity.

1-h is the labour production elasticity.

The production function in this case explicitly stated that technological progress is disembodied from capital accumulation. By differentiating the production function with respect to labour he derived

$$W(1) = A(1-h)\ (1+r)^{t}\ [K(1)/L(1)]^{h} \tag{97}$$

This equation shows the factor proportions consistent with the real wage rate (W) which will result in cost minimization by entrepreneurs in the region.

Solving for L(1) yields

$$L(1) = \left[\frac{A(1-h)\ (1+r)^{t}\ K(1)^{h}}{W(1)}\right]^{1/h} \tag{98}$$

In this instance the demand for labour is essentially equal to a function of the ratio of regional capital stock to the real wage rate. This equation is not actually estimated but the coefficients from equations (96) and (97) are substituted into it.

Another study which derived an employment demand function in terms of the real wage is that of Guccione and Gillen.[2] Starting from a Cobb-Douglas production function, they employed an output argument weighted by the real wage:

$$\ln N_{rt} = c_{ro} + c_{r1}\ \ln(P_{rt}\ Q_{rt}/W_{rt}) + c_{r2}\ \ln Nr_{t-1} + c_{r3}{}^{z} \tag{99}$$

where,

$c_{ro} \neq 0;\ 0 < c_{r1}, c_{r2} < 1;\ c_{r2} = 1 - c_{r1};\ c_{r3} < 0$

ln is the natural log.

$P_{rt}\ Q_{rt}$ is current price regional output in the manufacturing sector.

N_{rt} is the number of workers employed.

W_{rt} is the wage rate.

z is interpreted as a correction (for relative increases in fringe benefits and reductions in the hours of work) of the data used to measure wage rates.

Further, E_{rt} denotes average weekly earnings with W_{ro} and W_{r1} as positive parameters

$$W_{rt} = W_{ro}\ [\exp\ (W_{rt})]\ E_{rt} \qquad (100)$$

substituting (100) into (99) yields

$$\ln N_{rt} = (c_{ro} - c_{r1} \ln W_{ro}) + c_{r1} \ln (P_{rt} Q_{rt}) E_{rt}) + c_{r2} \ln N_{rt-1} + c_{r3}{}^{z} \qquad (101)$$

where,

$0 < c_{r1}, c_{r2} < 1;\ c_{r2} = 1 - c_{r1};\ \ c_{r3} < 0.$

Another author who argued for the theoretical inclusion of a term for the real wage in the regional employment demand relationship was Crow.[3] He stated, "employment is represented as positively related to gross product and negatively related to the wage rate, higher wage rates encouraging the substitutability of capital for labour".[4] On testing of his proposed relationship, however, he found that the term for the wage rate was not significant while the proxy time trend for productivity yielded significant results. He concluded "this would suggest that labour saving innovations in these industries takes place independent of labour costs".[5]

Several other studies have encountered the same problem as Crow when both the real wage and productivity terms are entered simultaneously. This suggests either that multicollinearity exists between the terms or that wages and employment move in phase yielding a positive coefficient due to cyclical effects. For instance, Adams et. al. model of Mississippi specified a labour demand equation derived from a constant elasticity of substitution production function (C.E.S.) under the assumption of profit maximization with a Koyck lag structure:

$$\ln L = a_0 + a_1 \ln Q + a_2 \ln(W/P) + a_3 t \tag{102}$$

where $a_2 < 0$, $a_3 < 0$ with L, Q, W/P, t, representing employment, output, the real wage, and the time trend respectively. Adams et al. concluded that "the W/P variable was not found to be significant in either of the manufacturing sectors, perhaps a reflection of technological constraints which preclude significant reductions in the use of labour as wages rise".[7]

Finally Lythe et al.,[8] who again use a C.E.S. production function under assumptions of constant returns to scale, perfect competition and profit maximization, derived the following theoretical form:

$$\ln L' = a_0' + a_1' \ln Q' + a_2' \ln(W'/P') + a'_3 t' \qquad (103)$$

where,

$a'_1 > 0;\ a'_2,\ a'_3 < 0$

Q' is constant price output.

P' is the U.K. industrial output price index.

W' is average hourly earnings.

t' is a time trend.

L' is either the number of employees (stock of labour) or the number of hours worked (labour utilization). The employment equations were in fact estimated in terms of number of hours worked per week.

As Adams et al., they encountered the same problem with W/P: "we attempted to incorporate all three explanatory variables in our specification. Upon estimation, however it was usually discovered impossible for the equation to contain both the time trend and the deflated hourly earnings owing to problems of multicollinearity".[9]

B. Output Oriented Employment Demand Functions

Several examples of the inverted production function approach shall now be considered. This approach differs from the more cost oriented approach reviewed above in that market imperfections are considered in the factor and product markets, i.e. prices are taken as given, demand is exogeneously determined and labour is treated as a quasi fixed factor.

For instance, Glickman [10] suggested a manufacturing employment demand function of the form:

$$E_m = f(Q_m, K_m(-1), t) \qquad (104)$$

where,

- E_m is regional manufacturing employment.
- $K_m(-1)$ is regional manufacturing capital stock in the last period.
- t is the time trend.

He also suggested alternative specifications which included government spending variables and a term for the real wage which is added essentially to pick up long-run supply side influences. These suggestions are basically ad hoc in that they are not suggested directly from the inverted production function.

Jefferson's regional model of Northern Ireland [11] also suggested the use of an inverted Cobb-Douglas production function of the form

$$Q = Ae^{yt} K^{a} N^{b} \qquad (105)$$

a, b are factor shares of capital and labour

y is the coefficient on the productivity trend t

$$N^{b} = QA^{-1} e^{-yt} K^{-a} \qquad (106)$$

$$\ln N = 1/b \ln A + 1/b \ln Q - a/b \ln K - a/bt \qquad (107)$$

The estimated equation was finally taken to be

$$E(m) = f(GDP(m), TREND, E(m)G.B.) \qquad (108)$$

where,

E(m) is employment in manufacturing (Northern Ireland).

GB is Great Britain.

TREND is a time trend which attempts to proxy technological progress.

E(m)GB is supposedly a proxy for increased productivity, technological progress and cyclical influences not accounted for by GDP(m) and the TREND.

A final example of the use of the inverted production function is by D. Bell[12] who looked at two components of labour services, namely the stock of employment (M) and the rate at which is it utilized (H). The postulated functional forms of desired H^* and M^* are

$$M^*_t = AQ_t^{a1}\ e^{a2} + [NW/W]^{a3}\ HS^{a4} \quad (109)$$

$$H^*_t = AQ^{b1}\ e^{b2} + [NW/W]^{b3}\ HS^{b4} \quad (110)$$

The ratio of non-wage cost to wage cost [NW/W] is trying to pick up the effects of a change in the fixed costs of employment on labour utilzation and the stock of employment. Ceteris paribus, one could expect that a decrease in the [NW/W] ratio would lead to an increase in the stock of employment rather than to an increase in labour utilization.

HS is a standard hours variable which seeks to capture the effects of a change in standard hours on M^*_t and H^*_t. For instance, if actual hours are less than standard hours then a change in standard hours has no effect on M^*_t and H^*_t. However, if standard hours have been exceeded then any increase in standard hours reduces the cost of employment since less hours are now paid for at the premium rate. Thus, the effect of an increase in HS, ceteris paribus, is to increase M^*_t and decrease H^*_t.

The above applications of the inverted production function approach, especially the British ones, are very much in the spirit of Brechling,[13] and Ball and St. Cyr[14] in that the stress is on aggregate demand in employment determination rather than on the availability and price of factors.

The employment/output relationship which is put forward by these studies is in fact the one which will be adopted in SIMFOR, the main reason being that the assumptions employed by a specification of this type are consistent with the emphasis applied elsewhere in SIMFOR. This consistency becomes more apparent, once the bases of this approach are examined.

The assumptions underlying the theory of labour demand as an inverted production function type relation are:[15]

1. The firm is a profit maximizer.
2. Labour supply is fixed and exogeneous.
3. The time period for analysis is the short to medium-term.
4. Commodity prices are rigid due to market imperfections.
5. Changes in capital stock and technological developments are long-run phenomena.
6. Changes in demand in the short-run are met by either increased labour utilization or increased employment, i.e. inventory changes are not explicitly considered.
7. Advertising can only affect demand in the long-run.

The problem for a firm facing fixed prices and excess factor supply is to minimize the cost of labour services subject to changes in demand.[16] Labour services are taken as the stock of employment (with the associated fixed costs of hiring, training, employers' contributions to social security, redundancy payments, etc.), and labour utilization (with the associated cost of premium wage rates once standard hours have been exceeded).

It is presumed that these relative costs are known to the firm and hence increases in demand for its output will lead to increased output via increased employment or increased labour utilization or increased capital utilization or some combination or all three. It is often argued that the fixed costs associated with varying the stock of employment can explain why there is a slow response between output and employment changes. For example, given an increase in demand, the firm may want to wait and see if the change will be sustained before incurring the fixed costs of hiring, training, etc. This same type of reasoning applies to down-turns in demand when labour hoarding is witnessed. In this case, the employer may want to make sure that the slump will be protracted before incurring redundancy payments and the further prospects of reincurring the fixed costs associated with rehiring, retraining, etc., if demand subsequently increases.

It is proposed here that an employment demand function of the form suggested by Bell [see equation (109)] be adopted for both the home and the foreign sectors.[17] However, regarding empirical testing there is a problem with the standard hours variable (HS) Bell stated "HS was not included in the empirical investigation because no consistent series were available at the regional level".[18] He goes on to say that since, "nationally HS has exhibited a very gradual long-run decline there is a clear danger that the effects of changes in standard hours will be absorbed by the time trend which is intended to proxy changes in technology and capital stock".[19] There is another problem as regards the right hand side variables suggested by Bell et. al., namely that there is not a consistent series relating to non-wage costs.[20] Bell attempted to construct a series which measured the ratio of non-wage to wage costs, so that the effect of the regional employment premium (REP) could be ascertained. The REP was a measure which in effect decreased wage costs and ceteris paribus could have a positive effect on the number of workers employed versus labour utilization. However, his conclusions on the effectiveness of the REP were inconclusive. As he puts it, "The results therefore do not necessarily imply that REP was ineffective. But they do not provide any evidence in its favour". The inability to achieve significance was attributed to "the inadequacy of the data series which were used, and in particular the omission of the non-statutory element of non-wage costs".[21]

The estimated functions for home and foreign employment in SIMFOR will hence contain only the arguments for output and productivity. Again, the error correction type model will be applied to the empirical work.

Empirical Results

The results of the two best competing dynamic specifications on home and foreign employment found after exhaustive and comprehensive testing of various alternatives are now presented.[22]

dlnSHEM = f(C, lnSHEM(-1), dlnSIOP, lnSIOP, TREND)[23] (111)

where,

- SHEM is Scottish manufacturing employment in the home sector.
- dlnSIOP is the growth of total Scottish manufacturing output.
- lnSIOP is the logged level of total Scottish manufacturing output.
- TREND is a time trend proxying technological change.

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-3.58	1.90	-1.85	.66		1.8	6.6
lnSHEM(-1)	-0.52	0.27	-1.94		.56		
dlnSIOP	0.49	0.15	3.16				
lnSIOP	0.14	0.10	1.43				
TREND	-0.01	0.71	-1.73				

(Estimation period is 1962-1980)

dlnSFEM = f(C, lnSFEM(-1), dlnSIOP, lnSIOP, TREND) (112)

where,

SFEM is Scottish manufacturing employment in the foreign sector.

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-1.96	0.65	-2.9	.69		1.54	
lnSFEM(-1)	-0.71	0.19	-3.69		.61		8.0
dlnSIOP	0.59	0.31	1.93				
lnSIOP	1.30	0.33	3.43				
TREND	-0.01	0.004	-2.17				

(Estimation period is 1962-1980)

The long run coefficients implied by each of these equations are:

lnSHEM = .26lnSIOP - .02TREND (113)

$$lnSFEM = 1.83lnSIOP - .014TREND \quad (114)$$

An alternative dynamic specification for manufacturing employment which yields quite significant results for both the home and foreign sector was one suggested by D. Bell.[24] The form of these equations and their results are as follows:

$$dlnSHEM = f(C, lnSIOP, lnSHEM(-1), lnSHEM(-2), TREND) \quad (115)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	8.47	1.47	5.75	.78		1.3	11.7
lnSIOP	0.29	0.06	4.69		.71		
lnSHEM(-1)	-0.61	0.17	-3.42				
lnSHEM(-2)	-0.059	0.17	-3.46				
TREND	-0.028	0.004	-6.72				

(Estimation period is 1962-1980)

$$dlnSFEM = f(C, lnSIOP, lnSFEM(-1), lnSFEM(-2), TREND) \quad (116)$$

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-2.10	.65	-3.20	.70		2.16	7.9
lnSIOP	1.17	.26	4.45		.62		
lnSFEM(-1)	-0.32	.19	-1.66				
lnSFEM(-2)	-0.34	.21	-1.63				
TREND	-0.003	.004	-0.72				

(Estimation period is 1962-1980)

The same arguments as equation (116) were also estimated without term for technological change.

dlnSFEM = f(C, lnSIOP, lnSFEM(-1), lnSFEM(-2)) (117)

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-2.11	0.64	-3.20	.70			
lnSIOP	1.19	0.25	4.60		.63	2.12	10.2
lnSFEM(-1)	-0.32	0.14	-1.68				
lnSFEM(-2)	-0.41	0.18	-2.32				

(Estimation period is 1962-1980)

The long-run coefficients implied by these specifications are

lnSHEM = 0.21 lnSIOP - .023 TREND (118)

lnSFEM = 1.77 lnSIOP - .004 TREND (119)

lnSFEM = 1.63 lnSIOP (120)

On comparing equation (111) with equation (115) it can be seen that by altering the dynamic specification quite a significant change occurs on individual coefficients, 't' values, overall equation fit as measured by 'F' and the correlation measure $\bar{R}^2$. In all these respects, equation (115) seems superior to equation (111), although (115) could be somewhat misspecified relative to (111) given the lower value of the D.W. statistic. Even though the reported statistics are quite different as regards the short-run dynamics, it is interesting to note that the long-run coefficients for lnSIOP and TREND in equations (113) and (118) are virtually the same. The small values of both coefficients suggest that the long-run elasticity of the home employment response to a 1% change in output is relatively low.

As regards the foreign sector case (i.e. comparing equation (112) with equations (116) and (117) it can be seen that the reverse is true of the D.W. statistic. In this case, the value of the D.W. for equations (116) and (117) is superior to that of equation (112) and, in addition, nothing is lost on the measures of correlation and individual equation measure of significance. Hence, the dynamic specification for equations (116) and (117) is clearly superior to that of equation (112). Equation (117) was eventually chosen to be the best foreign specification due to the insignificant 't' value for the trend in equation with (116). In contrast to the home employment specification, the message which comes through in equations (114), (119) and (120) is that in the long-run the elasticity of employment demand with respect to a change in output is above unity or, in other words, is relatively elastic.

The quite significant difference between home and foreign employment long-run demand elasticities with respect to output, could suggest the following explanations:

1. That indigenous firms have greater fixed costs of employment as compared to the foreign sector. These costs could be associated with a greater degree of labour utilization in British owned versus foreign owned plants, i.e. firms in the home sector work more overtime hours.
2. That there is a certain amount of long-run capital-labour substitution in indigenous firms, which could take the form of either increased capital utilization or the creation of new capital. On the other hand, it could be argued that the foreign sector tends to operate closer to capacity and demand changes tend to elicit simultaneous employment and capital creation, possibly due to the nature of the technology employed.
3. On the downside given a decrease in output, the different elasticities could reflect the fact that home firms (given the difference in industrial structure) are more skill intensive and tend to hoard skilled labour, whereas the foreign sector either does not need skilled employees to the same degree as the home sector or the skills are readily available.

Again, as was the case with output and investment, it is not the purpose of this exercise to individually test these varying hypotheses on a rigorous basis. The above is simply a statement of what the single equation results may suggest.

The Consumption and Manufacturing Wage Bill Equations

Before proceeding to Chapter VI, where the model will be assembled as a system of recursive and simultaneous equations, it is necessary to estimate several link equations which will close the system implied thus far.[25] These are the Scottish consumption and real wage bill equations. They are estimated and embedded in the overall model so that the second round expenditure effects, resulting from an exogenous shock can be measured. In other words, these equations provide a mechanism by which the earnings of labour can be translated into consumer spending on durable and non-durable goods.

This entails explicit modelling of the consumer expenditure (SCONK) component of Scottish aggregate domestic demand

$$DEM = (SCONK + SFIMK + SHIMK + STINMK + PAGSK) \quad (121)$$

SCONK will be the last component of DEM to be endogenized, with Scottish total non-manufacturing investment (STINMK) and public authority government spending (PAGSK) being taken as exogenous. The consumption function in this case has been devised with SIMFOR's specific modelling purposes in mind, hence it is not to be interpreted as a structural form which is derived directly from the theory.[26] The estimated specification in this case is along Keynesian lines in that consumption expenditure is regressed on disposable income. However, the real wage bill in Scottish manufacturing is deducted from total personal income before taxes and is treated as a separate argument. This deduction has been made so that the real wage bill in manufacturing can be related to manufacturing employment. The form of these two equations and their results are as follows:

dlnSCONK = f[C, lnSCONK(-1), dlnINC, lnINC(-1),
lnTWSMK, lnTSWMK(-1)] (122)

where,

SCONK is Scottish consumption.

dlnINC is the growth of Scottish personal disposable income net of the manufacturing real wage bill.

lnTWSMK is the logged level of total wages and salaries of the manufacturing sector.

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	2.28	.84	2.7	.70		1.7	5.0
lnSCONK(-1)	-0.87	.36	-2.4		.55		
dlnINC	.45	.13	3.3				
lnINC(-1)	.42	.14	2.8				
lnTWSMK	.42	.15	2.8				
lnTWSMK(-1)	-0.21	.12	-1.7				

(Estimation period is 1962-1980)

The long-run equillibrium solution implied by this equation is

$$\ln SCONK = .48 \ln INC + .24 \ln TWSMK \qquad (123)$$

The manufacturing real wage bill function is (124)

$$d\ln TWSMK = f(C, d\ln TWUKMK, d\ln STEM)$$

where,

dlnTWSMK is the growth in the manufacturing wage bill in Scotland.

dlnTWUKMK is the growth in the manufacturing wage bill in the rest of the U.K..

dlnSTEM is the growth in total manufacturing employment.

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	0.01	.008	2.23	.60		2.4	11.7
dlnTWUKMK	0.22	.089	2.51		.54		
dlnSTEM	0.79	.25	3.15				

(Estimation period is 1961-1980)

Again the importance of the above results lies in their function as link equations: they close the SIMFOR system and provide a way in which wage income can be translated back into demand. This is done by the dependence between consumption (a component of demand) and the wage bill in manufacturing. Hence, the arguments in equations (122) and (124) were largely determined by pragmatic considerations. Due to this fact, it is not felt necessary to elaborate in great detail on the arguments in these equations.[27] Suffice it to say at this point that the individual coefficients and overall equation results are all statistically significant and it is these estimates which will later have greater relative importance in the overall model as opposed to the single equation case.

Summary

This Chapter has been concerned with the empirical and theoretical issues as they relate to the home and foreign employment demand functions in the Scottish manufacturing sector. After a brief review of employment equations typically used at the regional level, the inverted production function approach in the spirit of D. Bell was adopted. A labour utilization function was excluded from the analysis due to the problems of data availability. Manufacturing employment was eventually taken to be dependent on arguments for lagged employment, output and a proxy for technological change. Unfortunately terms for standard hours, the REP and the fixed costs of employment could not be worked into the specification, again largely due to data constraints. As with the output and investment blocks, quite significant differences were found in the behaviour of the home and foreign sectors - especially regarding the long-run elasticity of employment demand with respect to output. Besides the econometric work on the employment equations, two further functions were estimated. These were the consumption and manufacturing real wage bill equations, which were constructed less rigorously. In the next Chapter the single equations estimated thus far will be assembled into a recursive and simultaneous system.

NOTES: CHAPTER V

1. See Bell, F. 'An Econometric Forecasting Model for a Region', _Journal of Regional Science_, Vol. 7, No. 2 (1967), pp. 104-127.

2. See Guccione, A. and Gillen, W. J. 'A Metzler Type Model for the Canadian Regions', _Journal of Regional Science_, Vol. 14, No. 2 (1974), pp. 173-189.

3. See Crow, R. T. 'A Nationally Linked Regional Econometric Model', _Journal of Regional Science_, Vol. 13, No. 2 (1973), pp. 187-204.

4. _Ibid_., p. 190.

5. _Ibid_., p. 190.

6. See Adams, F. G. et al. 'On the Specification and Simulation of a Regional Econometric Model: A Model of Mississippi', _The Review of Economics and Statistics_, Vol. 57 (1975), pp. 286-298.

7. _Ibid_., p. 290.

8. See Lythe, C., Dewhurst, J., Parrillo, S., Cox, M., Gausden, R. Temptress III, _Report to the Social Science Research Council_, Department of Economics, University of Dundee (May 1981).

9. _Ibid_., p. 15.

10. See Glickman, N. J. 'Son of "The Specification of Regional Econometric Models"', _Papers and Proceedings of the Regional Science Association_, Vol. 32 (1974), pp. 155-177.

11. See Jefferson, C. W. 'A Regional Econometric Model of the Northern Ireland Economy', _Scottish Journal of Political Economy_, Vol. 25. No. 3 (Nov. 1978), pp. 253-272.

12. See Bell, D. N. F. 'Regional Output, Employment and Unemployment Fluctuations' _Oxford Economic Papers_, Vol. 23, No. 1 (March 1981), pp. 112-60.

13. See Brechling, F. 'The Relationship Between Output and Employment in British Manufacturing Industry', _Review of Economic Studies_, Vol. 31 (July 1965), pp. 187-216.

14. See Ball, R. J. and St. Cyr, E. B. A. 'Short-term Employment Fluctuations in British Manufacturing Industry', _Review of Economic Studies_, Vol. 33 (1966),

pp. 179-207.

15. For a detailed theoretical derivation of the regional demand for labour services see Bell, D. N. F. and Hart, R. A. 'The Regional Demand for Labour Services', Scottish Journal of Political Economy, Vol. 27, No. 2 (June 1980).

16. This is consistent with the assumption made earlier in the output block (Chapter III) that Scotland should be treated as a price taker and that factor and product prices are exogenous and determined in the rest of the U.K..

17. A demand or hours function on labour utilization, i.e. equation (110), will not be estimated on two grounds. The first is that it is not of direct relevance to SIMFOR, although general indicative information on utilization can be implied from the estimated coefficients on output in the employment functions. Secondly, and more importantly, the data which is necessary for direct examination of utilization (usually hours worked) is not available for the home/foreign distinction.

18. See Bell, D. N. F. (1981), op.cit., p. 46.

19. Ibid., p. 46.

20. For the theoretical framework in which the effects of statutory non-wage costs are analyzed see Bell, D. 'Labour Utilization and Statutory Non-wage Costs'. The Fraser of Allander Institute Discussion Paper 16, University of Strathclyde (Feb. 1980).

21. See Bell, D. N. F. op.cit., (1981) pp. 53.

22. Refer to Appendix 3 'Data Used in SIMFOR', for discussion of data construction, sources, and methods.

23. Refer to Appendix 2 'Abbreviations, Variable Definitions, Equations, Identities and Definitional Relationships in SIMFOR'.

24. See Bell, D. N. F. Regional Econometric Modelling with Special Reference to Scotland, Ph.D. dissertation, University of Strathclyde (July 1984).

25. The need for these equations will become clearer when the overall model is explicitly discussed. They are presented at this point in order to maintain the continuity of presentation. Chapters III - V have been concerned with single equation problems, issues,

results, etc., whereas Chapters VI and VII will be concerned with multi-equation model issues such as SIMFOR's historical tracking performance, dynamic properties, simulation experiments, etc.

26. Before it was apparent that this function would have to be tailored for model specific purposes, various different consumption functions were experimented with. One of the more interesting and notable results, was the specification suggested by Davidson, J. E. H., Hendry, D. F., Srba, F. and Yeo, S., 'Econometric Modelling of the Aggregate Time-Series-Relationship between Consumer's Expenditure and Income in the United Kingdom', Economic Journal, Vol. 88, (1978), pp. 661-692, which yielded satisfactory results for the Scottish data. For instance the equation

$$dlnSCONK = f(C,\ dlnSPDY,\ d\dot{P},\ \dot{P},\ lnSCONK(-1)/lnSPDY(-1))$$

where dlnSCONK = the growth of consumer expenditure.

dlnSPDY = the growth of personal disposable income.

$d\dot{P}$ = the growth of the inflation rate.

$\dot{P}$ = the inflation rate.

yielded the result,

$$\underset{(-2.84)}{dlnSCONK = 0.13} + \underset{(4.22)}{0.65\ dlnSPDY} - \underset{(-2.82)}{0.53\ lnSCONK(-1)/lnSPDY(-1)} - \underset{(-2.80)}{.03\ ln\dot{P}} - \underset{(-2.21)}{.02\ dln\dot{P}}$$

$R^2 = .66$, $\bar{R}^2 = .55$, D.W. = 1.8, F = 5.9

Although this result is encouraging for further work and even may hold theoretical significance as a structural form, it has not been adopted since it does not suit the needs of SIMFOR as specified thus far.

27. It should be noted, however, that the simple Keynesian consumption function is not at odds with the theoretical spirit of the rest of SIMFOR.

CHAPTER VI

THE ECONOMETRICS OF SIMFOR AS A SYSTEM

Introduction

The purpose of Chapter VI is to further prepare the ground for the proposed counter-factual policy simulation of Chapter VII. Specifically, Chapter VI will deal with the construction of a multi-equation simultaneous and recursive system, based upon the single equations discussed in Chapters III to V. The econometric problems of identification, estimation technique, model solution, and model evaluation will be discussed in turn. Finally, a summary of the empirical work, resulting from model evaluation experiments is presented.

However, prior to dealing with the econometric problems listed above, it would be useful to refer to Appendix 1 'Flow Chart of the SIMFOR Model of Scotland' and Appendix 2 'Equations, Identities and Definitional Relationships of SIMFOR', in order to obtain an intuitive feel for the relationships in the model. The overall model is comprised of 8 estimated equations representing behavioural relationships, 3 identities and 29 definitional relationships. The variables in Appendix 1 outside the dotted perimeter are the exogenous variables, i.e. world demand (WXV), Scottish non-manufacturing investment (STINMK), Scottish public authority government spending (PAGSK), the ratio of U.K. to European rates of return (RAT1), the index of U.K./U.S. exchange rates (IER), the U.K. long-term nominal interest rate (UKR), the U.K. real wage bill (TWUKMK), a proxy for technological change (TREND), and personal disposable income (INC).

The other predetermined varibles include the lagged endogenous variables, i.e. consumption (SCONK(-1)), home output (SHIOP(-1)), demand (DEM(-1)), foreign output (SFIOP(-1)), home investment (SHIMK(-2)), foreign investment (SFIMK(-1)), output weighted by the price of U.K. investment goods and the expected long-run rate of return in the U.K. (JVE(-1)), home employment (SHEM(-1)), SHEM(-2)), foreign employment (SFEM(-1)), SFEM(-2)).

The endogenous variables are consumption (SCONK), Scottish real wage bill (TWSMK), home output (SHIOP), foreign output (SFIOP), home investment (SHIMK), foreign investment (SFIMK), home employment (SHEM), foreign employment (SFEM), demand (DEM), total output (SIOP), total employment (STEM).

In order to understand how the model operates, consider a simple example with the aid of Appendix 1. Ceteris paribus, an on/off increase in demand in year t would have the following effects:

1. To increase both home and foreign manufacturing employment, i.e. total manufacturing employment.
2. To increase both home and foreign manufacturing investment, i.e. total manufacturing investment.

3. To increase both home and foreign manufacturing output, i.e. total manufacturing output.
4. The increase in total manufacturing employment in turn leads to an increase in the manufacturing total wage bill.
5. The increased wage bill should in turn lead to an increase in consumer expenditure.
6. The higher levels of consumption and investment which implicitly encompass import demand are then fed back into Scottish demand, setting off another round of changes in the model. These changes continue to operate until all the implicit leakages into imports and savings have occurred.

Identification

The first econometric issue to be discussed concerns identification, which is really a problem of model formulation rather than estimation or appraisal. The identification problem addresses the question whether the structural equations can be determined given knowledge of their reduced forms. In other words, a model is exactly identified only if it is in unique statistical form, enabling unique estimates of its coefficients to be made from the sample data. For a simultaneous equation model to be complete it must contain at least as many equations as endogenous variables. For an entire model to be identified, it therefore must be complete and each linearly independent equation must be identified. An equation is said to be under-identified if there is no way of estimating all the structural parameters from the reduced form and over-identified if more than one value is obtainable for some parameters. Thus the equations of a model can be estimated and solved for chosen values of their endogenous variables, only if each of the equations is exactly identified or overidentified. However, before an equation can be identified, two conditions must be fulfilled. These are known as the order and rank[1] conditions. The order condition states that for an equation to be identified the total number of variables excluded from an equation must be greater than or equal to the number of endogenous variables in the model minus 1.

Let A = the total number of variables in the model, both endogenous and predetermined.

B = number of variables, endogenous and exogeneous, included in a particular equation.

C = the total number of endogenous variables or the total number of equations in the model.

The order condition states that

$$(A - B) \geq (C - 1) \tag{125}$$

However, relatively recently, Sims[2] has objected to the way in which traditional econometric models are specified. He describes the identifying restrictions used to obtain equation by equation interpretations of traditional models as 'incredible' and argues that they are only practical simplifications, imposed to avoid conflicts with the data. While acknowledging their use in a forecasting model, he argued that that they do not represent a priori knowledge and hence cannot be helpful in identifying the model. He argued instead for the specification of vector autoregressive equations,[3] where each variable is taken to be a function of its own lagged values and the lagged values of other variables. It is generally argued that although this method imposes some restrictions on the data (e.g. the number of variables that must be used, the length of lags and, in some instances, the cross-equation restrictions on the coefficients), these are less restrictive than the ones used in the traditional approach.[4]

Estimation Techniques

The next econometric topic to be considered concerns the estimation procedure to be adopted for the system parameters. The choice of estimation procedure is important if simultaneous equation bias is a problem. If this is the case then ordinary least squares (OLS) estimation will yield biased and inconsistent parameter estimates. In a simultaneous system, the lagged dependent variables that appear on the R.H.S. have both a systematic and a random component. It is the random component which is potentially problematic since it can be the cause of the simultaneous equation bias. This is due to the fact that it is correlated with the random error term of the equation in which it appears as a dependent variable, resulting in cross equation correlation of error terms.

The estimation method called two stage least squares (2SLS) developed by Theil[5] is the one most commonly used in dealing with the problem of simultaneous equation bias and is applied to overidentified models.[6] If the random component associated with the endogenous variable (Y_t) were known, it could be taken away from (Y_t); the problem, however, is that it is unobservable. It is possible, nevertheless, to obtain an estimate of this random component by regressing (Y_t) on all the predetermined variables in the model. This estimate ($\hat{Y}$) is then used as an explanatory variable in the original equation which contained (Y_t) on the right hand side, instead of (Y_t). In other words, the 2SLS technique is an extension of instrumental variable estimation and is simply a weighted average of a multiple solution, where a linear function is used as an instrument.

One of the restrictions of 2SLS however is that it requires a large number of observations, especially if the model includes many predetermined variables. The problem in the case of SIMFOR is that the number of observations is less than the number of predetermined variables, (i.e. the undersized sample problem), hence the two stage estimator cannot be formed. Kloek and Mennes[7] suggested a practical method of using the principal components (PC) of instrumental variables as a means of reducing the number of predetermined variables. Principal components is a special case of the more general method of factor analysis. The aim of the method is the construction of a new set of variables (Pi) called principal components, out of a set of predetermined variables X_i (i = 1, 2, 3, ... j).

$$
\begin{aligned}
P_1 &= a_{11} X_1 + a_{12} X_2 + \ldots + a_{1j} X_j. \\
P_2 &= a_{21} X_1 + a_{22} X_2 + \ldots + a_{2j} X_j. \\
&\vdots \\
P_j &= a_{j1} X_1 + a_{j2} X_2 + \ldots + a_{jj} X_j.
\end{aligned}
$$

The a's are called loading factors and are chosen so that the construction of the principal components satisfy two conditions:

1) That the principal components are orthogonal, i.e. uncorrelated.

2) That the first principal component absorbs and accounts for the maximum possible proportion of the total variation in the set of X_i, the second component

absorbs the maximum of the remaining variation in X_i, and so on.

In the event that simultaneous equation bias was a problem in SIMFOR, the method of PC was applied. The results are now compared with those obtained from OLS.[8]

OLS - (A) dlnSCONK = 2.28 - 0.87lnSCONK(-1) + 0.45dlnINC + .42lnINC(-1) + 0.42lnTWSMK - 0.21lnTWSMK(-1)

PC - (B) dlnSCONK = 2.52 - 0.90lnSCONK(-1) + 0.44dlnINC + .41lnINC(-1) + 0.41lnTWSMK - 0.18lnTWSMK(-1)

OLS - (A) dlnTWSMK = .018 + 0.22dlnTWUKMK + 0.79dlnSTEM

PC - (B) dlnTWSMK = .013 + 0.30dlnTWUKMK + 0.79dlnSTEM

OLS - (A) dlnSHIOP = -3.11 - 0.59lnSHIOP(-1) + 1.22dlnDEM + 0.62lnDEM(-1) + 0.42dlnWXV

PC - (B) dlnSHIOP = -2.81 - 0.56lnSHIOP(-1) + 1.11dlnDEM + 0.57lnDEM(-1) + 0.43dlnWXV

OLS - (A) dlnSFIOP = -8.85 - 0.30lnSFIOP(-1) + 1.34dlnDEM + 1.06lnDEM(-1) + 0.60dlnWXV

PC - (B) dlnSFIOP = -7.40 - 0.25lnSFIOP(-1) + 1.53dlnDEM + 0.88lnDEM(-1) + 0.61dlnWXV

$$\text{OLS - (A)}\ d\ln SHIMK = 1.70 - 0.82\ln SHIMK(-2) + 0.60\ d^2\ln ACC + 0.33\ln ACC$$

$$\text{PC - (B)}\ d\ln SHIMK = 1.73 - 0.83\ln SHIMK(-2) + 0.60 d^2\ln ACC + 0.33\ln ACC$$

$$\text{OLS - (A)}\ d\ln SFIMK = -7.75 - 0.57\ln SFIMK(-1) + 0.50 d\ln JVE + 0.81\ln JVE + 0.57\ln RAT1(-1)$$

$$\text{PC - (B)}\ d\ln SFIMK = -7.56 - 0.43\ln SFIMK(-1) + 0.72 d\ln JVE + 0.76\ln JVE + 0.45 RAT1(-1)$$

$$\text{OLS - (A)}\ d\ln SHEM = 8.47 + 0.29\ln SIOP - 0.61\ln SHEM(-1) - 0.59\ln SHEM(-2) - .02TREND$$

$$\text{PC - (B)}\ d\ln SHEM = 8.29 + 0.28\ln SIOP - 0.59\ln SHEM(-1) - 0.58\ln SHEM(-2) - .02TREND$$

$$\text{OLS - (A)}\ d\ln SFEM = -2.11 + 1.19\ln SIOP - 0.32\ln SFEM(-1) - 0.41\ln SFEM(-2)$$

$$\text{PC - (B)}\ d\ln SFEM = -2.25 + 1.23\ln SIOP - 0.29\ln SFEM(-1) - 0.45\ln SFEM(-2)$$

With the exception of the foreign output and foreign investment equations, the values of the structural equation coefficients are virtually the same. Even in these two cases, the differences are not highly significant. It can hence be concluded either that PC estimation has not removed the problem or that the OLS estimates provide reasonable results since simultaneous equation bias does not seem to be in evidence. This latter rather intuitive conclusion will be examined further in the final section of this Chapter when comparing the historical performance of the OLS estimated model with that of the PC estimated model.

Model Solution

Next to be discussed is the overall model solution or simulation. (These terms are synonymous in econometric nomenclature). A model simulation can either be static where the actual values of the lagged endogenous variables are used for each period's solution, or dynamic where the solved values for the previous period's endogenous variable are used for the current period's lagged endogenous values.

Further distinctions must be made regarding the error term when solving a model. The simulation is called deterministic if only one set of values of the error term is used. The usual practice is to set the values of the error term to 0 in this type of solution. A stochastic simulation, on the other hand, utilises a Monte Carlo method by which a number of solutions are produced based upon random number generation for the error term. The solution obtained takes the form of a probability distribution rather than a single value.

As regards the actual simulation, the method of solving a linear system by substituting the values of the predetermined variables into the system's solution expression (reduced form) is not applicable to a non-linear system such as SIMFOR. Alternatively, for solving a non-linear system an iterative or numerical procedure must be used, e.g. Gauss-Seidel, Newton-Raphson, Fletcher-Powell, etc.[9] The basics of the Gauss-Seidel (GS) solution technique are as follows:

As is the case with all iterative procedures, the GS technique requires a set of starting values for each endogenous variable of the system. These take the form of guesses about initial solution values, although the usual practice is to take the observed or actual value in period t. The first iteration, consists of passing through the entire model and solving for each of the endogenous variables, given the initial guess for the endogenous variable, the estimated parameter values, and the actual value of the predetermined variables. The second iteration proceeds along the same lines except that the values for the endogenous variable are those obtained from the first iteration. This process continues until the absolute change

$$\left| \hat{Y}_{it}^{(n)} - \hat{Y}_{it}^{(n-1)} \right| < d \tag{126}$$

or the absolute proportionate change

$$\left| \hat{Y}_{it}^{(n)} - \hat{Y}_{it}^{(n-1)} \Big/ \hat{Y}_{it}^{(n-1)} \right| < d \tag{127}$$

Where, d is a preset tolerance limit. In the case of SIMFOR, a proportionate criterion was used with the conventional tolerance limit of one tenth of 1% i.e. d = .001. SIMFOR will in fact employ a dynamic, deterministic simulation using the (GS) iterative technique.

Model Evaluation

A discussion now follows on the battery of tests which will be employed to arrive at the "best" version of SIMFOR for subsequent use in the proposed simulation experiments of Chapter VII. "Best" refers not only to "good" test statistics, but also to the "realism" of the model with regard to the consistency of its dynamics and simultaneity with perceived economic realities.

The tests which will be used to analyze historical tracking performance include the following:

(1) The Root mean square error (RMSE)

where,

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s - Y_t^a)^2} \qquad (128)$$

where,

Y_t^s are the simulated values of Y_t.

Y_t^a are the actual values of Y_t.

T is the number of periods in the simulation.

The RMSE simply measures the deviation of Y_t^s from Y_t^a and the magnitude of the error can only be evaluated by comparing it with the average value of Y_t^a. The RMSE will be zero only if the forecast is perfect.

(2) Mean Absolute Error (MAE)

$$MAE = \frac{1}{T} \sum_{t=1}^{T} \left| (Y_t^s - Y_t^a)^2 \right| \qquad (129)$$

Again the measure will be zero if the forecast is perfect. This measure penalizes large errors less than the RMSE does.

(3) Theil Inequality Coefficient (U)

$$U = \frac{\sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s - Y_t^a)^2}}{\sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^s)^2} + \sqrt{\frac{1}{T} \sum_{t=1}^{T} (Y_t^a)^2}} \qquad (130)$$

U is always between 0 and 1 and if

$U = 0$, $Y_t^s = Y_t^a$ for all t.

The simulation error can be broken down into its characteristic sources as follows:

$$U^M + U^S + U^C = 1 \quad (131)$$

U^M is the bias proportion and is defined as

$$UM = \frac{(\bar{Y}^s - \bar{Y}^a)^2}{(1/T)\sum(Y_t^s - Y_t^a)} \quad (132)$$

where,

$\bar{Y}^s$ and $\bar{Y}^a$ are the mean values of the actual and simulated series.

U^M indicates the existence of systematic error and measures the extent to which the average value of simulated and actual values deviate from each other.

U^s is the variance proportion and is defined as

$$U^s = \frac{(\sigma^s - \sigma^a)^2}{(1/T)\sum(Y^s - Y^a)^2} \quad (133)$$

where,

σ^s and σ^a are the standard deviations of simlulated and actual from their means. This measure indicates the ability of the model to replicate the degree of variability of Y_t^a.

U^c is the covariance proportion, which measures the unsystematic error and represents the remaining error after U^M and U^S have been accounted for.

(4) Tracking Performance

Another desirable feature of a good forecast would be for the predicted series to replicate the turning points in the actual series.

(5) Sensitivity Analysis

This is really a test of the robustness of the model. The idea in this case is that adjustments to the estimation period, the estimated coefficients and the time paths of the exogenous variable should not substantially alter the values of the simulated series.

(6) Model Stability

The usual procedure for testing the stability of linear systems of equations (e.g. a second order difference equation) is to first obtain the general solution composed of the complementary function and a particular solution. Stability is then tested by examining the values of the distinct real roots, the repeated real roots and the complex roots. This procedure will not however be used in the case of SIMFOR since it would require an analytical reformulation of the non-linear system into a linear one.[10] The usual acid test on model stability and one which will be used shortly, is to solve the model dynamically. This is a very stringent test since there is a greater probability of explosive behaviour than in a static simulation, due to the cumulative nature of forecasting errors.

Empirical Results

Having concluded the econometric discussion as it pertains to model identification, estimation, solution and evaluation, what follows are explicit simulation experiments which try to establish the 'best' version of SIMFOR for use in the proposed counter-factual policy analysis of Chapter VII. To achieve this, a quite comprehensive evaluation procedure was performed on six separate versions (V) of the model. These included

V^1 - 29 equations (totally recursive model).

V^2 - 33 equations (20 recursive, 13 simultaneous). In this case the accelerator was "turned on", i.e. endogenized.

V^3 - 32 equations (11 recursive, 21 simultaneous). In V^3 the accelerator was "turned off", and the wage link was endogenized.

V^4 - 36 equations (9 recursive, 27 simultaneous). Both the accelerator and the wage link were endogenized.

V^5 - 37 equations (18 recursive, 19 simultaneous). In V^5, the output term in the foreign investment function was endogenized as well as the accelerator term in home investment.

V^6 - 40 equations (8 recursive, 32 simultaneous). This is the most complex version and contains the highest degree of simultaneity. V^6 differs from V^5 in that the wage link is now endogenized.

Seventy-two different variations were run on the six versions just presented. These included OLS and PC, OLS with a serial correlation correction on dlnSHIMK and PC with the auto correlation correction on dlnSHIMK. Sensitivity analysis was carried out by changing the estimation period, changing the parameter values and applying different exogenous time paths , all of which were performed via deterministic dynamic solutions. Again the idea for all these runs, from the simplest to the most complex version of SIMFOR, was to evaluate the model's historical tracking performance and dynamic properties in order to ascertain which version would be "best" for further analysis.

It was decided on the basis of these results that V^6 estimated by OLS with a serial correlation correction on dlnSHIMK would be the most appropriate version for this exercise.[11] The key points which are relevant to this simulation as well as the results are reported below:

(i) The estimated parameters of the structural equations are those estimated in the body of the thesis e.g.

C	lnSCONK(-1)	dlnINC	lnTWSMK	lnTSWMK(-1)
2.28	-0.87	0.45	0.42	-0.21

C	dlnTWUKMK	dlnSTEM
.018	0.22	0.74

C	lnSHIOP(-1)	dlnDEM	lnDEM(-1)	dlnWXV
-3.11	-0.59	1.22	0.62	0.42

C	lnSFIOP(-1)	dlnDEM	lnDEM(-1)	dlnWXV
-8.85	-0.30	1.34	1.06	0.60

C	lnSHIMK(-2)	d^2lnLACC	lnACC
1.70	-0.82	0.60	0.33

C	lnSFIMK(-1)	dlnJVE	lnJVE	RAT1(-1)
-7.75	-0.57	0.50	0.81	0.57

C	lnSIOP	lnSHEM(-1)	lnSHEM(-2)	TREND
8.47	0.29	-0.61	-0.59	-.028

C	lnSIOP	lnSFEM(-1)	lnSFEM(-2)
-2.11	1.19	-0.32	-0.41

(ii) The equations were solved in the following order:

1. dlnSCONK	21. SHEM
2. dlnTWSMK	22. lnSHEM
3. dlnSHIOP	23. SFEM
4. dlnSFIOP	24. lnSFEM
5. dlnSHIMK	25. SIOP
6. dlnSFIMK	26. lnSIOP
7. dlnSHEM	27. lnSIOP
8. dlnSFEM	28. DEM
9. SCONK	24. lnDEM
10. lnSCONK	30. dlnDEM
11. TWSMK	31. ACC
12. lnTWSMK	32. lnACC
13. SHIOP	32. lnACC
14. lnSHIOP	34. d^2lnACC
15. SFIOP	35. STEM
16. lnSFIOP	36. lnSTEM
17. SHIMK	37. dlnSTEM
18. lnSHIMK	38. JVE
19. SFIMK	39. lnJVE
20. lnSFIMK	40. dlnJVE

The statistics and graphics relating to the historical simulation are reported below along with the actual, fitted and residual values for selected equations from the above list.[12]

Comparison of Actual and Predicted Series

1. Actual: SCONKA Predicted: SCONKF Residual: SCONKR

Correlation coefficient = 0.9874 (Squared = 0.9749)

Root-mean-squared error = 74.06

Mean absolute error = 61.52

Mean error = 6.01

Regression coefficient of actual on predicted = 0.9456

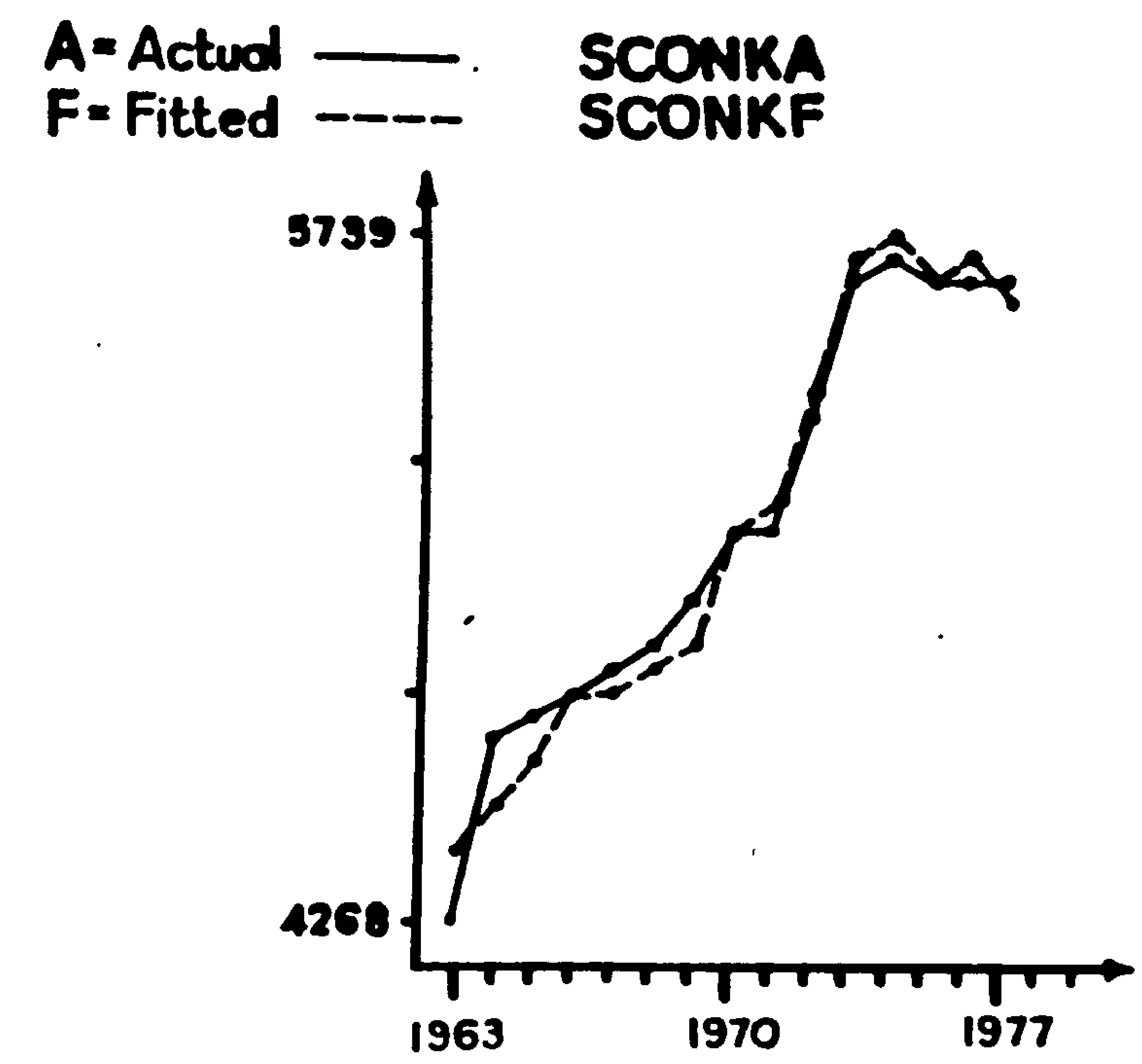
Theil's inequality coefficient = 0.7213D-02

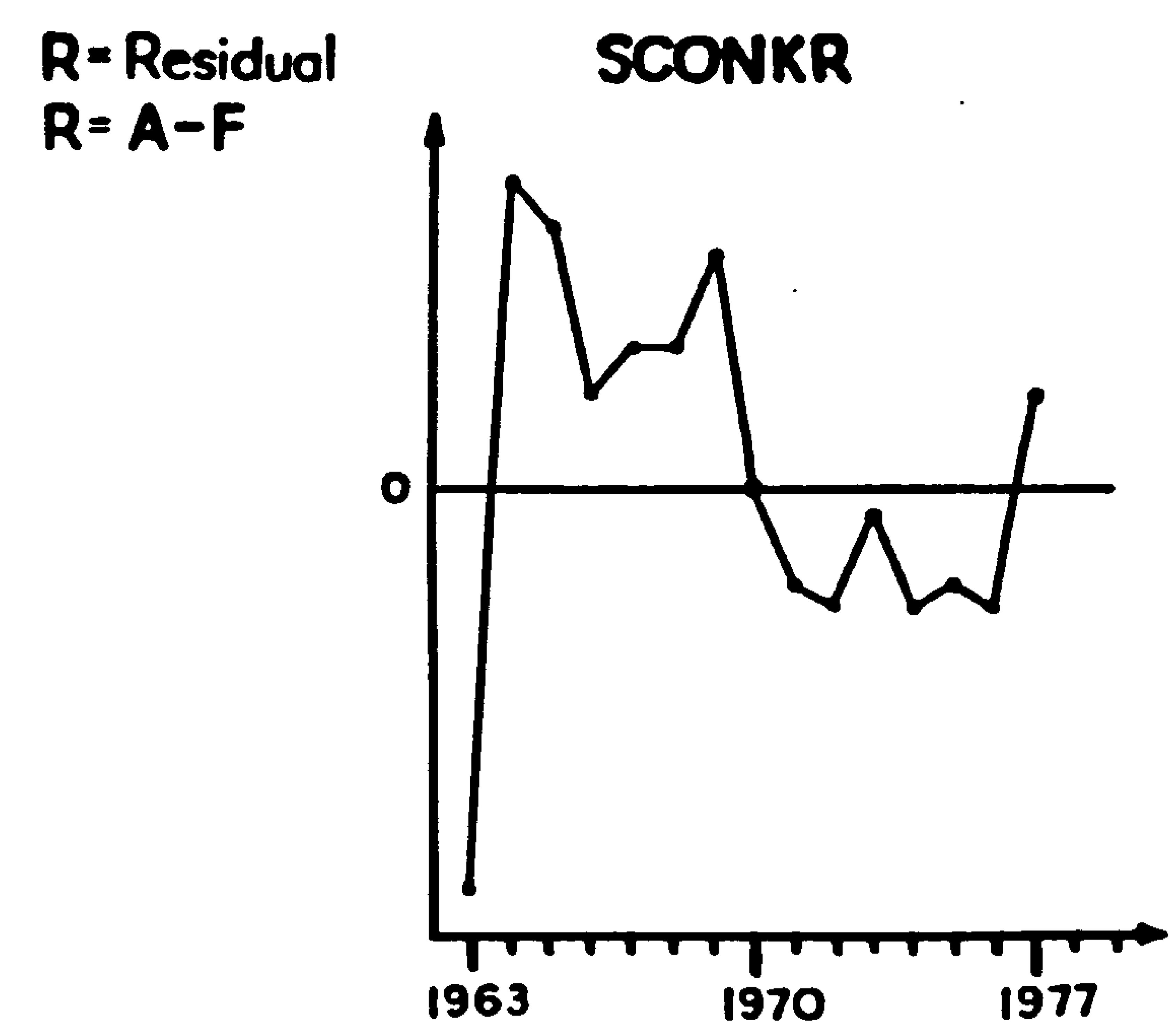
Fraction of error due to bias = 0.6586D-02

Fraction of error due to different variation = 0.6820D-01

Fraction of error due to different co-variation = 0.9252

Time	Actual	Fitted	Residual
1963	4268.	4435.	-167.0
1964	4656.	4533.	122.0
1965	4696.	4592.	105.0
1966	4771.	4734.	36.8
1967	4800.	4745.	54.8
1968	4876.	4820.	55.5
1969	4948.	4855.	93.1
1970	5083.	5088.	-4.7
1971	5092.	5134.	-42.8
1972	5329.	5387.	-48.7
1973	5665.	5680.	-15.1
1974	5692.	5739.	-46.7
1975	5620.	5659.	-39.4
1976	5634.	5686.	-56.1
1977	5633.	5594.	39.2





3. Actual: TWSMKA Predicted: TWSMKF Residual: TWSMKR

Correlation coefficient = 0.9375 (Squared = 0.8788)

Root-mean-squared error = 51.87

Mean absolute error = 46.37

Mean error = 13.75

Regression coefficient of actual on predicted = 0.9178

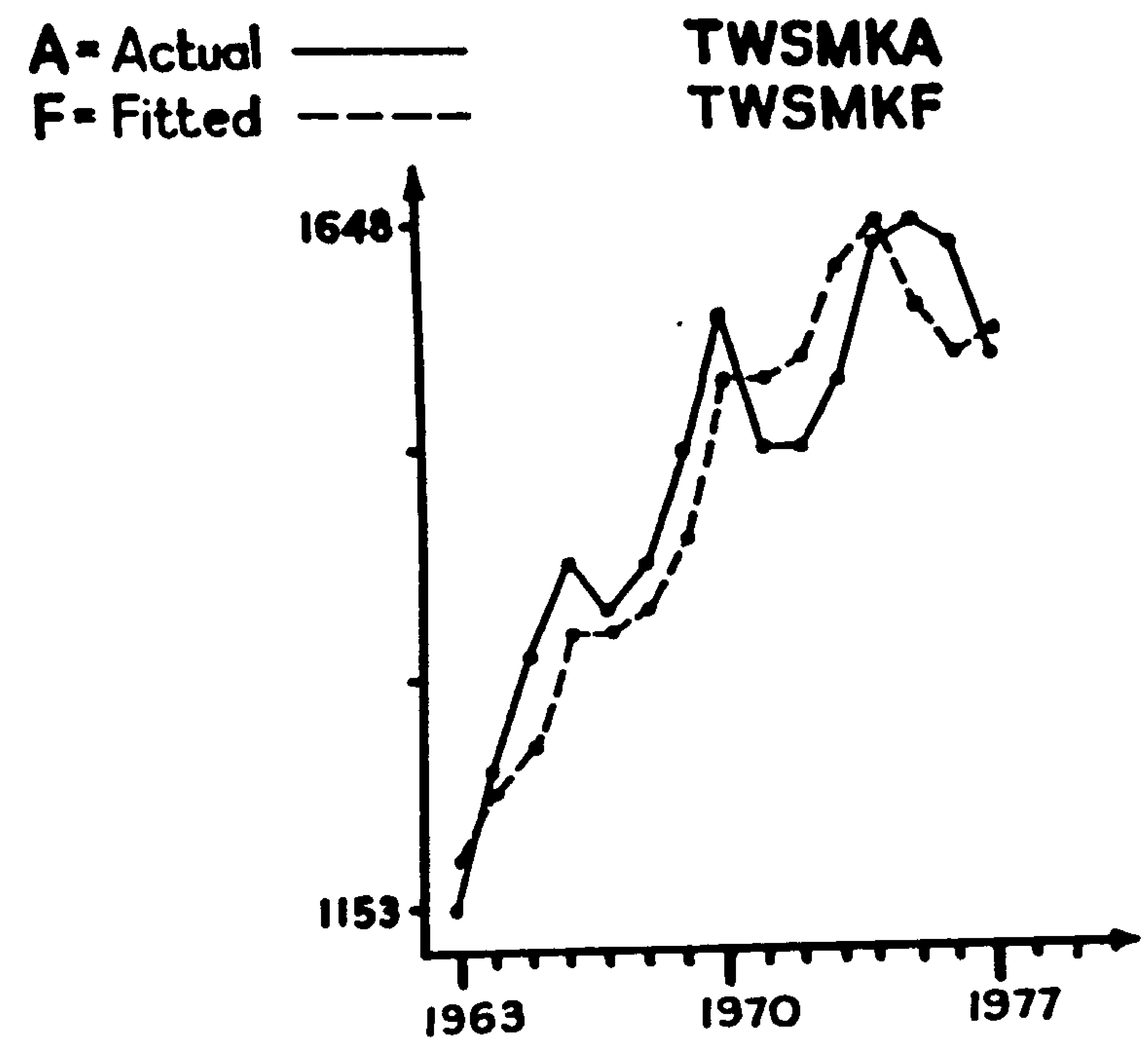
Theil's inequality coefficient = 0.1722D-01

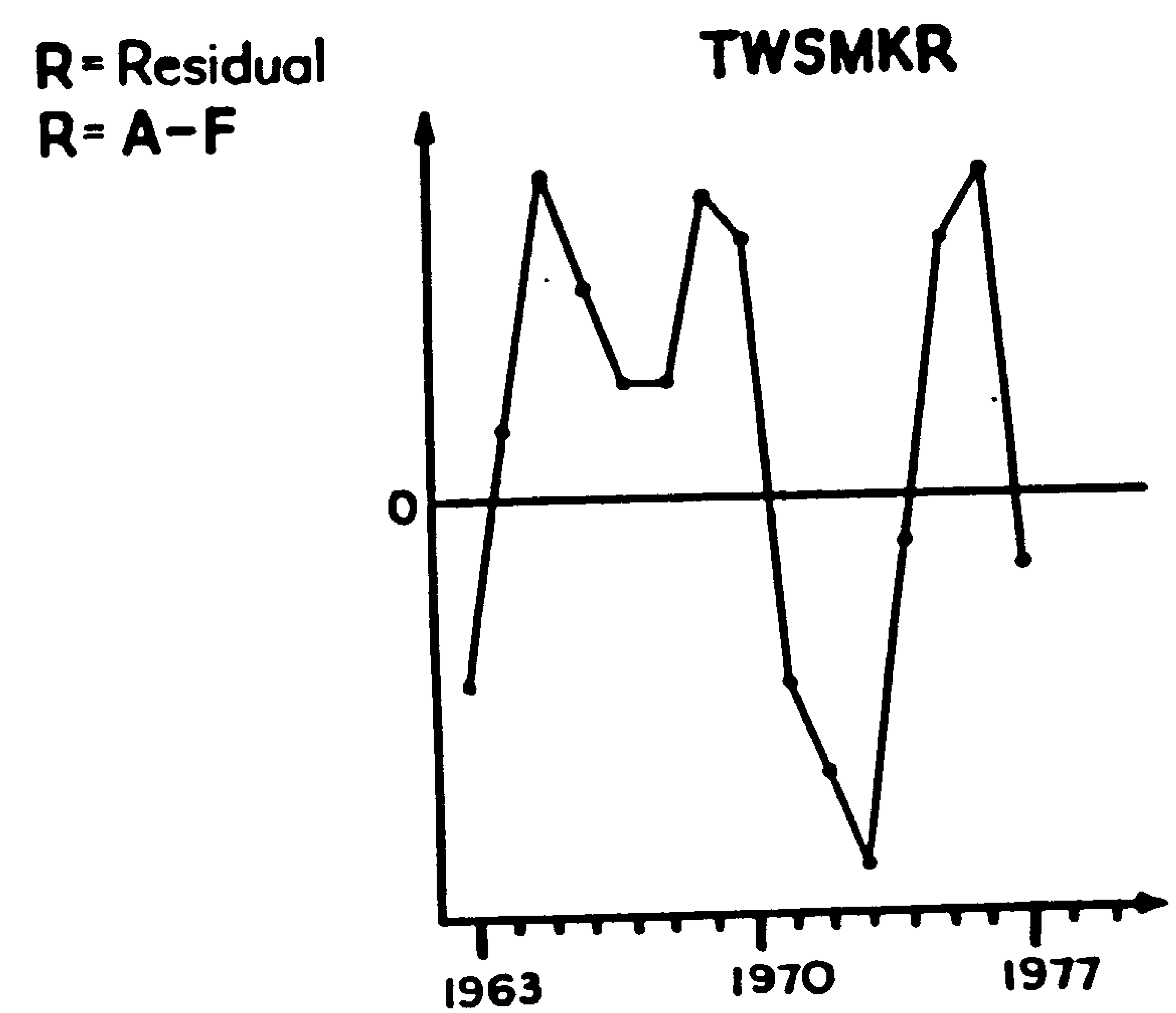
Fraction of error due to bias = 0.7029D-01

Fraction of error due to different variation = 0.3331D-02

Fraction of error due to different co-variation = 0.9264

Time	Actual	Fitted	Residual
1963	1153.	1192.	-38.7
1964	1248.	1233.	14.9
1965	1339.	1265.	74.5
1966	1397.	1351.	46.6
1967	1375.	1348.	26.8
1968	1400.	1371.	29.2
1969	1483.	1414.	69.8
1970	1586.	1528.	58.6
1971	1490.	1530.	-39.8
1972	1486.	1550.	-63.3
1973	1535.	1616.	-81.4
1974	1635.	1644.	- 9.0
1975	1648.	1588.	60.0
1976	1624.	1553.	70.6
1977	1547.	1559.	-12.3





4. Actual: dlnTWSMKA Predicted: dlnTWSMKF Residual: dlnTWSMKR

Correlation coefficient = 0.6106 (Squared = 0.3728)

Root-mean-squared error = 0.3459D-01

Mean absolute error = 0.2918D-01

Mean error = -0.5299D-03

Regression coefficient of actual on predicted = 0.9343

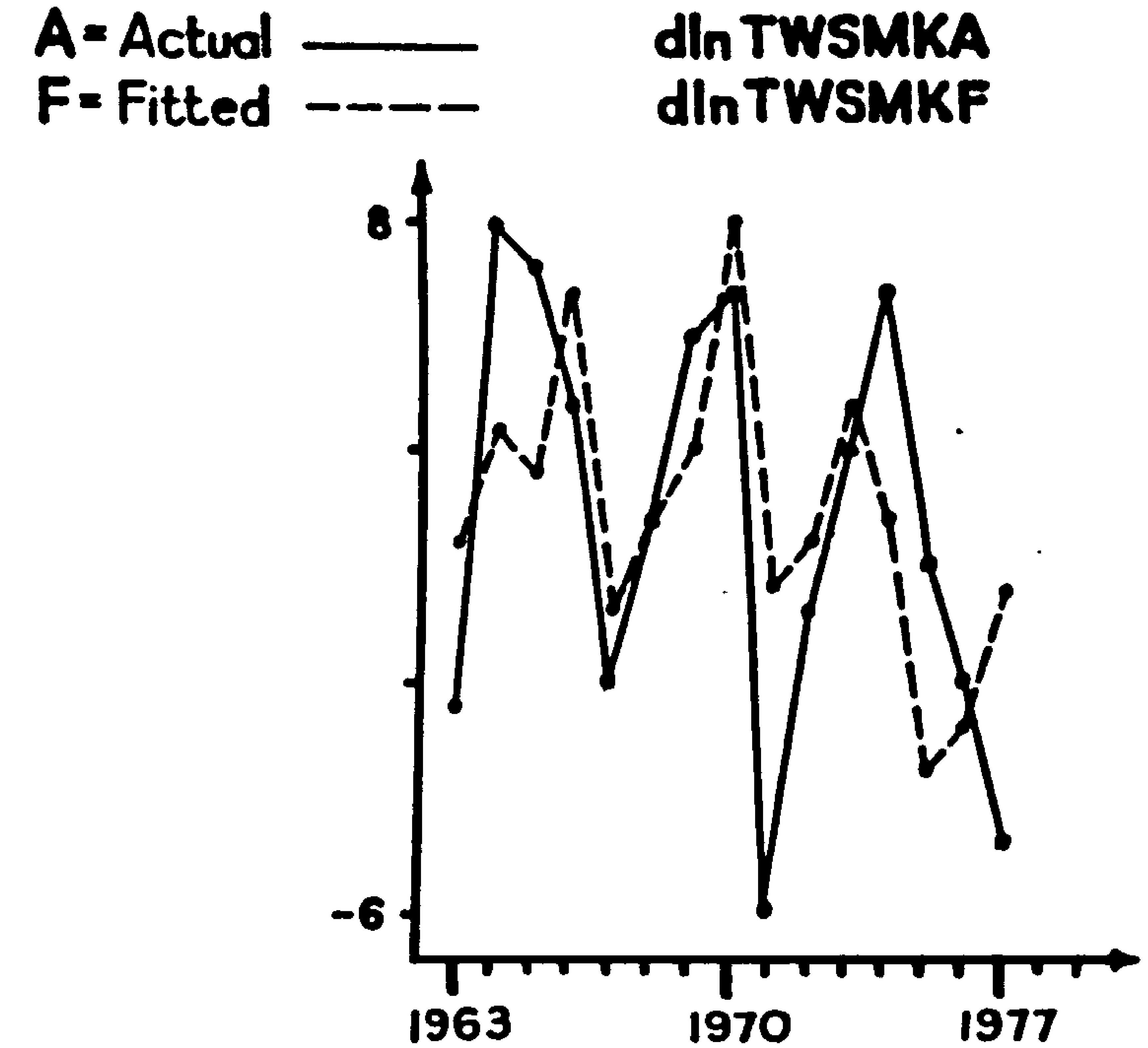
Theil's inequality coefficient = 0.4249

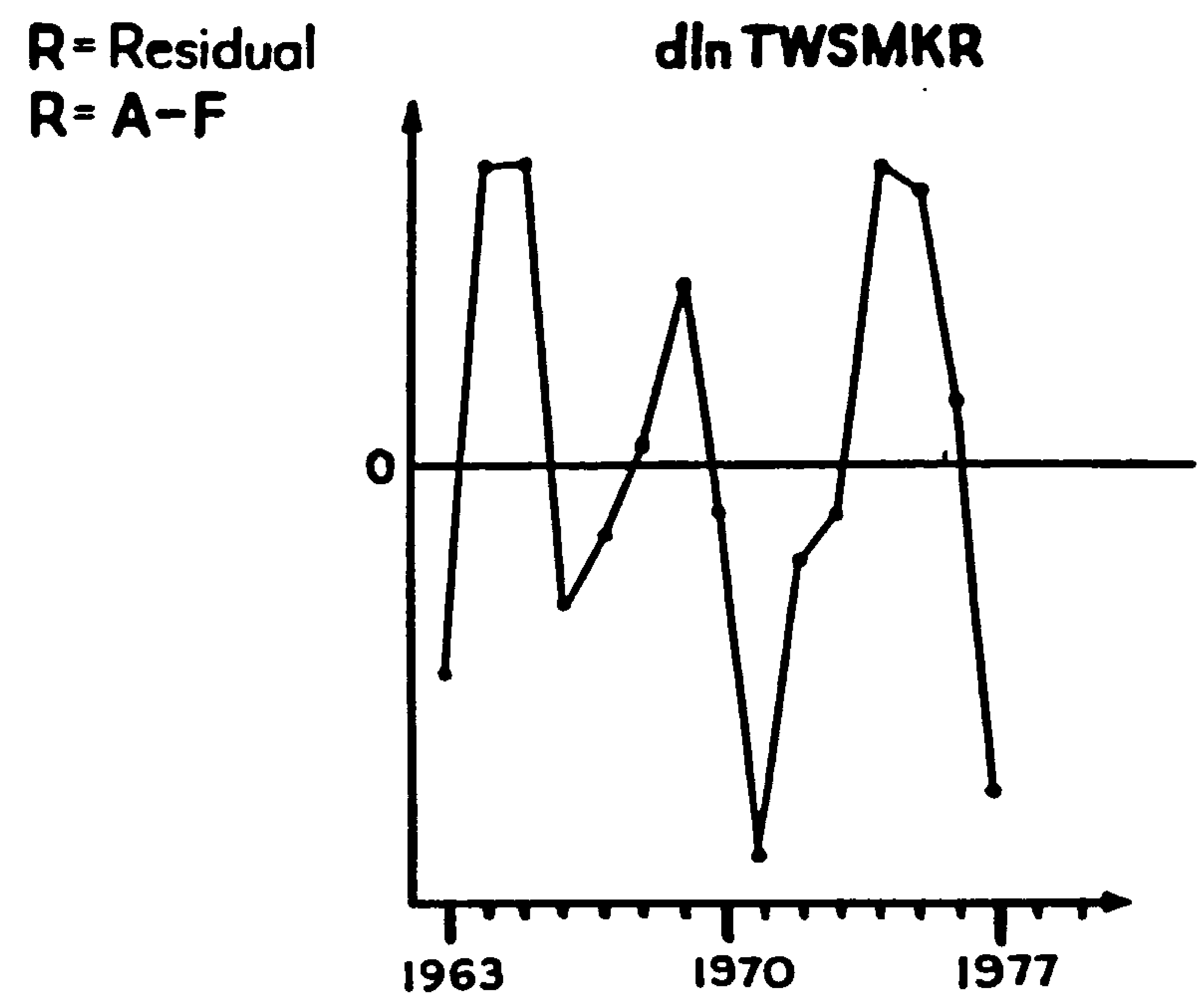
Fraction of error due to bias = 0.2348D-01

Fraction of error due to different variation = 0.1908

Fraction of error due to different co-variation = 0.8090

Time	Actual	Fitted	Residual
1963	-0.2037E-01	0.1268E-01	-0.331E-01
1964	0.7954E-01	0.3446E-01	0.451E-01
1965	0.7050E-01	0.2532E-01	0.452E-01
1966	0.4212E-01	0.6544E-01	-0.233E-01
1967	-0.1604E-01	-0.1836E-02	-0.142E-01
1968	0.1810E-01	0.1675E-01	0.135E-02
1969	0.5783E-01	0.3069E-01	0.271E-01
1970	0.6703E-01	0.7753E-01	0.105E-01
1971	-0.6273E-01	0.1325E-02	-0.641E-01
1972	-0.2280E-02	0.1305E-01	-0.153E-01
1973	0.3224E-01	0.4219E-01	0.996E-02
1974	0.6327E-01	0.1709E-01	0.462E-01
1975	0.8052E-02	-0.3453E-01	0.426E-01
1976	-0.1522E-01	-0.2256E-01	0.734E-02
1977	-0.4826E-01	0.4129E-02	-0.524E-01





As regards the link equations, (SCONK and TWSMK) the levels of consumption and the manufacturing real wage bill seem to be tracking the historical data fairly well. This was evidenced in both cases by the plots of actual on fitted and further by the favourable simulation statistics. For instance the correlation coefficients of actual on fitted are very high, the Theil inequality coefficients are significantly less than 1 and the inequality coefficients are displaying the desired apportioning of error for both SCONK and TWSMK, i.e. the largest portion of error was attributable to different covariation (UC).

As expected the difference models dlnSCONK and dlnTWSMK did not perform as well as their level counterparts in terms of simulation statistics. This was of course due to the increased difficulty in modelling growth rates. However, with the exception of 1963-1965, the dlnSCONKF equation tracked the turning points of the actual series very well. The problem in the period 1963 - 1965 obviously cropped up in the multi-equation model since the single equation fitted values (see Appendix 4) tracked well during this period. The actual and fitted values of dlnTWSMK also seem to track turning points reasonably well, with the exception of 1966, 1971 and 1977.

<u>Note</u>: the residual graphs are not drawn to scale and are 'blown up' so as to highlight the pattern of variation around 0 as opposed to the magnitude of the residual.

5. Actual: SHIOPA Predicted: SHIOPF Residual: SHIOPR

Correlation coefficient = 0.9788 (Squared = 0.9580)

Root-mean-squared error = 1.43

Mean absolute error = 1.08

Mean error = 0.2440

Regression coefficient of actual on predicted = 0.9509

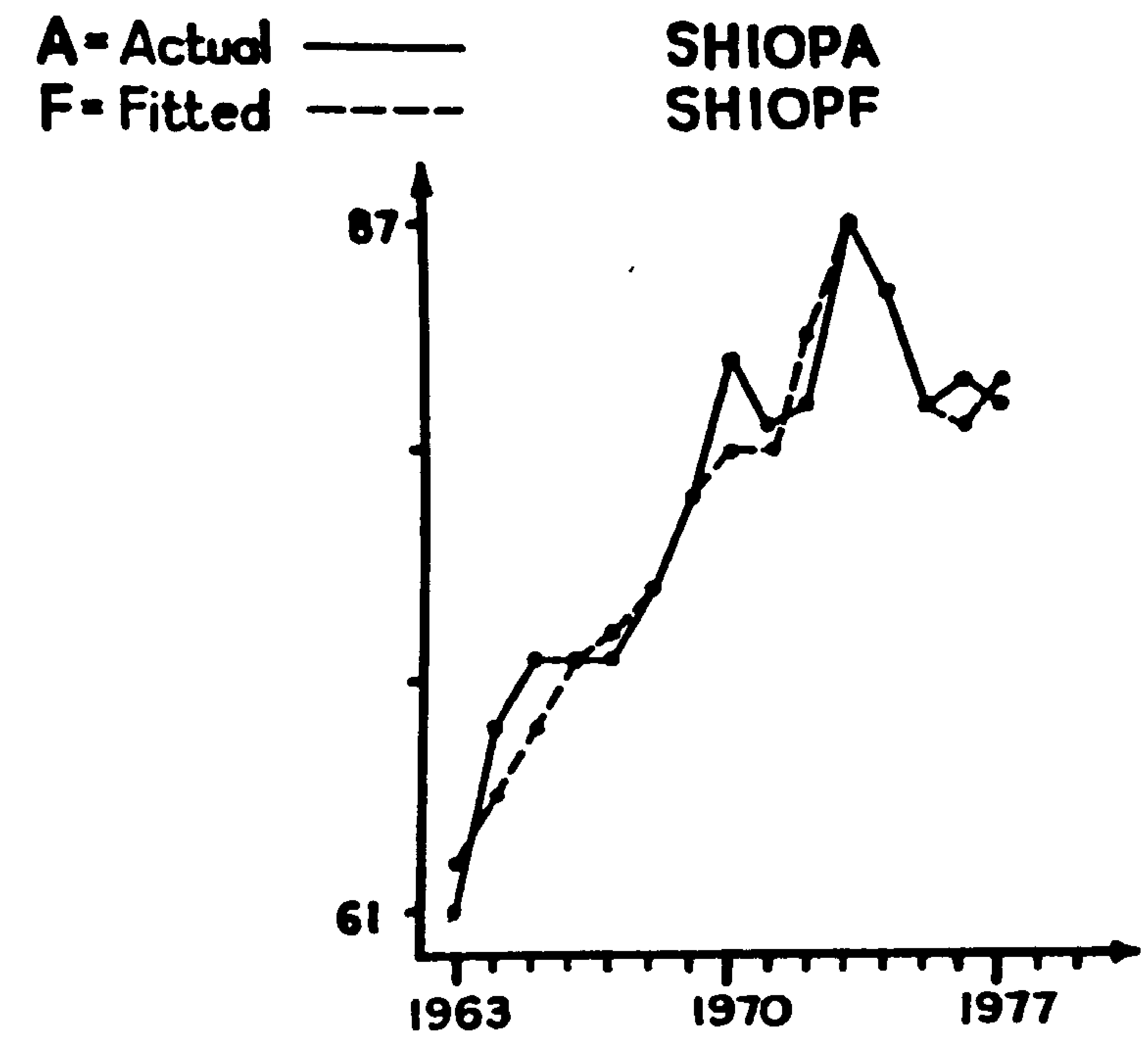
Theil's inequality coefficient = 0.9388D-02

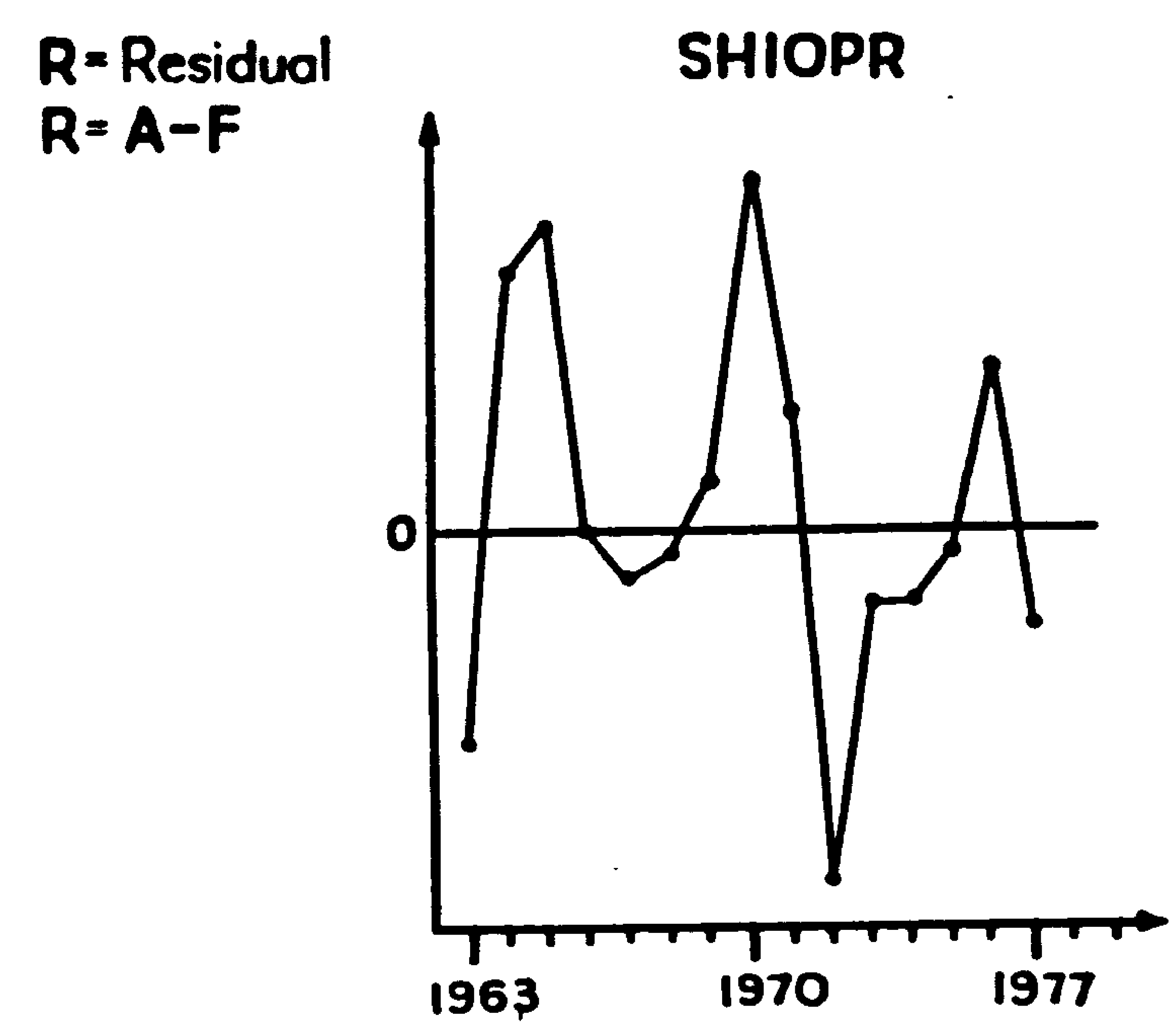
Fraction of error due to bias = 0.2873D-01

Fraction of error due to different variation = 0.1877D-01

Fraction of error due to different co-variation = 0.9525

Time	Actual	Fitted	Residual
1963	61.19	62.78	-1.58
1964	67.97	65.83	2.14
1965	70.65	68.19	2.46
1966	71.16	70.95	0.20
1967	71.16	71.49	-0.33
1968	73.53	73.66	-0.13
1969	77.22	76.86	0.36
1970	81.74	79.00	2.74
1971	79.79	78.91	0.84
1972	80.32	82.98	-2.66
1973	86.81	87.15	-0.34
1974	84.52	84.94	-0.42
1975	79.89	79.99	-0.98E-01
1976	80.50	79.61	1.19
1977	89.50	81.25	-0.74





6. Actual: dlnSHIOPA Predicted: dlnSHIOPF Residual: dlnSHIOPR

Correlation coefficient = 0.767 (Squared = 0.5892)

Root-mean-squared error = 0.2596D-01

Mean absolute error = 0.2036D-01

Mean error = -0.6168D-03

Regression coefficient of actual on predicted = 1.01

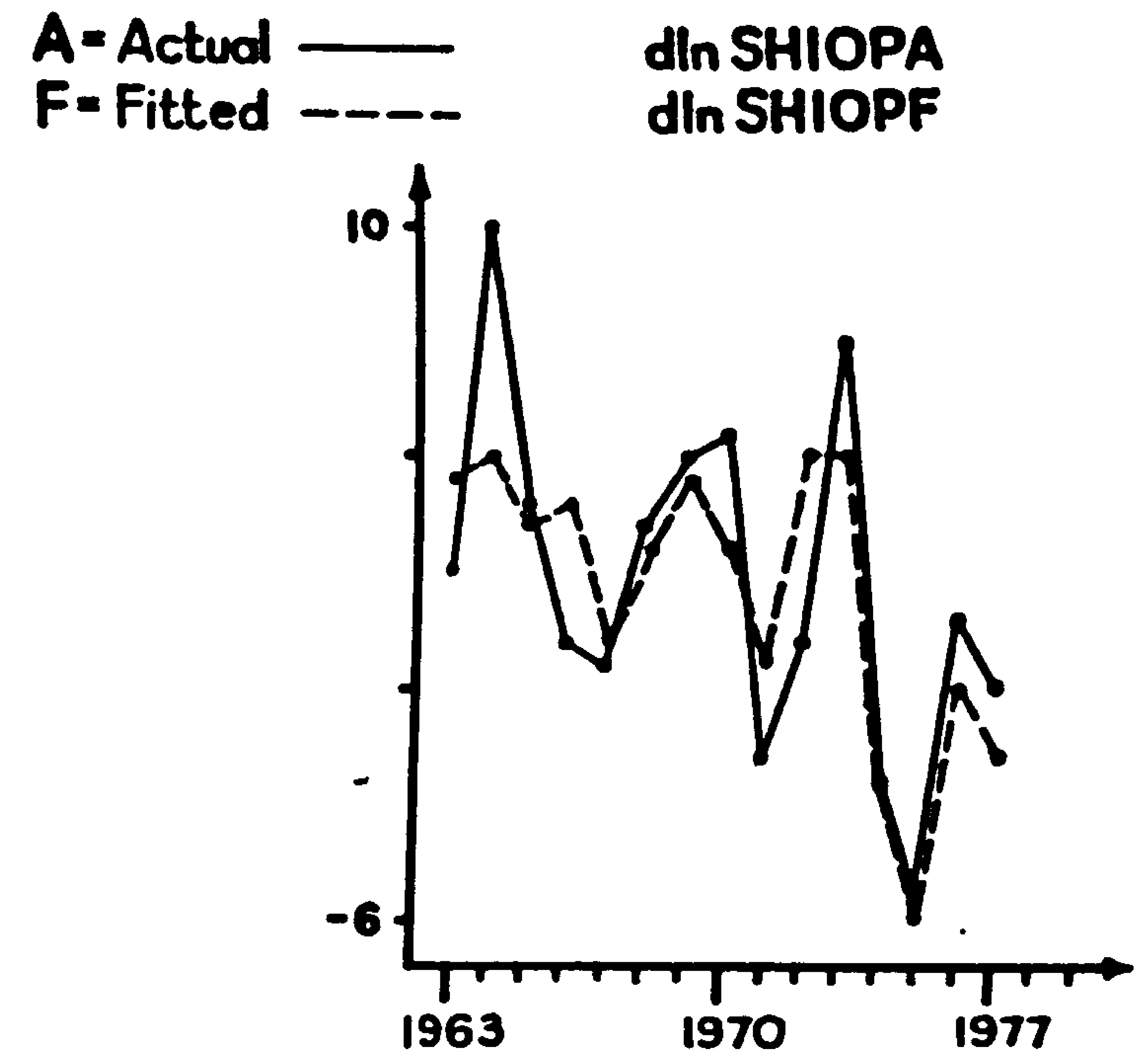
Theil's inequality coefficient = 0.3176

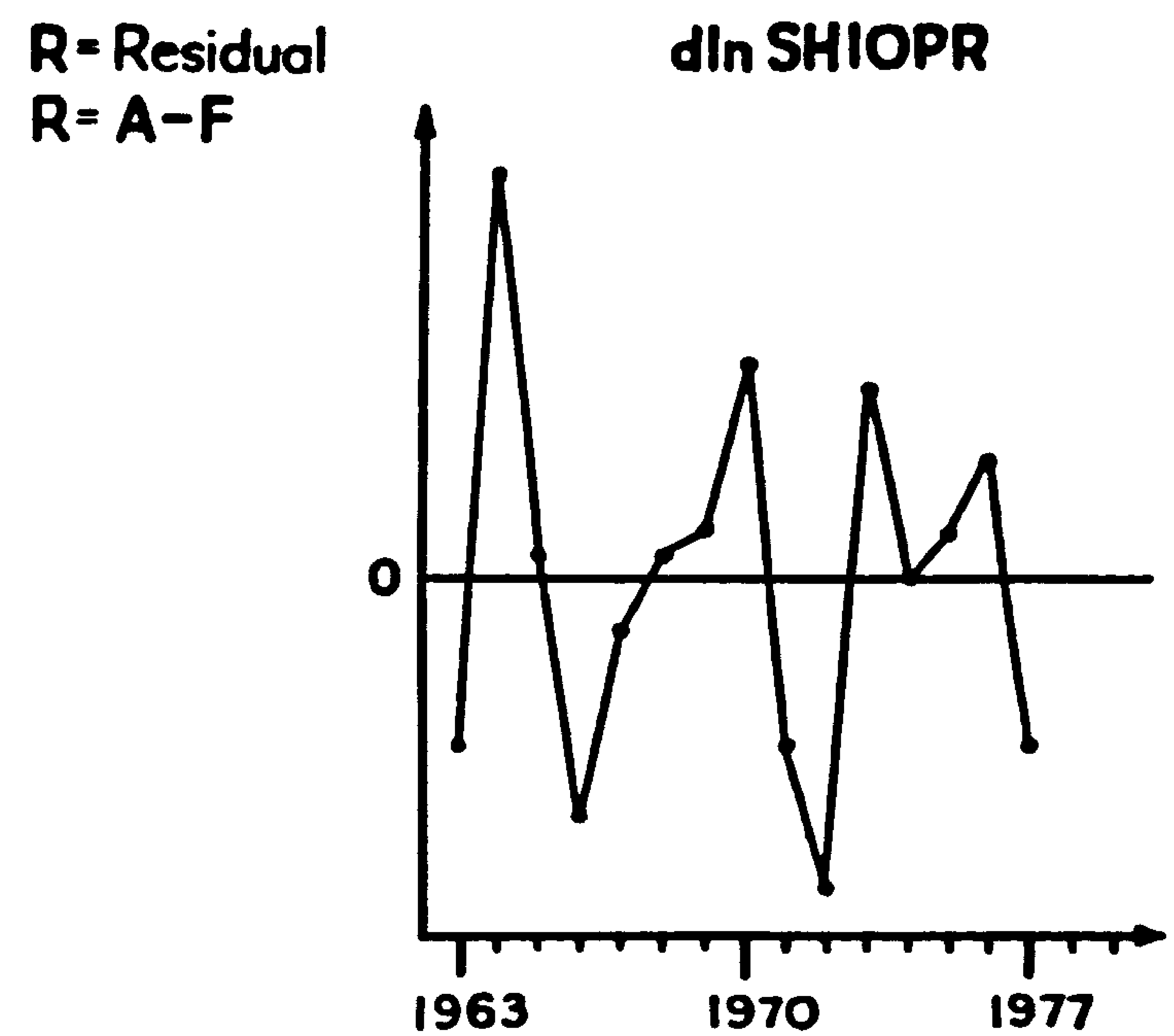
Fraction of error due to bias = 0.5646D-03

Fraction of error due to different variation = 0.1418

Fraction of error due to different co-variation = 0.8576

Time	Actual	Fitted	Residual
1963	0.1955E-01	0.4511E-01	-0.256E-01
1964	0.1050	0.4747E-01	0.575E-01
1965	0.3863E-01	0.3515E-01	0.348E-02
1966	0.7104E-02	0.3971E-01	-0.325E-01
1967	0.5404E-04	0.7601E-02	-0.755E-02
1968	0.3258E-01	0.2988E-01	0.280E-02
1969	0.4911E-01	0.4252E-01	0.659E-02
1970	0.5685E-01	0.2753E-01	0.293E-01
1971	-0.2412E-01	-0.1180E-02	-0.229E-01
1972	0.6596E-02	0.5035E-01	-0.438E-01
1973	0.7763E-01	0.4901E-01	0.286E-01
1974	-0.2665E-01	-0.2567E-01	-0.983E-03
1975	-0.5634E-01	-0.6015E-01	0.382E-02
1976	0.1130E-01	-0.4649E-02	0.160E-01
1977	-0.3728E-02	0.2032E-01	-0.240E-01





7. Actual: SFIOPA Predicted: SFIOPF Residual: SFIOPR

Correlation coefficient = 0.9894 (Squared = 0.9790)

Root-mean-squared error = 0.6986

Mean absolute error = 0.5971

Mean error = 0.1612

Regression coefficient of actual on predicted = 0.9928

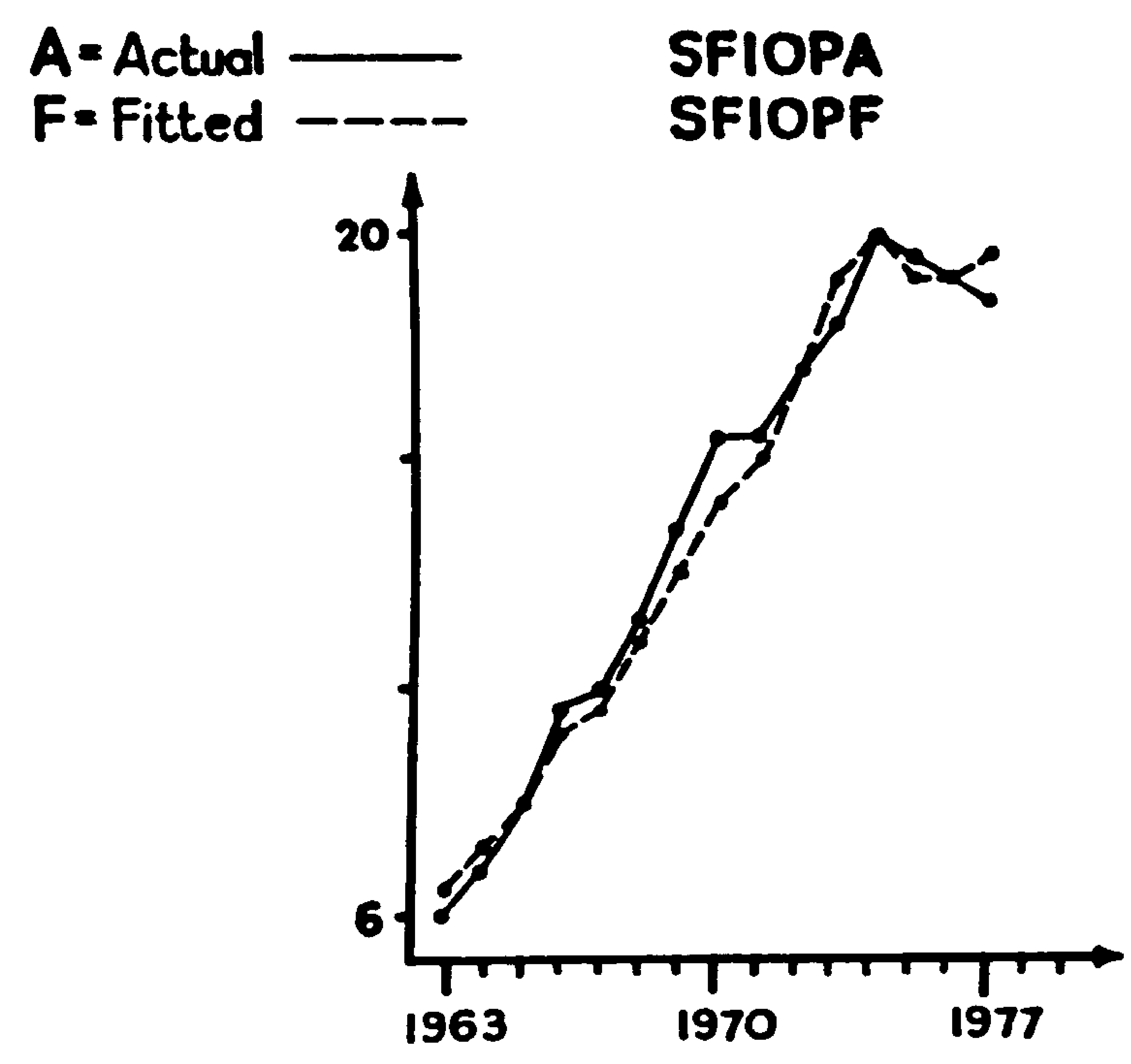
Theil's inequality coefficient = 0.2282D-01

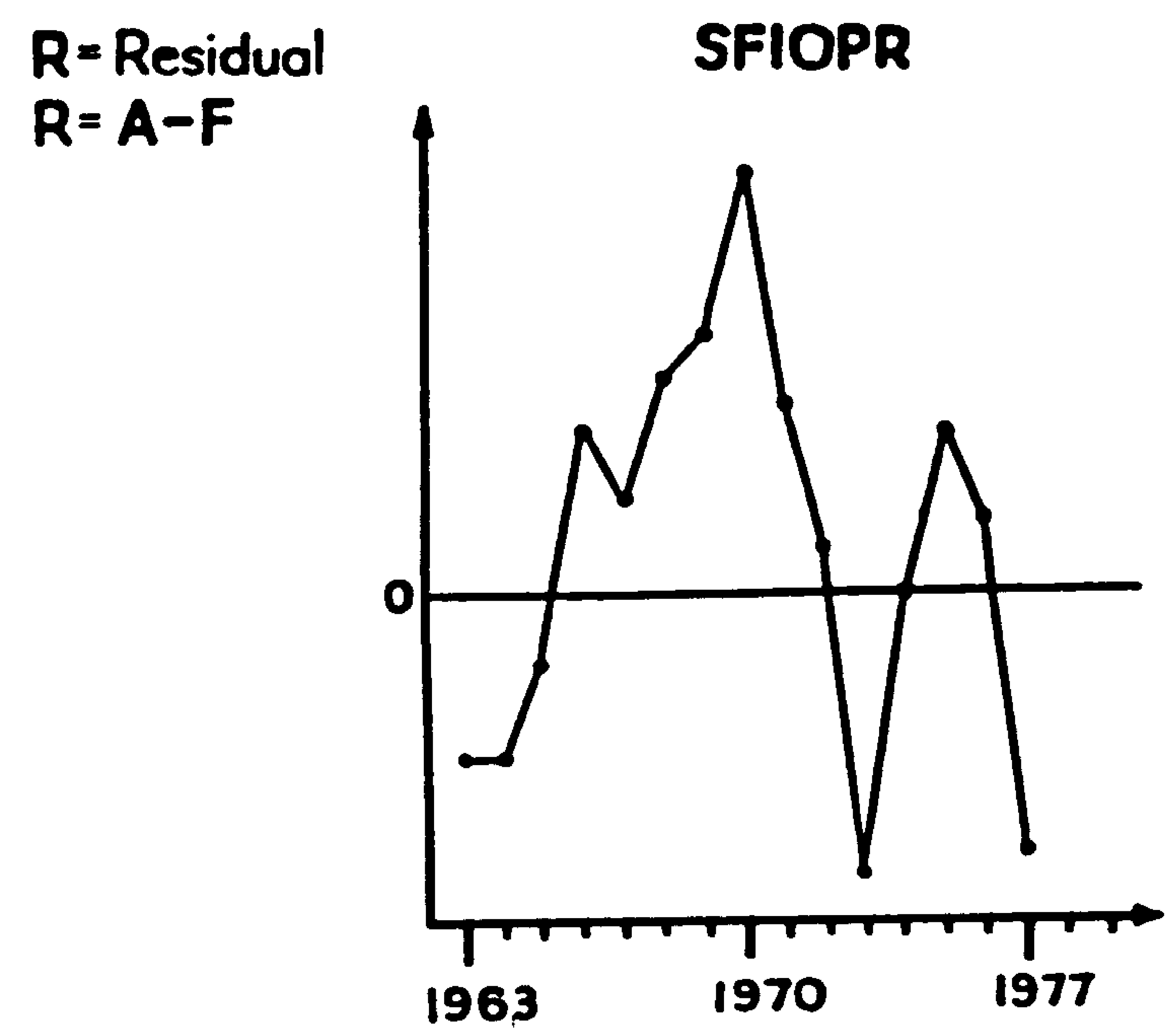
Fraction of error due to bias = 0.5326D-01

Fraction of error due to different variation = 0.5113D-03

Fraction of error due to different co-variation = 0.9462

Time	Actual	Fitted	Residual
1963	6.40	7.00	-0.60
1964	7.43	7.96	-0.53
1965	8.76	8.97	-0.22
1966	10.64	10.04	0.60
1967	11.14	10.79	0.35
1968	12.58	11.89	0.77
1969	14.38	13.46	0.92
1970	16.26	14.81	1.45
1971	16.41	15.81	0.59
1972	17.68	17.49	0.18
1973	18.69	19.67	-0.97
1974	20.48	20.44	0.41
1975	20.11	19.54	0.57
1976	19.60	19.41	0.19
1977	19.30	20.24	-0.93





8. Actual: dlnSFIOPA Predicted: dlnSFIOPS Residual: dlnSFIOPR

Correlation coefficient = 0.7201 (Squared = 0.5185)

Root-mean-squared error = 0.4810D-01

Mean absolute error = 0.4178D-01

Mean error = -0.3161D-02

Regression coefficient of actual on predicted = 1.00

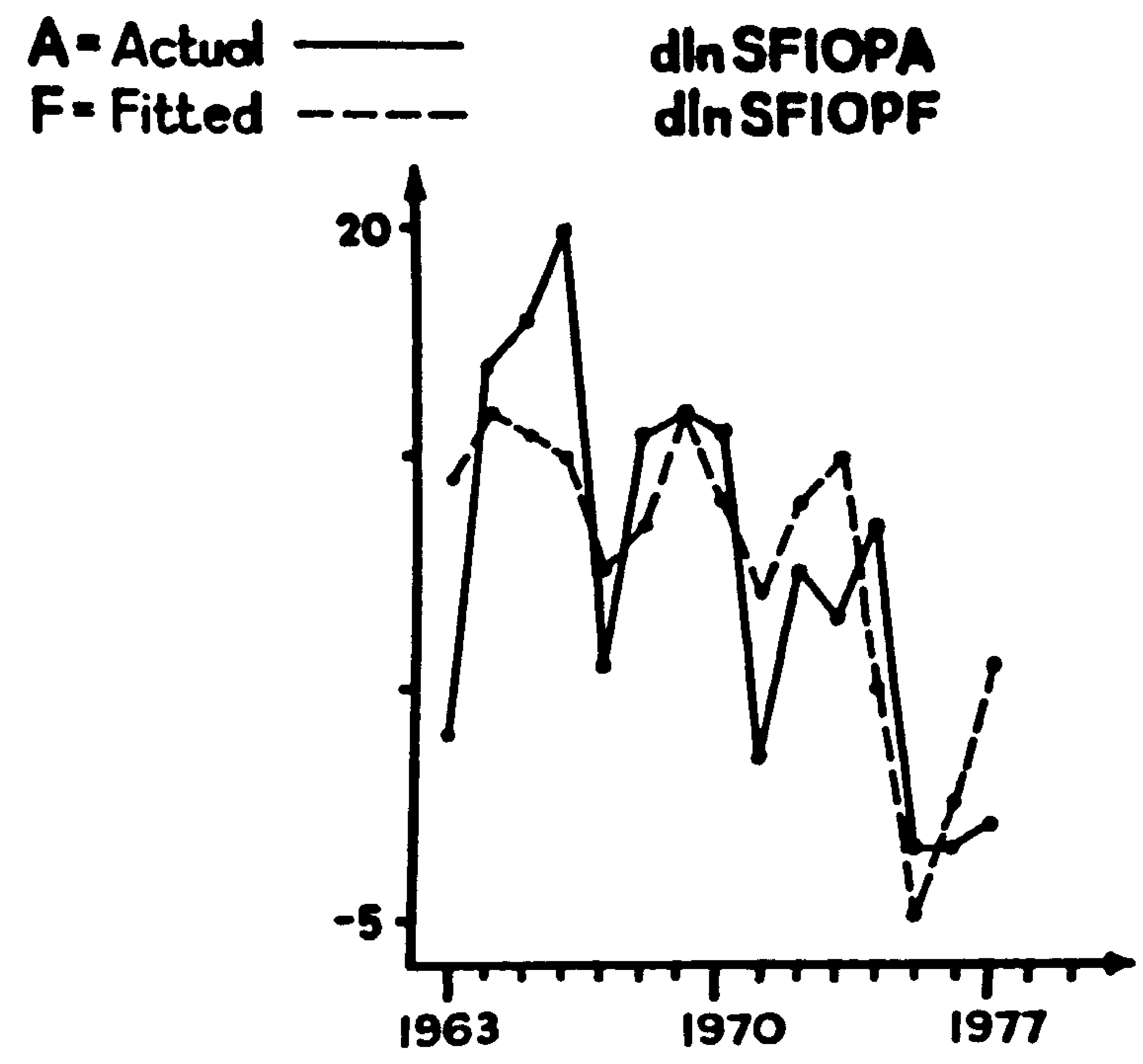
Theil's inequality coefficient = 0.2477

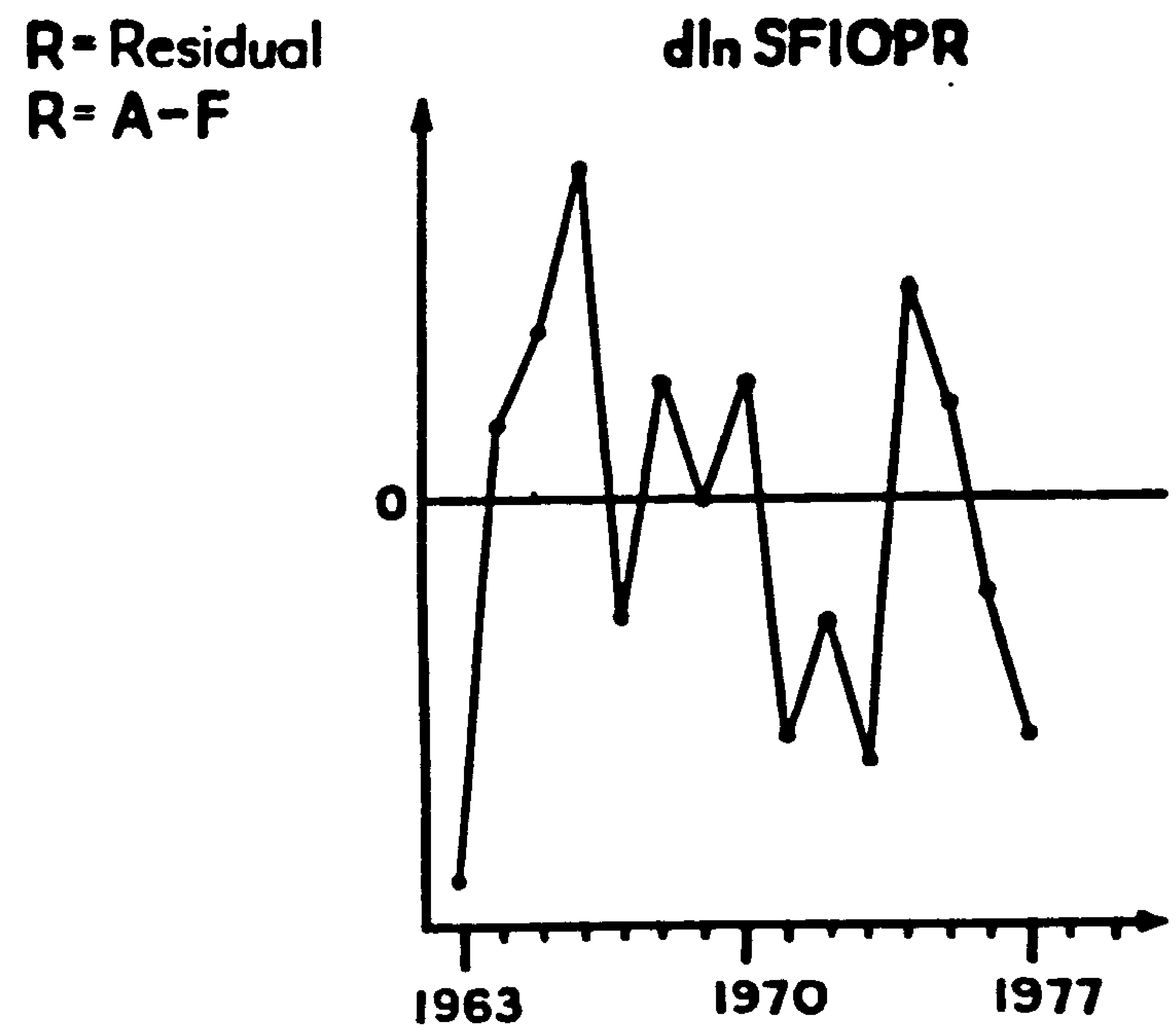
Fraction of error due to bias = 0.4320D-02

Fraction of error due to different variation = 0.1648

Fraction of error due to different co-variation = 0.8309

Time	Actual	Fitted	Residual
1963	0.182E-01	0.108	0.899E-01
1964	0.148	0.128	0.202E-01
1965	0.163	0.119	0.448E-01
1966	0.195	0.112	0.835E-01
1967	0.455	0.722E-01	0.267E-01
1968	0.121	0.898E-01	0.315E-01
1969	0.133	0.131	0.274E-02
1970	0.123	0.956E-01	0.274E-01
1971	0.904E-02	0.654E-01	-0.564E-01
1972	0.746E-01	0.101	-0.267E-01
1973	0.559E-01	0.117	-0.611E-01
1974	0.910E-01	0.383E-01	0.528E-01
1975	-0.182E-01	-0.449E-01	0.267E-01
1976	-0.253E-01	-0.668E-01	-0.188E-01
1977	-0.153E-01	0.419E-01	-0.573E-01





10. Actual: dlnSIOPA Predicted: dlnSIOPF Residual: dlnSIOPR

Correlation coefficient = 0.7870 (Squared = 0.6193)

Root-mean-squared error = 0.2460D-01

Mean absolute error = 0.2015D-01

Mean error = -0.1116D-02

Regression coefficient of actual on predicted = 0.9717

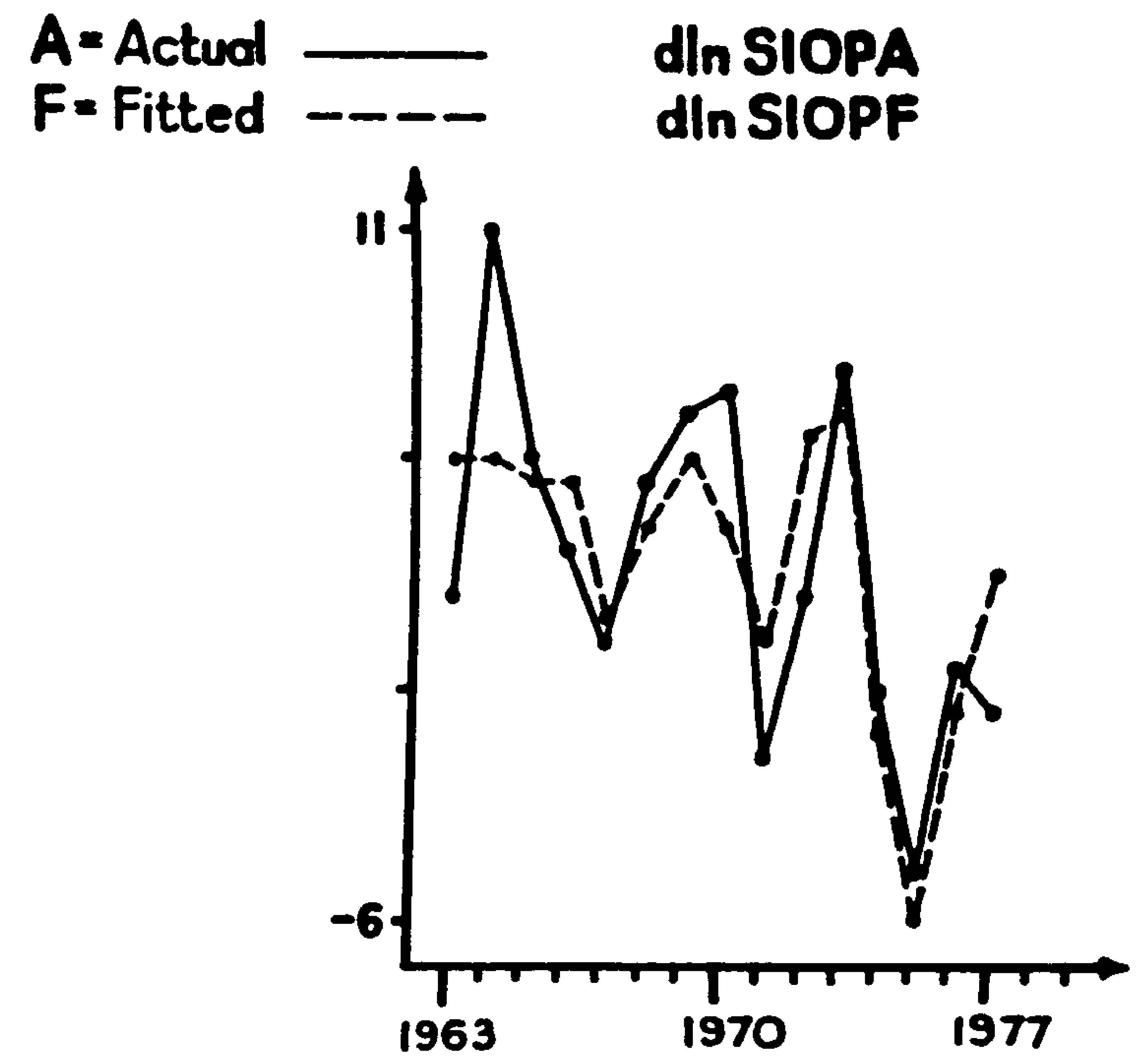
Theil's inequality coefficient = 0.2697

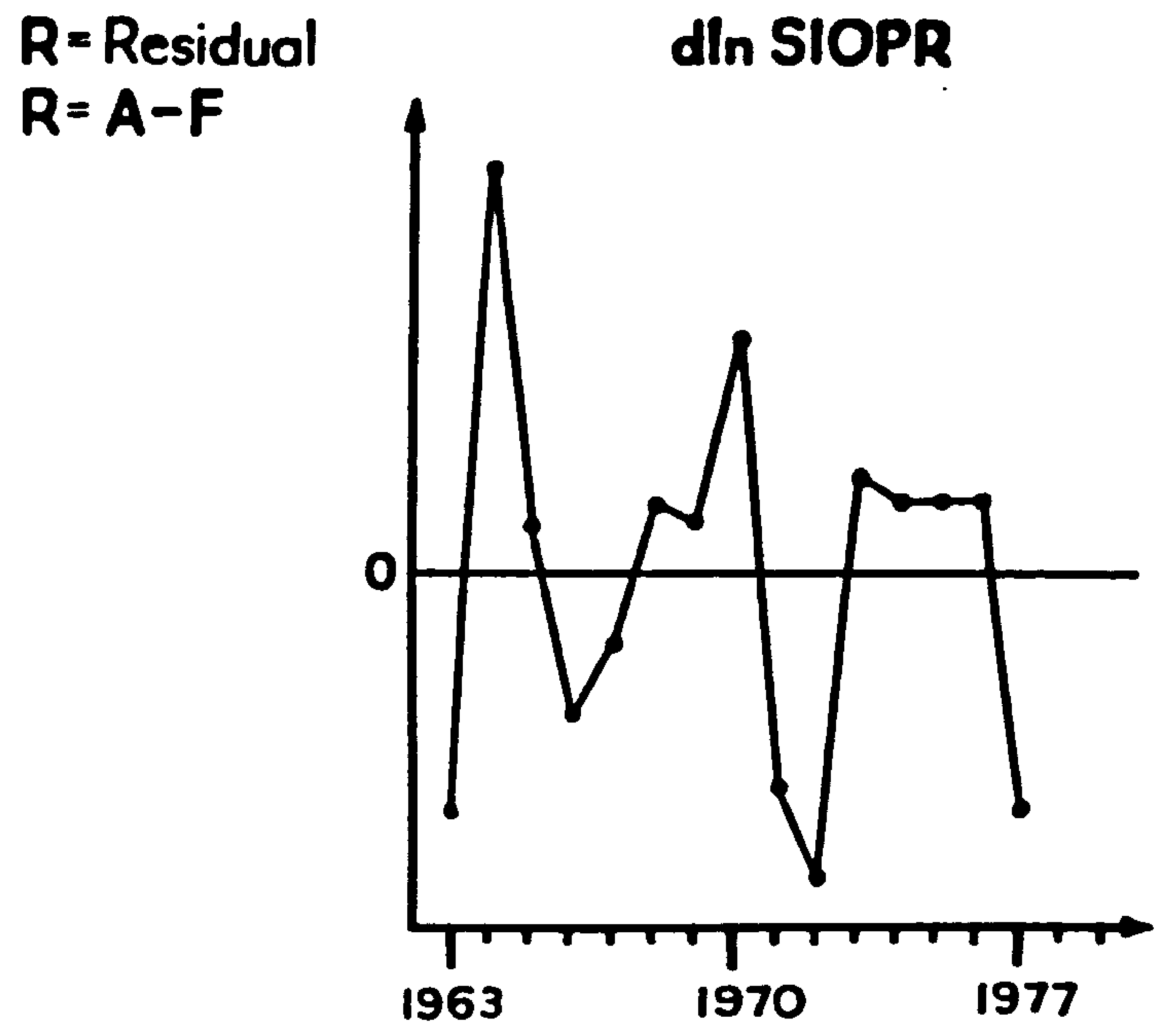
Fraction of error due to bias = 0.2060D-02

Fraction of error due to different variation = 0.9459D-01

Fraction of error due to different co-variation = 0.9034

Time	Actual	Fitted	Residual
1963	0.194E-01	0.512E-01	0.318E-01
1964	0.109	0.558E-01	0.533E-01
1965	0.516E-01	0.445E-01	0.714E-02
1966	0.297E-01	0.483E-01	-0.186E-01
1967	0.609E-02	0.158E-01	-0.975E-02
1968	0.451E-01	0.379E-01	0.719E-02
1969	0.692E-01	0.552E-01	0.671E-01
1970	0.675E-01	0.379E-01	0.295E-01
1971	-0.185E-01	0.963E-02	-0.282E-01
1972	0.185E-01	0.580E-01	-0.405E-01
1973	0.737E-01	0.611E-01	0.126E-01
1974	-0.475E-02	-0.135E-01	0.882E-02
1975	-0.487E-01	-0.571E-01	0.840E-02
1976	0.399E-02	-0.504E-02	0.904E-02
1977	-0.599E-02	0.245E-01	-0.306E-01





As regards the output block, the 'levels' of SHIOPF, SFIOPF and the identity SIOPF all seem to track the actual series quite well. As with the link equations, the simulation statistics are all in good order. For instance the correlation coefficients of actual on fitted are very high, the Theil inequality coefficients are significantly less than 1 and UC, in the worst case is (.93). Examination of the plots of actual on fitted for each equation also complements the findings from the simulation statistics.

The equations estimated in differences for dlnSHIOP, dlnSFIOP and dlnSIOP also look quite reasonable by 'non-level' standards. In the case of dlnSHIOP, the fitted results track the actual results fairly closely with the exception of 1965, 1969 (where the fitted series peaked one period early) and 1972. The dlnSFIOP fitted results also track reasonably well and peak before the actual figures early in the estimation period and again towards the end of the period. The fitted values for the identity dlnSIOP also do not look bad in that they fairly closely replicate the actual series except at the very beginning and the very end of the estimation period. Further encouraging signs as regards these results are the fairly high UC statistics (for equations estimated in differences) and correlation coefficients of actual on fitted.

11. Actual: SHIMKA Predicted: SHIMKF Residual: SHIMKR

Correlation coefficient = 0.4939 (Squared = 0.2440)

Root-mean-squared error = 37.77

Mean absolute error = 33.88

Mean error = 4.56

Regression coefficient of actual on predicted = 0.8537

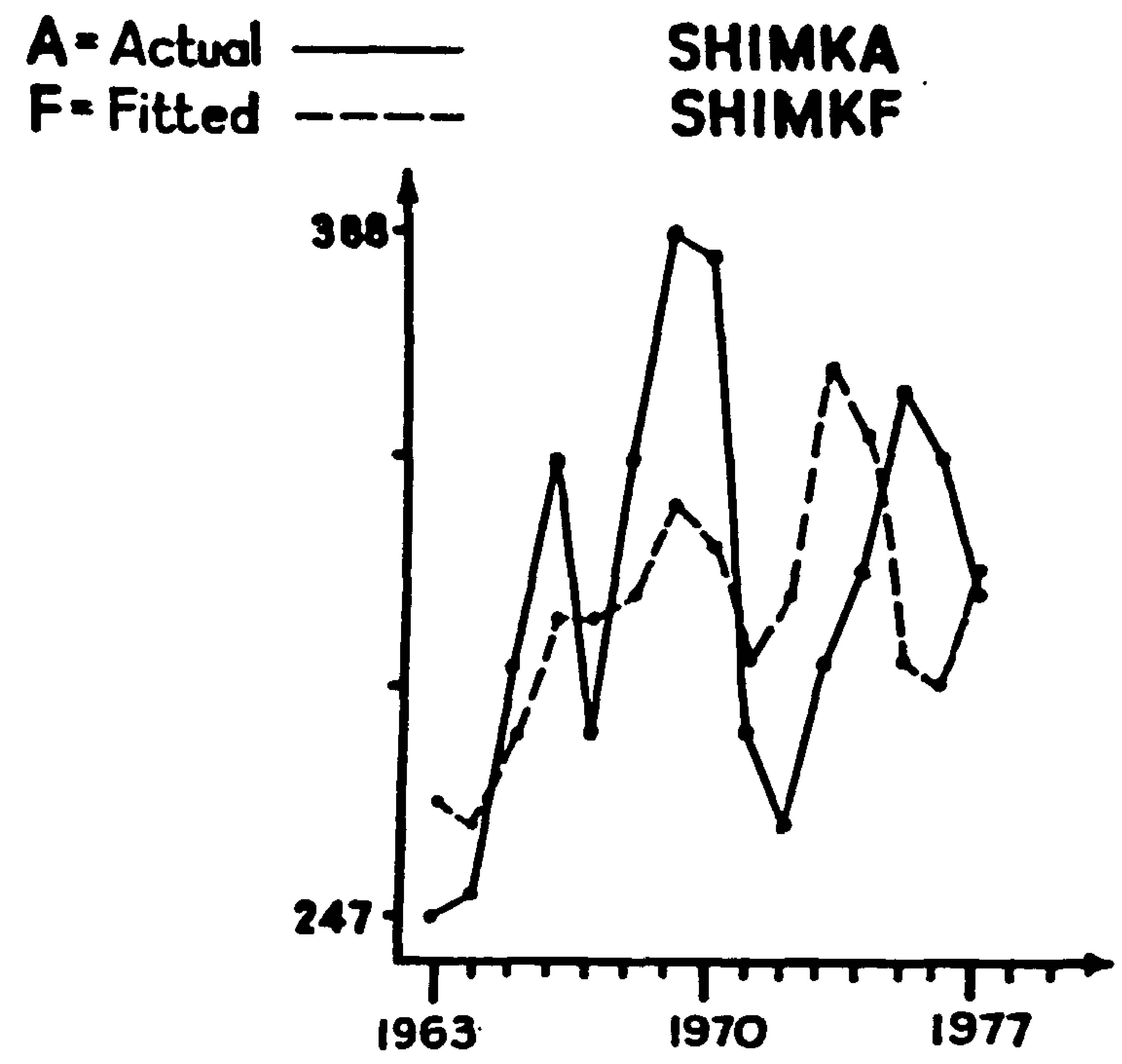
Theil's inequality coefficient = 0.6026D-10

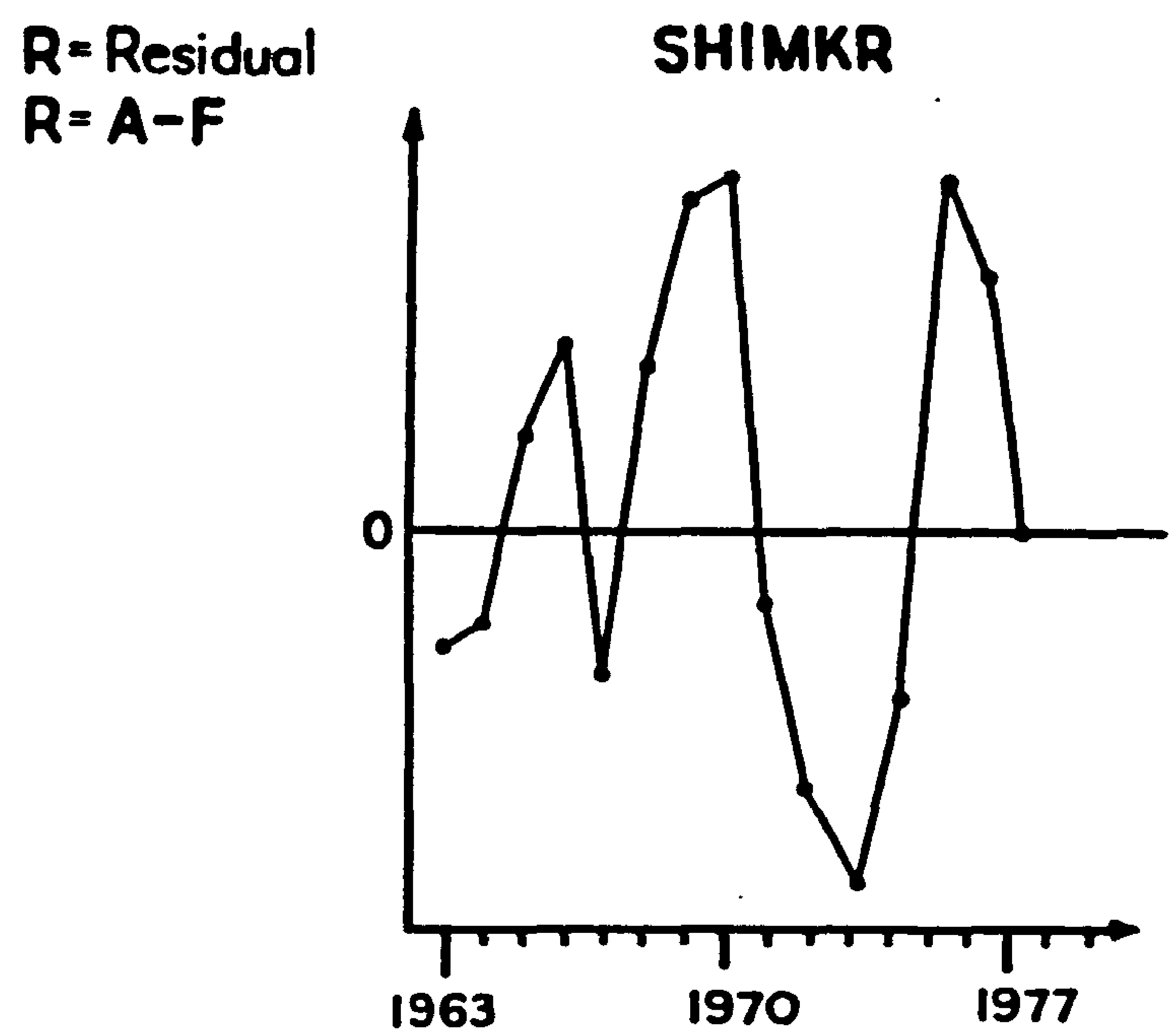
Fraction of error due to bias = 0.1462D-01

Fraction of error due to different variation = 0.2293

Fraction of error due to different co-variation = 0.7561

Time	Actual	Fitted	Residual
1963	247.1	270.9	-23.8
1964	250.2	265.1	-14.9
1965	298.6	278.1	20.5
1966	339.0	301.2	37.8
1967	283.4	304.4	-21.0
1968	341.7	314.3	27.4
1969	388.2	334.3	53.9
1970	384.4	327.8	56.5
1971	284.1	303.0	-18.8
1972	265.2	315.0	-49.8
1973	297.7	357.0	-59.3
1974	317.7	344.5	-26.7
1975	357.5	303.0	54.4
1976	339.4	301.6	37.8
1977	313.5	318.9	- 5.3





12. Actual: dlnSHIMKA Predicted: dlnSHIMKF Residual: lnSHIMKR

Correlation coefficient = 0.4707 (Squared = 0.2215)

Root-mean-squared error = 0.1280

Mean absolute error = 0.1062

Mean error = -0.1136D-02

Regression coefficient of actual on predicted = 0.9666

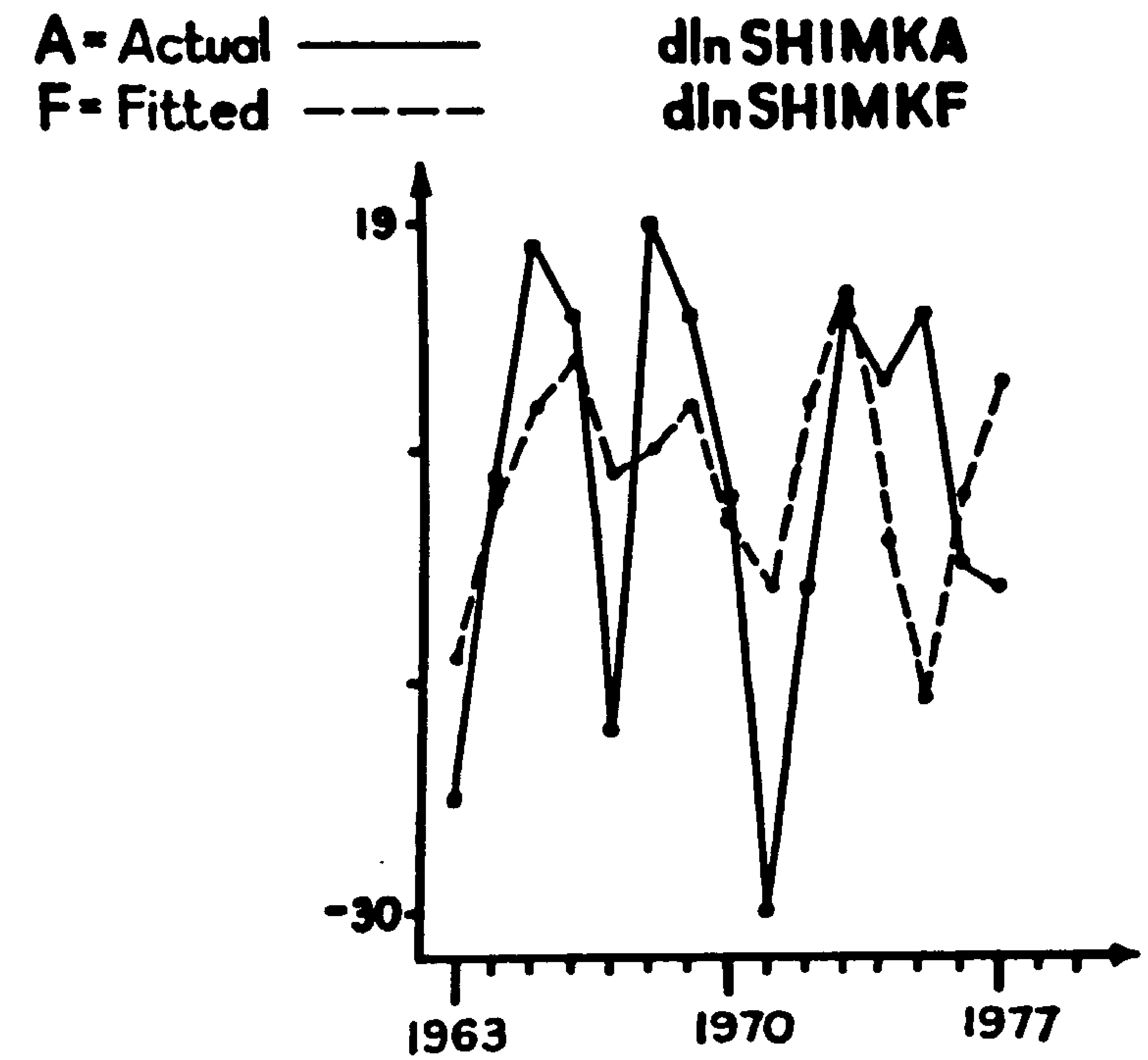
Theil's inequality coefficient = 0.5934

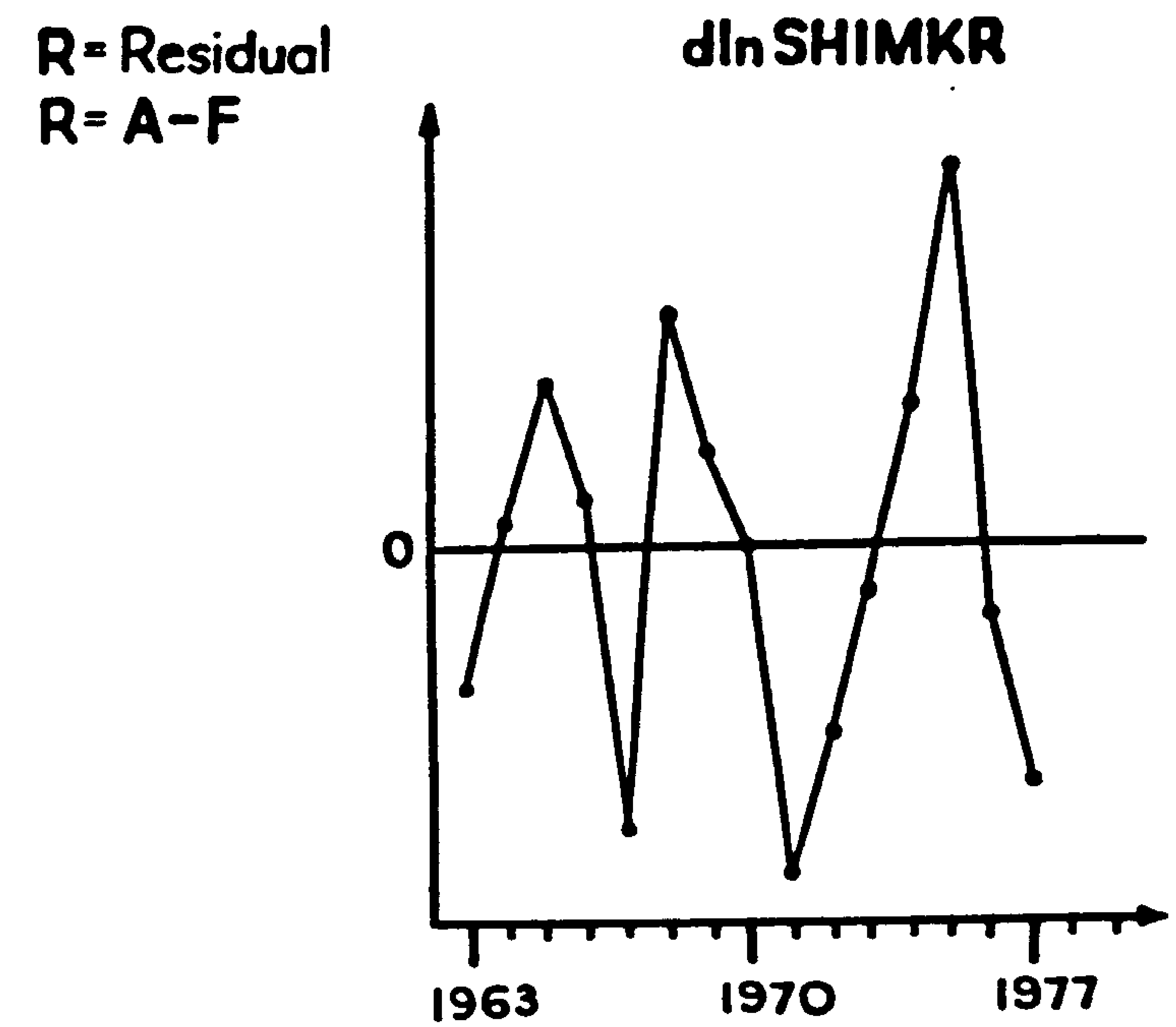
Fraction of error due to bias = 0.7877D-04

Fraction of error due to different variation = 0.3380

Fraction of error due to different co-variation = 0.6619

Time	Actual	Fitted	Residual
1963	-0.219	-0.127	-0.920E-01
1964	0.126E-01	-0.215E-01	0.341E-01
1965	0.176	0.478E-01	0.129
1966	0.126	0.797E-01	0.471E-01
1967	-0.179	0.106E-01	-0.190
1968	0.127	0.317E-01	0.155
1969	0.186	0.619E-01	0.657E-01
1970	-0.989E-02	-0.195E-01	0.969E-02
1971	-0.302	-0.789E-01	-0.223
1972	-0.688E-01	0.390E-01	-0.108
1973	0.115	0.125	-0.959E-02
1974	0.652-01	-0.357E-01	0.101
1975	0.117	-0.128	0.246
1976	-0.519E-01	-0.476E-02	-0.472E-01
1977	-0.792E-01	0.557E-01	-0.135





13. Actual: SFIMKA Predicted: SFIMKF Residual: SFIMKR

Correlation coefficient = 0.9399 (Squared = 0.8835)

Root-mean-squared error = 5.16

Mean absolute error = 4.62

Mean error = 0.2084

Regression coefficient of actual on predicted = 0.9268

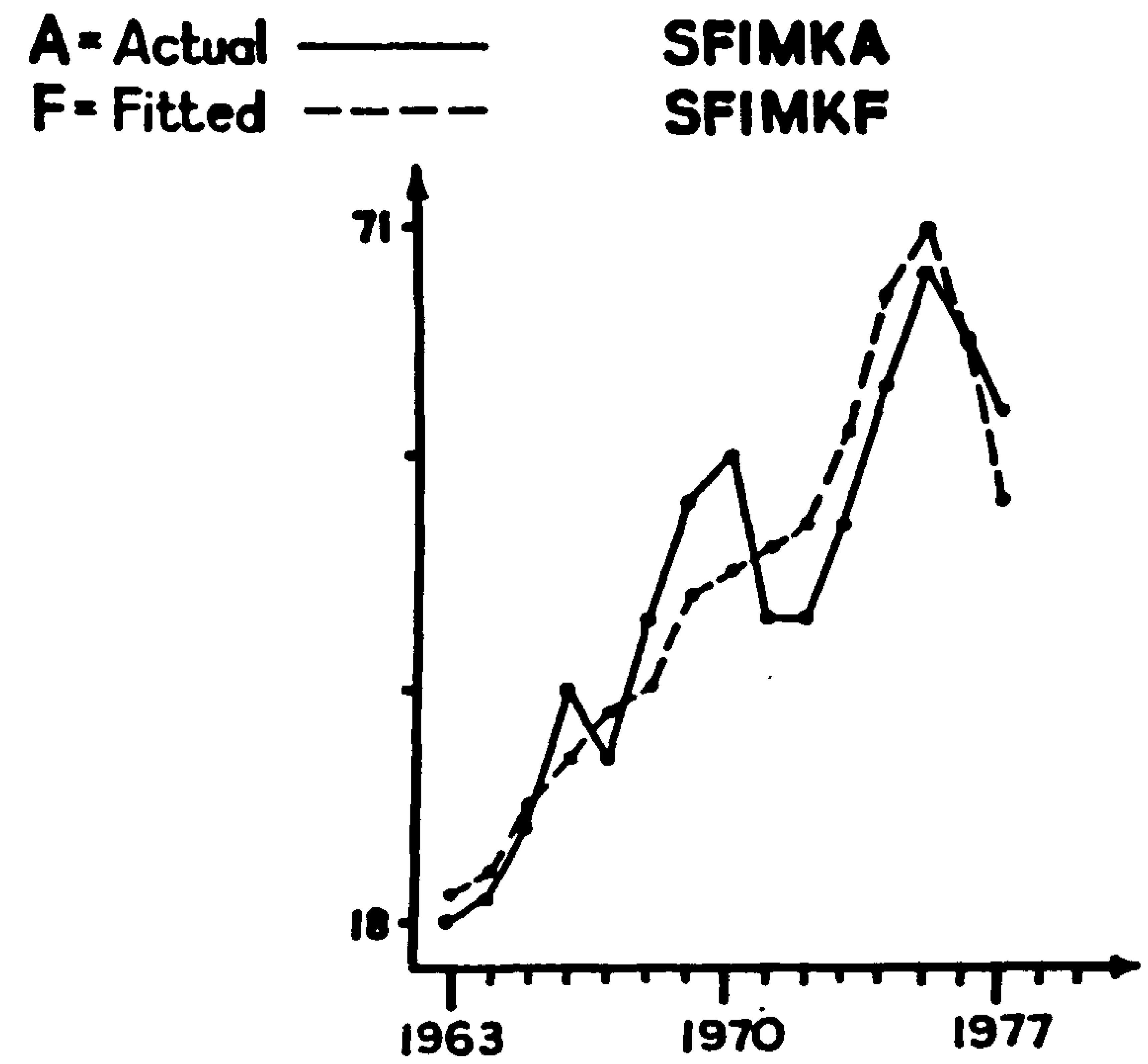
Theil's inequality coefficient = 0.5629D-01

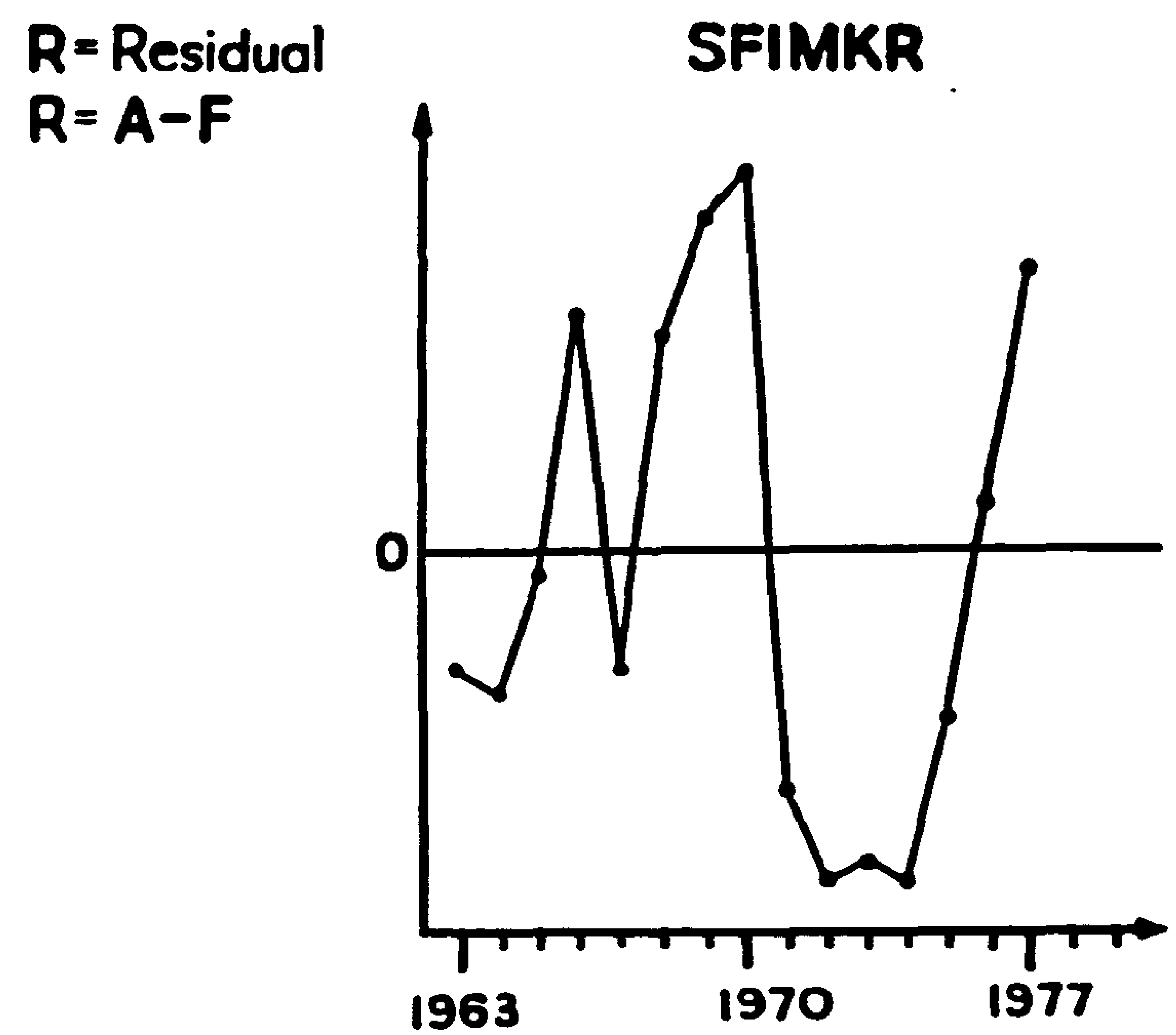
Fraction of error due to bias = 0.1629D-02

Fraction of error due to different variation = 0.1633D-02

Fraction of error due to different co-variation = 0.9967

Time	Actual	Fitted	Residual
1963	18.12	20.32	-2.20
1964	19.38	22.27	-2.89
1965	25.96	26.46	-0.49
1966	35.58	30.27	5.31
1967	31.26	33.73	-2.46
1968	41.11	36.15	4.97
1969	49.62	42.48	7.14
1970	52.74	44.44	8.30
1971	40.69	45.70	-5.01
1972	40.80	47.46	-6.66
1973	47.83	54.22	-6.39
1974	59.17	66.03	-6.86
1975	67.55	70.81	-3.27
1976	62.65	61.41	1.24
1977	56.61	50.45	6.71





14. Actual: dlnSFIMKA   Predicted: dlnSFIMKF   Residual: dlnSFIMKR

Correlation coefficient = 0.6662   (Squared = 0.4439)

Root-mean-squared error = 0.1322

Mean absolute error = 0.1008

Mean error = 0.7687D-02

Regression coefficient of actual on predicted = 1.06

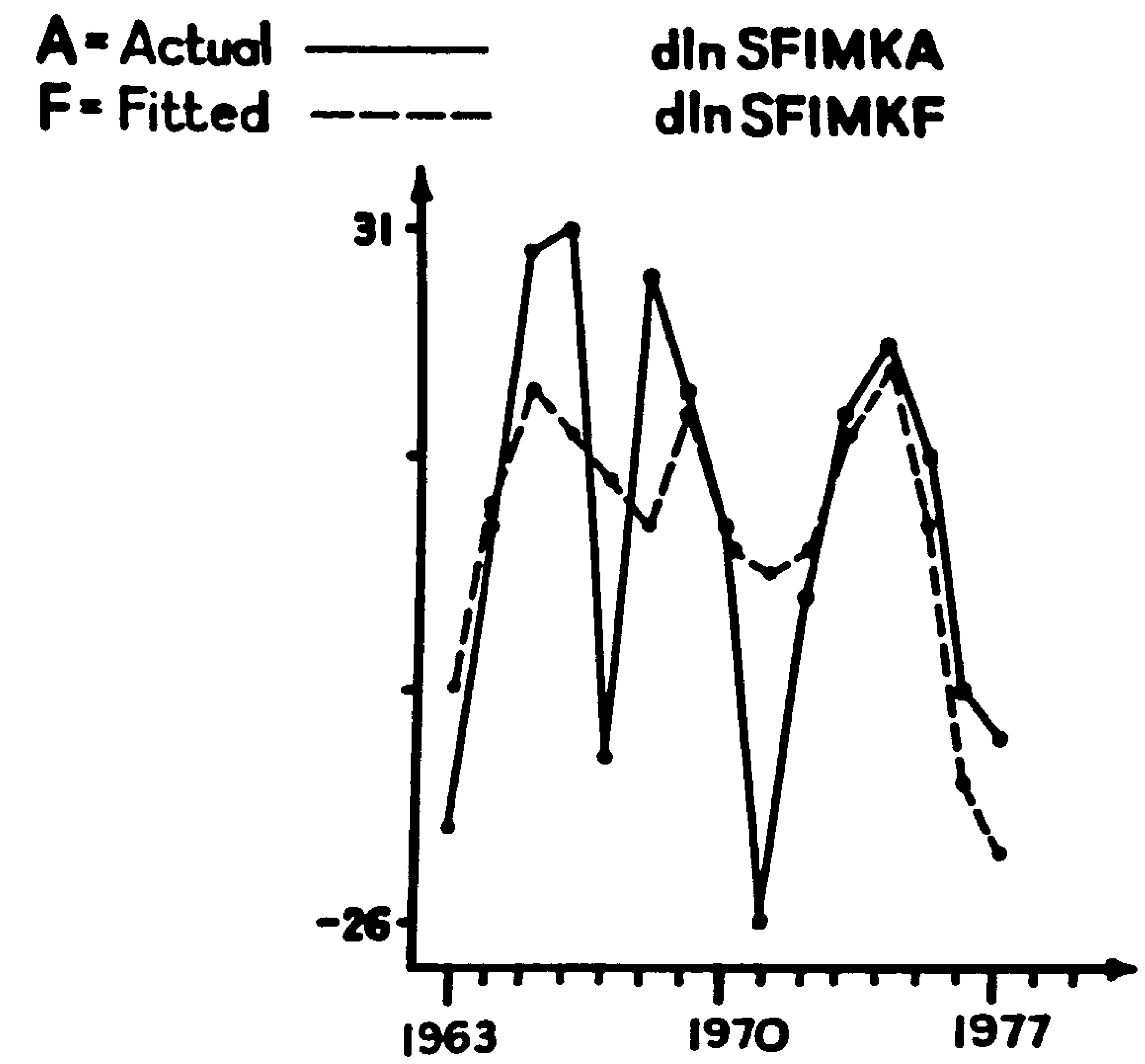
Theil's inequality coefficient = 0.4246

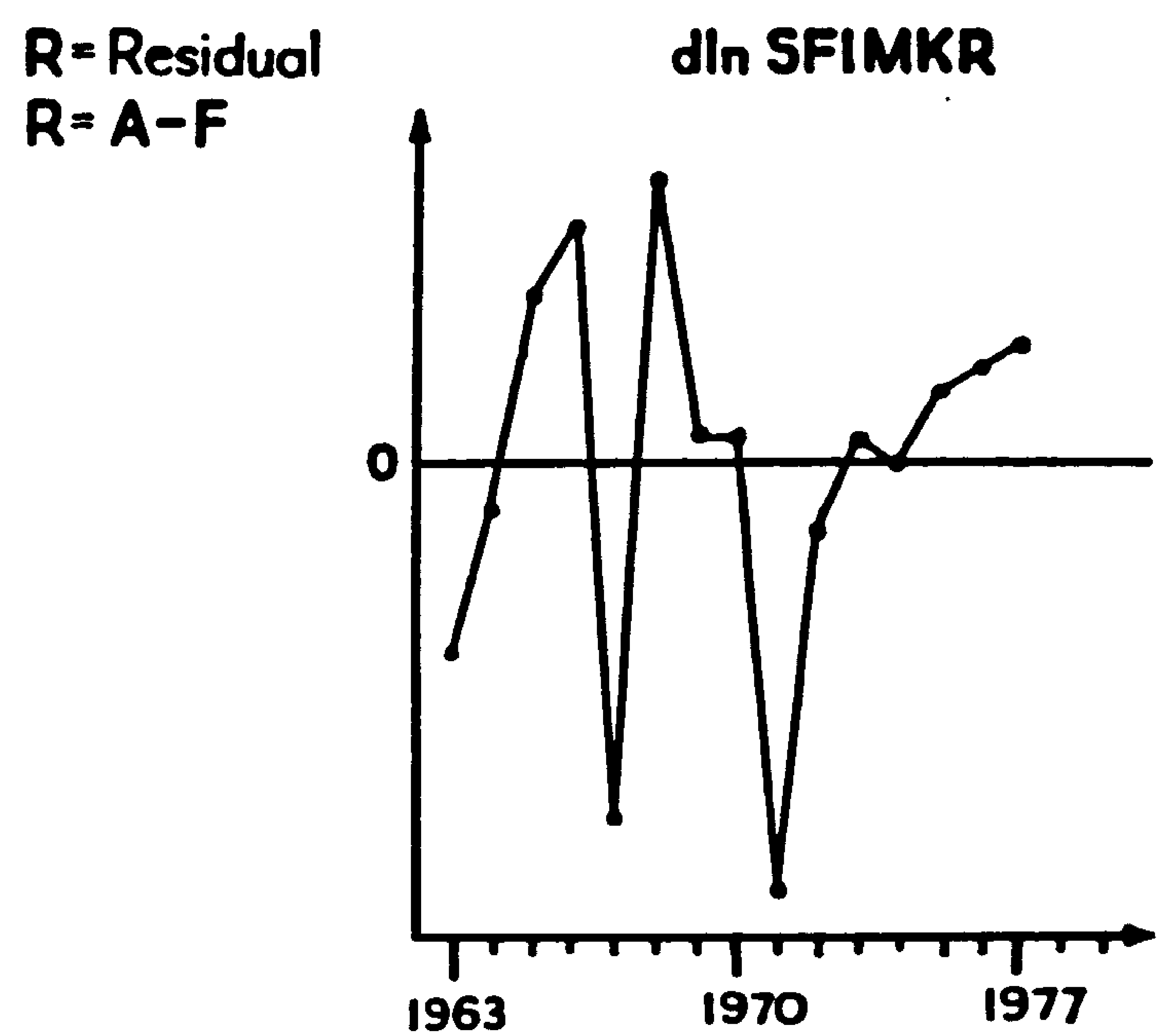
Fraction of error due to bias = 0.3382D-02

Fraction of error due to different variation = 0.2506

Fraction of error due to different co-variation = 0.7460

Time	Actual	Fitted	Residual
1963	-0.191	-0.768E-01	-0.115
1964	0.674E-01	0.915E-01	-0.241E-01
1965	0.292	0.172	0.120
1966	0.315	0.134	0.180
1967	-0.129	0.108	-0.237
1968	0.273	0.693E-01	0.205
1969	0.188	0.161	0.266E-01
1970	0.610E-01	0.451E-01	0.159E-01
1971	-0.259	0.279E-01	-0.287
1972	0.274E-02	0.378E-01	-0.351E-01
1973	0.159	0.133	0.259E-01
1974	0.212	0.197	0.157E-01
1975	0.132	0.699E-01	0.624E-01
1976	-0.753E-01	-0.142	0.672E-01
1977	-0.101	-0.196	0.954E-01





In the overall model sense the level version of SHIMKF performed least well of all the level equations, probably reflecting the fact that investment is an extremely difficult phenomenonto model given the empirical limits imposed by annual data. As can be seen from the time series plots, the actual series is quite volatile, while the Theil inequality coefficient, the covariation proportion (UC) and the correlation coefficient of actual on fitted are not spectacular. The level version of SFIMKA is however a lot smoother and the SFIMKF series tracks it fairly closely. In all of the simulation statistic categories monitored above, the foreign investment function performs better than home investment.

Regarding the dln versions of the two equations, dlnSHIMKF was below the standard of most the other growth equations in the model with a relatively low UC and a low correlation coefficient of actual on fitted. However considering the complexity of modelling investment and the added difficulty of finding good fits for models estimated in growth rates, both the level and difference results for SHIMK seem acceptable. As in levels, the dln version of SFIMK performed better as regards simulation statistics and turning points than did the dlnSHIMK.

15. Actual: SHEMA Predicted: SHEMF Residual: SHEMR

Correlation coefficient = 0.9684 (Squared = 0.9378)

Root-mean-squared error = 12.10

Mean absolute error = 10.19

Mean error = 0.7368

Regression coefficient of actual on predicted = 1.019

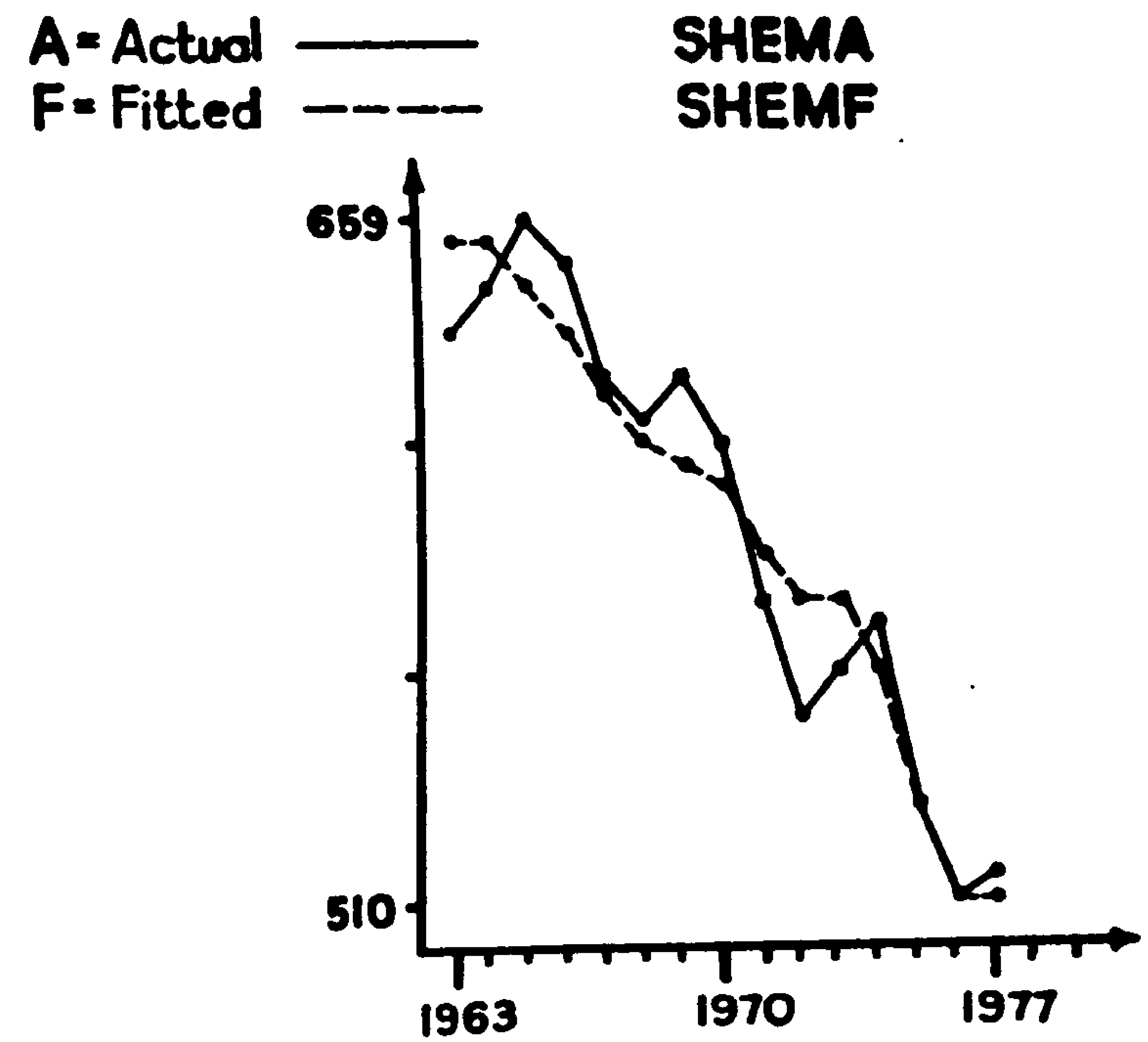
Theil's inequality coefficient = 0.1020D-01

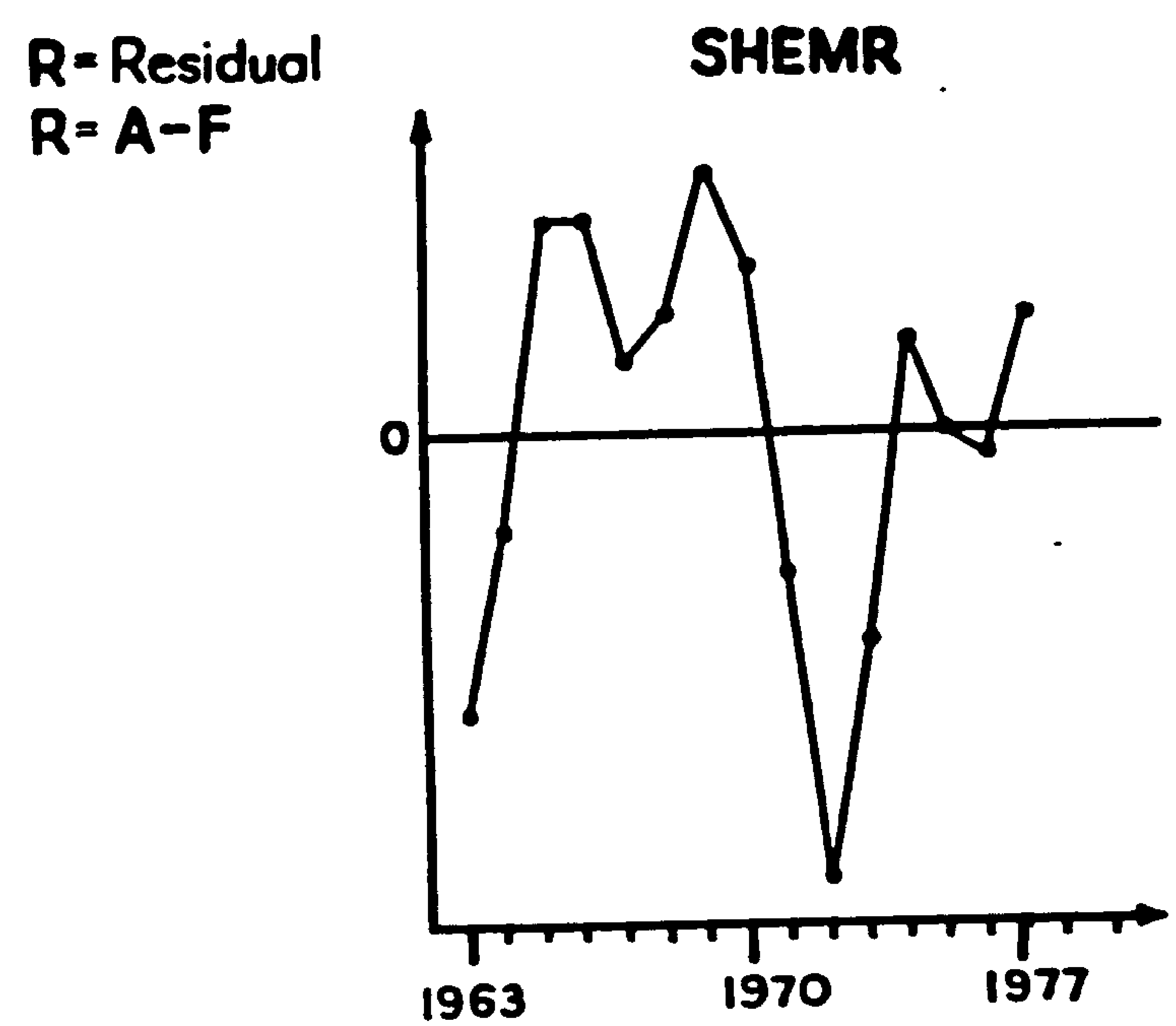
Fraction of error due to bias = 0.3706D-02

Fraction of error due to different variation = 0.3888D-01

Fraction of error due to different co-variation = 0.9574

Test	Actual	Fitted	Residual
1963	635.9	652.2	-16.3
1964	646.6	651.7	- 5.0
1965	659.1	646.0	13.1
1966	648.2	634.7	13.4
1967	624.0	618.6	5.3
1968	615.4	608.1	7.2
1969	622.3	605.8	16.5
1970	611.7	600.5	11.2
1971	575.7	584.4	-8.6
1972	547.5	574.7	-27.2
1973	561.6	574.2	-12.6
1974	568.1	561.0	7.1
1975	531.9	531.3	0.6
1976	510.5	511.7	-1.2
1977	517.3	509.9	7.3





16. Actual: dlnSHEMA Predicted: dlnSHEMF Residual: dlnSHEMR

Correlation coefficient = 0.7682 (Squared = 0.5901)

Root-mean-squared error = 0.2118D-01

Mean absolute error = 0.1799D-01

Mean error = 0.9566D-03

Regression coefficient of actual on predicted = 1.61

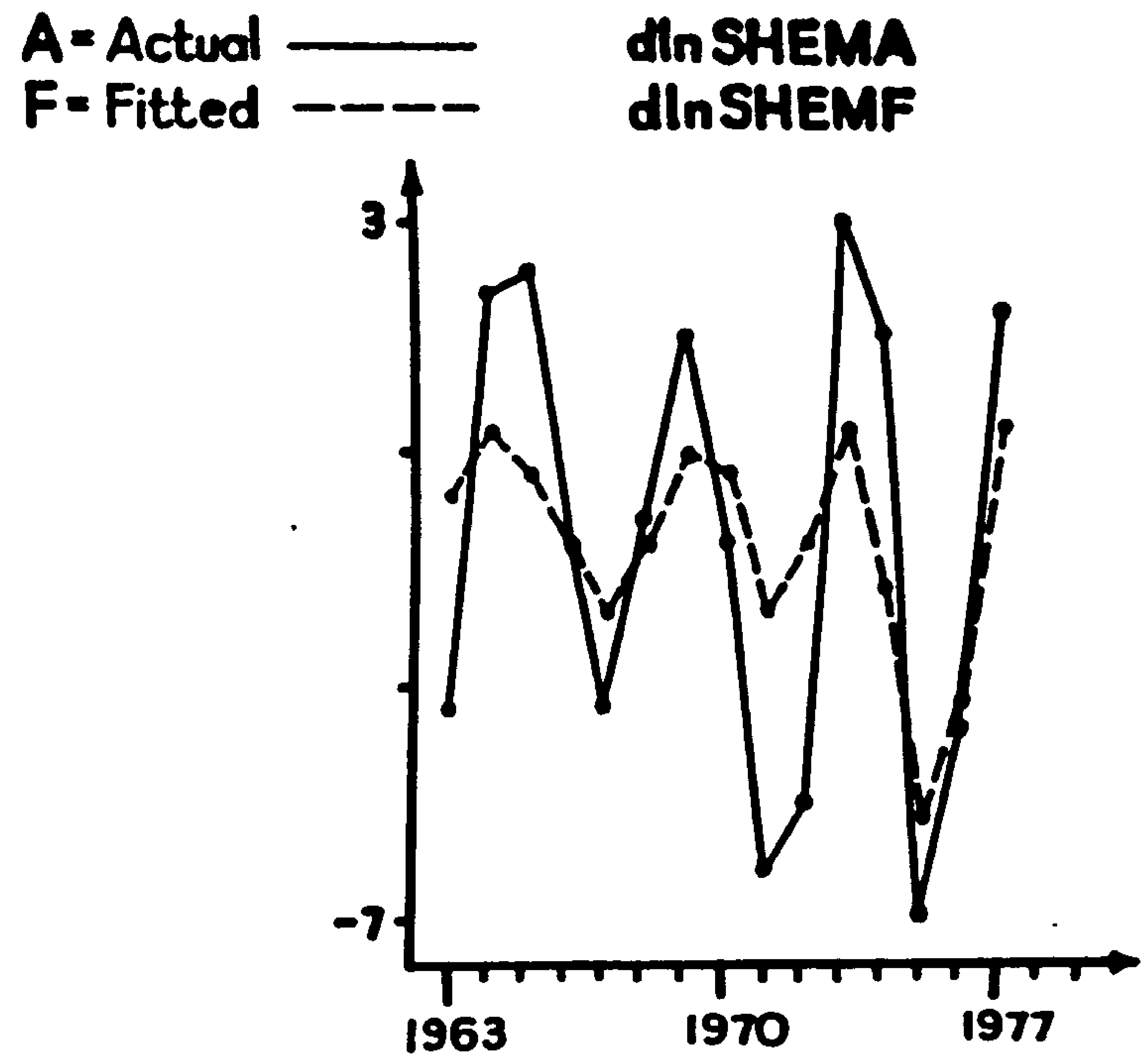
Theil's inequality coefficient = 0.3745

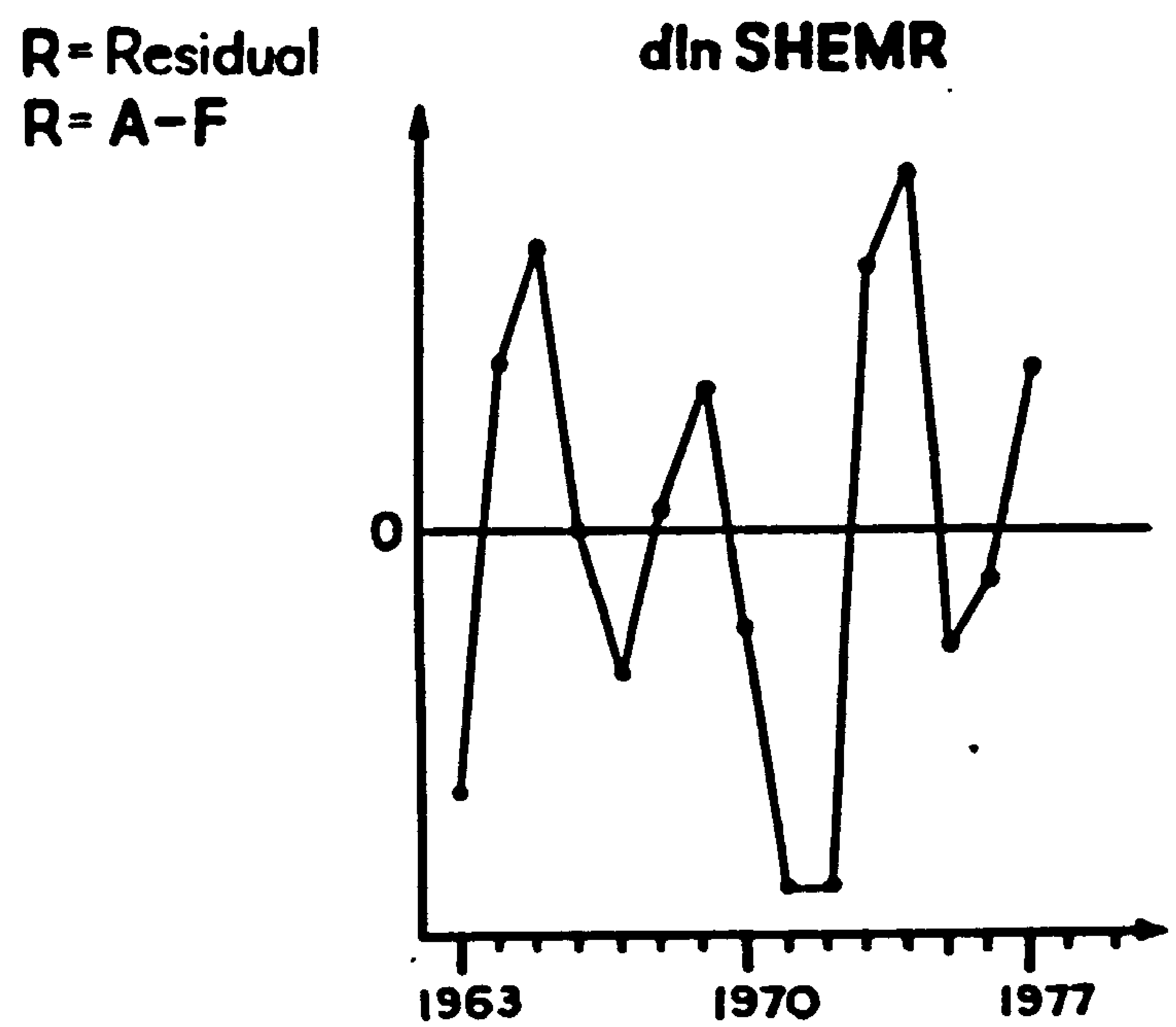
Fraction of error due to bias = 0.2039D-02

Fraction of error due to different variation = 0.5533

Fraction of error due to different co-variation = 0.4447

Time	Actual	Fitted	Residual
1963	-0.373E-01	-0.120E-01	-0.253E-01
1964	0.167E-01	-0.817E-01	0.175E-01
1965	0.190E-01	-0.880E-02	0.279E-01
1966	-0.167E-01	-0.175E-01	0.812E-03
1967	-0.380E-01	-0.267E-01	-0.123E-01
1968	-0.139E-01	-0.171E-01	0.321E-02
1969	0.111E-01	-0.375E-02	0.149E-01
1970	-0.171E-01	-0.885E-02	-0.834E-02
1971	-0.606E-01	-0.272E-01	-0.334E-01
1972	-0.501E-01	-0.166E-01	-0.335E-01
1973	0.253E-01	-0.885E-03	0.263E-01
1974	0.114E-01	-0.233E-01	0.347E-01
1975	-0.658E-01	-0.543E-01	-0.114E-01
1976	-0.410E-01	-0.374E-01	-0.356E-02
1977	0.132E-01	-0.351E-02	0.167E-01





17. Actual: SFEMA Predicted: SFEMF Residual SFEMR

Correlation coefficient = 0.9421 (Squared = 0.8876)

Root-mean-squared error = 5.73

Mean absolute error = 4.74

Mean error = 0.9981

Regression coefficient of actual on predicted = 0.9084

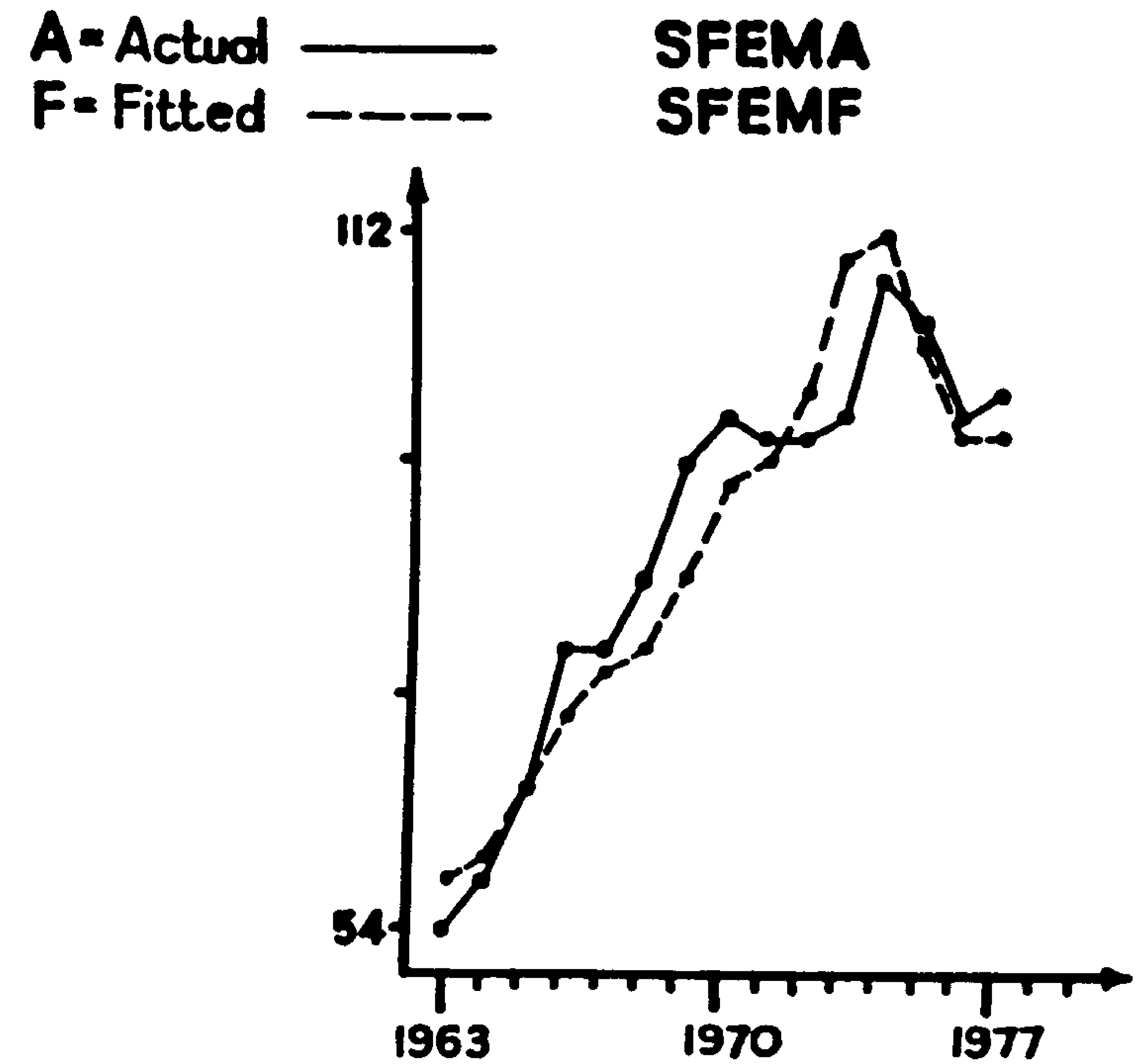
Theil's inequality coefficient = 0.3282D-01

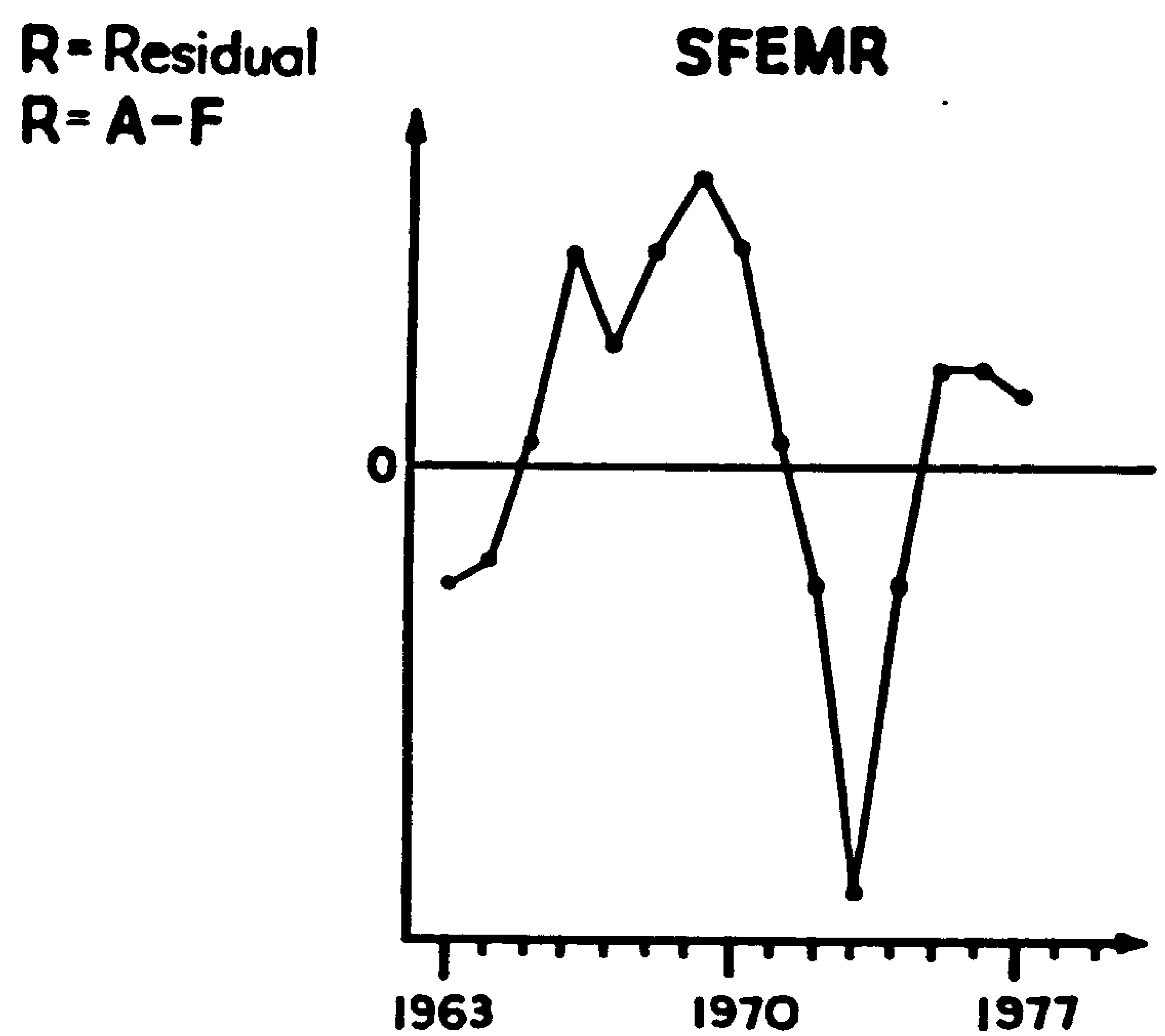
Fraction of error due to bias = 0.3025D-01

Fraction of error due to different variation = 0.1099D-01

Fraction of error due to different co-variation = 0.9588

Time	Actual	Fitted	Residual
1963	53.57	57.54	-3.97
1964	56.85	60.18	-3.33
1965	65.51	64.55	0.95
1966	77.42	70.39	7.03
1967	77.91	73.88	4.03
1968	83.74	77.04	6.70
1969	91.91	82.98	8.93
1970	96.32	89.74	6.58
1971	93.60	92.79	0.80
1972	95.05	98.59	-3.54
1973	95.48	109.00	-13.50
1974	108.10	111.90	-3.77
1975	105.00	102.00	3.00
1976	97.29	94.19	3.11
1977	97.49	95.53	1.96





18. Actual: dlnSFEMA Predicted: dlnSFEMF Residual: dlnSFEMR

Correlation coefficient = 0.5822 (Squared = 0.3390)

Root-mean-squared error = 0.5764D-01

Mean absolute error = 0.4938D-01

Mean error = 0.1357D-02

Regression coefficient of actual on predicted = 0.7549

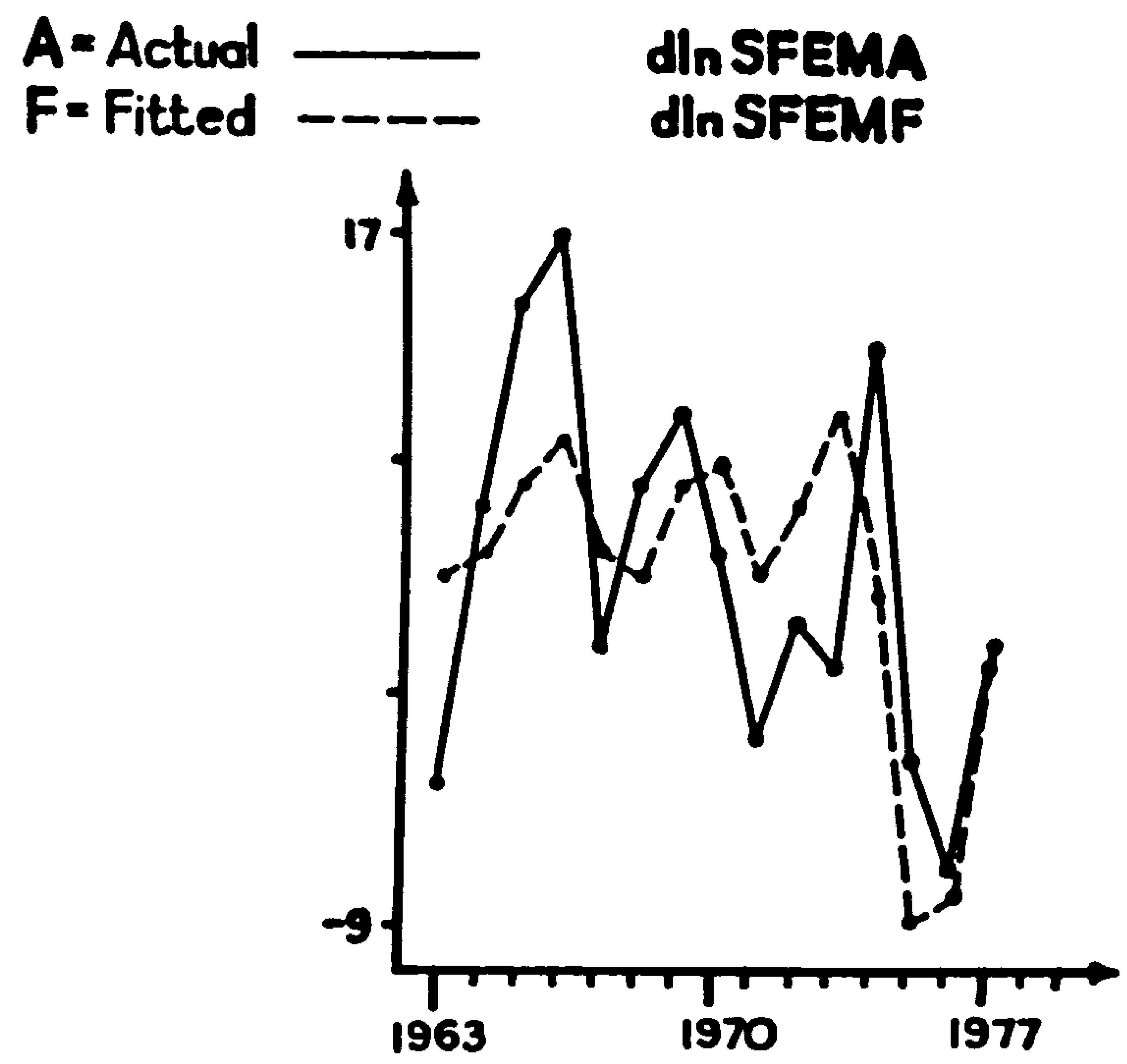
Theil's inequality coefficient = 0.4038

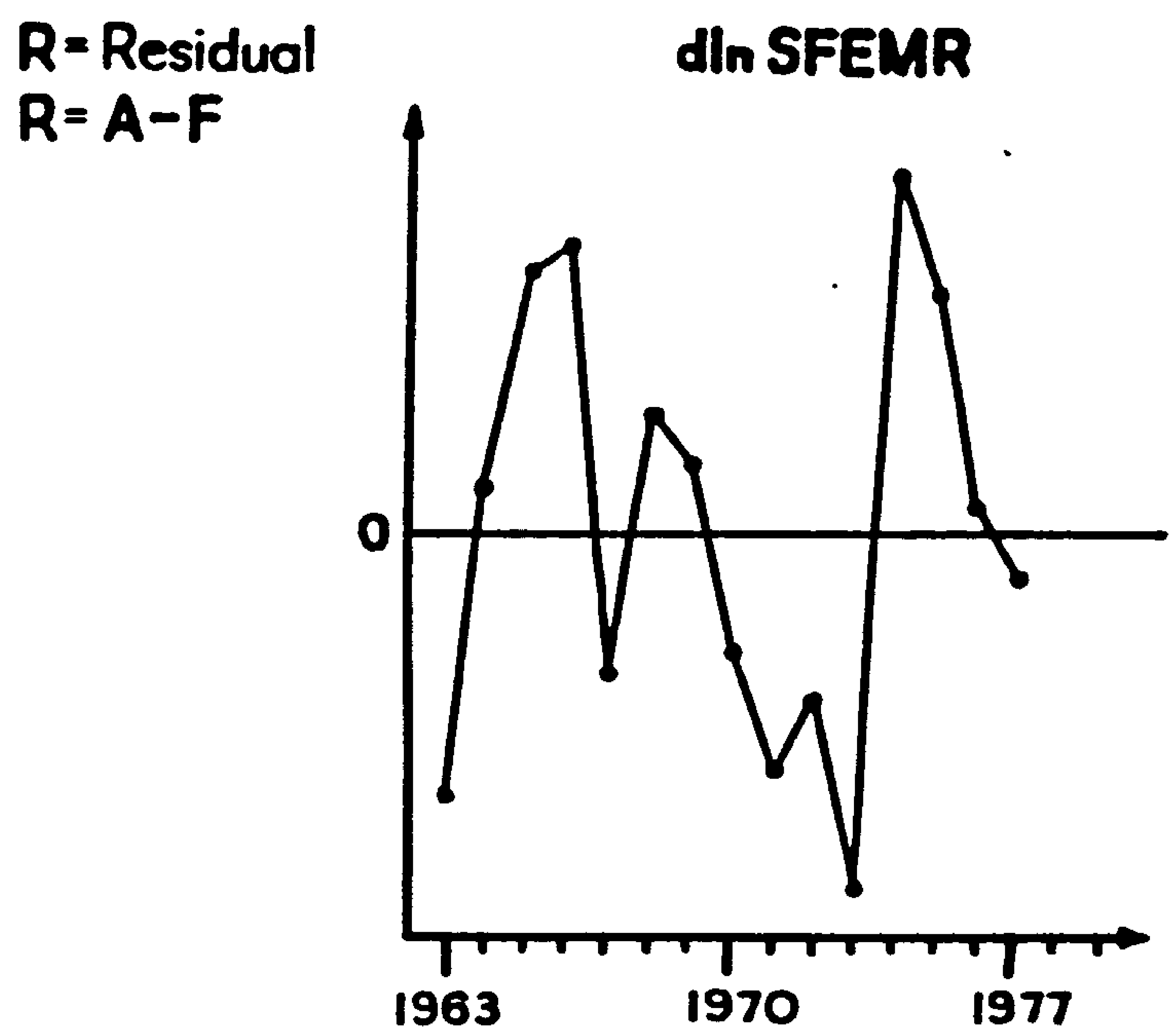
Fraction of error due to bias = 0.5542D-03

Fraction of error due to different variation = 0.7506D-01

Fraction of error due to different co-variation = 0.9244

Time	Actual	Fitted	Residual
1963	-0.386E-01	0.327E-01	-0.714E-01
1964	0.594E-01	0.449E-01	0.145E-01
1965	0.141	0.700E-01	0.716E-01
1966	0.167	0.866E-01	0.805E-01
1967	0.625E-02	0.483E-01	-0.421E-01
1968	0.721E-01	0.419E-01	0.302E-01
1969	0.931E-01	0.743E-01	0.189E-01
1970	0.468E-01	0.782E-01	-0.315E-01
1971	-0.286E-01	0.334E-01	-0.621E-01
1972	0.154E-01	0.606E-01	-0.452E-01
1973	0.447E-02	0.100	-0.959E-01
1974	0.124	0.263E-01	0.982E-01
1975	-0.293E-01	-0.926E-01	0.633E-01
1976	-0.763E-01	-0.797E-01	0.342E-02
1977	0.205E-02	0.141E-01	-0.121E-01





19. Actual: DEMA Predicted: DEMF Residual: DEMR

Correlation coefficient = 0.9944 (Squared = 0.9887)

Root-mean-squared error = 95.38

Mean absolute error = 82.21

Mean error = 10.37

Regression coefficient of actual on predicted = 0.9762

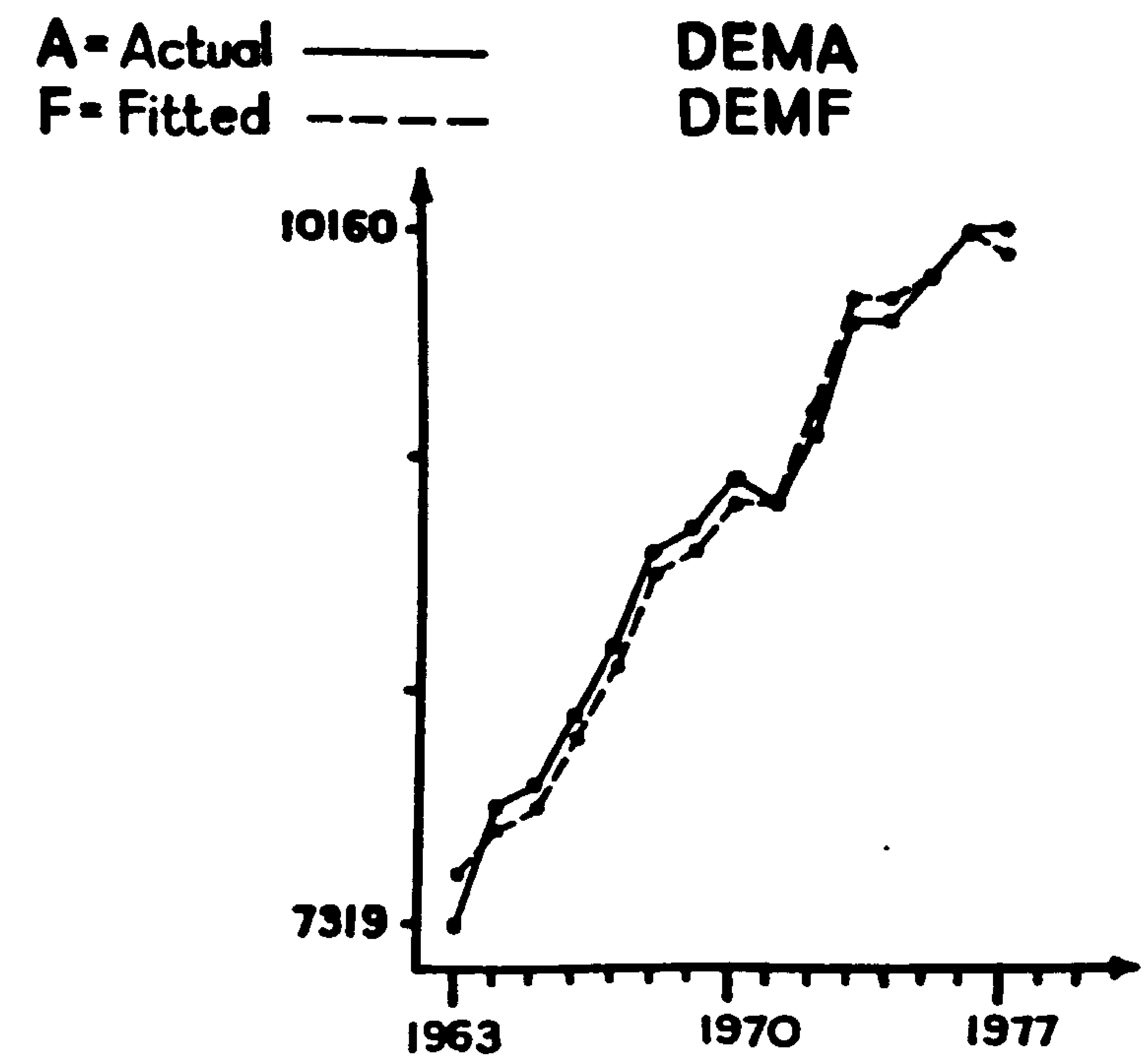
Theil's inequality coefficient = 0.5288D-02

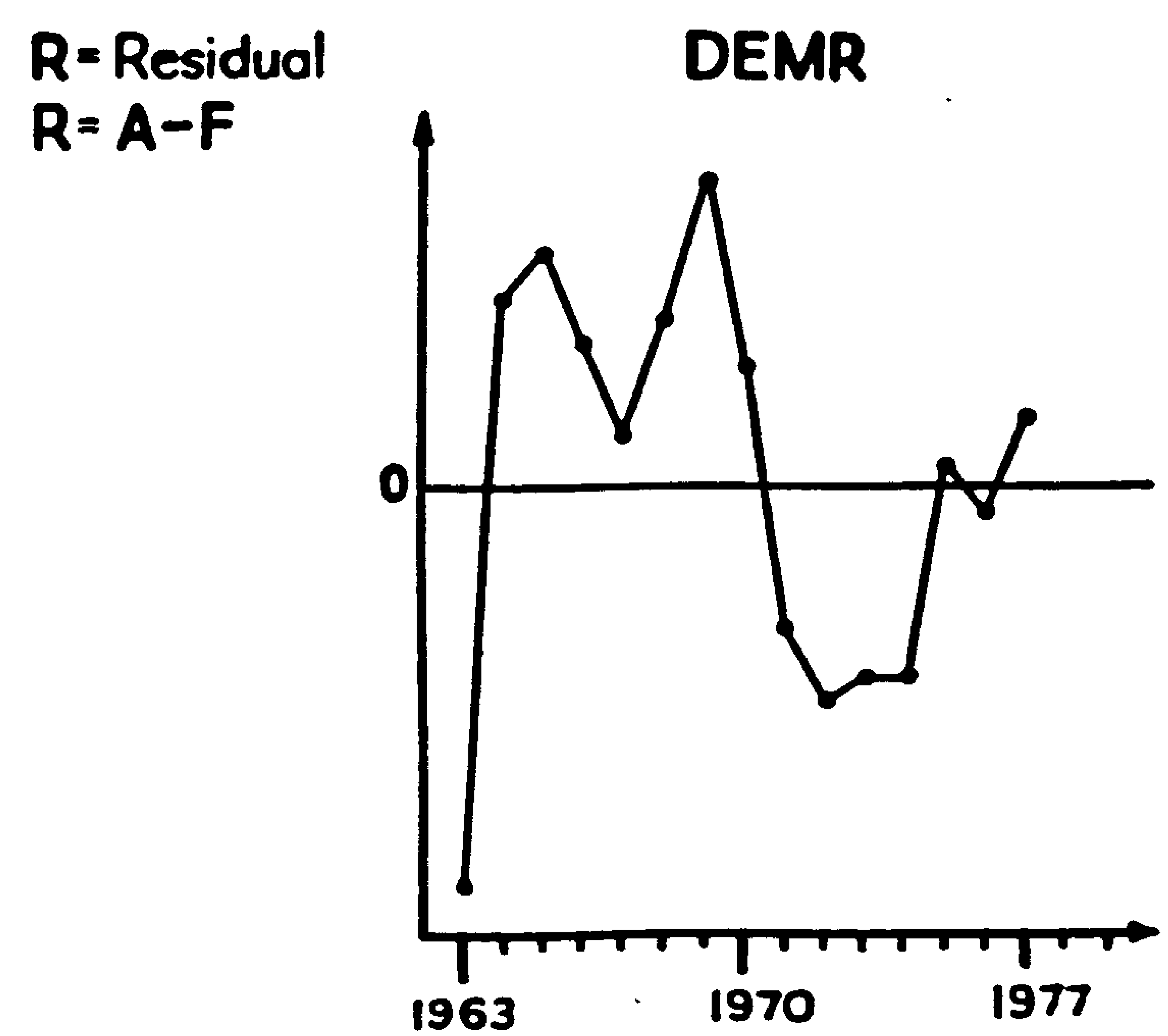
Fraction of error due to bias = 0.1182D-02

Fraction of error due to different variation = 0.2872D-01

Fraction of error due to different co-variation = 0.9595

Time	Actual	Fitted	Residual
1963	7319.	7512.	-193.0
1964	7793.	7688.	105.0
1965	7920.	7795.	125.0
1966	8166.	8086.	79.9
1967	8409.	8378.	31.3
1968	8870.	8782.	87.9
1969	8967.	8813.	154.0
1970	9132.	9072.	60.0
1971	8997.	9063.	-66.7
1972	9327.	9432.	-105.0
1973	9756.	9837.	- 80.8
1974	9797.	9878.	- 80.3
1975	9965.	9954.	11.8
1976	0.1015E 05	0.1016E05	-13.1
1977	0.1013E 05	0.1009E05	40.0





20. Actual: dlnDEMA Predicted: dlnDEMF Residual: dlnDEMR

Correlation coefficient = 0.7356 (Squared = 0.5411)

Root-mean-squared error = 0.7356

Mean absolute error = 0.13820D-01

Mean error = 0.9483D-02

Regression coefficient of actual on predicted = 0.8699

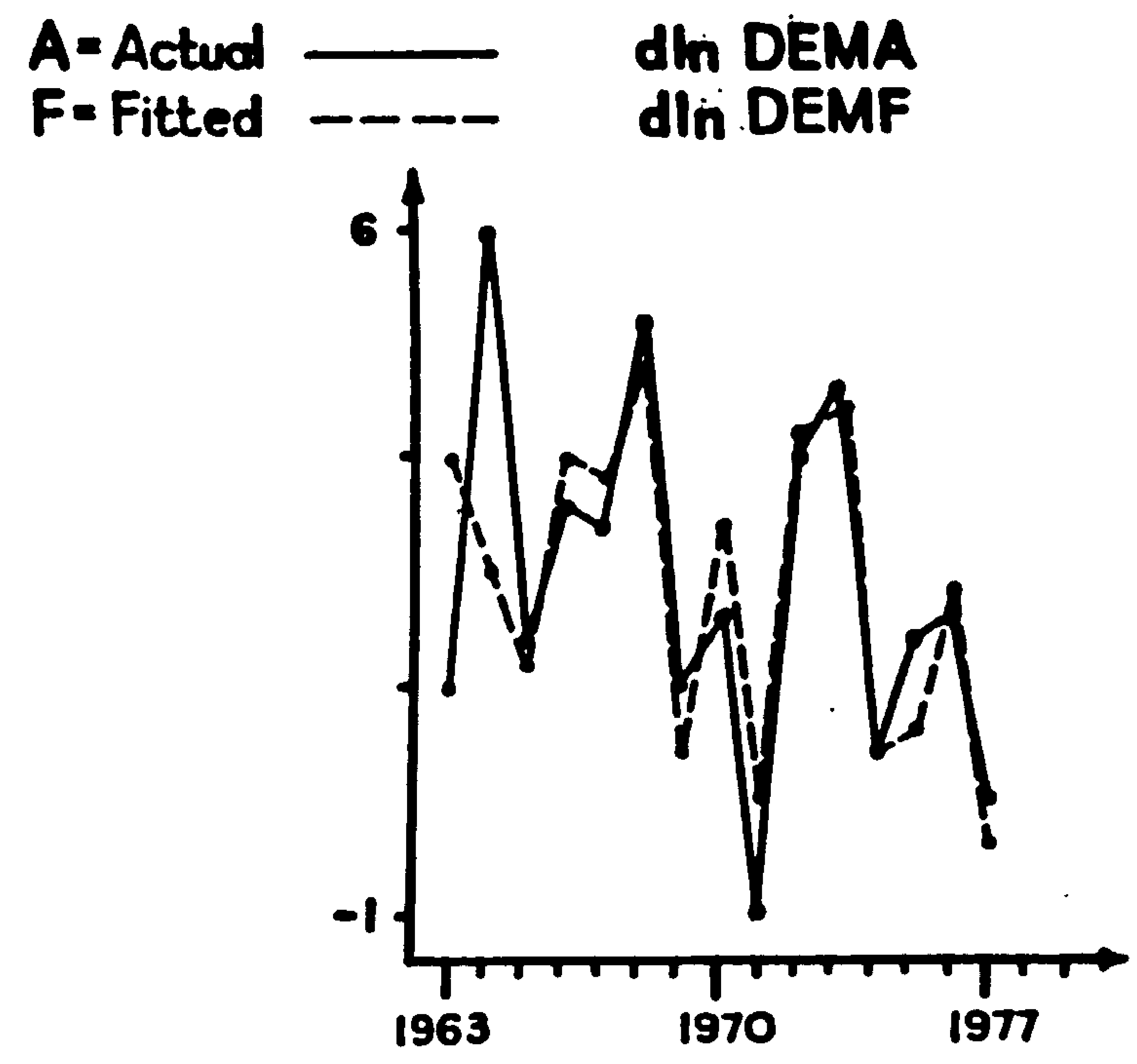
Theil's inequality coefficient = 0.2380

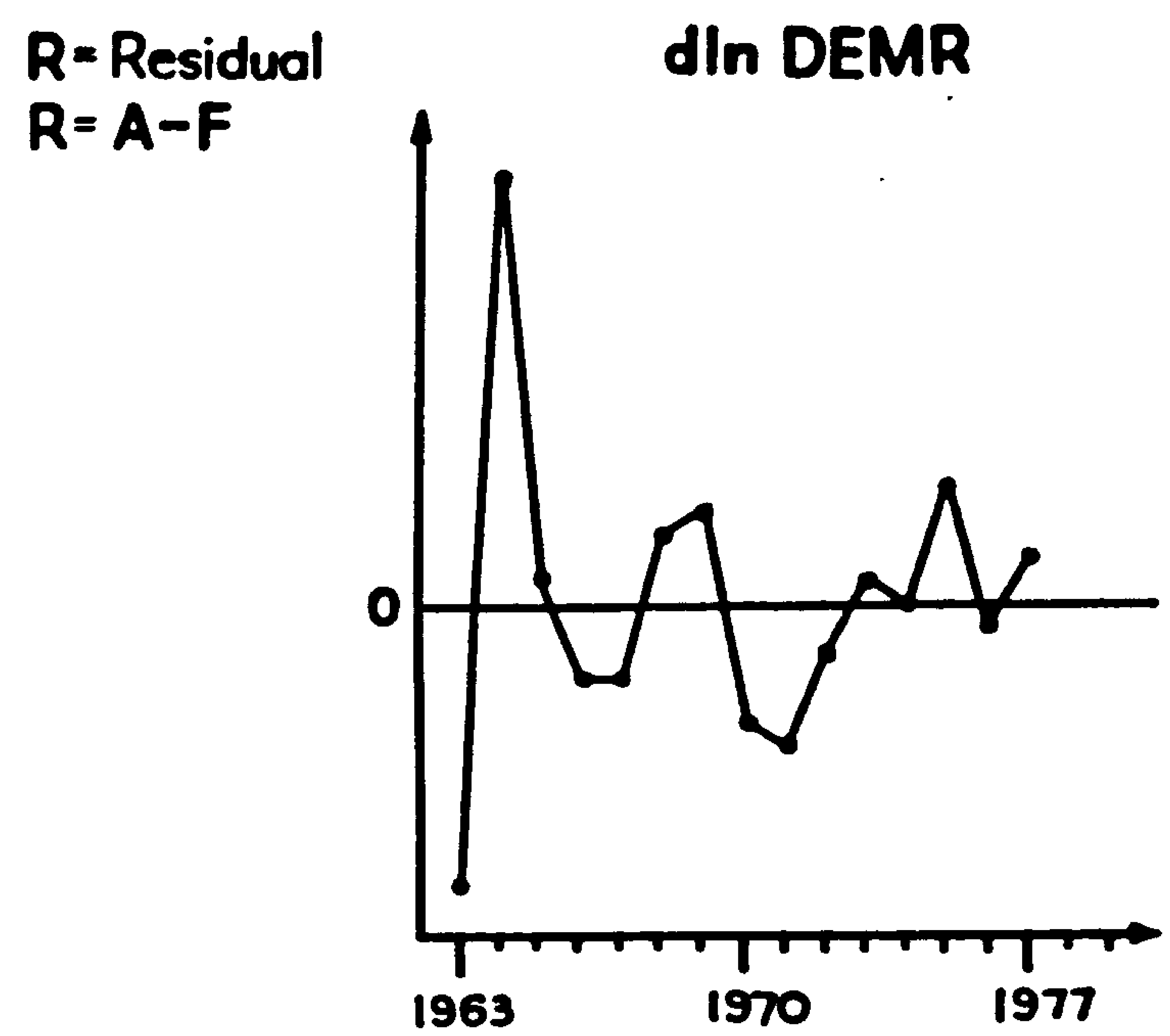
Fraction of error due to bias = 0.3638D-01

Fraction of error due to different variation = 0.5063D-01

Fraction of error due to different co-variation = 0.9490

Time	Actual	Fitted	Residual
1963	0.110E-01	0.370E-01	-0.260E-01
1964	0.626E-01	0.231E-01	0.395E-01
1965	0.161E-01	0.138E-01	0.234E-02
1966	0.306E-01	0.366E-01	-0.603E-02
1967	0.293E-01	0.354E-01	-0.611E-02
1968	0.534E-01	0.471E-01	0.623E-02
1969	0.108E-01	0.347E-02	0.738E-02
1970	0.182E-01	0.289E-01	-0.107E-01
1971	-0.149E-01	-0.937E-03	-0.140E-01
1972	0.361E-01	0.399E-01	-0.382E-02
1973	0.449E-01	0.420E-01	0.296E-02
1974	0.420E-02	0.411E-02	0.845E-04
1975	0.170E-01	0.767E-02	0.935E-02
1976	0.185E-01	0.209E-01	-0.248E-02
1977	-0.203E-02	-0.727E-02	0.525E-02





21. Actual: STEMA Predicted: STEMF Residual: STEMR

Correlation coefficient = 0.8964 (Squared = 0.8035)

Root-mean-squared error = 16.61

Mean absolute error = 14.16

Mean error = 1.73

Regression coefficient of actual on predicted = 0.9931

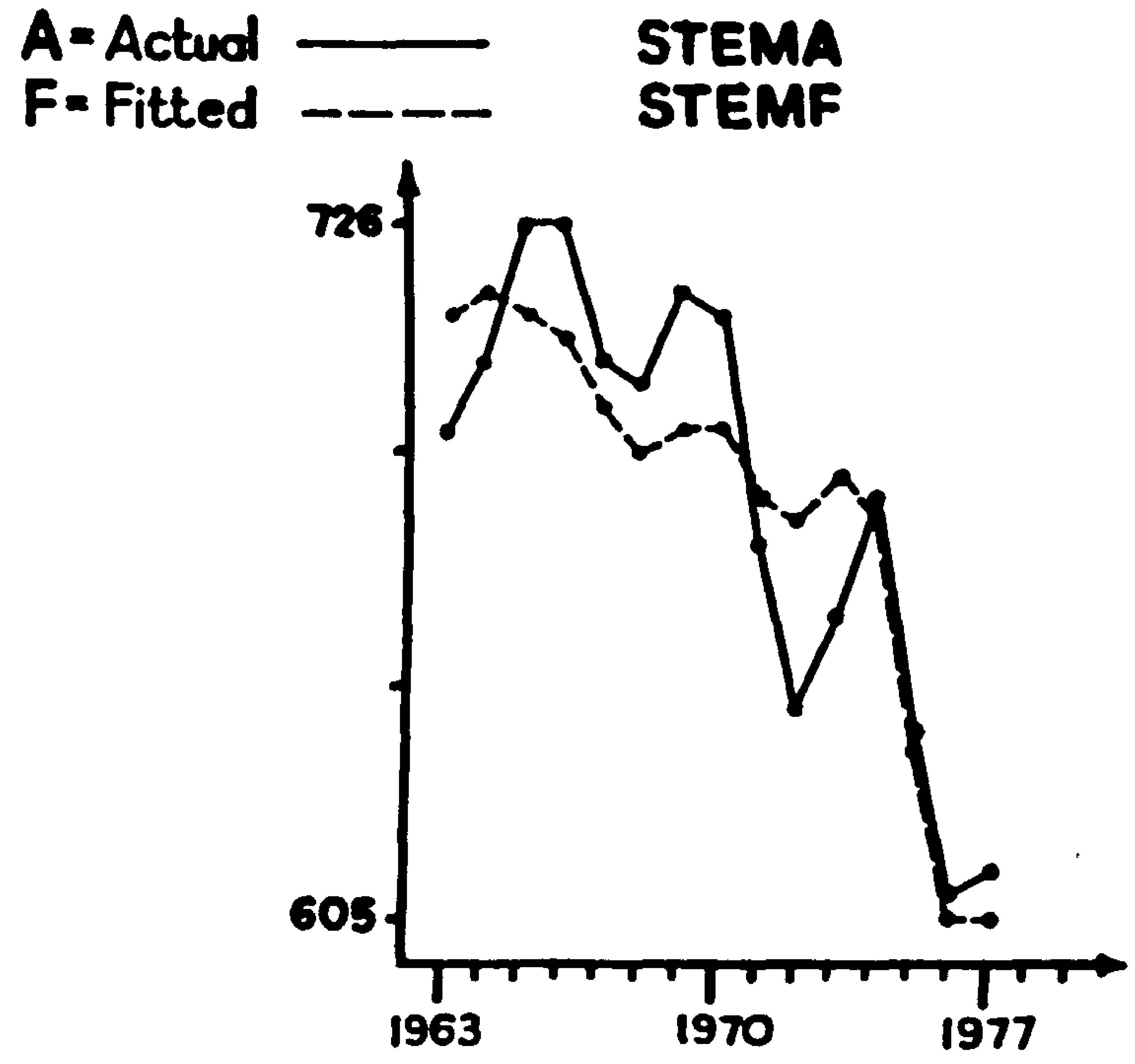
Theil's inequality coefficient = 0.1225D-01

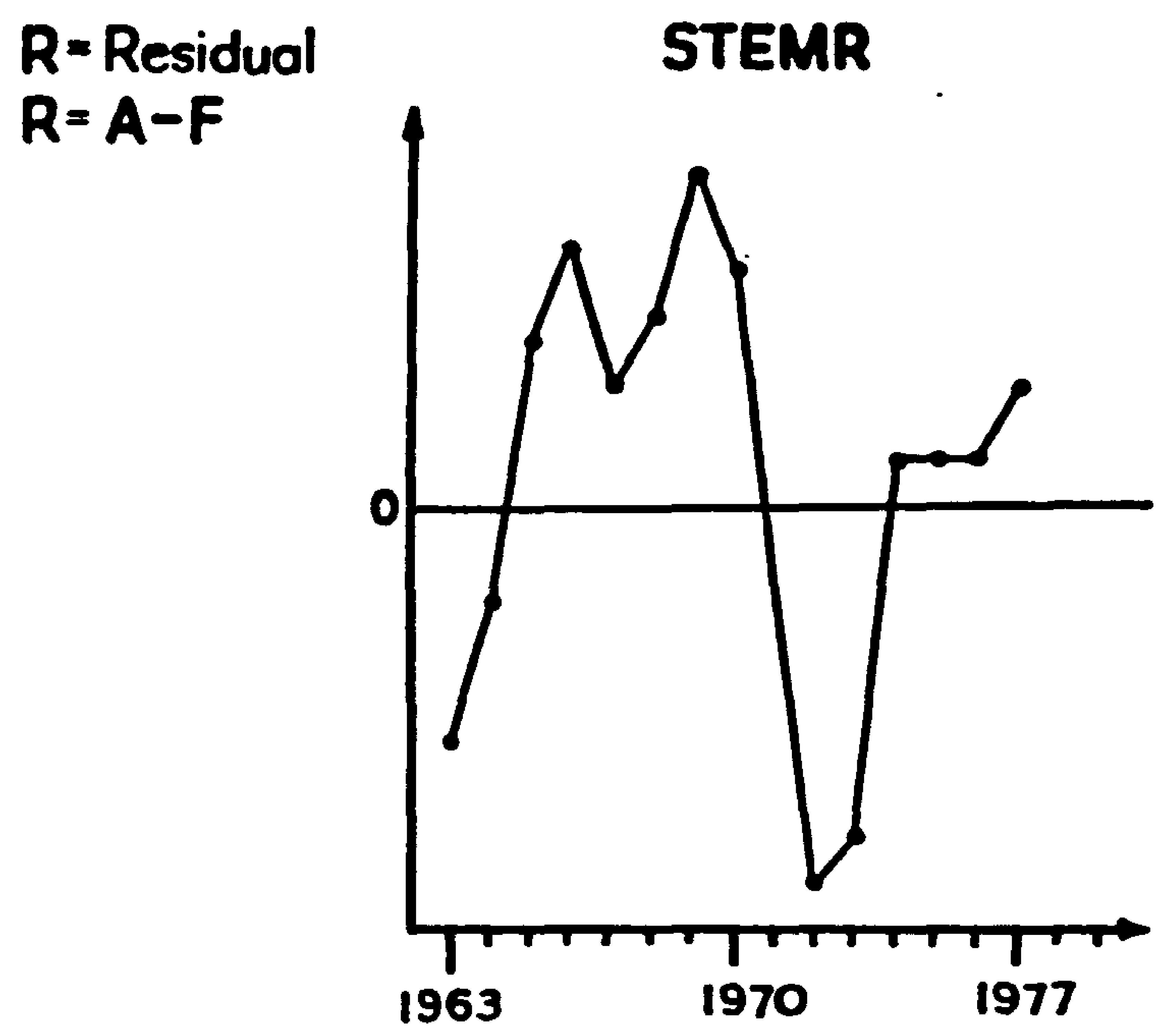
Fraction of error due to bias = 0.1091D-01

Fraction of error due to different variation = 0.4776D-01

Fraction of error due to different co-variation = 0.9413

Time	Actual	Fitted	Residual
1963	689.5	709.7	-20.2
1964	703.5	711.9	- 8.3
1965	724.6	710.5	14.1
1966	725.6	705.1	20.5
1967	701.9	685.2	9.4
1968	669.1	685.2	13.9
1969	714.2	688.8	25.4
1970	708.0	690.2	17.8
1971	669.3	677.3	- 7.8
1972	642.6	673.3	-30.7
1973	657.1	683.2	-26.1
1974	676.2	672.9	3.3
1975	636.9	633.3	3.6
1976	607.8	605.9	1.8
1977	614.8	605.5	9.3





22. Actual: dlnSTEMA   Predicted: dlnSTEMF   Residual: dlnSTEMR

Correlation coefficient = 0.7091   (Squared = 0.5029)

Root-mean-squared error = 0.2249D-01

Mean absolute error = 0.1829D-01

Mean error = 0.1020D-02

Regression coefficient on actual of predicted = 1.19

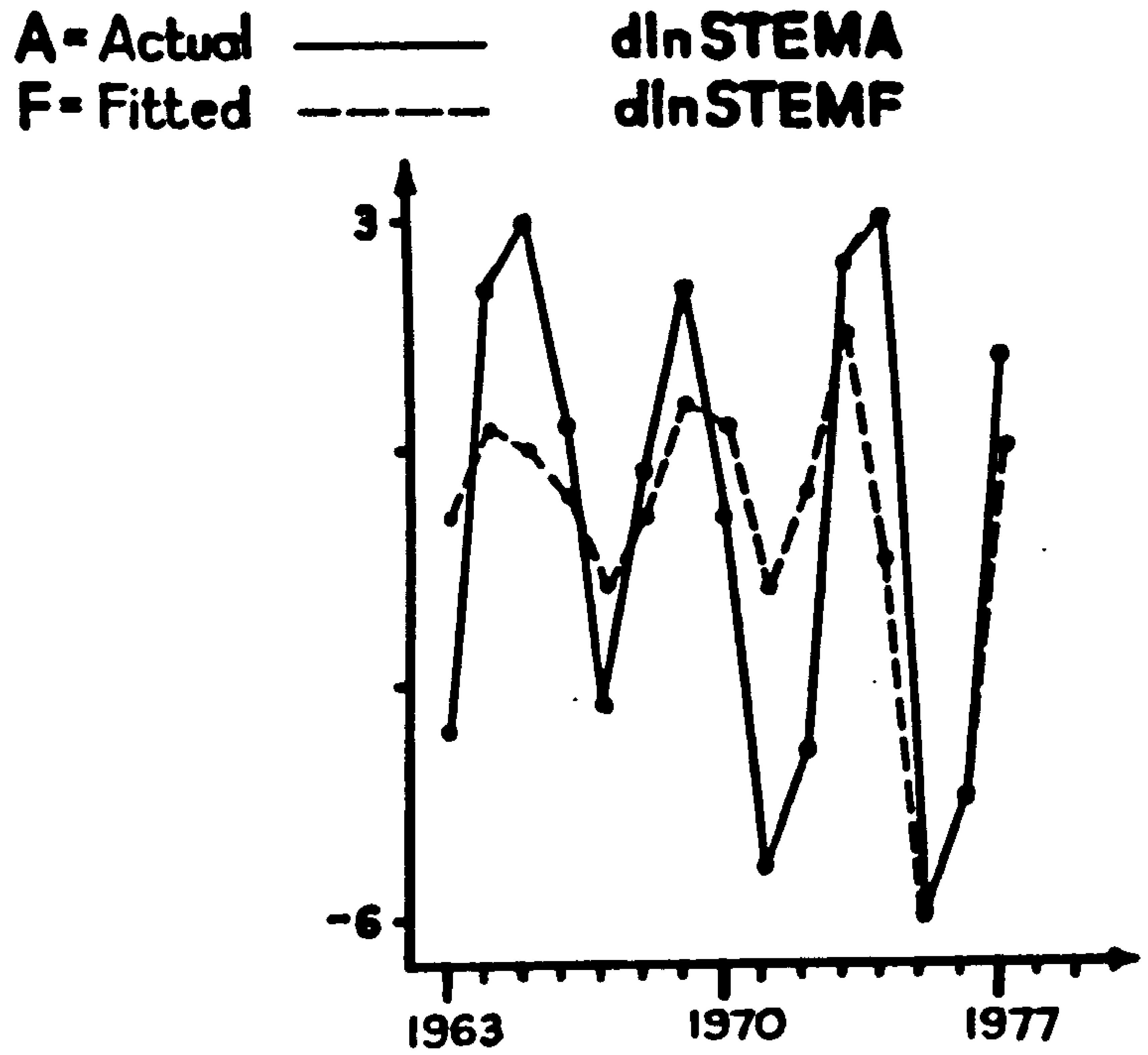
Theil's inequality coefficient = 0.4106

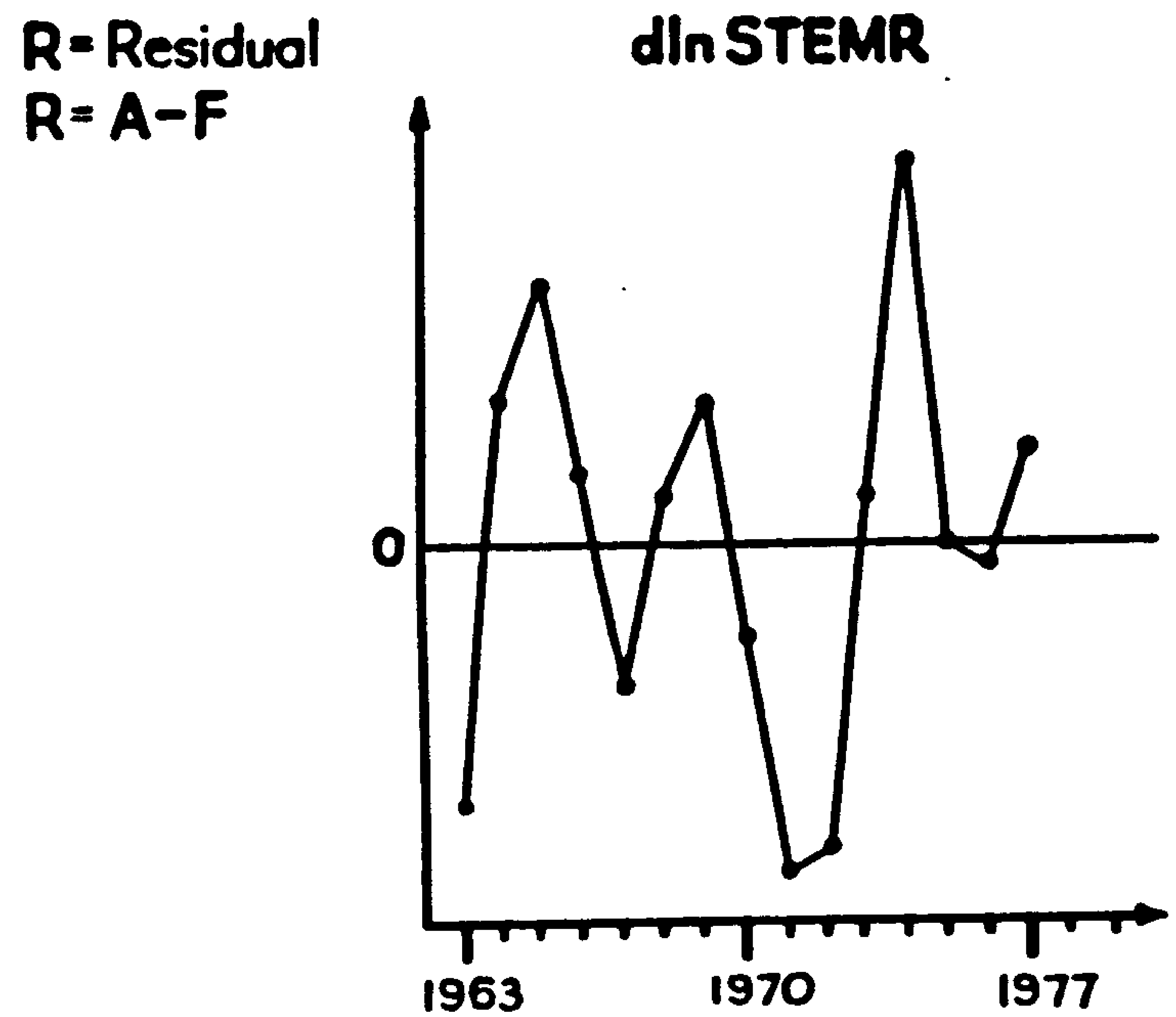
Fraction of error due to bias = 0.2057D-01

Fraction of error due to different variation = 0.3233

Fraction of error due to different co-variation = 0.6746

Time	Actual	Fitted	Residual
1963	-0.374E-01	-0.850E-02	-0.289E-02
1964	0.201E-01	0.297E-02	0.171E-01
1965	0.295E-01	-0.189E-02	0.314E-01
1966	0.137E-02	-0.758E-02	0.897E-02
1967	-0.332E-01	-0.180E-01	-0.151E-01
1968	-0.399E-02	-0.106E-01	0.666E-02
1969	0.213E-01	0.532E-02	0.160E-02
1970	-0.871E-02	0.205E-02	-0.108E-01
1971	-0.562E-01	-0.191E-01	-0.371E-01
1972	-0.407E-01	-0.570E-02	-0.350E-01
1973	0.224E-01	0.145E-01	0.772E-02
1974	0.286E-01	-0.152E-01	0.439E-01
1975	-0.598E-01	-0.606E-01	0.763E-03
1976	-0.467E-01	-0.441E-01	-0.260E-02
1977	0.114E-01	-0.744E-03	0.122E-01





The 'levels' equations in the employment block all seem to be performing quite well as evidenced by the plots of actual on fitted and by the reported simulation statistics. UC for example is .95 in both the home and foreign employment equations and .92 for the total employment identity. The largest residuals occurring in 1972 for SHEM and 1973 for SFEM. However, in all these cases the correlation coefficient of actual on fitted is quite high.

The employment equations in rates of growth also seem to track reasonably well, with the dlnSFEM equation either leading or lagging the turning points in the actual series by approximately one year over most of the estimation period. The dlnSHEMF series, on the other hand, matches the turning points in dlnSFEMA quite consistently although the fitted series seem to alternate quite consistently at over and under predicting, perhaps reflecting the auto-correlation present in the single equation specification.

Finally, the DEM identities in levels and rates of change track the historical data very well, with the exception of the first several periods in the dlnDEM equations. As usual this can be verified by actual and fitted plots as well as the simulation test statistics.

Note: Comment was not made on the RMSE, MAE and the mean error (ME) throughout this Chapter since these statistics are more relevant to comparing competing models i.e. assuming everything else equal, it is desirable to use the model with the lowest values for each of these measures. These statistics were however used in combination with other model evaluation criterion when choosing between different versions of the model earlier in this Chapter.

Summary

Chapter VI has been concerned with the econometrics of SIMFOR as a multi-equation system. It has been argued that identification in the traditional sense is not a problem in SIMFOR, that OLS should be the estimation method used for obtaining the structural parameters of the system, and that the Gauss-Seidel solution technique in a dynamic deterministic mode should be applied. Following the above, six separate versions of the model were set out, on which various evaluation procedures were applied (e.g. sensitivity analysis, historical simulation properties, turning points, etc.) in order to arrive at the "best" version for use in Chapter VII. This was followed by a presentation of the empirical results of a historical simulation (V^6), for the key blocks of the model. Both plots of actual on fitted and the simulation statistics, e.g. RMSE's, Theil inequality coefficients, correlation coefficients, etc. were reported. Having done this, Chapter VII follows with the simulation experiments that will enable the net overall macro impacts of FDI on Scotland to be ascertained.

NOTES: CHAPTER VI

1. The rank condition states that if it is possible to construct at least one non-zero determinant of order (C - 1) from the parameters of the variables excluded from that equation but contained in the other equations of the model, then in the system of C equations, that particular equation is identified. In other words, a sufficient condition for the identification of a relationship, is that the rank of the matrix of coefficients of all the excluded variables from that equation be equal to (C - 1). In practice, however, this condition is rarely used since it is only applicable to simple linear equations.

2. See Sims, C. A. 'Macroeconomics and Reality', *Econometrica*, Vol. 48, No. 1 (Jan. 1980), pp. 1-48.

3. See Sims, C. A. 'Policy Analysis with Econometric Models', *Brookings Papers on Economic Activity*, Vol 1 (1982), pp. 107-152.

4. While Sims' approach suggests a constructive alternative to a complicated methodological problem, it has not been taken on board within this thesis since identification in the traditional sense did not pose a problem. In fact, the way in which the single equations were specified, allowed the model to be formulated without ad hoc adjustment and in every equation (A - B) $\geq$ (C - 1)

5. See Theil, H. *Estimation and Simultaneous Correlation in Complete Equation Systems*, The Hague: Central Planning Bureau (mimeographed) (1953).

6. Although there is no guarantee that it will yield less biased more consistent estimation for small samples.

7. See Kloek, T. and Mennes, L. B. 'Simultaneous Equation Estimation Based on Principal Components of Predetermined Variables', *Econometrica*, Vol. 28 (1960), pp. 45-61.

8. Refer to Appendix 6 for a full description of the results of principal components of instrumental variables estimation.

9. The Gauss-Seidel is the method usually applied in empirical work and is in fact the method which will be employed in SIMFOR. This is mainly due to its easy access on the computer software (TSP 3.2 package) available at Glasgow University. Although this method can be sensitive to the way in which the relationships are ordered, i.e. the covergence time, TSP has provided a

procedure called collect/solve which orders the system in the most efficient manner for rapid convergence.

10. The costs associated with this exercise did not outweight the perceived benefits.

11. The results of all 72 runs will not be presented in the thesis since they are a rather tedious collection of computer output. V^6 was chosen since it was the most realistic version and it was felt that this represented more closely than the others the way in which the economy operated. Although with the increasing degree of simultaneity the test statistics for the models historical tracking performance deteriorated, this did not happen to a significant degree, even in worst cases. This and the fact that this highly simultaneous version with its quite complex dynamics actually solved and stayed on track, outweighed the cost of the slight loss of inefficiency in forecasts.

12. The logged level results of the variables were excluded from the presentation since they basically told the same story as the unlogged level results.

CHAPTER VII

POLICY SIMULATION

Introduction

The purpose of Chapter VII is to use the solved model (V^6) of Chapter VI to explore the relative home/foreign macroeconomic impacts. The proposed method of analysis is via counter-factual ex-post policy simulation. Ex-ante forecasts will not be performed due to insufficient current data observations.[1]

The Chapter will be broken down as follows: Firstly there is a discussion of the macro-type questions which SIMFOR will attempt to answer. Next is a discussion of the design of the simulation experiments. Finally, the empirical results along with interpretation and conclusions are presented.

Questions that SIMFOR will Attempt to Address

SIMFOR provides information relevant to the following questions:

1) Given an exogenous shock, which sector is able to sustain the momentum of that change for the longer time period? In other words, which sector is able to set off the longer running multiplier-type effects?
2) In response to a given exogenous shock, which sector reacts in the more 'elastic' manner, and is this response maintained over the simulation period?

3) Which sector has the greatest export propensity and does this change over the simulation period?

4) At the aggregate level, which sector displays the greater degree of dependence on the other?

5) Is there a propensity for the foreign sector to lead to greater capital intensity in the long-run and hence less employment opportunities relative to the home sector?

6) Is there a tendency for the foreign sector to hamper the growth prospects of the home sector over time?

7) What are the net impacts of FDI on Scottish output, employment and investment over the simulation period?

8) Does the foreign sector exaggerate the deflationary tendencies of the economy?

Design of the Simulation Experiments

Two different types of shocks will be applied to the predetermined variables of the system.

1. Impulse Shocks - which will be changes applied in a once and for all manner, to selected lagged dependent variables in the home and foreign sectors. These alterations will be brought about by an (arbitrary) 25% increase in the level of the lagged dependent variable.[2]

In this type of experiment it should become clear as to which sector responds in more sensitive manner to the proposed change and further which sector is able to sustain for a longer time period, the momentum of the change.

2. Exogenous shocks - in this case several hypothetical shocks will be applied to the exogenous variables in order not only to analyze the foreign/home relative responses but further to ascertain the net foreign investment position. The changes in this case will be brought about by altering 'levels' and growth rates of the exogenous variables via maintained as opposed to on/off policy changes. As usual these shocks will be on various combinations of exogenous variables which are either internal or external to Scotland. As stated in Chapter II, the method of counter-factual analysis takes the form of postulating what might have happened in the absence of foreign investment and deducting this result from what actually happened hence yielding net foreign investment. Fitted SIMFOR as reported in Chapter VI is taken as the control run (CR) and represents the structure of the economy in the period 1963 - 1977. It is the shocked values of this model which will be compared with various alternative scenarios in order to arrive at net foreign investment impacts.[3]

The alternative scenarios which will be subtracted from the shocked values of CR for selected impact categories include: (1) Shock-Hypothetical Simulation 1 (SH1), an extreme example which assumes that no foreign investment had occurred during the simulation period and that the home sector was unable to substitute for any of the lost output, employment and investment. (2) Shock-Hypothetical Simulation 2 (SH2) which represents a more likely scenario, and arbitrarily assigns the home sector 25% of lost foreign aggregates in output, employment and investment.[4] In other words, it is postulated that the home sector attempts to replace 1/4 of lost foreign activity.[5] (3) Shock-Hypothetical Simulation 3 (SH3) is the final situation to be examined and is the opposite extreme to (SH1) and assumes that the home sector attempts to replace all foreign investment, output and employment.

It must be noted at this point that in a non-linear model the response of the system depends on the size of the shocks and the values of the endogenous variables. Hence, discussion of the system response to various shocks cannot take place in terms of simple unique multipliers and elasticities as is the case with linear models, but rather in terms of dynamic responses of the system to postulated shocks.

Empirical Results

A. Impulse Shocks

The results of the impulse shocks on selected lagged dependent variables are as follows:

The case where lagged foreign and lagged home output were both shocked by 25% on Model CR (i.e. fitted SIMFOR V[6]).

where,

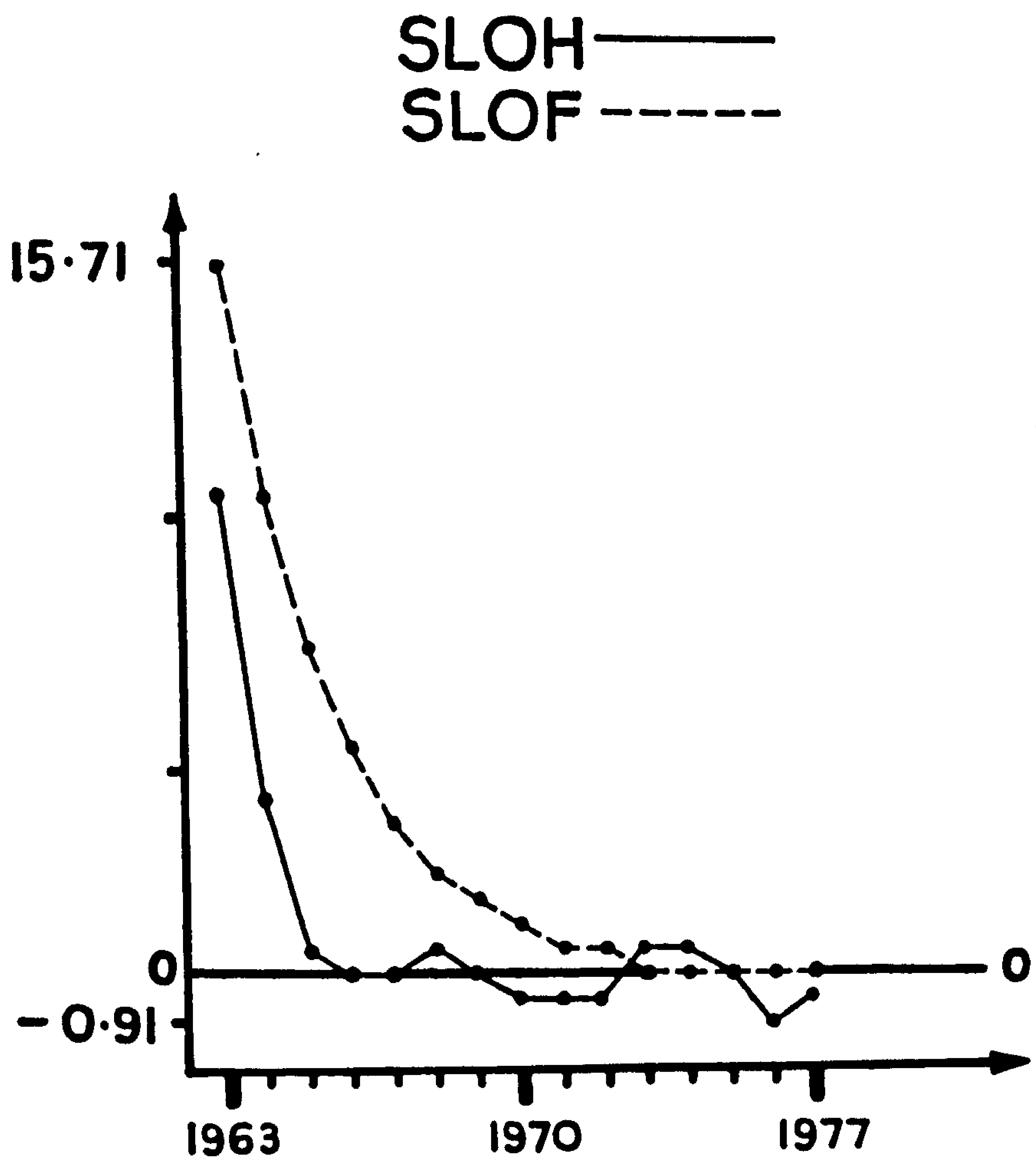
C	is the control value.
S	is the shocked value.
(S-C)	is the difference between control and the shocked values.
(S-C/C) x 100	is the percentage deviation of the shocked from the control value.

Table 1 SLOH

Year	SHIOPC	SHIOPS	(S-C)	(S-C/C) x 100
1963	62.77	69.64	6.86	10.88
1964	65.85	68.60	2.75	4.10
1965	68.24	68.85	0.61	0.89
1966	71.03	71.04	0.16E-01	0.22
1967	71.53	71.79	0.25	0.35
1968	73.65	74.06	0.40	0.55
1969	76.82	77.02	0.20	0.26
1970	78.96	78.85	-0.10	-0.13
1971	78.87	78.70	-0.16	-0.21
1972	82.98	82.93	-0.45E-01	-0.54
1973	87.20	87.27	0.67E-01	0.77
1974	84.97	85.05	0.82E-01	0.97
1975	79.92	79.95	0.25E-01	0.32
1976	79.53	79.52	-0.72E-01	-0.91
1977	81.23	81.20	-0.28E-01	-0.35

Table 2 SLOF

Year	SFIOPC	SFIOPS	(S-C)	(S-C/C) x 100
1963	7.00	8.20	1.19	15.71
1964	7.97	8.89	0.92	11.00
1965	8.98	9.68	0.70	7.55
1966	10.05	10.58	0.52	5.13
1967	10.81	11.20	0.39	3.56
1968	11.81	12.12	0.30	2.55
1969	13.46	13.70	0.24	1.83
1970	14.80	14.99	0.18	1.26
1971	15.79	15.93	0.13	0.84
1972	17.48	17.58	0.99E-01	0.56
1973	19.67	19.75	0.79E-01	0.40
1974	20.44	20.50	0.61E-01	0.29
1975	19.52	19.57	0.42E-01	0.21
1976	19.38	19.41	0.20E-01	0.15
1977	20.21	20.23	0.20E-01	0.10


SLOH
SLOF
15·71
0
-0·91
0
1963
1970
1977

Given that the foreign sector is significantly smaller than the home sector, it is not surprising that the initial shocked absolute values of the home sector are greater than the foreign values. The most interesting aspect of this result, and one which sheds new light on the longer term question of relative foreign investment impacts, can be seen by examining column (5) (tables 1 and 2) in the home (SLOH) and foreign (SLOF) cases where, SLOH is Shock on Lagged Output in the Home sector and SLOF is Shock on Lagged Output in the Foreign sector. These figures (dynamic responses) can essentially be viewed as something akin to 'dynamic elasticities'.[6] In other words, the 25% change in foreign and home output in 1962 brought about the above proportionate responses over time. The foreign sector not only had a greater initial 'elastic' response of 15.71% as opposed to 10.88% for SLOH but further this greater responsiveness was maintained over the whole simulation period with the exception of 1973 and 1974. Furthermore, as regards the momentum of the change, it only took the home sector 3 years to go less than a 1% change in (S-C/C) x 100, whereas it took SLOF until 1971, i.e. 8 years. These results seem to suggest that either the foreign sector has relatively stronger linkages with the Scottish economy than is normally thought to be the case,[7] or that the foreign sector has relatively higher export propensities or some combinations of the two.

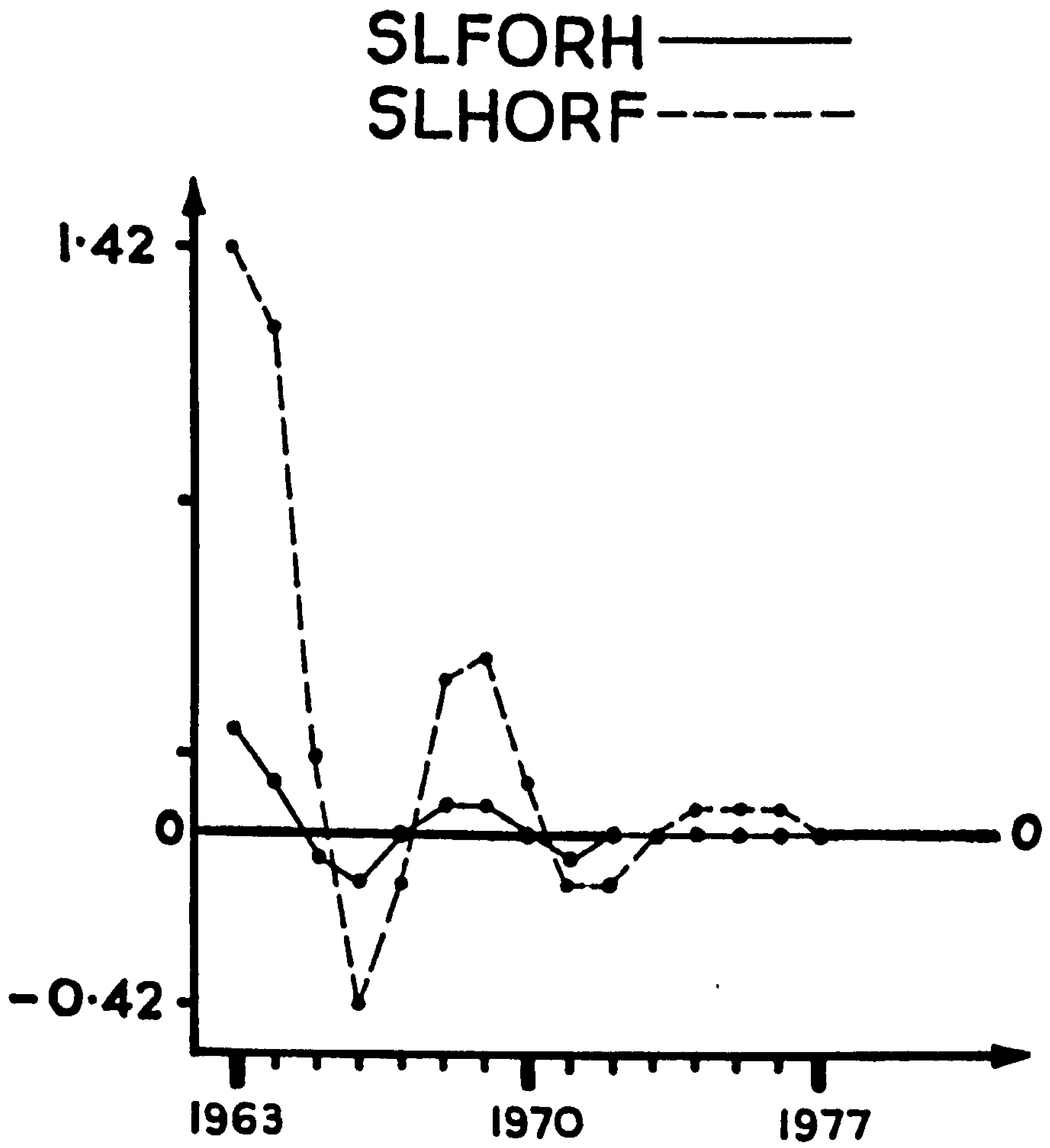
Another interesting aspect of this type of shock can be seen by looking at the shocked values of foreign output when it is home output which has been directly shocked and vice-versa i.e. Shock Lagged Home Output and examine the Response of the Foreign sector (SLHORF).

Table 3 SLHORF

Year	SFIOPC	SFIOPS	(S-C)	(S-C/C) x 100
1963	7.00	7.10	0.10	1.42
1964	7.97	8.07	0.10	1.25
1965	8.98	9.00	0.15E-01	0.17
1966	10.05	10.01	-0.42E-01	-0.42
1967	10.81	10.80	-0.97E-02	-0.90
1968	11.81	10.86	0.47E-01	0.40
1969	13.46	13.52	0.60E-01	0.45
1970	14.80	14.82	0.17E-01	0.11
1971	15.79	15.77	-0.20E-01	-0.12
1972	17.48	17.46	-0.21E-01	-0.12
1973	19.67	19.67	0.79E-03	0.41E-02
1974	20.44	20.46	0.19E-01	0.94E-01
1975	19.52	19.54	0.17E-01	0.87E-01
1976	19.38	19.39	0.93E-02	0.48E-01
1977	20.21	20.21	-0.45E-03	-0.22E-02

Table 4 SLFORH

Year	SHIOPC	SHIOPS	(S-C)	(S-C/C) x 100
1963	62.77	62.94	0.16	0.25
1964	65.85	65.95	0.10	0.16
1965	68.24	68.22	-0.22E-01	-0.32E-01
1966	71.03	70.96	-0.64E-01	-0.91E-01
1967	71.53	71.54	0.25E-02	0.36E-02
1968	73.65	73.71	0.61E-01	0.83E-01
1969	76.82	76.87	0.54E-01	0.70E-01
1970	78.96	78.96	0.20E-01	0.26E-02
1971	78.87	78.85	-0.24E-02	-0.30E-01
1972	82.98	82.96	-0.14E-01	-0.16E-01
1973	87.20	87.21	0.63E-02	0.73E-02
1974	84.97	84.98	0.16E-01	0.19E-01
1975	79.92	79.93	0.99E-02	0.12E-01
1976	79.53	79.53	0.31E-02	0.39E-02
1977	81.23	81.23	-0.26E-02	-0.32E-02


SLFORH
SLHORF
1·42
0
-0·42
0
1963
1970
1977

These results seem to suggest that the 25% shock to lagged home output elicits a much greater 'elasticity' of response from the foreign sector than does the corresponding 25% foreign output shock to the home sector. Under this type of simulation the foreign sector seems to display a greater degree of dependence in terms of its growth prospects on the growth of the home sector than the reverse case.[8] An obvious policy implication in this instance (ceteris paribus, assuming employment creation is the main policy objective) is that assistance to the home sector alone has wider implications for both the home and foreign sectors than assistance to the foreign sector exclusively.

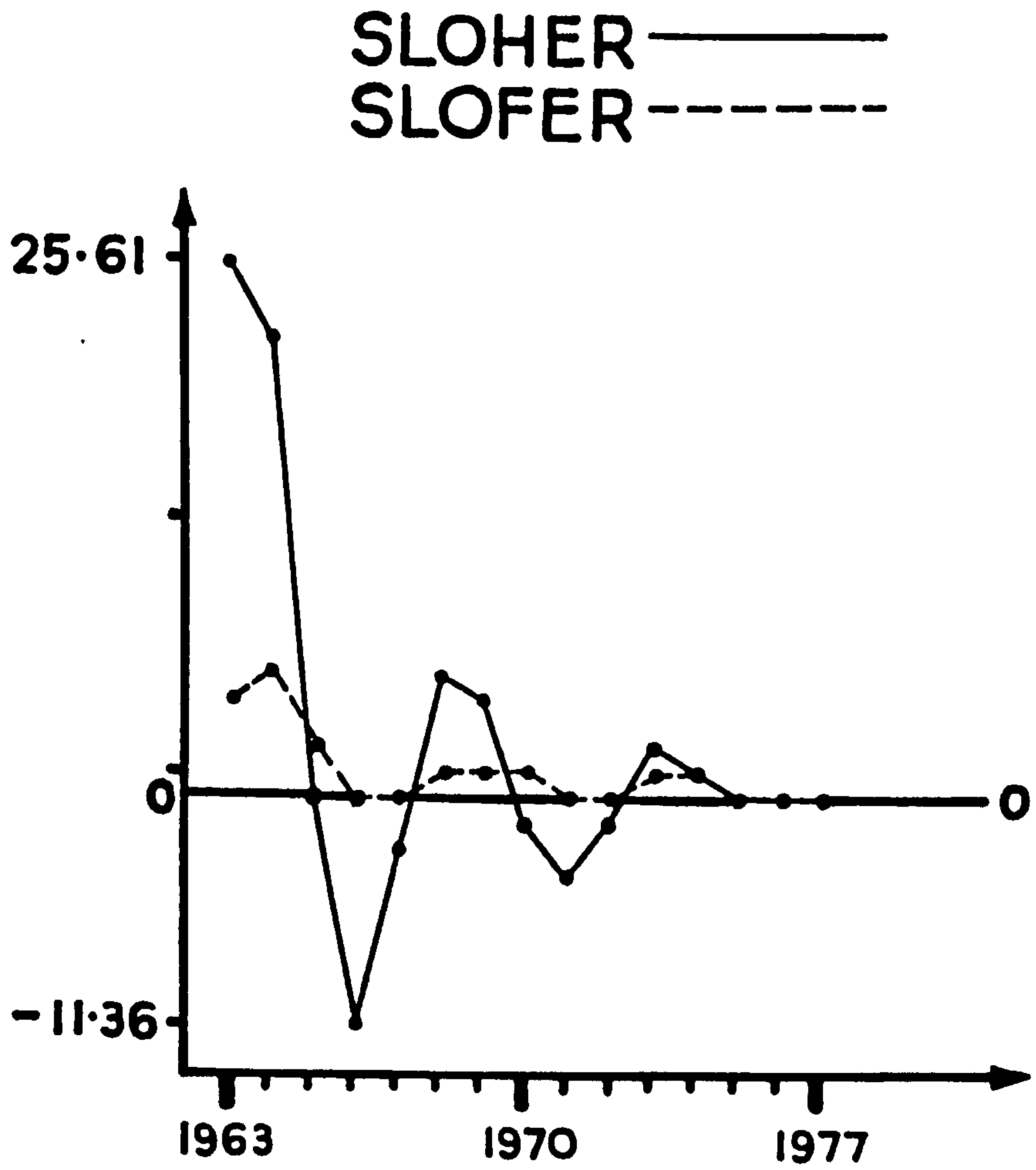
As regards total employment gains, (i.e. home and foreign) the higher percentage increase in SLHORF translates into a higher absolute employment increase, not only due to the greater 'elasticity' of response that the home sector elicits, but more obviously also to the fact that the home sector is significantly larger than the foreign sector. The total employment figures which are obtained as a result of shocking lagged home and foreign output are SLOHER and SLOFER respectively. From tables 5 and 6 it can be seen that SLOHER is exhibiting damped oscillatory behaviour and is less than SLOFER for only 5 years of the simulation period, i.e. 1966, 1967, 1970, 1971 and 1972. Hence it could be argued that on policy grounds, it would be more beneficial in terms of percentage response of the foreign sector and eventual absolute employment gains in both the home and foreign sector to concentrate on stimulating the home rather than foreign sector.

Table 5 SLOHER

Year	SHEM (C-S)	SFEM (C-S)	STEM (C-S)
1963	18.67	6.94	25.61
1964	14.61	7.85	22.47
1965	-3.83	2.98	- 0.85
1966	-9.89	-1.47	-11.36
1967	-0.99	-2.15	- 3.14
1968	6.34	-0.37	5.97
1969	3.54	1.04	4.58
1970	-2.55	0.84	-1.71
1971	-3.34	-0.11	-3.46
1972	0.83E-01	-0.54	-0.96
1973	2.12	-0.26	1.85
1974	0.91	0.20	1.10
1975	-0.77	0.28	-0.48
1976	-0.78	0.10	-0.67
1977	0.99E-01	-0.69E-01	0.30E-01

Table 6 SLOFER

Year	SHEM (C-S)	SFEM (C-S)	STEM (C-S)
1963	3.72	1.33	5.06
1964	4.13	1.97	6.11
1965	1.05	1.48	2.54
1966	-0.93	0.62	-0.31
1967	-0.81E-01	0.15	-0.78E-01
1968	1.28	0.22	1.50
1969	1.14	0.42	1.56
1970	0.40E-01	0.41	0.45
1971	-0.44	0.22	-0.22
1972	-0.47E-01	0.68E-01	0.20E-01
1973	0.38	0.47E-01	0.42
1974	0.29	0.98E-01	0.39
1975	-0.20E-01	0.10	0.85E-01
1976	-0.11	0.69E-01	-0.48E-01
1977	-0.65E-01	0.26E-01	0.14E-01



SLOHER
SLOFER
25·61
0
-11·36
0
1963
1970
1977

Tables 7 and 8 represent the results of shocking the lagged values of home (SLIH) and foreign (SLIF) investment respectively. As can be seen in these tables and the graph, SLIH shocked by 25% in periods (-1) and (-2) exhibits damped oscillatory behaviour and fluctuates in percentage terms at both higher and lower rates than does the foreign sector (SLIF). The foreign sector returns to steady state equilibrium after 3 years (1966) as seen by the smoothly declining series. It actually takes until 1966 for the effect of the shock to home investment to work its way through, i.e. 13.49% in 1966. So it seems that in a model sense the foreign sector reacts in a relatively more 'elastic' manner in the short-run, whereas the home sector takes longer to react, but once it has, it tends to set off cyclical rounds of investment (in the (+) and (-) direction) for a longer time period. However, given that the model is non-linear and dynamic, what could also be being witnessed is that the type of shock imposed exposes a degree of instability in the investment equation (which is not surprising given the problems found in the single equation modelling of Chapter IV). Thus, due to this problem it is difficult to meaningfully comment on the duration of the SLIH and SLIF shocks.

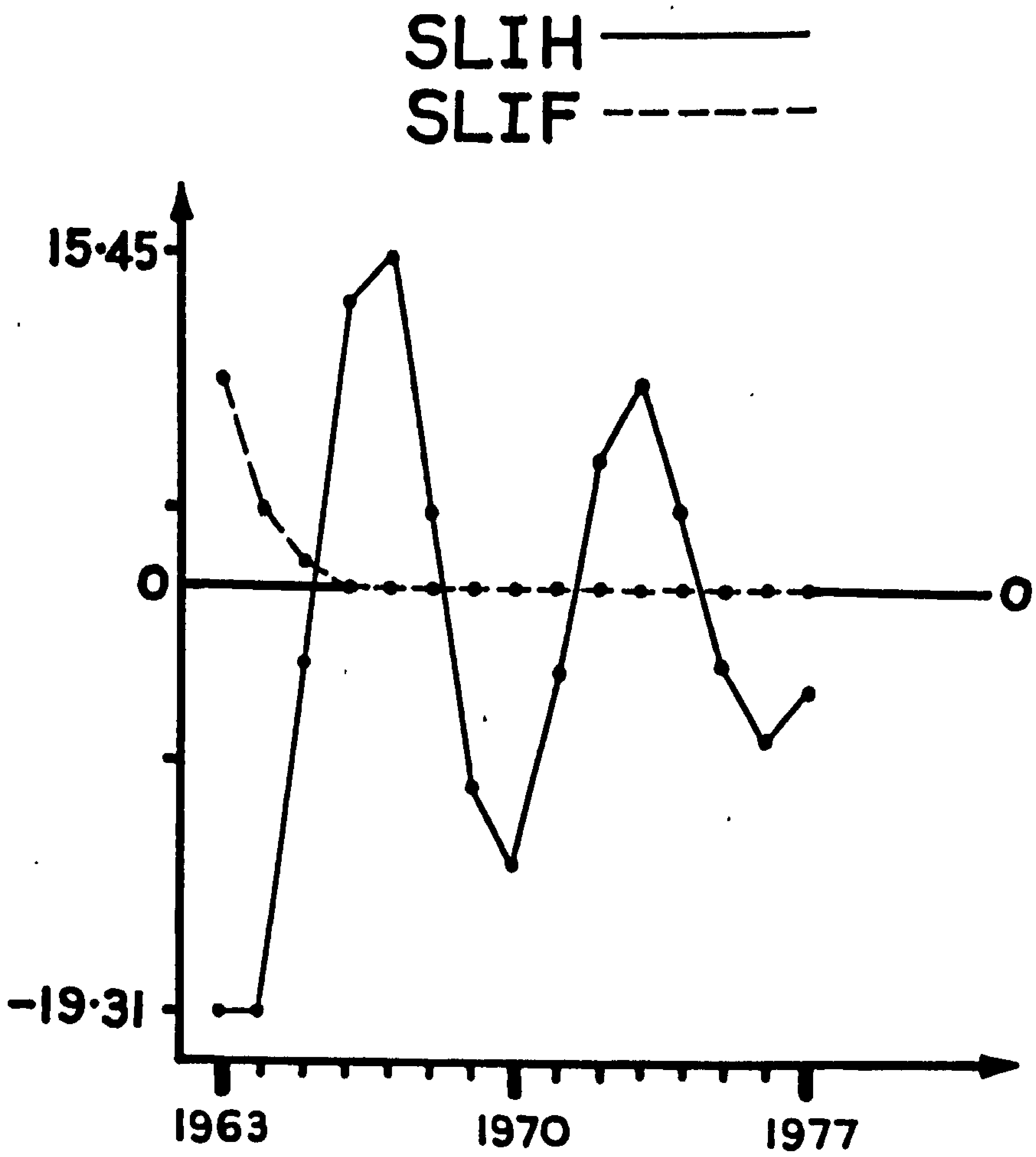
Further experiments along these lines (i.e. impulse shocks) on the lagged values of foreign and home employment were not very illuminating since the equations which determine employment's indirect effects, i.e. the real wage bill and consumption equations, do not distinguish between foreign and home behaviour. In this case only the absolute levels of higher spending in the home sector come through due to greater absolute employment and hence higher wage bill.

Table 7 SLIH

Year	SHIMKC	SHIMKS	(S-C)	(S-C/C) x 100
1963	270.92	223.33	-47.58	-19.31
1964	226.78	220.54	-46.24	-19.03
1965	283.06	275.67	- 7.39	- 2.64
1966	353.46	353.46	44.62	13.49
1967	309.78	361.56	51.78	15.45
1968	315.01	327.41	12.40	3.86
1969	332.02	303.19	-28.82	- 9.08
1970	324.28	287.26	-37.01	-12.12
1971	299.40	286.65	-12.75	- 4.35
1972	314.24	333.09	18.84	5.82
1973	361.26	397.02	35.76	9.44
1974	346.95	362.48	15.52	4.38
1975	298.43	288.07	-10.36	- 3.53
1976	294.46	274.28	-20.19	- 7.10
1977	316.67	303.98	-12.69	- 4.09

Table 8 SLIF

Year	SFIMKC	SFIMKS	(S-C)	(S-C/C) x 100
1963	20.31	22.36	2.04	9.60
1964	22.27	23.21	0.94	4.14
1965	26.47	26.95	0.47	1.79
1966	30.30	30.54	0.23	0.77
1967	33.77	33.88	0.11	0.33
1968	36.17	36.23	0.52E-01	0.14
1969	42.49	42.51	0.27E-01	0.65E-01
1970	44.43	44.44	0.12E-01	0.28E-01
1972	45.68	45.68	0.57E-02	0.12E-01
1972	47.44	47.44	0.26E-02	0.55E-02
1973	54.22	54.22	0.14E-02	0.27E-02
1974	66.05	66.05	0.11E-02	0.17E-02
1975	70.81	70.81	0.79E-02	0.11E-02
1976	61.36	61.36	0.41E-03	0.76E-03
1977	50.40	50.40	0.16E-03	0.38E-03


SLIH
SLIF
15·45
0
-19·31
0
1963
1970
1977

B. Exogenous Shocks

The following are the results of various exogenous shocks which will enable the relative home/foreign impacts as well as net foreign investment impacts to be highlighted for further analysis. The proposed shocks are of a simple hypothetical nature and attention should be drawn towards the reactions of the home and the foreign sector versus the exact method of implementing the policy change.[10]

The first shock to be considered is a maintained increase in Public Authority Government Spending (PAGSK) of 200 million pounds per year over the simulation period 1963-1977. In percentage terms, the increase in PAGSK is approximately 2.7% of Scottish Domestic Demand (DEM) in 1963, which falls off to approximately 2.0% of DEM by 1977.[11] As a matter of convenience and in order to simplify the analysis, it is assumed that this 200 million pound increase is applied in the form of aid from U.K. central government, i.e. it is not raised by taxing current Scottish activity. As regards the alternatives to FDI, it should be recalled from Chapter II that there were five options:

1) Raising the capital and other resources domestically.
2) Borrowing from abroad.
3) Some combination of 1 and 2.

4) Importing the finished product.

5) Not carrying out the investment.

The assumptions made in SH1 correspond to alternative (5) above, whereas the assumptions in SH2 and SH3 correspond to (1), (2) and (3). Option (4) is not explicitly considered in this exercise.

A further simplification of the analysis is that there was no explicit consideration as to how the finance was raised and repaid (i.e. in scenarios SH2 and SH3). Having said this, it must be noted that the most probable scenario (SH2) was chosen with implicit finance and resource constraints in mind. It was felt reasonable to assume that the home sector could probably attempt to replace approximately 25% of lost foreign activity in output, employment and investment without undue resource and financial stress. The SH3 scenario was not felt very plausible since it would place an extremely heavy burden on central and local government. However, it is not felt that these simplifications in any way detract from the findings of this exercise. The important point is that a quantitative structural difference between the two sectors has been found. The purpose of the simulations is therefore to draw out the differing impacts of each sector, so as to ascertain the relative importance of the foreign sector in the Scottish context.

The results for the Government spending Shock (GS) on Fitted SIMFOR (CR) and GSH1 - GSH3 for output, investment and employment are described below.

As can be seen, in tables 9, 10, 11 and the graph of GSHO on GSFO on GSTO, the single equation story remains consistent and reaffirms itself in a multi-equation context, i.e. that the proportionate responses of the foreign sector to changes in exogenous demand are greater than for the home sector response right throughout the historical period. GSFO is at its maximum in 1971 and very gradually declines after this period whereas the home sector GSHO hits its peak much earlier, i.e. 1965 and thereafter (as GSFO) declines very gradually.

The same general finding as above also applies to the reactions in the investment block, e.g. see tables 12, 13 and the graph of GSHI on GSFI. Right through the simulation period the 'elasticity' of responsiveness of GSFI is greater than GSHI with the exception of 1963. GSFI displays a smoothly ascending simulation path peaking approximately in 1971 and levelling off in the long-run at approximately 4.9%. In contrast, GSHI exhibits damped oscillatory behaviour which peaks in 1964, 1969 and 1970 and seems to eventually be levelling off at approximately 1.60% by the end of the simulation.

As regards the employment response to the change in government spending, (see tables 14, 15, 16 and the graph of GSHE, GSFE and GSTE), the foreign sector exhibits greater 'elasticity' of responsiveness in every period of the simulation than the home sector. This is not surprising, given the single equation employment results and the model results for output and investment. GSFE is at its maximum in 1965 (6.16%) and after 1970 seems to level off at approximately 5.5%. GSHE on the other hand changes by 1% at its peak in 1964 and stays less than 1% for the remaining part of the simulation period.

The final two graphs in this section (i.e. GSFO on GSFE on GSFI and GSHO on GSHE on GSHI) simply display the information already presented but in a slightly different manner. The interesting aspect of these graphs is that in response to the change in demand, (in order to obtain the proportionate increase in output) the foreign sector (GSFO) used proportionately more labour than capital, than did the home sector (GSHO) except for 1966, 1967 and 1973. This result suggests that the presence of the foreign sector does not in fact hamper long-run employment creating potential of the economy due to increased capital intensity.

Table 9 GSHO

Year	SHIOPC	SHIOPS	(S-C)	(S-C/C) x 100
1963	62.77	63.93	1.15	1.82
1964	65.85	67.54	1.69	2.54
1965	68.24	70.11	1.86	2.70
1966	71.03	72.90	1.87	2.60
1967	71.53	73.39	1.85	2.56
1968	72.65	75.55	1.89	2.54
1969	76.82	78.87	2.05	2.63
1970	78.96	81.00	2.04	2.55
1971	78.87	80.89	2.02	2.53
1972	82.98	85.00	2.02	2.40
1973	87.20	89.26	2.05	2.33
1974	84.97	87.01	2.04	2.37
1975	79.92	81.83	1.90	2.36
1976	79.53	81.37	1.83	2.28
1977	81.23	83.12	1.89	2.30

Table 10 GSFO

Year	SFIOPC	SFIOPS	(S-C)	(S-C/C) x 100
1963	7.00	7.22	0.21	3.04
1964	7.97	8.39	0.42	5.16
1965	8.98	9.58	0.60	6.49
1966	10.05	10.80	0.75	7.19
1967	10.81	11.66	0.85	7.61
1968	11.81	12.78	0.96	7.86
1969	13.46	14.60	1.14	8.14
1970	14.80	16.07	1.26	8.21
1971	15.79	17.15	1.35	8.25
1972	17.48	18.97	1.48	8.14
1973	19.67	21.31	1.63	8.00
1974	20.44	22.14	1.69	7.95
1975	19.52	21.13	1.60	7.89
1976	19.38	20.94	1.56	7.77
1977	20.21	21.83	1.62	7.71

Table 11 GSTO

Year	SIOPC	SIOPS	(S-C)	(S-C/C) x 100
1963	69.78	71.16	1.37	1.95
1964	73.82	75.94	2.12	2.83
1965	77.22	79.69	2.47	3.15
1966	81.09	83.71	2.62	3.18
1967	82.35	85.06	2.71	3.24
1968	85.47	88.33	2.86	3.29
1969	90.28	93.47	3.19	3.47
1970	93.76	97.08	3.31	3.47
1971	94.67	98.05	3.38	3.50
1972	100.47	103.97	3.50	3.43
1973	106.88	110.58	3.69	3.40
1974	105.41	109.15	3.73	3.48
1975	99.45	102.32	3.51	3.47
1976	98.91	102.96	3.40	3.38
1977	101.45	104.96	3.51	3.40

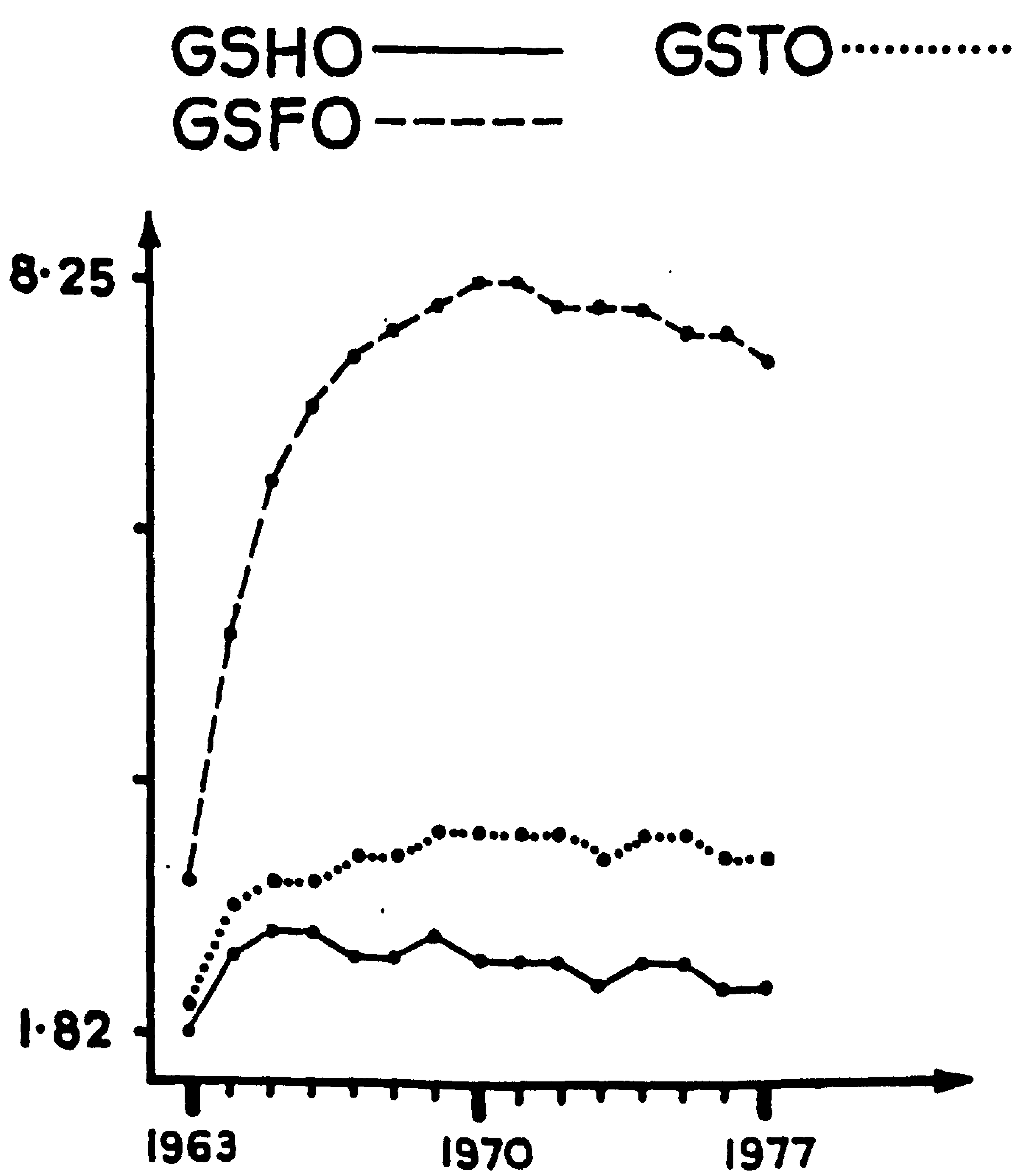


Table 12 GSHI

Year	SHIMKC	SHIMKS	(S-C)	(S-C/C) x 100
1963	270.92	275.96	5.04	1.84
1964	266.78	272.58	5.80	2.15
1965	283.06	286.89	3.82	1.34
1966	308.83	310.27	1.43	0.46
1967	309.78	311.21	1.43	0.46
1968	315.01	318.77	3.76	1.18
1969	322.02	388.92	6.90	2.05
1970	324.28	331.27	6.99	2.13
1971	299.40	304.34	4.94	1.63
1972	314.24	317.27	3.02	0.95
1973	361.26	364.09	2.83	0.78
1974	346.95	351.25	4.30	1.23
1975	298.43	303.54	5.11	1.69
1976	294.46	299.73	5.27	1.77
1977	316.67	321.71	5.05	1.58

Table 13 GSFI

Year	SFIMKC	SFIMKS	(S-C)	(S-C/C) x 100
1963	20.31	20.51	0.20	0.98
1964	22.27	22.82	0.55	2.46
1965	26.47	27.42	0.95	3.53
1966	30.30	31.57	1.27	4.10
1967	33.77	35.28	1.51	4.39
1968	36.17	37.87	1.69	4.56
1969	42.49	44.55	2.06	4.74
1970	44.43	46.65	2.22	4.88
1971	45.67	47.99	2.31	4.95
1972	47.44	49.85	2.41	4.95
1973	54.22	56.95	2.73	4.91
1974	66.05	69.39	3.34	4.93
1975	70.81	74.41	3.60	4.96
1976	61.36	64.46	3.09	4.92
1977	50.40	52.93	2.52	4.89

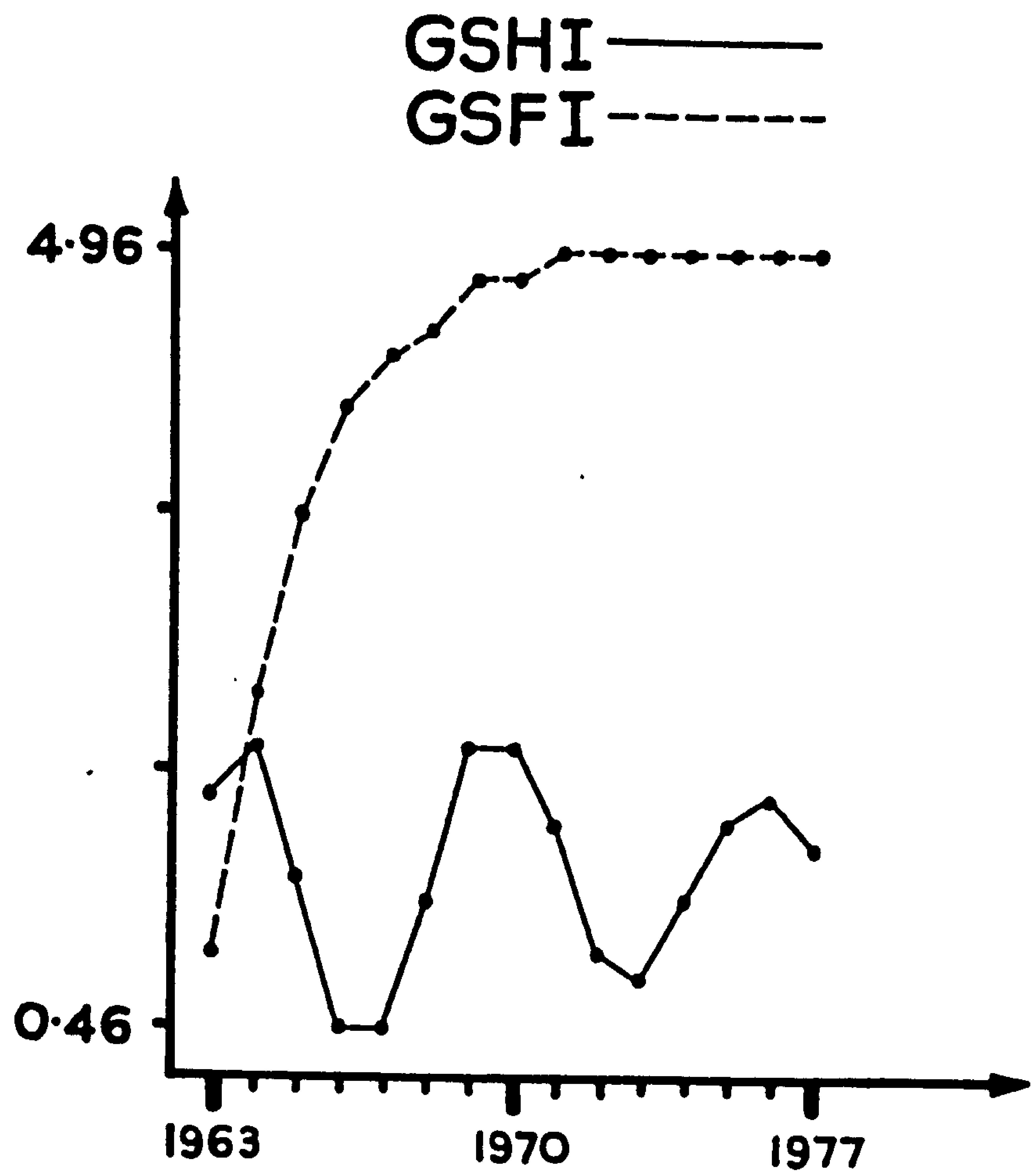

GSHI
GSFI
4·96
0·46
1963
1970
1977

Table 14 GSHE

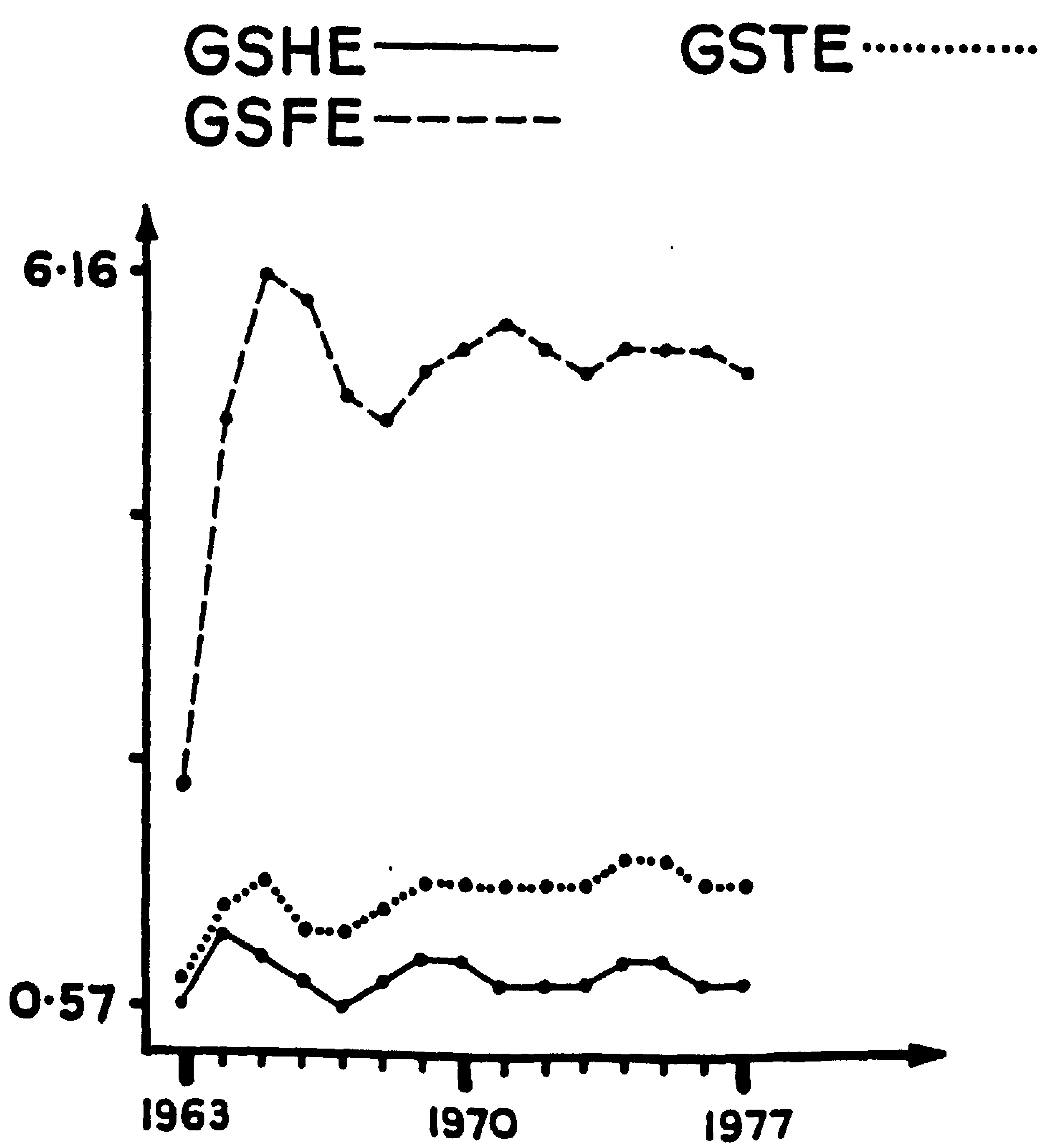
Year	SHEMC	SHEMS	(S-C)	(S-C/C) x 100
1963	652.20	655.98	3.78	0.57
1964	651.72	658.69	6.97	1.06
1965	646.13	652.62	6.48	0.99
1966	635.02	639.42	4.40	0.69
1967	618.77	622.68	3.91	0.63
1968	608.03	612.95	4.92	0.80
1969	605.65	611.52	5.87	0.96
1970	600.38	605.93	5.54	0.91
1971	584.74	589.12	4.79	0.81
1972	574.74	579.25	4.50	0.78
1973	574.31	579.05	4.73	0.82
1974	561.04	566.01	4.97	0.88
1975	531.12	535.81	4.68	0.87
1976	511.47	515.65	4.17	0.81
1977	509.86	513.95	4.08	0.79

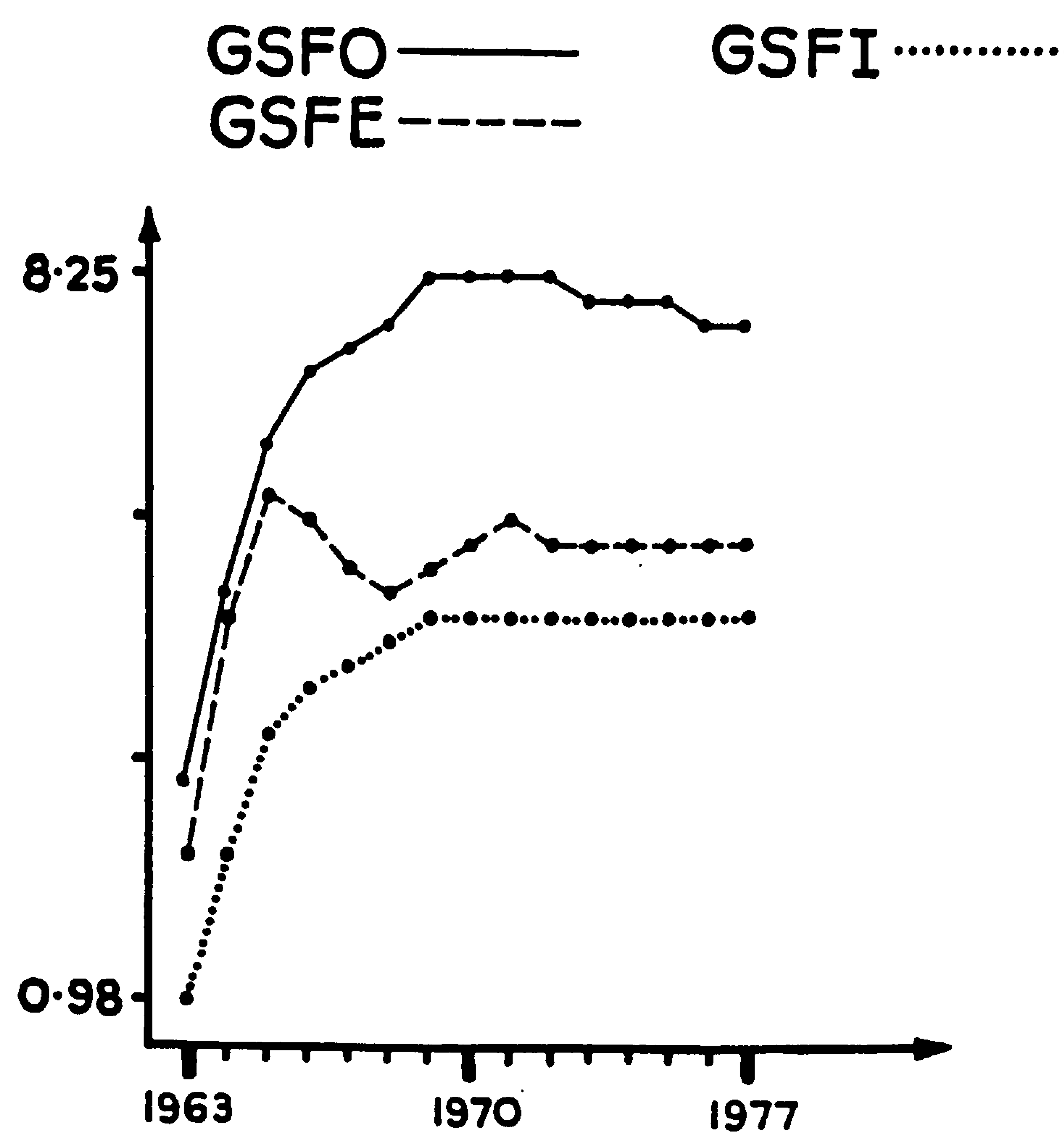
Table 15 GSFE

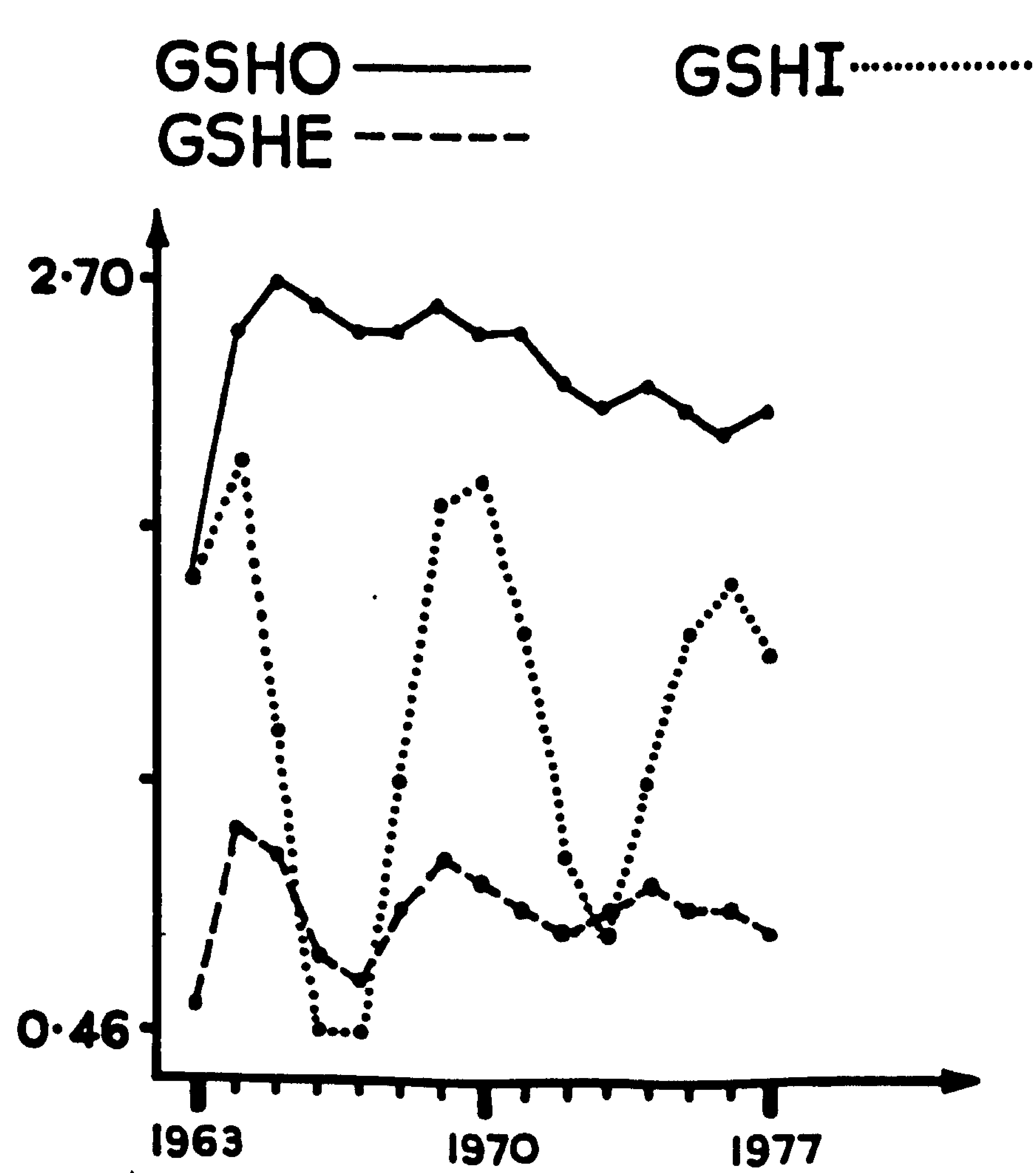
Year	SFEMC	SFEMS	(S-C)	(S-C/C) x 100
1963	57.54	58.90	1.36	2.33
1964	60.20	63.27	3.07	4.97
1965	64.63	68.74	4.11	6.16
1966	70.55	74.84	4.29	5.90
1967	74.02	78.05	4.03	5.30
1968	77.08	81.09	4.00	5.07
1969	82.91	87.49	4.58	5.38
1970	89.61	94.85	5.24	5.68
1971	92.68	98.22	5.53	5.79
1972	98.56	104.30	5.73	5.65
1973	109.11	115.25	6.14	5.48
1974	112.04	118.40	6.35	5.51
1975	101.97	107.84	5.87	5.60
1976	93.99	99.34	5.35	5.53
1977	95.37	100.75	5.37	5.48

Table 16 GSTE

Year	STEMC	STEMS	(S-C)	(S-C/C) x 100
1963	709.74	714.88	5.14	0.72
1964	711.93	721.97	10.04	1.40
1965	710.77	721.36	10.59	1.47
1966	705.57	714.27	8.69	1.22
1967	692.80	700.74	7.94	1.14
1968	685.11	694.04	8.93	1.29
1969	688.56	699.01	10.45	1.50
1970	690.00	700.78	10.78	1.55
1971	677.02	687.35	10.32	1.51
1972	673.30	683.55	10.24	1.51
1973	683.42	694.30	10.87	1.57
1974	673.09	684.42	11.32	1.66
1975	633.09	643.65	10.56	1.65
1976	605.47	615.00	9.53	1.56
1977	605.24	614.70	9.45	1.55




GSFO
GSFI
GSFE
8·25
0·98
1963
1970
1977


GSHO
GSHI
GSHE
2·70
0·46
1963
1970
1977

The shocked values (GSCR) for output, employment and investment will next be used as benchmarks in combination with the shocked values of GSH1 - GSH3 in order to determine the net impacts of FDI between 1963 - 1977. The first case to be considered is the extreme scenario of GSH1, i.e. where it is assumed that none of the lost foreign output, employment and investment is compensated for by the home sector. The exogenous shock is again the 200 million pound increase in PAGSK.

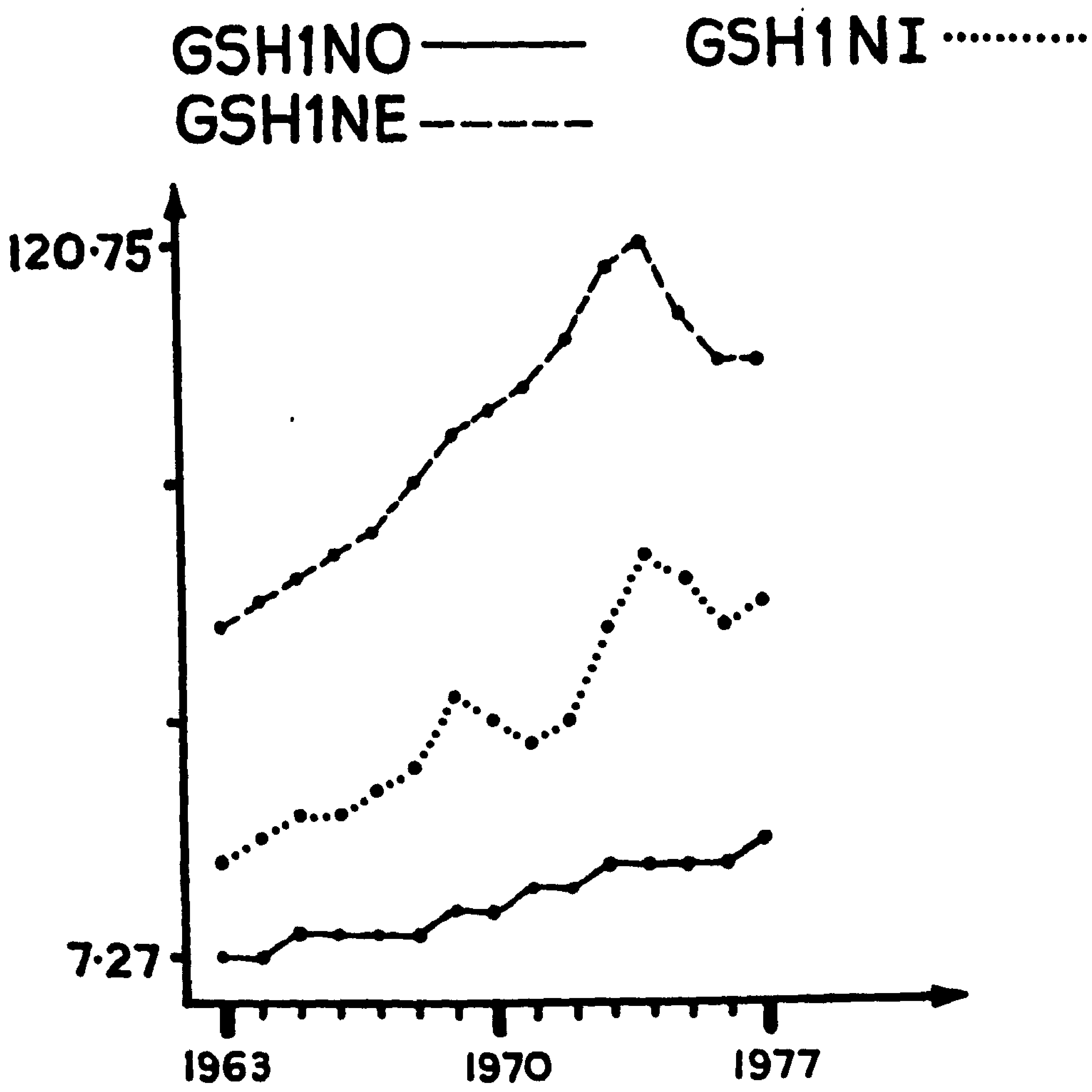
The shocked values for model GSH1 are presented in table 17. The net contribution of FDI to the Scottish economy is therefore (GSCR - GSH1). These figures are presented in table 18 and graphically, where the series are reported in 'levels'. The output figures GSH1NO (N = net) are based on the index of production (1975 = 100); the employment figures GSH1NE are in thousands; and the investment figures GSH1NI are in £ million. Under this scenario the Scottish economy would have had to forego approximately 120,000 jobs with the associated 71 million pounds of investment at the period of peak loss in 1974. It is hardly surprising that in not one year of the simulation would the Scottish economy have been better off in terms of output, employment and investment without the foreign sector. The results of this simulation are obviously true by definition given the assumptions of the model. However, this simulation has been run not only for the sake of completeness, but for further use in comparing relative losses with those of other exogenous shocks.

Table 17

TIME	SIOPS	STEMS	STIMKS
1963	63.89	653.71	275.10
1964	67.52	656.54	270.29
1965	70.07	652.84	284.79
1966	73.01	642.01	310.39
1967	73.41	624.25	314.02
1968	75.55	612.69	320.34
1969	78.68	610.23	336.40
1970	81.05	606.15	334.63
1971	80.89	589.94	313.63
1972	84.86	579.73	322.99
1973	88.82	578.38	359.76
1974	86.53	563.67	349.33
1975	81.71	533.32	310.17
1976	81.47	514.32	302.70
1977	83.01	512.49	310.53

Table 18

TIME	GSH1NO	GSH1NE	GSH1NI
1963	7.27	61.17	21.37
1964	8.42	65.43	25.11
1965	9.62	68.52	29.52
1966	10.70	72.26	31.45
1967	11.65	76.49	32.47
1968	12.78	81.35	36.30
1969	14.79	88.78	47.07
1970	16.03	94.63	43.29
1971	17.16	97.41	39.78
1972	19.11	103.83	44.13
1973	21.76	115.96	61.28
1974	22.62	120.75	71.31
1975	21.26	110.33	67.78
1976	20.85	100.68	61.49
1977	21.95	102.21	64.12


GSH1NO
GSH1NI
GSH1NE
120·75
7·27
1963
1970
1977

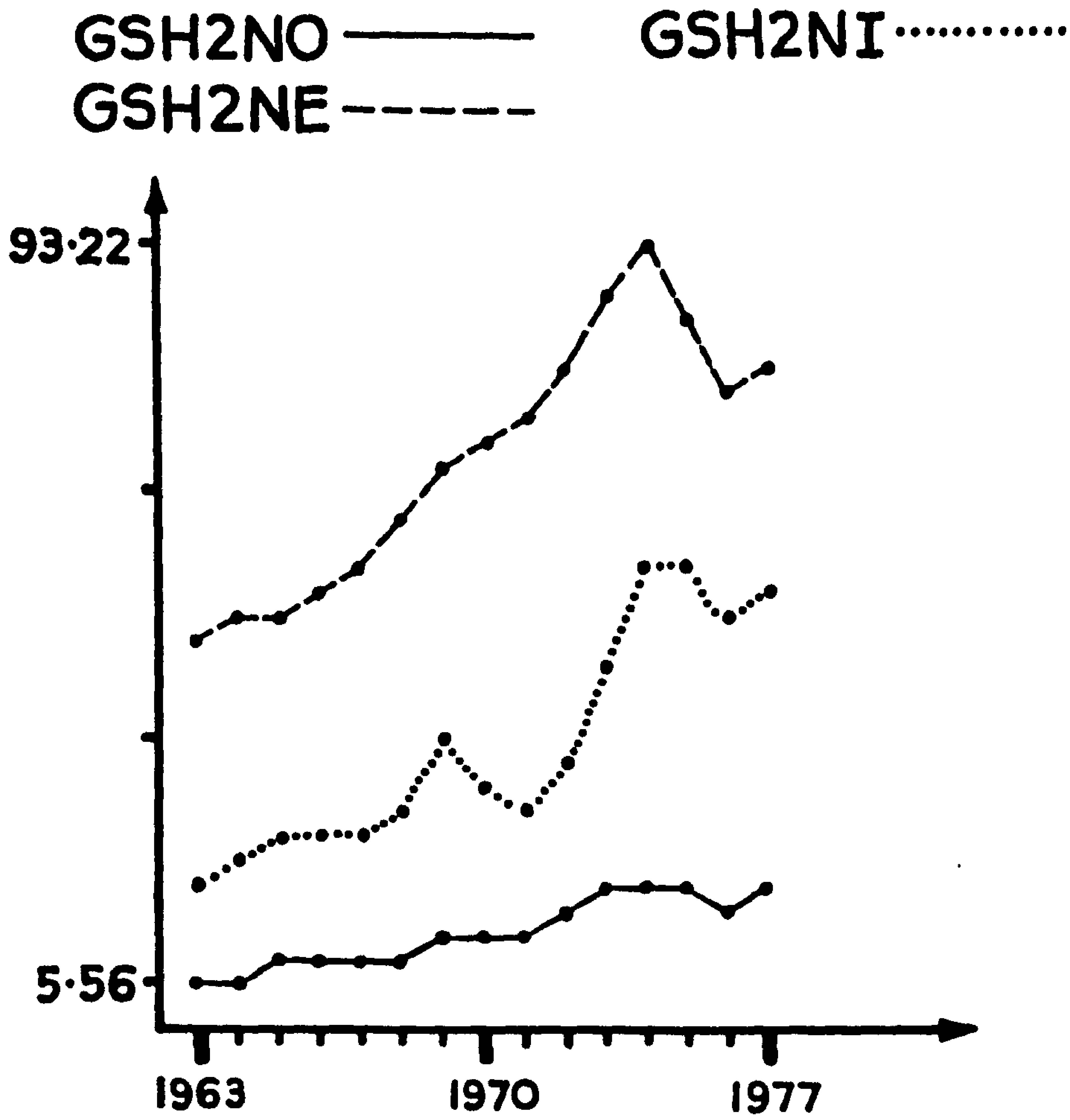
Under the assumption of GSH2, it is next assumed that the home sector attempts to replace 25% of lost foreign output, investment and employment. The shocked results for model GSH2 are presented in table 19. The net contribution of FDI in this case is (GSCR - GSH2). These net impact figures are in table 20 and the graph which follows. This more probable scenario yields jobs losses of approximately 47,000 and lost investment of approximately 16 million at best in 1963; and approximately 93,000 lost jobs with the associated 54 million pounds of lost investment at worst in 1974. Relative to GSH1 the Scottish economy is obviously better off, although as in GSH1, in not one year of the simulation period is the Scottish economy better off for the lack of a foreign sector. Again this may not be surprising given the assumptions of the model and knowledge of the results which preceeded, i.e. that the foreign sector reacts in a relatively more elastic manner. If in fact the reverse structural differences between sectors had been found, then it is obviously conceivable that the Scottish economy may have been better off in this type of simulation.

Table 19

TIME	SIOPS	STEMS	STIMKS
1963	65.60	667.73	280.14
1964	69.55	671.91	267.33
1965	72.50	670.70	292.21
1966	75.80	662.03	319.15
1967	76.55	645.09	323.23
1968	79.00	634.10	330.78
1969	82.49	632.89	349.29
1970	85.20	630.26	348.42
1971	85.28	614.51	326.24
1972	89.60	605.10	336.54
1973	94.13	605.56	377.16
1974	92.04	591.20	366.41
1975	86.97	558.84	323.80
1976	86.58	538.46	315.41
1977	88.15	537.17	323.79

Table 20

TIME	GSH2NO	GSH2NE	GSH2NI
1963	5.56	47.15	16.33
1964	6.39	50.06	19.07
1965	7.19	50.66	22.10
1966	7.91	52.24	22.69
1967	8.51	55.65	23.26
1968	9.33	59.94	25.88
1969	10.98	66.12	34.18
1970	11.88	70.52	29.50
1971	12.77	72.84	26.09
1972	14.37	78.45	30.58
1973	16.45	88.74	43.88
1974	17.11	93.22	54.23
1975	16.00	84.81	54.15
1976	15.74	76.54	48.78
1977	16.81	77.53	50.86



GSH2NO
GSH2NI
GSH2NE
93·22
5·56
1963
1970
1977

The final scenario to be considered in the case of increased government spending is GSH3, i.e. where it is assumed that the home sector attempts to replace all of the lost foreign output, employment and investment. The shocked values of GSH3 are in table 21, with the net contribution of FDI being (GSCR - GSH3). These net figures are presented in table 22 and the graph which follows. The negative figures represent the years in which the Scottish economy would have been better off without foreign investment, e.g. 1965 - 1971 for GSH3NE or, in other words, 7 out of the 15 years in the simulation period. It is interesting to note that for the other 8 years (1963-1964 and 1972-1977), the Scottish economy still would have been worse off. The peak period of net 'gain' (i.e. that in which the Scottish economy would not only have done as well but 'better' than the foreign sector) for the Scottish economy was 1966, with approximately 7,400 extra jobs while the peak period of net loss was 1974, i.e. approximately 9,600 less jobs. In terms of investment 'gains' and 'losses', GSH3NI showed net gains between 1966 and 1973 (i.e. 8 years out of the years 15 in the historical period), whereas a net loss occurred in 1963-1965 and 1974-1977. The peak net gain of GSH3NI was 1971 (an extra 12.65 million pounds), and the peak net loss was 1975 (12.79 million pounds loss). In terms of net output GSH3NO, net gain was obtained in the period 1966-1972, whereas net loss was displayed in 1963-1965 and

1973-1977. In other words, the Scottish economy was still worse off in over half the years of the simulation period.

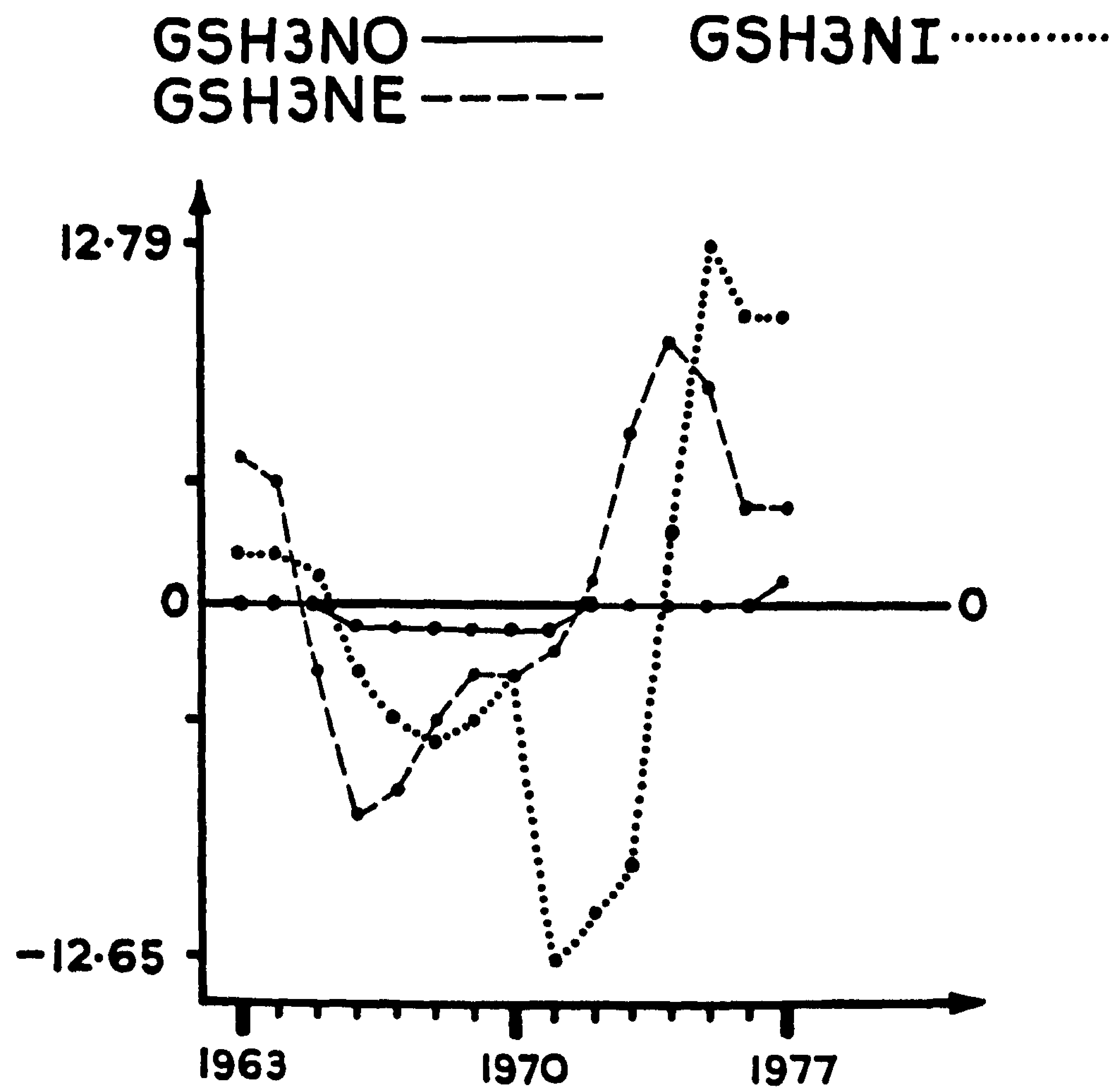
It is quite clear from this last scenario that on balance (considering GSH1 - GSH3) the foreign sector bestows a real and positive contribution to the Scottish economy. The structure of the home sector suggests that even in the highly unlikely event of it replacing all the lost foreign output, employment and investment, it can still not outperform the situation with FDI in approximately half of the years in the simulation run. Given this finding, it can be deduced that the foreign sector does not seem to be hampering the growth prospects of the home sector and in turn of the Scottish economy over time.[12]

Table 21

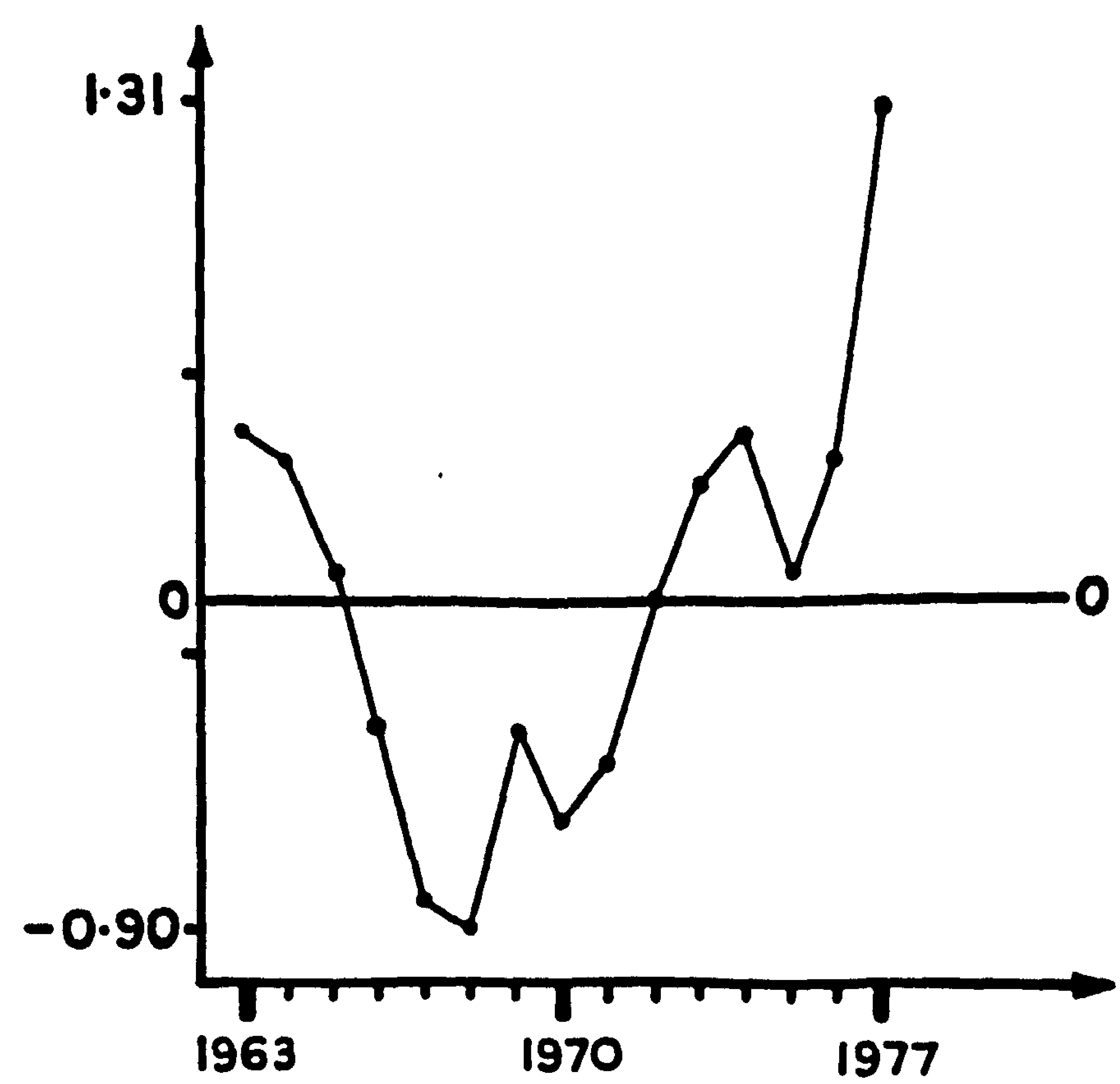
TIME	SIOPS	STEMS	STIMKS
1963	70.73	709.80	294.90
1964	75.56	717.50	293.50
1965	79.65	723.60	313.40
1966	84.09	721.70	344.50
1967	85.85	707.60	350.20
1968	89.23	698.40	361.60
1969	93.65	701.00	388.00
1970	97.65	702.80	389.90
1971	98.49	688.70	364.60
1972	104.00	682.24	378.00
1973	110.27	688.34	430.45
1974	108.75	674.79	418.36
1975	102.88	636.14	365.16
1976	101.99	611.46	354.23
1977	103.60	611.38	364.46

Table 22

TIME	GSH3NO	GSH3NE	GSH3NI
1963	0.43	5.08	1.53
1964	0.36	4.38	1.81
1965	0.04	-2.24	0.89
1966	-0.38	-7.46	-2.73
1967	-0.79	-6.95	-3.77
1968	-0.90	-4.40	-5.02
1969	-0.39	-2.08	-4.59
1970	-0.57	-2.06	-2.06
1971	-0.44	-1.39	-12.65
1972	-0.03	1.31	-10.88
1973	0.31	5.96	-9.41
1974	0.40	9.63	2.28
1975	0.09	7.51	12.79
1976	0.33	3.54	9.96
1977	1.33	3.32	10.19



BLOW-UP OF GSH3NO



The next hypothetical shock to be considered is one which is external to Scotland/rest of the U.K. In this case the proposed change takes the form of accelerating the rate of growth of world demand. The increase is a maintained one of 15% and is applied right throughout the historical period 1963-1977.

The results for the World demand Shock (WS) on Fitted SIMFOR (CR) and WSH1 - WSH3 reporting for output, investment and employment are as follows:

As can be seen in tables 23, 24 and the corresponding graph of WSHI on WSFI, the foreign sector responds in a relatively more 'elastic' manner in the vast majority of years in the simulation. The exceptions are 1963, 1964 and 1977. WSFI is at a peak in 1973 at 2.04% and at its lowest point in 1977 at -0.33%. On the other hand, WSHI is at a maximum in 1970 at 1.38% and at a minimum in 1975 at -0.74%. It is interesting to note that after 1973 foreign investment falls off quite dramatically whereas the home sector investment is rising between 1976 and 1977.

As regards the response of output to the proposed shock, it can be seen in tables 25 - 27 and the corresponding graph of WSHO on WSFO on WSTO, that the WSFO has a greater proportionate change in every period of the simulation. Both WSFO and WSHO peak in 1973 and fall off thereafter, furthermore they both reach a trough in 1976.

In terms of employment (see tables 28-30 and the corresponding graph of WSHE on WSFE on WSTE) the same type of behaviour as was the case for output and investment is witnessed. In every year, with the exception of 1976 and 1977, WSFE is greater than WSHE. WSFE peaks in 1966 and 1977 at 2.68% and is at its lowest point in 1976 at 1.67%. WSHE, on the other hand, peaks in 1977 at 0.56% and is at its lowest point in 1976 at -0.44%.

The last two graphs in this section (i.e. WSHE on WSHI on WSHO and WSFE on WSFI on WSFO) display the information already presented, in a slightly different manner. In the short to medium-term for instance the foreign sector uses relatively less capital than labour than does the home sector to create the output which was called forth by the increase in world demand. Only in 1968 did the foreign sector employment change less than the change in investment. On the other hand, the home sector responds in a more labour intensive manner in both 1967 and 1968. In the long-run the story reverses for both the home and foreign sectors. In the home sector, post 1973 marks a more labour intensive method of production whereas in the foreign sector post 1973 shows a relatively capital intensive mode of production. Considerable caution must be exercised however, when interpreting these long-run results, due to the fact that 'levels' variables for world demand were not entered in the single equation output functions (see Chapter III).

In other words it could be expected that the single equation relationship would collapse in the long-run due to its econometric specification. This probably explains the steep drop in the output, employment and investment aggregates in the early 1970's for both the home and foreign sectors. It can hence safely be concluded that in the short to medium-run, the foreign sector responds in a more 'elastic manner'

Table 23 WSHI

TIME	SHIMKC	SHIMKS	(S-C)	(S-C/C) x 100
1963	270.92	271.75	0.83	0.30
1964	266.78	268.80	2.02	0.75
1965	283.06	285.65	2.58	0.90
1966	308.83	310.22	1.38	0.44
1967	309.78	308.64	-1.14	-0.36
1968	325.01	313.45	-1.55	-0.49
1969	332.02	335.52	3.49	1.04
1970	324.28	328.81	4.53	1.38
1971	299.40	302.41	3.01	1.00
1972	314.24	315.22	0.98	0.31
1973	361.38	361.38	0.12	-0.34E-01
1974	346.95	346.50	-0.44	-0.12
1975	298.43	296.21	-2.22	-0.74
1976	294.46	292.93	-1.53	-0.52
1977	316.67	319.11	2.43	0.76

Table 24

TIME	SFIMKC	SFIMKS	(S-C)	WSFI (S-C/C) x 100
1963	20.31	20.35	0.33E-01	0.16
1964	22.27	22.40	0.13	0.62
1965	26.47	26.80	0.32	1.23
1966	30.30	30.80	0.50	1.64
1967	33.77	34.29	0.52	1.53
1968	36.17	36.58	0.40	1.12
1969	42.49	43.03	0.54	1.28
1970	44.43	45.17	0.74	1.65
1971	45.67	46.53	0.85	1.84
1972	47.44	48.38	0.93	1.95
1973	54.22	55.34	1.12	2.04
1974	66.05	67.33	1.28	1.91
1975	70.81	71.59	0.78	1.10
1976	61.36	61.38	0.19E-01	0.31E-01
1977	50.40	50.23	-0.17	-0.33

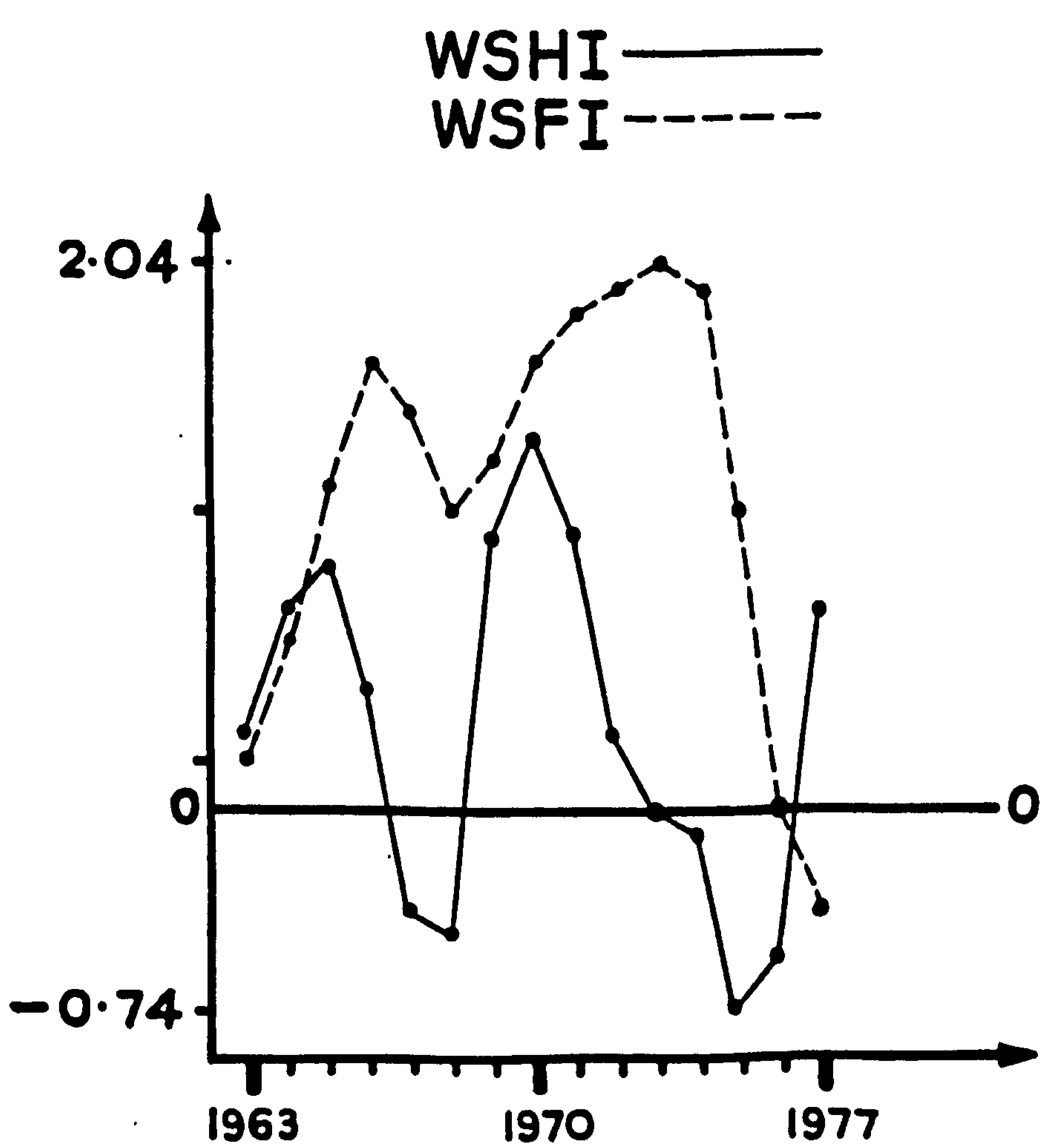


Table 25 WSHO

TIME	SHIOPC	SHIOPS	(S-C)	(S-C/C) x 100
1963	62.77	62.97	0.19	0.31
1964	65.85	66.40	0.55	0.84
1965	68.24	69.10	0.86	1.26
1966	71.03	71.88	0.85	1.19
1967	71.53	71.98	0.44	0.62
1968	73.65	73.84	0.18	0.25
1969	76.82	77.70	0.88	1.14
1970	78.96	79.86	0.90	1.13
1971	78.87	79.77	0.89	1.13
1972	82.98	83.91	0.92	1.11
1973	87.20	88.22	1.01	1.16
1974	84.97	85.63	0.66	0.77
1975	79.92	79.61	-0.30	-0.38
1976	79.53	78.84	-0.69	-0.87
1977	81.23	81.05	-0.17	-0.21

Table 26 WSFO

TIME	SFIOPC	SFIOPS	(S-C)	(S-C/C) x 100
1963	7.00	7.03	0.30E-01	0.43
1964	7.97	8.07	0.10	1.29
1965	8.98	9.18	0.20	2.20
1966	10.05	10.31	0.25	2.53
1967	10.81	11.03	0.21	2.00
1968	11.81	11.98	0.16	1.40
1969	13.46	13.78	0.32	2.38
1970	14.80	15.19	0.38	2.59
1971	15.79	16.24	0.44	2.79
1972	17.48	18.00	0.51	2.90
1973	19.67	20.28	0.60	3.03
1974	20.44	20.97	0.52	2.55
1975	19.52	19.29	0.16	0.82
1976	19.38	19.29	-0.84E-01	-0.43
1977	20.21	20.18	-0.36E-01	-0.17

Table 27 WSTO

TIME	SIOPC	SIOPS	(S-C)	(S-C/C) x 100
1963	69.78	70.01	0.22	0.32
1964	73.82	74.48	0.66	0.89
1965	77.22	78.29	1.06	1.37
1966	81.09	82.20	1.11	1.36
1967	82.35	83.01	0.66	0.80
1968	85.47	85.82	0.35	0.41
1969	90.28	91.49	1.20	1.32
1970	93.76	95.05	1.28	1.36
1971	94.67	96.01	1.34	1.41
1972	100.40	101.91	1.44	1.42
1973	106.80	108.51	1.62	1.50
1974	105.41	106.61	1.19	1.12
1975	99.45	99.30	-0.14	-0.14
1976	98.91	98.14	-0.77	-0.78
1977	101.45	101.23	-0.21	-0.20

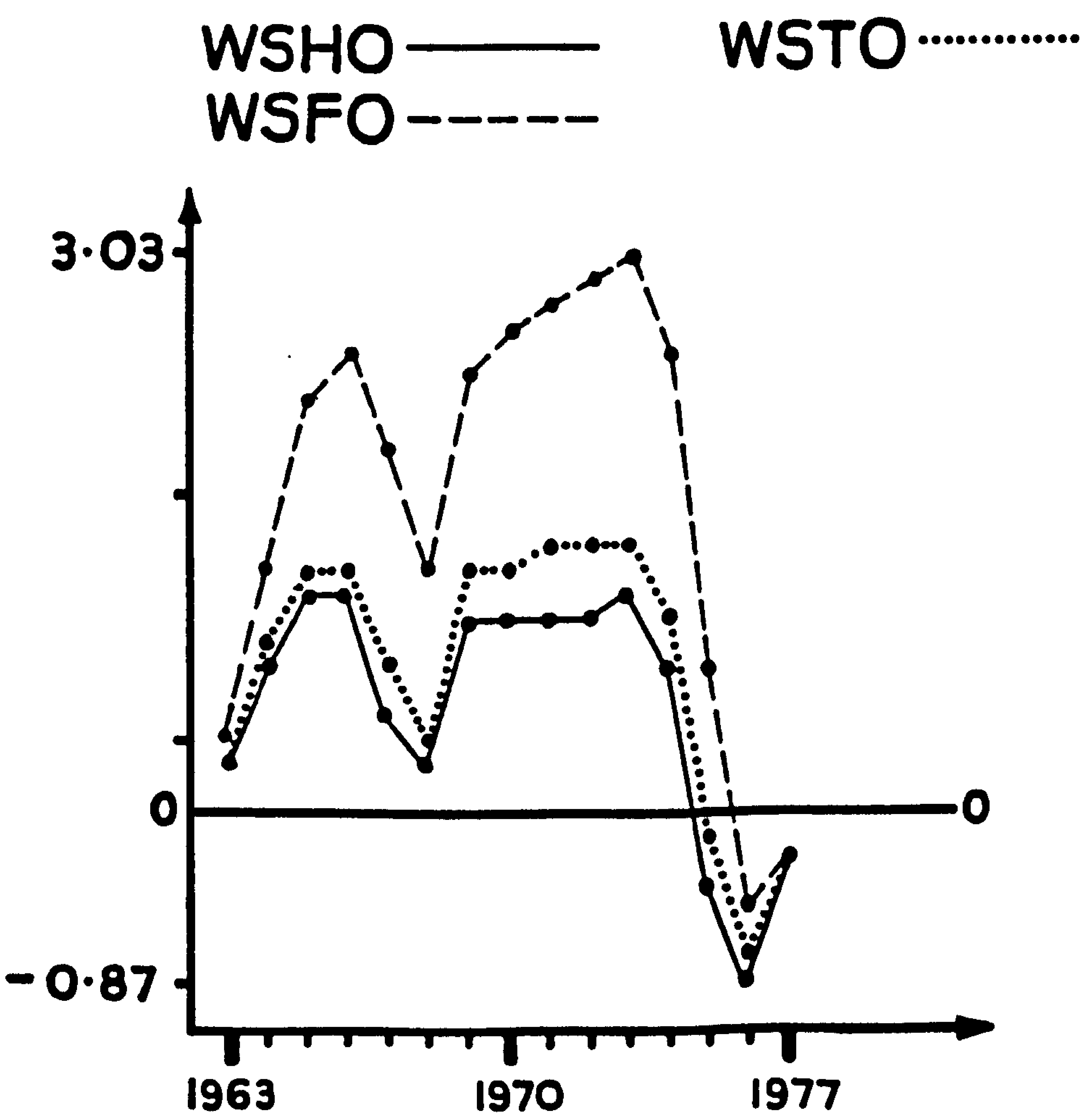


Table 28 WSHE

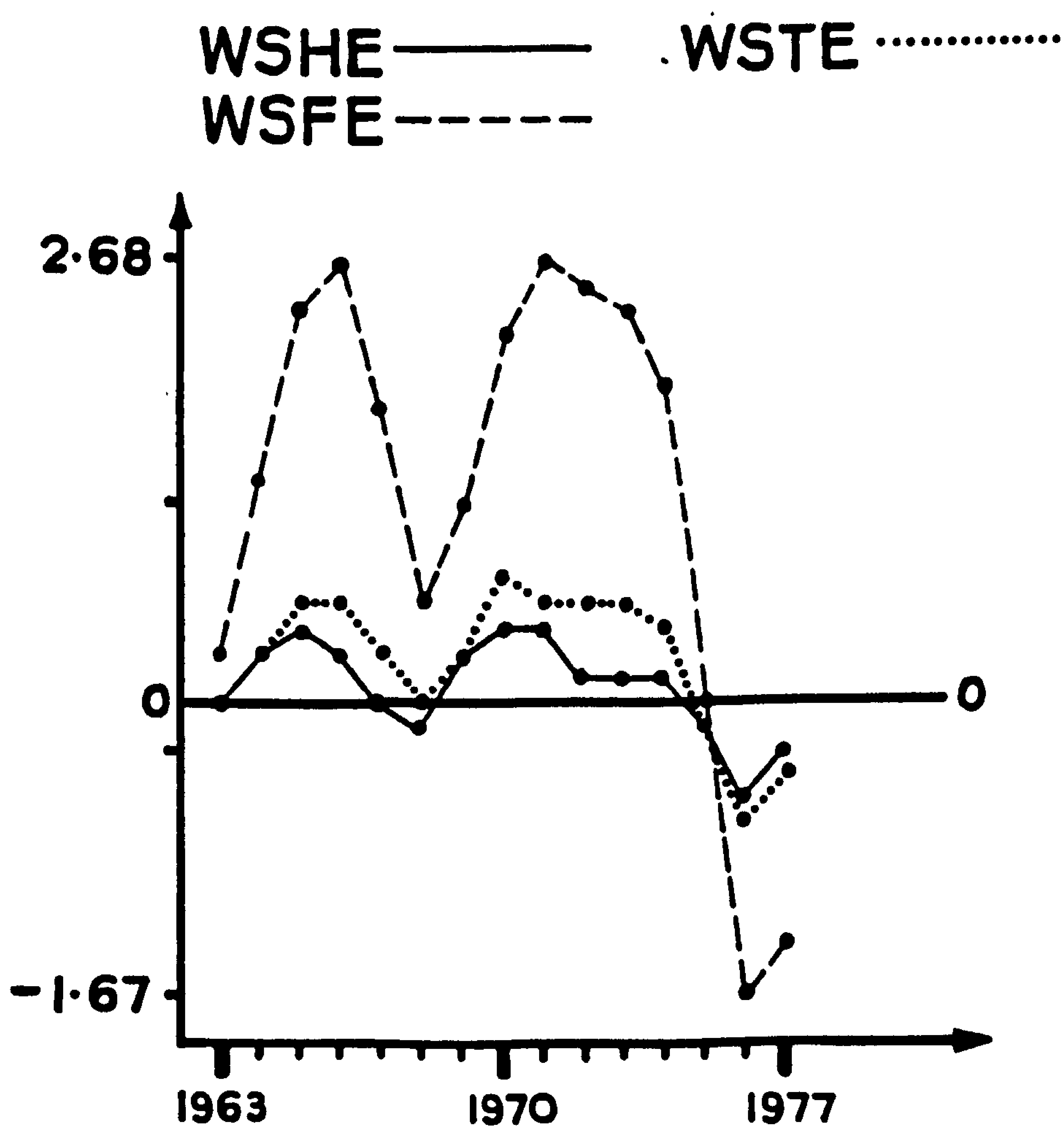
TIME	SHEMC	SHEMS	(S-C)	(S-C/C) x 100
1973	652.20	652.83	0.63	0.96E-01
1964	651.72	653.69	1.96	0.30
1965	646.13	649.15	3.01	0.46
1966	635.02	637.58	2.56	0.40
1967	618.77	619.48	0.71	0.11
1968	608.03	607.58	-0.44	-0.73E-01
1969	605.65	607.44	1.79	0.29
1970	600.38	603.78	3.39	0.56
1971	584.33	587.02	2.68	0.45
1972	574.74	576.24	1.50	0.26
1973	574.31	575.89	1.57	0.27
1974	561.04	562.63	1.58	0.28
1975	531.12	530.60	-0.52	-0.98E-01
1976	511.47	509.22	-2.25	-0.44
1977	509.86	508.98	-0.88	-0.17

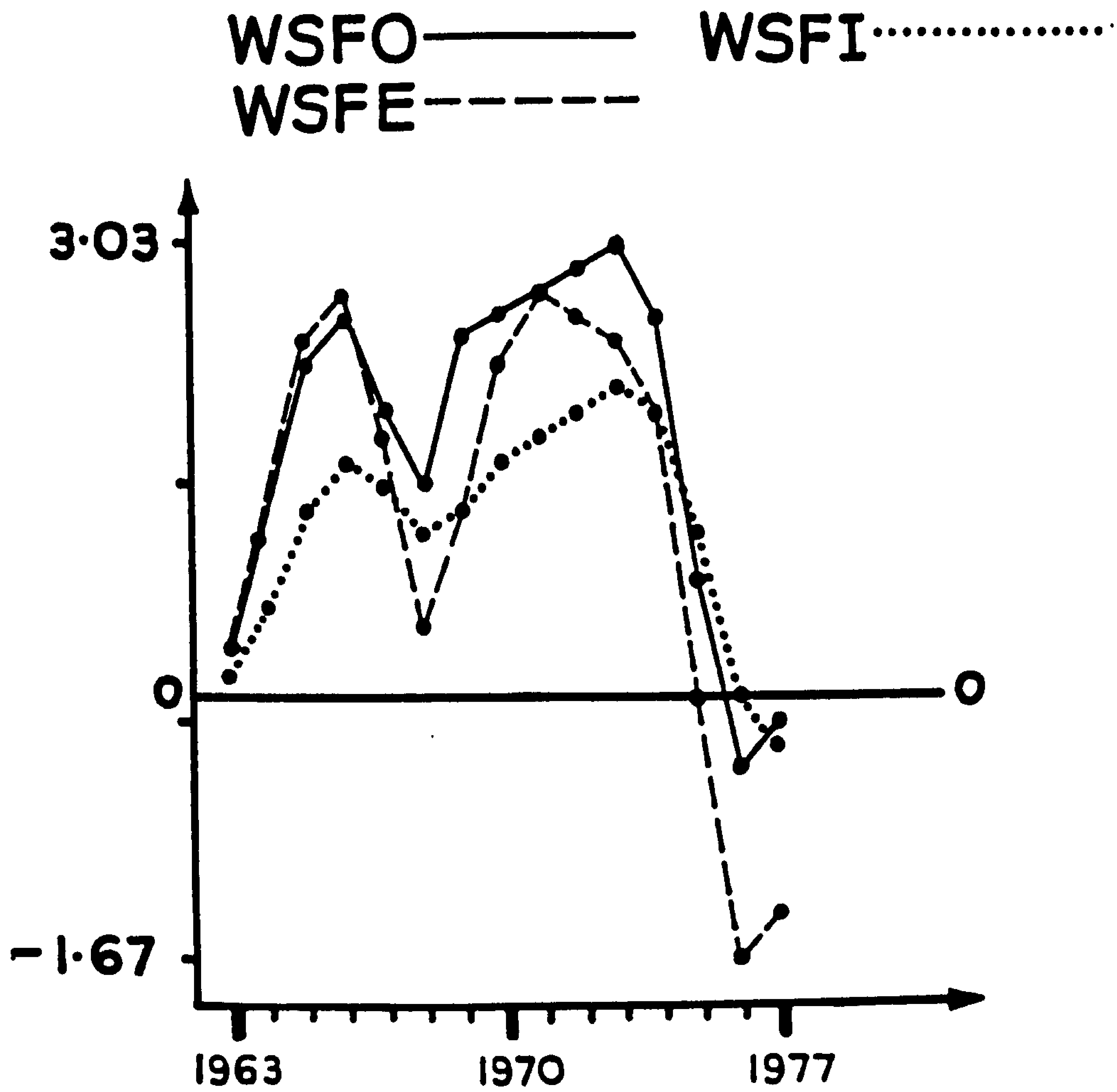
Table 29 WSFE

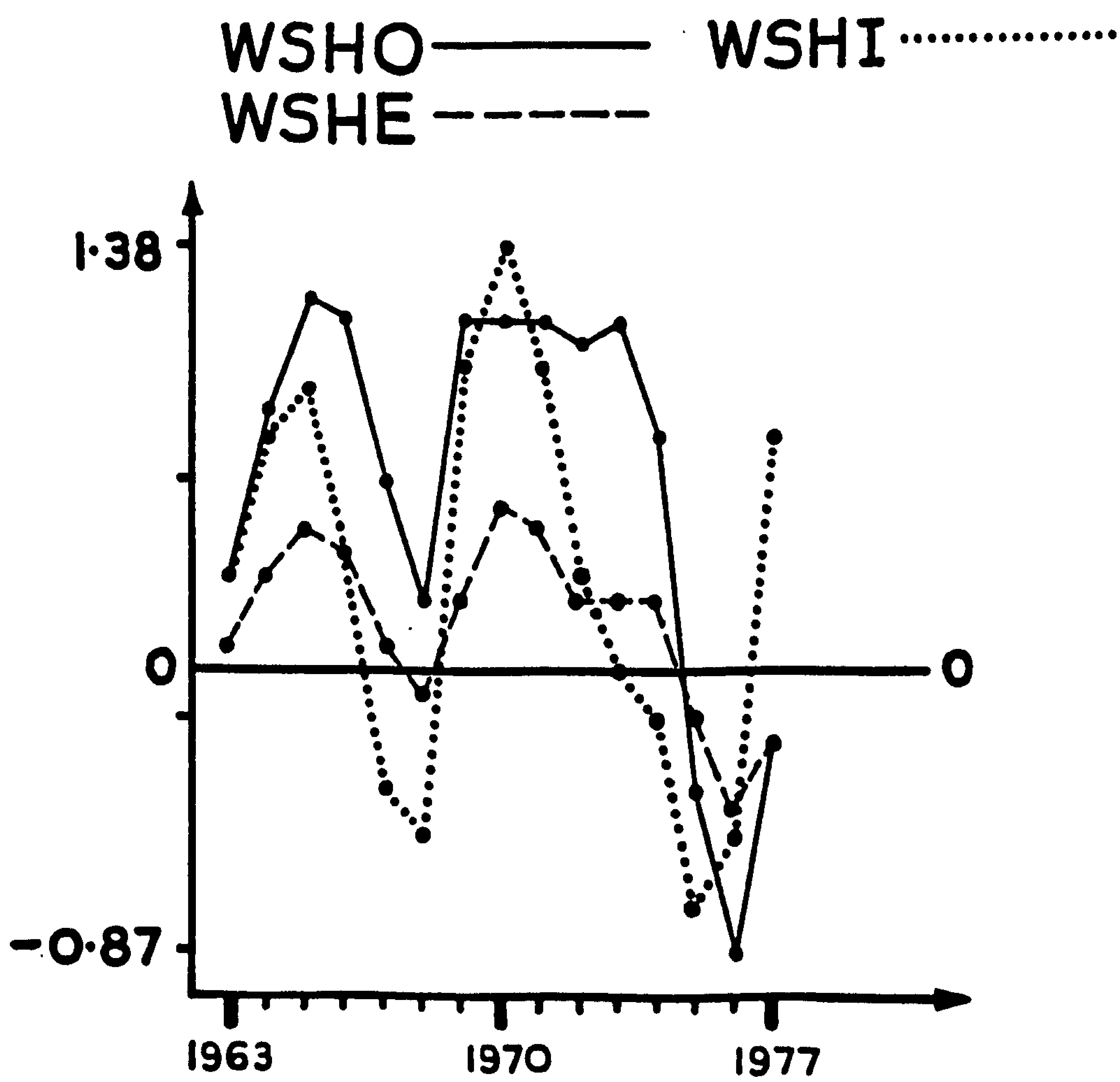
TIME	SFEMC	SFEMS	(S-C)	(S-C/C) x 100
1963	57.54	57.76	0.22	0.39
1964	60.20	61.01	0.80	1.33
1965	64.43	66.19	1.55	2.38
1966	70.55	72.47	1.92	2.68
1967	74.02	75.35	1.33	1.78
1968	77.08	77.53	0.45	0.58
1969	82.91	83.94	1.03	1.23
1970	89.61	91.63	2.02	2.23
1971	92.68	95.20	2.51	2.68
1972	98.56	101.15	2.58	2.58
1973	109.11	111.80	2.69	2.43
1974	112.04	114.21	2.16	1.91
1975	101.97	102.07	0.10	0.99E-0
1976	93.99	92.43	-1.56	-1.67
1977	95.37	94.02	-1.35	-1.42

Table 30 WSTE

TIME	STEMC	STEMS	(S-C)	(S-C/C) x 100
1963	709.74	710.59	0.85	0.12
1964	711.93	714.70	2.77	0.38
1965	710.77	715.34	4.56	0.64
1966	705.57	710.05	4.48	0.63
1967	692.80	694.84	2.04	0.29
1968	685.11	685.11	0.4E-02	0.57E-03
1969	688.56	691.39	2.83	0.41
1970	690.00	695.42	5.41	0.78
1971	677.02	682.22	5.20	0.76
1972	673.30	677.39	4.09	0.60
1973	683.42	687.69	4.26	0.62
1974	673.09	676.84	3.75	0.55
1975	633.09	632.67	-0.42	-0.66E-01
1976	605.47	601.65	-3.81	-0.63
1977	605.24	603.01	-2.23	-0.36




WSFO
WSFI
WSFE
3·03
0
-1·67
0
1963
1970
1977


WSHO
WSHI
WSHE
1·38
0
-0·87
0
1963
1970
1977

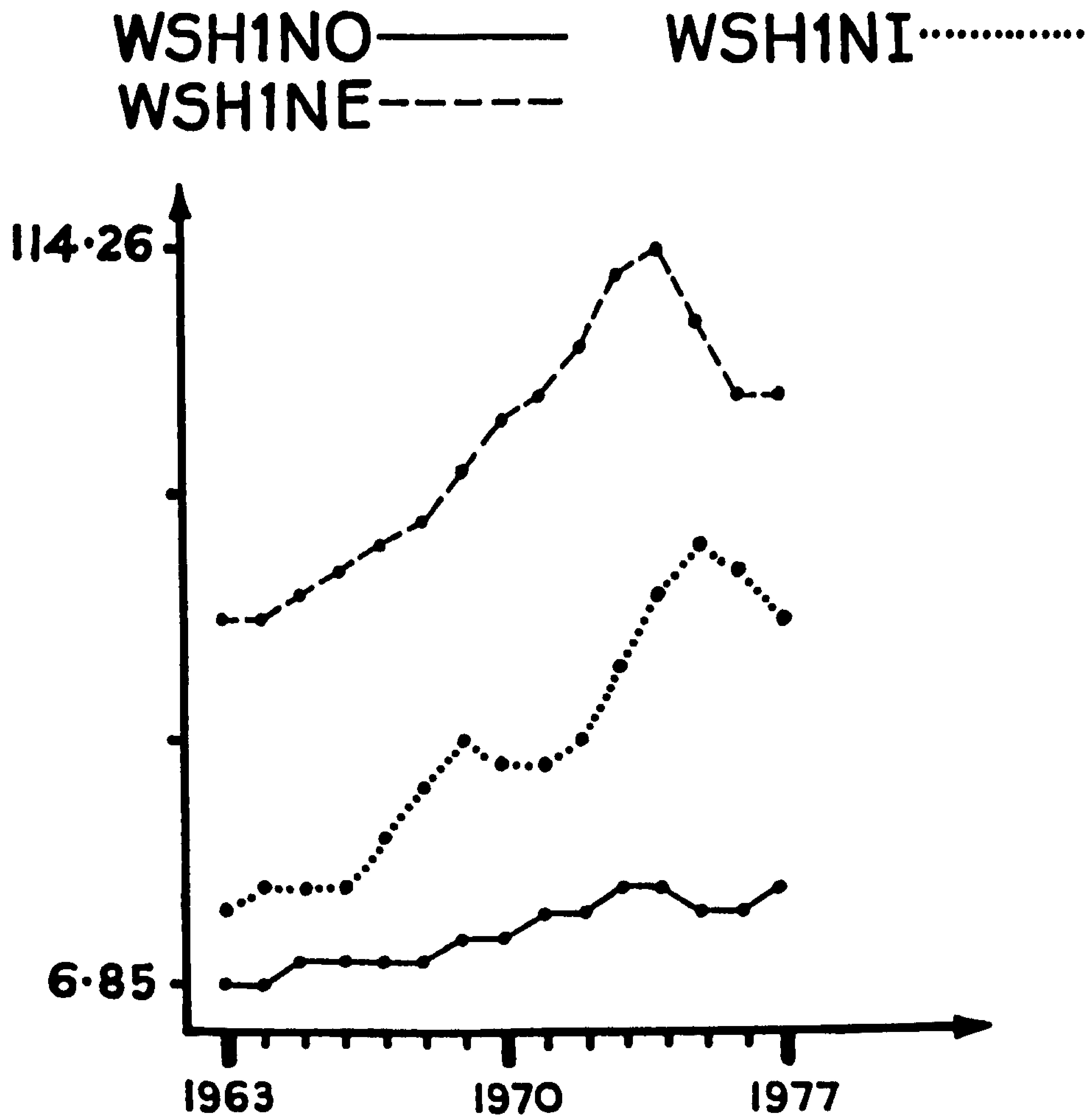
The shocked values of WSCR for output, employment and investment will next be used as benchmarks in combination with the shocked values of WSH1 - WSH3 is order to determine the net impacts of FDI between 1963 - 1977. The first case to be considered is WSH1, where dlnWXV is again shocked by a maintained 15% increase throughout the period. The shocked values for WSH1 are in table 31. The net contribution of FDI is (WSCR - WSH1) and these figures are presented in table 32 and the graph which follows. At the peak period of net loss, the Scottish economy would have had to forego approximately 114,000 jobs with the associated 64 million pounds of capital expenditure. As expected, in no year of the simulation period would the Scottish economy have been better off without the foreign sector. The interesting aspect of this result when comparing it to the GS shock is that in every period the Scottish economy is relatively worse off in output, employment and investment. This suggests that the government spending multipliers are greater than the export multipliers.

Table 31

TIME	SIOPS	STIMKS	STEMS
1963	63.16	272.08	651.15
1964	66.63	268.59	652.44
1965	69.40	287.58	650.39
1966	72.46	316.88	641.59
1967	72.35	315.51	622.32
1968	74.28	316.38	608.55
1969	78.04	333.10	607.81
1970	80.45	330.48	605.91
1971	80.13	307.36	589.27
1972	84.18	319.39	577.96
1973	88.38	362.42	577.00
1974	85.86	348.67	562.58
1975	80.18	299.30	530.15
1976	79.53	289.81	509.32
1977	81.51	305.93	508.86

Table 32

TIME	WSH1NO	WSH1NI	WSH1NE
1963	6.85	19.15	59.44
1964	7.85	20.96	62.26
1965	8.89	21.95	64.95
1966	9.74	22.25	68.46
1967	10.66	28.04	72.52
1968	11.54	34.80	76.56
1969	13.45	41.14	83.58
1970	14.60	38.23	89.51
1971	15.88	37.71	92.95
1972	17.73	42.29	99.43
1973	20.13	53.06	110.69
1974	20.75	64.33	114.26
1975	19.12	69.94	102.56
1976	18.61	66.01	92.33
1977	19.72	61.14	94.15


WSH1NO
WSH1NI
WSH1NE
114·26
6·85
1963
1970
1977

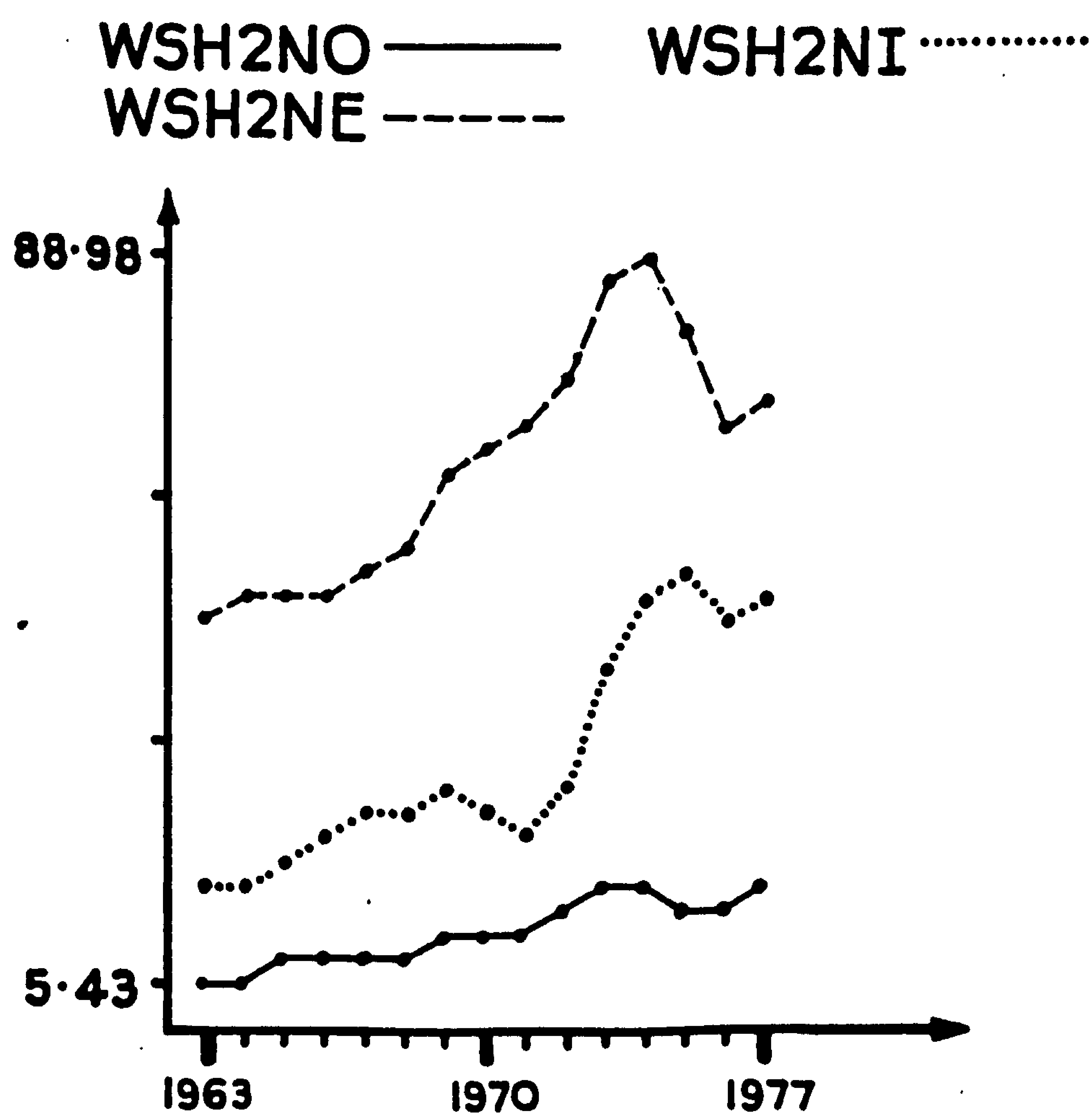
Under the assumption of WSH2, the shocked values which result are in table 33. The net contribution of FDI is (WSCR - WSH2). The figures are presented in table 34 and the graph which follows. The peak period of net loss was again in 1974, i.e. approximately 89,000 jobs with the associated 51 million pounds of investment. Although this scenario is obviously better than WSH1, the Scottish economy on balance is still better off in all years with the foreign sector present. In comparison with GSH2, the implication again is that the government spending multipliers are greater than the export multipliers.

Table 33

TIME	SIOPS	STIMKS	STEMS
1963	64.58	275.99	663.96
1964	68.28	271.20	665.78
1965	71.32	288.80	666.22
1966	74.60	316.71	659.71
1967	74.95	319.45	641.64
1968	77.10	325.26	628.28
1969	81.10	345.49	628.41
1970	83.85	345.11	627.96
1971	83.96	323.22	612.54
1972	88.31	333.58	602.32
1973	92.91	374.11	602.59
1974	90.50	361.94	587.86
1975	84.57	316.45	553.38
1976	83.82	307.31	531.61
1977	85.81	318.27	531.96

Table 34

TIME	WSH2NO	WSH2NI	WSH2NE
1963	5.43	15.24	46.63
1964	6.20	17.43	48.92
1965	6.97	20.73	49.12
1966	7.60	22.42	50.34
1967	8.06	24.10	53.20
1968	8.72	25.92	56.83
1969	10.39	29.02	62.98
1970	11.20	23.60	67.46
1971	12.05	21.85	69.68
1972	13.60	28.10	75.07
1973	15.60	41.37	85.10
1974	16.11	51.06	88.98
1975	14.73	52.79	79.29
1976	14.32	48.51	70.04
1977	15.42	48.80	71.05



The final scenario to be considered is WSH3 the shocked values of which can be found in table 35. The figures pertaining to the net contribution of FDI in this case are in table 36 and the graphs which follow. In terms of output (WSH3NO), the Scottish economy is better off without the foreign sector in 9 out of the 15 years in the simulation. These years fall in between the period 1966-1972 and 1975-1976. The peak period of extra output is in 1968. The periods in which the Scottish economy would have been worse include the years 1963-1965, 1973-1974 and 1977 (the peak period of loss). In the case of employment (WSH3NE) the Scottish economy would have been better off in the absence of the foreign sector in 8 out of the 15 years in the simulation (1965-1972) with the peak period employment gain (approximately 7,000 extra employees) in 1966. The periods in which the Scottish economy would still have been worse off include 1963-1964 and 1973-1977, with the period of peak loss in 1974. In terms of investment WSH3NI, again it is only 8 out of the 15 years in which the Scottish economy would have been better off (1966-1973) with a peak in 1971. On the other hand it would have been worse off in 1963-1965 and 1974-1977 with a peak in 1975 and an associated loss of 14.32 million pounds of investment.

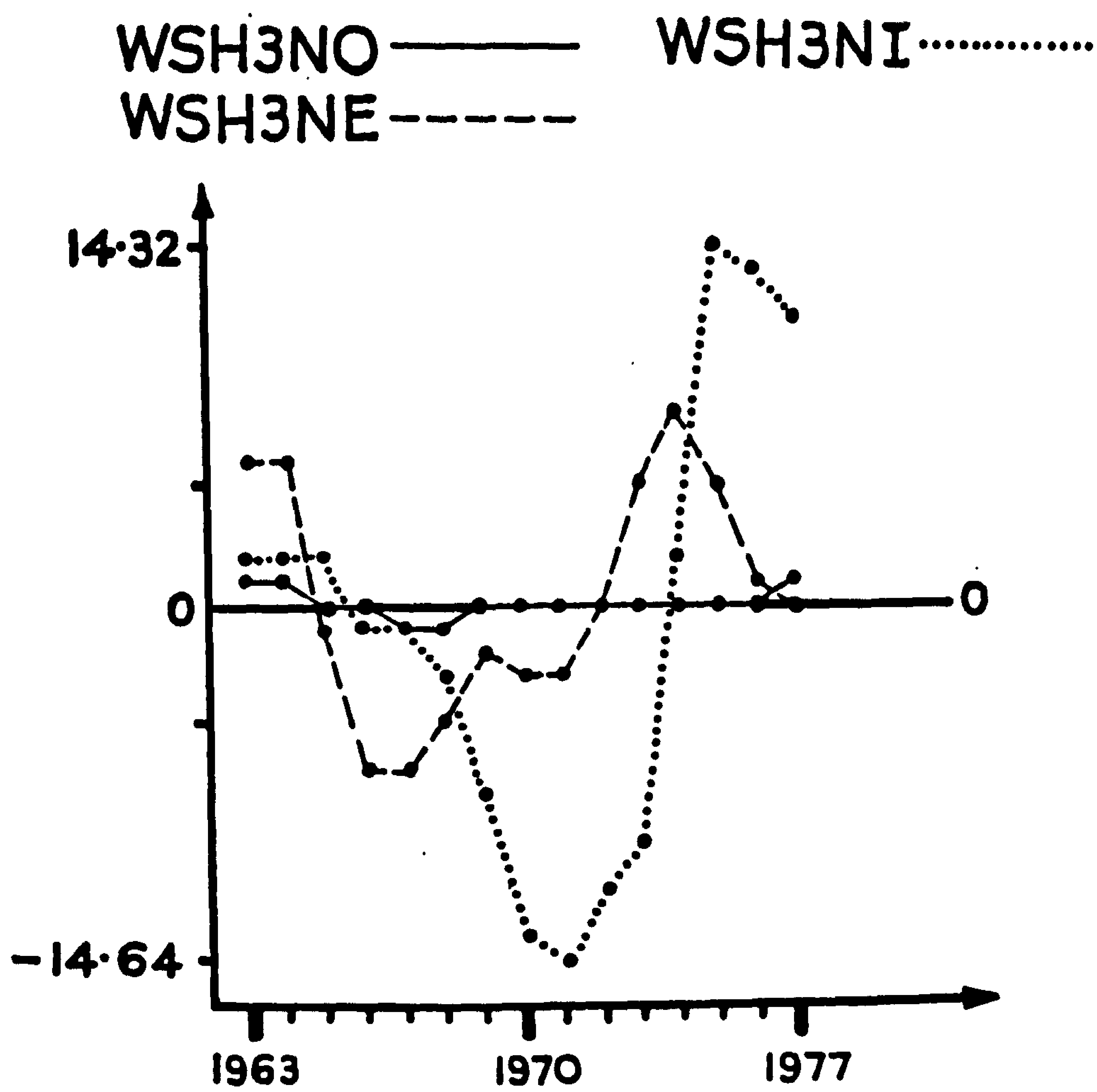
The results of this simulation coincide with the Government spending shock in that the foreign sector does not seem to be hampering the growth of the home sector and in turn the growth prospects of the Scottish economy.

Table 35

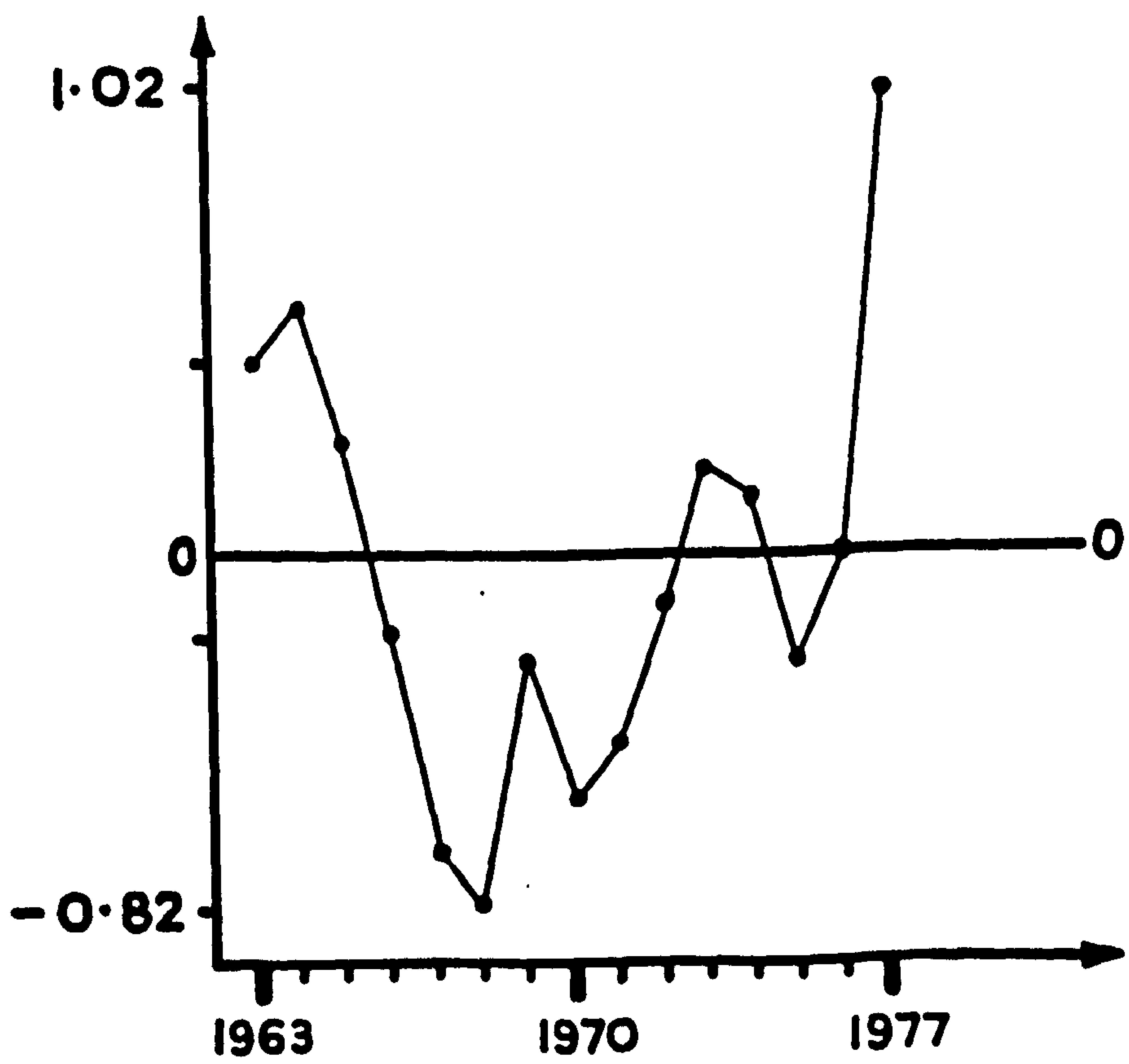
TIME	SIOPS	STIMKS	STEMS
1963	69.58	289.89	704.93
1964	73.97	287.34	709.23
1965	78.05	308.35	716.71
1966	82.41	340.58	717.41
1967	83.70	344.77	702.11
1968	86.64	353.91	698.89
1969	91.76	381.96	693.96
1970	95.61	384.51	698.38
1971	96.49	359.71	684.87
1972	102.00	373.19	677.58
1973	108.30	425.40	683.50
1974	106.40	411.61	669.41
1975	99.59	354.92	627.88
1976	98.16	342.74	601.14
1977	100.20	355.79	602.90

Table 36

TIME	WSH3NO	WSH3NI	WSH3NE
1963	0.43	1.34	5.66
1964	0.51	1.71	5.47
1965	0.24	1.81	-1.37
1966	-0.21	-1.45	-7.36
1967	-0.69	-1.22	-7.27
1968	-0.82	-2.73	-4.78
1969	-0.27	-7.45	-2.57
1970	-0.56	-13.25	-2.96
1971	-0.48	-14.64	-2.65
1972	-0.12	-11.51	-0.19
1973	0.15	-9.92	4.19
1974	0.13	1.39	7.43
1975	-0.29	14.32	4.74
1976	-0.02	13.08	0.51
1977	1.02	11.28	0.11



BLOW-UP OF WSH3NO



Summary of Findings

It should be clear at this point that the preceeding simulation experiments have provided information which is relevant to addressing the 8 questions set out at the beginning of this Chapter. By way of reiteration these questions are:

1) Given an exogenous shock, which sector is able to sustain the momentum of that change for the longer time period? In other words, which sector is able to set off the longer running multiplier-type effects?
2) In response to a given exogenous shock, which sector reacts in the more 'elastic' manner, and is this response maintained over the simulation period?
3) Which sector has the greatest export propensity and does this change over the simulation period?
4) At the aggregate level, which sector displays the greater degree of dependence on the other?
5) Is there a propensity for the foreign sector to lead to greater captial intensity in the long-run and hence less employment opportunities relative to the home sector?
6) Is there a tendency for the foreign sector to hamper the growth prospects of the home sector over time?
7) What are the net impacts of FDI on Scottish output, employment and investment over the simulation period?
8) Does the foreign sector exaggerate the deflationary tendencies of the economy?

Question 1 (Q.1) seems to be answered to a large extent by the results of the lagged output impulse simulations. In this case the foreign sector quite clearly was able to sustain the momentum of the shock for a longer time period. The implication under the assumptions of the simulation was that the foreign sector had longer running output 'multiplier' type effects than the home sector. This seems to suggest either proportionately greater relative export propensities to rest of the U.K. and rest of the world (which is relevant to Q.3) or proportionately greater relative linkages with the local economy or some combination of both.

As regards Q.2, there is no doubt that the foreign sector responds in a proportionately more 'elastic' way than does the home sector to exogenous shocks. This behaviour was evidenced in the lagged output impulse shock (with the exception of 1973-1974), the government spending shock in output, employment and investment (with the exception of 1963 in investment) and the world demand shock in output, employment (with the exception of 1976-1977) and investment (with the exception of 1963-1964 and 1977). This higher relative 'elasticity' of response can again be taken to suggest proportionately higher relative export propensities to the rest of the U.K. and to rest of the world or proportionately greater relative linkages with the local economy or some combination of the two.

In response to Q.4 it was found in the lagged output impulse shock that in aggregate terms the foreign sector is more dependent on the growth prospects of the home sector and the domestic economy at large rather than the reverse case. This suggests, in policy terms, that if policy were to be applied to only one sector that it should be the home sector which receives attention. This would result not only in greater proportionate responses in output and employment from the home sector, but further it would carry the foreign sector proportionately further than the foreign sector would carry the home sector.

As regards Q.5, it was found in the government spending shock that in order to create the output which was called forth by the increase in demand, the foreign sector had to use relatively more labour than capital in every period of the simulation (with the exception of 1966, 1967, and 1973). Therefore it does not seem that the foreign sector is hampering long-run employment potential due to increased capital intensity over time. This finding is further supported in the short to medium-term by evidence from the world demand shock where it was found that the foreign sector used relatively more labour than capital up to 1974 (with the exception of 1968).

Q.6 on net impacts is answered unambiguously in the government spending and world demand shocks. Under the assumption of SH1 and SH2 in no year is the Scottish economy better off in the absence of the foreign sector. Even in the final extreme scenario of SH3, the Scottish economy is only better off in approximtely one half of the 15 years in the simulation.

The results obtained for SH3 in both the government spending and world demand shocks are relevant in answering Q.7. For instance, if under the assumptions of SH3, the home sector cannot better or at least replicate the foreign sector performance (even before the realities of finance and technological constraints are considered) then it can fairly safely be concluded at the aggregate level that the foreign sector is not monopolizing the home sector and starving it of opportunities.

Finally, if the conclusions pertaining to Q.1, Q.2 and Q.3 are correct, then it can be deduced that in time of cyclical downturn, the foreign sector would be relatively worse off which would tend to complement the deflationary tendencies of the economy.

Following in Chapter VIII is a summary of the main findings and conclusions of the thesis.

NOTES: CHAPTER VII

1. Scottish data in this sense is typical of regional data which suffers from time lags in reporting. As was clear from the solved model presented in Chapter VI the simulation period for the model is constrained by the shortest data series or identity in the system. (In the case of SIMFOR, 1977).

2. Even though the model is non-linear and dynamic, experiments with various alternative shocks (e.g. 10%, 40%, and 60%) showed that the non-linear relationships gave rough approximations to linear scaled up results. This not only reflected a certain amount of robustness in the overall model results but can also be taken to suggest overall model stability. The shock of 25% was finally chosen since it was large enough to allow the proposed changes to work their way through the system.

3. It is the shocked values (endogenous variables) of CR versus the actual historical time paths of the endogenous variables with which the alternative scenarios will be compared. This is due to the fact that the estimated SIMFOR system is only an approximation of the true system and is hence subject to errors. In order not to burden the simulation results with these errors which are not easily identifiable, it is necessary to abstract away from them and assume that the estimated system adequately represents the true system. Further elaboration on this point can be found in Challen, D. W. and Hagger, A. J., _Macroeconometric Systems: Construction, Validation and Applications_ (Macmillan 1983), pp. 142-160.

4. This point will be covered in more detail in the next section (empirical results) under the sub-heading exogenous shocks.

5. In SH1, the estimated coefficients for the home sector are essentially the same as those in CR, since in SH1 the home sector is not assumed to take over any foreign investment. In SH2, however, there is a proposed structural change in the home sectors' behavior, i.e. that it will attempt to take up 25% of foreign activity in output, investment and employment. In this case, therefore, the home equations are reestimated with the same functional form and lag structure but now include information which pertains to foreign sector activity. The same procedure is applied to SH3 where it is postulated that the home sector attempts to take up all the foreign sector activity. The results of the above

reestimation, can be found in Appendix 7.

6. They are not in fact elasticities in the strict sense since the response figures would all have to be divided by (.25).

7. Recall the findings of McDermott, reviewed in Chapter I, who found that in the electronics industry there were not strongly pronounced linkages between the home and foreign sector. This finding was also asserted at a more aggregate level in the earlier study by Forsyth (see also Chapter I).

8. Although McDermott (see Chapter I) did not find strong linkages between the home and foreign sectors in the electronics industry, he did find that the home sector was more dependent on the foreign sector rather than the other way around. As seen from the simulation results of SIMFOR, at the aggregate level, the reverse seems to be the case.

9. As regards U.K. policy this distinction between home and foreign is in fact not made. Both indigenous and foreign firms are eligible for the same incentive packages. Later, when applying the maintained exogenous shocks both sectors will in fact be stimulated simultaneously.

10. Recall that in Chapters IV and V explicit attempts were made at trying to get to grips with the incorporation of regional policy measures. However, this proved to be a difficult task due to data and specification problems.

11. This occurs simply due to the fact that DEM increases over the time period. The same type of experiment was carried out with a maintained 3% increase in DEM (via increasing PAGSK). While relative magnitudes were different, the basic reactions of the model were analogous to the 200 million increase in PAGSK, hence it was not felt necessary to report this second set of results.

12. This finding goes counter to the argument suggested by Firn in Chapter I.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

Introduction

The first part of this Chapter is concerned with the presentation of the main assumptions and findings of this thesis. This is followed by the overall conclusions which can be drawn from these results and suggestions for further developments of the model.

Main Assumtions and Findings

(1) In Chapter I the perceived irrelevance of theoretical method in the neo-classical literature and the lack of theoretical/empirical method in the Scottish studies (as regards the impacts of FDI) rendered both approaches as inappropriate for the purposes of this thesis. It was hence decided that there was a need for an applied macroeconomic methodology which was capable of ascertaining the structural differences between the home and the foreign sectors and, in turn, the net impacts of the foreign sector on a host economy/region.

(2) Given (1), in Chapter II it was decided that the most appropriate methodological approach would be the macro-econometric modelling as opposed to the economic base or the input-output approaches.

(3) In Chapter III itwas decided that due to the

conceptual and technical difficulties associated with modelling income and expenditure, the model should proceed in the spirit of the output approach (albeit in a more narrowly defined manner in that it was the determinants of manufacturing output as opposed to total output which were to be examined).

(4) Given (3), in Chapter III it was decided that a demand oriented theoretical specification, as opposed to a supply side approach, was more appropriate in a regional context for both the home and foreign sectors.

(5) Given (4), in Chapter III it was decided that for the purposes of SIMFOR it was more appropriate to specify both home and foreign output as functions of Scottish domestic expenditure aggregates (which implicitly included rest of the U.K. behaviour) as opposed to taking regional output as a function of national output.

(6) Given the theoretical form implied by (5), in Chapter III it was found that the hypothesis of no relationship between the growth of home/foreign output and the growth of Scottish demand, the lagged level of Scottish demand, the growth of world demand and the lagged values of home and foreign output respectively should be rejected.

(7) Given the empirical results implied by (6), in Chapter III it was found that the short-run

'elasticities' of responsiveness of the growth in home and foreign output with respect to a 1% change in the growth of Scottish demand were similar at 1.2% and 1.3% respectively.

(8) It was also found in Chapter III that the short-run 'elasticities' of responsiveness of the growth in home and foreign output with respect to a 1% change in the growth of world demand were less than the Scottish demand elasticities at .42% and .60% respectively.

(9) Regarding the long-run elasticities of home and foreign output with respect to a 1% change in Scottish demand, it was found in Chapter III that the home sector reacted in an approximately unit elastic manner (at 1.05%) whereas the foreign sector reacted in a relatively elastic manner (at 3.53%).

(10) As was the case with the output equation (assumption [4]), it was decided in Chapter IV that demand oriented specifications were more appropriate for the home and foreign investment functions as opposed to a more supply oriented type equations. However it was also assumed that there were a priori theoretical reasons for differentiating the home and foreign equation by modifying the foreign investment function to take into account more cost oriented factors.

(11) As regards home investment, given the theoretical form implied by (10), it was found in Chapter IV that an accelerator model modified by capacity utilization

successfully fitted the data. Competing specifications such as interest rate and profit functions were not found to be statistically significant.

(12) Given the empirical results implied by (11), it was found in Chapter IV that the short-run 'elasticity' of the growth in home investment with respect to a 1% change in the accelerator term (d^2lnFLEXACC) and (lnFLEXACC) were .60% and .33% respectively. In the long-run it was found that the elasticity of home investment with respect to a 1% change in the accelerator term was relatively elastic at 2.48%.

(13) In Chapter IV it was found that the hypothesis of no relationship between the growth of foreign investment and an output argument weighted by the expected long-run rate of return on capital in the U.K. and a second argument in terms of relative rates of return between the U.K. and Europe (EEC-6) should be rejected. The competing arguments which either could not be tested or were not found to be statistically significant included arguments for a simple accelerator model, a cost of capital model, regional policy, a dummy variable for Britain's accession to the EEC and relative location type variables.

(14) Given the empirical results implied by (13), it was found in Chapter IV that in the short-run the 'elasticities' of the growth in foreign investment

with respect to a 1% change in the growth of the weighted output argument (dlnJVE), the 'level' of the weighted output arguments (lnJVE) and the lagged 'level' of the ratio of U.K. to European rates of return [RAT1(-1)] were 0.59%, 0.81% and 0.57% respectively.

(15) In Chapter IV it was found in the long-run that the elasticities of foreign investment with respect to a 1% change in the weighted output argument and the relative rates of return argument were 1.42% and 1.00% respectively.

(16) In Chapter V it was decided that an inverted production function approach (with arguments for output and technological change) was more appropriate in specifying labour demand than was an approach which emphasized the cost of labour.

(17) Given theoretical form implied by (16) it was found in Chapter V that the hypothesis of no relationship between the growth of home employment and the lagged values of the level of home employment in years (-1) and (-2), the level of current output, and finally a time trend (to proxy technological change) should be rejected. The same argument with the exception of the time trend term was found to be statistically significant in the foreign sector. Variables representing standard hours, the regional employment premium, and fixed costs of employment were not

incorporated into the equations due to the problems of data availability.

(18) Given the empirical results implied by (17) it was found in Chapter V that the short-run 'elasticity' of the growth in home employment with respect to a 1% change in output was 0.29%, whereas the growth in foreign employment had an output 'elasticity' of 1.19%.

(19) In Chapter V it was found that the long-run elasticity of employment with respect to a 1% change in output for the home and foreign sectors was 0.21% and 1.63% respectively.

(20) In the context of SIMFOR it was found in Chapter VI that the OLS parameter estimates did not differ significantly from the principal components estimated parameters.

(21) It was found in Chapter VI that identification was not a problem in SIMFOR and that OLS was the most appropriate estimation technique for the equation system. Furthermore it was decided to solve the model in a dynamic deterministic mode i.e. via the Guass-Seidel iterative technique.

(22) It was found in Chapter VII that the foreign sector had longer running output multipliers than did the foreign sector. This finding implied that the foreign sector had proportionately greater relative export propensities to the rest of the U.K./rest of the world

or proportionately greater relative linkages with the local economy or some combination of both.

(23) It was also found in Chapter VII that the foreign sector displayed proportionately greater relative responsiveness in output, employment and investment to various exogenous shocks than did the home sector. These findings led to the same implications as (22).

(24) In Chapter VII it was found that the foreign sector was more dependent on the growth prospects of the home sector and the domestic economy at large as opposed to the reverse case. In policy terms this finding implied that it would be more beneficial to concentrate on stimulating the home versus the foreign sector.

(25) In Chapter VII it was deduced from evidence on the government spending shock that the foreign sector was not hampering the long-run employment creating potential of the economy due to increased capital intensity over time. This finding was also supported by evidence from the world demand shock up to the medium-term.

(26) In Chapter VII it was found that in the absence of the foreign sector the Scottish economy would have been worse off in terms of output employment and investment in nearly every hypothetical situtaion postulated. The exception was in the extremely unlikely scenario that all lost foreign aggregates

would have been attempted by the home sector, where it was found that the home sector was still worse off in nearly half the years in the simulation period. This last finding can be taken to imply that the foreign sector was not monopolizing the home sector and starving it of opportunities.

(27) It was deduced on the basis of the previous finding in Chapter VII that in times of recession the foreign sector would be relatively worse off than the home sector and would tend to complement the deflationary tendencies of the economy.

(28) In Chapter VII it was deduced on the basis of evidence from the government spending shock (GS) and the world demand shock (WS) that the multipliers associated with GS were greater than those associated with WS.

Overall Conclusions and Future Developments

On balance the main objectives of this thesis have been fulfilled i.e. the identification and evaluation of the macroeconomic impacts of foreign direct investment on a host economy/region. More specifically a single/multi-equation macro-econometric model of the Scottish manufacturing industry has been specified, estimated and simulated. The results of the single equation exercise based on the Hendry-type estimation in 'levels' and 'differences' yielded quite robust results which permitted more sophisticated single equation diagnostics than is usually the case in regional modelling. In this context the single equations did enable quite distinct short-run and long-run differences between the home and foreign sector to be highlighted and quantified. Furthermore the multi-equation exercise also produced quite robust results reflected by all the overall model evaluation procedures. Subsequent work with this initial set of simulation results did in fact allow quite interesting and important questions to be addressed which were inaccessible in other studies. For instance the results from the above two exercises (outlined in the first section of this Chapter) strongly suggest that FDI in the Scottish manufacturing sector bestows a positive net benefit and that it should be allowed to continue. This conclusion was reached on the basis of the following main findings.

1. The greater foreign relative output, employment and investment response elasticities obviously translate into a more dynamic faster growing economy.
2. The proportionately greater relative export propensities or local linkages or some combination of both means that foreign sector is again exhibiting greater relative growth.
3. (1) and (2) are further complemented by longer running foreign output multiplier type effects.
4. The foreign sector bestows positive net impacts in output, employment and investment (in the vast majority of simulations) when the opportunity costs associated

with FDI were explicitly considered.

5. The foreign sector displays no marked tendency to create less employment opportunities over time.
6. There was no apparent tendency for the foreign sector to starve the local economy of investment opportunities.

The above conclusion must be qualified however on several grounds. Firstly, since no apparent asymmetry was found between upturns and downturns in demand, deflationary influences of the foreign sector will be correspondingly greater in times of recession. This could simply be viewed as a price that has to be paid for the relatively greater prosperity during periods of growth since the absence of a foreign sector even combined with growth would translate into a net loss (due to the failure of the domestic sector to adequately compensate for the loss). Broadly speaking even in periods of decline the Scottish economy would not suffer net loss in the presence of the foreign sector, therefore the argument that it tends to complement deflationary tendencies would alone not be enough to negate its presence.

A second qualification of the above conclusion is the consideration of the costs of inducing the foreign firm to locate in Scotland. The policy of aiding both the home and foreign sectors simultaneously via grants not only has the explicit costs associated with the foreign sector but further the implicit cost of aiding the home sector since the latter could be forced to undertake investments in disadvantaged regions e.g. via IDC control (this is also true for the foreign firms already located in the rest of the U.K., but obviously not true for those not yet located in the rest of the U.K.). Having said this it does not seem to be the case that these policies were developed with the foreign sector solely in mind but were part and parcel of U.K. regional policy and were available to both home and foreign sector alike. Furthermore it can be argued that this point has less relevance when it is acknowledged that these regional policy resources do not come from an exclusively Scottish tax base, but from the U.K. as a whole.

It must further be noted that the approach applied in this thesis is not without its drawbacks. The most obvious are the limitations imposed by the lack of regional data and the associated problems of small samples even when the data does exist. In the context of SIMFOR the lack of data observations limited the dynamic specification of the single equations. This was most evident in the investment functions, which usually need quite sophisticated lag structures in order to reproduce the actual data accurately. Furthermore, the general lack of data prohibited the testing of certain right hand side arguments which were thought to be significant. For instance the fixed costs of employment and the influence of the regional employment premium in the employment functions; and host governments' attitudes to FDI and Britain's accession in the EEC in the foreign investment function. Other arguments could often not be tested even when the data existed due to specification problems e.g. regional development grants and IDC control in the investment functions. Another area inhibited by the shortage of data observations was obviously ex-ante forecasting. With the passage of time, the constraints associated with lack of observations should become less acute. Additional observations will obviously yield more reliable parameter estimates, more sophisticated lag structures, and possibly permit ex-ante forecasts to be performed (assuming that collecting and reporting up to date information at the regional level becomes less of a problem). Another interesting but extremely problematic area for someone wishing to carry forward work of this type is in the specification of explicit policy instruments with some sort of trade-off function which allows more realistic examination of the alternative scenarios. This further allows the comparison of the relative effectiveness of various policy instruments. Such improvements as outlined above will undoubtedly enhance the modelling tool as a more reliable policy guide.

As regards overall policy in the Scottish context, if it is accepted that the assumptions (notably less than full employment) and qualifications made in this thesis are broadly consistent with reality then it is possible to argue that McDermott's challenge has been met albeit in a negative manner. (Recall the quote presented in Chapter I).

> "unless it can be demonstrated that long-run damage to the Scottish economy has resulted from this, it would be difficult to argue for any change to the policies which have encouraged such investment".

On balance it has been demonstrated that within the historical period 1961-1977 that long-run damage to the Scottish economy has not occurred, but rather the contrary. Furthermore, assuming that the structure found in SIMFOR approximates the current situation in Scotland then it would be extremely difficult to disagree with the argument that this investment should continue to be encouraged in the future.

Appendix 1

FLOW CHART FOR THE SIMFOR MODEL OF SCOTLAND

Appendix 2

Abbreviations, Variable Definitions, Equations, Identities, Definitional Relationships in SIMFOR.

Abbrevations, Variable Definitions

ln	is the natural logarithm.
d	is the difference operator.
dln	approximates the percentage rate of change or rate of growth of a variable. This is computed by taking lnX - lnX(-1) which equals dlnX.
a b, c . . z	small letters refer to estimated parameters.
(-i)	annual lag.

1. Consumption Equation

dlnSCONK	is the rate of change of Scottish consumer expenditure in constant (1975) prices.
lnSCONK(-1)	is the logged level last period of constant Scottish consumer expenditure.
dlnINC	is the rate of change of Scottish personal disposable income minus the real wage bill in the manufacturing sector in constant (1975) prices.
lnINC(-1)	is the logged level last period of constant personal disposable income.
lnTWSMK	is the logged level of the Scottish manufacturing wage bill in constant (1975)

prices.

2. Real Wage Bill Equation

dlnTWSMK — is the growth rate of the wage bill in the Scottish manufacturing sector in constant (1975) prices.

dlnTWUKMK — is the growth rate of the U.K. manufacturing wage bill in constant (1975) prices.

dlnSTEM — is the rate of growth of total manufacturing employment in Scotland.

3. Scottish Home Manufacturing Output Equation

dlnSHIOP — is the rate of change of Scottish output in the home manufacturing sector, based on the index of production series, in constant (1975) prices.

lnSHIOP(-1) — is the logged level last period of Scottish manufacturing output.

dlnDEM — is the rate of growth of Scottish domestic demand, where DEM = SCONK + SHIMK + SFIMK + STINMK + PAGSK.

SCONK — is constant Scottish consumer expenditure.

SHIMK — is constant Scottish manufacturing investment in the home sector.

SFIMK — is constant Scottish manufacturing investment in the foregin sector.

STINMK — is total Scottish non-manufacturing investment.

PAGSK — is public authority government spending in Scotland.

lnDEM(-1) — is the logged level last period of Scottish domestic demand in constant prices.

dlnWXV — is rate of growth of proxied world demand (export volume index) in constant (1975) prices.

4. Scottish Foreign Manufacturing Output Equation

dlnSFIOP — is the rate of change of Scottish foreign output, based on the index of production in constant (1975) prices.

lnSFIOP(-1) — is the logged level last period of Scottish foreign output in constant prices.

5. Scottish Home Manufacturing Investment Equation

dlnSHIMK — is the rate of change of Scottish home manufacturing investment in constant (1975) prices.

lnSHIMK(-2) — is the logged level of Scottish home manufacturing investment in constant prices, lagged two years.

d^2lnACC — is the term used in the flexible accelerator function and is comprised of the product of Scottish manufacturing output (1975) prices

	and capacity utilization in Scottish manufacturing (1970) prices.
lnACC	the logged level of the product of Scottish manufacturing output and capacity utilization in Scottish manufacturing, before the differencing operation.

6. Scottish Foreign Manufacturing Investment

dlnSFIMK	is the rate of growth of Scottish foreign manufacturing investment in constant (1975) prices.
dlnJVE	is the rate of change of the market size variable weighted by the cost of investment goods and expected long-term rates of return. It is comprised of output, the interest rate and the exchange rate in constant prices.
lnJVE(-1)	is the logged level of the above variable for last period in constant prices. JVE = [(WPUK x SIOP/PIGUK) x (UKR x IER)]
WPUK	is the index of wholesale prices in the U.K. in (1975) prices.
PIGUK	is the price of U.K. investment goods in (1975) prices.
UKR	is the U.K. nominal long term corporate bond rate.
IER	is the U.K. index of exchange rates,

relative to the U.S. dollar 1975 = 100.

RAT(-1) is the ratio of U.K. to European rates of return lagged one year.

7. Scottish Home Manufacturing Employment Equation

lnSIOP logged level of total Scottish manufacturing output, index of production (1975 = 100).

dlnSHEM is the growth rate of home manufacturing employment.

lnSHEM(-i) is the logged lagged level of home manufacturing employment in period (i).

TREND is a time trend, which attempts to proxy technological change.

8. Scottish Foreign Manufacturing Employment Equation

dlnSFEM is the rate of growth of Scottish foreign manufacturing employment.

lnSFEM(-i) is the logged lagged level of foreign manufacturing employment in period (i).

9. Scottish Domestic Demand

STINMK Scottish total non-manufacturing investment in constant (1975) prices.

PAGSK Scottish public authority government spending in constant (1975) prices.

10. Scottish Total Output

SIOP Scottish total manufacturing output, index and production, (1975 = 100).

11. Scottish Total Employment

STEM is total manufacturing employees employment in Scotland.

Behavioural Equations

1. Scottish Consumption Function

   dlnSCONK = a + blnSCONK(-1) + cdlnINC + elnINC(-1) + flnTWSMK + glnTWSMK(-1).

2. Scottish Real Wage Bill Equation

   dlnTWSMK = a + bdlnTWUKMK + cdlnSTEM.

3. Scottish Home Manufacturing Output Equation

   dlnSHIOP = a + blnSHIOP(-1) + cdlnDEM + elnDEM(-1) + flnWXV.

4. Scottish Foreign Manufacturing Output Equation

   dlnSFIOP = a + blnSFIOP(-1) + cdlnDEM + elnDEM(-1) + flnWXV.

5. Scottish Home Manufacturing Investment Equation

   dlnSHIMK = a + blnSHIMK(-2) + cd^2lnACC + elnACC.

6. Scottish Foreign Manufacturing Investment Equation

   dlnSFIMK = a + blnSFIMK(-1) + cdlnJVE + elnJVE + flnRAT1(-1).

7. Scottish Home Manufacturing Employment Equation

   dlnSHEM = a + blnSIOP + clnSHEM(-1) + elnSHEM(-2) + fTREND.

8. Scottish Foreign Manufacturing Employment Equation

dlnSFEM = a + blnSIOP + clnSFEM(-1) + elnSFEM(-2).

Identities

9. Scotish Domestic Demand

DEM = (SCONK + SHIMK + SFIMK + STINMK + PAGSK).

10. Scottish Total Manufacturing Output

SIOP = SHIOP + SFIOP.

11. Scottish Total Manufacturing Employment

STEM = SHEM + SFEM.

Definition Relationships

12. lnDEM = ln(DEM).

13. dlnDEM = lnDEM - lnDEM(-1).

14. SCONK = Exp(dlnSCONK + lnSCONK(-1)).

15. lnSCONK = ln(SCONK).

16. dlnTWSMK = Exp(dlnTWSMK - lnTWSMK(-1)).

17. lnTWSMK = ln(TWSMK).

18. SHIOP = Exp(dlnSHIOP + lnSHIOP(-1)).

19. lnSHIOP = ln(SHIOP).

20. SFIOP = Exp(dlnSFIOP + lnSFIOP(-1)).

21. lnSFIOP = ln(SFIOP).

22. SHIMK = Exp(dlnSHIMK + lnSHIMK(-1)).

23. lnSHIMK = ln(SHIMK).

24. SFIMK = Exp(dlnSFIMK + lnSFIMK(-1)).

25. lnSFIMK = ln(SFIMK).

26. SHEM = Exp(dlnSHEM + lnSHEM(-1)).

27. lnSHEM = ln(SHEM).

28. SFEM = Exp(dlnSFEM + lnSFEM(-1)).

29. lnSFEM = ln(SFEM).

30. lnSIOP = ln(SIOP).

31. dlnSIOP = lnSIOP - lnSIOP(-1).

32. ACC = SCUIK x SIOP.

33. lnACC = ln(ACC).

34. dlnACC = lnACC - lnACC(-1).

35. d^2lnACC = dlnACC - dlnACC(-1).

36. lnSTEM = ln(STEM).

37. dlnSTEM = lnSTEM - lnSTEM(-1).

38. JVE = [(SIOP x WPUK/PIGUK) x (UKR x IER)].

39. lnJVE = ln(JVE).

40. dlnJVE = lnJVE - lnJVE(-1).

Appendix 3

'Data used in SIMFOR'

The following sections summarize the definitions, sources and methods used both in constructing the identities and in the estimation of the behavioural equations used in SIMFOR. There was no intention in this thesis to conduct a critical survey of all the documented work regarding the main time series available for Scotland. Furthermore, it was not proposed to expend much effort on trying to up-grade the existing published and unpublished series, although a certain amount of minor reconstruction was inevitable and these adjustments will be described herein.

(I) Dependent Variables

A) Output Block

The dependent or endogenous variables in this block of equations are total manufacturing output (SIOP) which is disaggregated into its home (SHIOP) and foreign (SFIOP) components. The measure adopted for (SIOP) was the Scottish Index of Industrial Production (1975 = 100) obtained from the Dundee Scottish Economic Modelling Group (DSEMG), 'Output in Scotland, 1958-1979', Research Paper 82/D/12, (n.d.), pp. 1-195. Refer to pp. 5-6 for sources and methods and p. 32 for the actual data series.

The index (SIOP) is one of the key indicators of economic activity in Scotland and is designed to represent value added or net output. Net output is defined in the Business Monitor Series P.A. 1002 as gross output (i.e. the value of total sales and work done) minus the cost of purchases and industrial services. In reality the net output information is seldom available and instead some variation of gross output measure is applied. The series constructed by DSEMG was based on published figures, (e.g. see various issues of the Scottish Abstract of Statistics (SAS) and the Scottish Economic Bulletin (SEB)). The index in the official estimates was base weighted in the form,

$$In = \frac{\sum [P_o(Q'_n/Q'_o)]}{P_oQ_o}$$

where,

In = the index in period n.

P_oQ_o = net output or value added in the base period.

Q'_n/Q'_o = the ratio of some proxy indicator of net output, in period n, to that of the base period.

$\sum$ = the summation over all the series used to construct the index.

For further details of index constructions, problems with the main data series and the technical problems of rebasing the index, refer to the following: 'The Index of Production for Scotland', SEB, No. 10 (Summer 1976), pp. 8-18; 'Analysis of Industrial Production in Scotland by Market Sector', SEB, No. 11 (Winter 1977), pp. 21-22; 'Index of Industrial Production for Scotland - Rebasing to 1975', SEB, No. 19 (Autumn 1979), pp. 15-18; Burnside, A. M. and Henderson, D. S. 'The Revised Index of Industrial Production for Scotland, for the Period 1958-1970, Sources and Methods', E.S.U. Discussion Paper, No. 6 (Feb. 1980), pp. 1, 79.

As regards the other dependent variables in this block, i.e. (SHIOP) and (SFIOP), it must be noted that the summation of (SHIOP) and (SFIOP) is equal to (SIOP). Figures pertaining to foreign output in Scotland were obtained from various issues of the Business Statistics Office Annual Census of Production Publication, Business Monitor P.A. 1002, see table 20 (1973, 1975, 1977, 1979). For a more detailed discussion of certain aspects of the 1977 data, see Hetherington, I. P., and Horn, M. E., 'Overseas-owned Manufacturing Establishments in Scotland: Output, Investment and Employment', SEB, No. 24 (Spring 1982), pp. 15-21. These figures are essentially net output figures (as defined above) in current prices. Net output for overseas enterprises pertains to establishments with more than 80% of their employment in the country. An enterprise is defined as a business consisting of either a single establishment or two or more establishments under common ownership or control.

In order to arrive at a series which was consistent with the time-frame specified in Chapter III, the net output information obtained from the Business Monitor series (above) was combined with foreign manufacturing employment data (SCOMER data-base), SIOP data (above) and total manufacturing employment data (DSMEG) in order to derive a scaling ratio which would enable the rest of the SFIOP series to be derived, e.g. it was found for the years obtained that the ratio SIOP/STEM / SFIOP/SFEM was relatively constant
where,

STEM = total manufacturing employment in Scotland.

SFEM = foreign manufacturing employment in Scotland.

(Note: The definitions, sources, methods, etc. for (STEM) and (SFEM) will be presented in the block relating to employment).

The stability of the total to foreign aggregate output per employment ratio at .82 enabled SFIOP to be calculated, since the data for all of the other series in the ratio existed for the period 1961-1979. Thus,
SFIOP = (SIOP x SFEM)/(.82 x STEM).

B) Investment Block

The left hand side variables in this block of equations included total gross domestic fixed capital formation in Scottish manufacturing (STIMK), foreign gross capital expenditure in Scottish manufacturing (SFIMK) and home gross investment in Scottish manufacturing (SHIMK) reported in £ million. The constant price series for STIMK was obtained from the DSEMG, 'Investment in Scotland, 1961-1979', Research Paper 81/D/6, (Nov. 1981), pp. 1-59. Refer to p. 2 for the sources of the current price manufacturing investment data, and to table 1 for the actual current price data series. See also p. 6 for the methods with which the constant price series was constructed, and to table 37, p. 48 for the constant price series. Gross domestic fixed capital formation (GDFCF) was defined in the (SAS) as gross expenditure on, less receipts from, sales of fixed assets, these being:

(i) land and existing buildings.

(ii) new dwellings and other new construction work (including civil engineering) together with all extension and improvements and all fixtures and integral equipment.

(iii) vehicles.

(iv) plant and machinery of all kinds.

Item (i) also extends to site preparation costs and to architects', surveyors' and other professional fees.

Net capital expenditure in the manufacturing industries differs from (GDFCF) by the inclusion of land

and existing buildings. Both the gross and net capital expenditure figures can also be found in various issues of the (SAS) and the (SEB).

Data pertaining to (SFIMK) was obtained from Business Monitor P.A. 1002, table 21, (1973, 1975, 1977, 1979). This was net capital expenditure data (SNFIMK) as defined above as opposed to (GDFCF). For a more detailed discussion of certain aspects of the foreign investment data for 1977, see Hetherington, I. P. and Horn, M. E. op.cit., (1982) and 'Overseas Investment in Scottish Manufacturing Industry', SEB., No. 20 (Spring 1980) pp. 10-15.

Again, as was the case with SFIOP, the data for SFIMK was derived by combining the foreign investment information available with foreign/total employment data and total net capital expenditure data (SNTIMK) which was obtained from Business Monitor P.A. 1002. As was the case with the output to employment ratios, the ratio of SNTIMC/STEM / SNFIMC/SFEM remained relatively constant at 1.03, hence permitting the calculation of SFIMK for the period 1961-1978.

C) Employment Block

The dependent variables in this block of equations were total manufacturing employment in Scotland (STEM), home manufacturing employment in Scotland (SHEM) and foreign manufacturing employment in Scotland (SFEM) all reported in thousands). The measure adopted for (STEM) was employees in employment in all the manufacturing industries, which was defined in the Department of Employment Gazette as the total in civil employment less self-employed. The data was obtained from the DSEMG, 'A Manual/Non-Manual Division of Employees in Employment by Sex and Industrial Order: Scotland 1954-1980', Research Paper 81/D/1 (n.d.), pp. 1-75. Refer to pp. 1-6 for the sources and methods employed in order to arrive at the consistent estimated series (1959-1980) of employees in employment in all industries and services within Scotland Table 3, p. 32. The actual STEM (1961-1979) series can be found in this table on p. 41.

Data pertaining to (SFEM) were obtained from the Scottish Office, Scottish Economic Planning Department, Economics and Statistics Unit, Glasgow. The information was held in the Scottish Manufacturing Establishments Record (SCOMER) of which the main definitional points to note are:

a) Coverage - SCOMER covers all manufacturing units with 11 or more employees.
b) Incomer - Any manufacturing unit opening in Scotland since 1 January 1945 and having its origin outside Scotland; or, any manufacturing unit opening in Scotland having as its origin an Incomer, where origin refers to the previous manufacturing unit (in the same enterprise) having the closest ties with the new unit.

c) Non-Incomer - is any manufacturing unit present in Scotland at some time since 1945 which is not an Incomer. Note that Non-Incomer does not mean indigenous (wholly Scottish) companies since many English owned and overseas owned units present in 1945 and their subsequent branches will be considered Non-Incomers.

d) Ownership - denoted the location of control of the enterprise of which the unit is a part. If the ultimate holding company of an enterprise is an overseas company then all the members of the enterprise are classed as being under overseas ownership.

e) Employment - the data referred to total employment in each year. The employment figures reflected the employment for units two years after opening.

The annual time series (SFEM) supplied by the Scottish Office (1950-1981) included in the overseas Incomer variables employment in units of U.S. origin, European origin, and other foreign origins. Published work making use of SCOMER can be found in the following: 'Relative Performance of Incoming and Non-Incoming Industry in Scotland' SEB, No. 13 (Aut. 1977), pp. 14-25; 'Annual Gross Changes in Manufacturing Employment in the Scottish New Towns and the Rest of Scotland, 1950-70', SEB, No. 14 (Spring 1978), pp. 10-15; 'Charts and Statistics, Employment in Scottish Manufacturing Industry: Analysis of Annual Components of Change by Region and

Industry', SEB, No. 17 (Spring 1979), pp. 14-32; 'Overseas Investment in Scottish Manufacturing Industry', SEB, No. 20 (Spring 1980), pp. 10-15; 'Charts and Statistics, Manufacturing Employment Estimates', SEB, No. 23, (Summer 1981), pp. 20-21.

There is however a discrepancy between the SCOMER estimates of employment and those found in the Annual Census of Production, Buiness Monitor P.A. 1002. For instance, Horn and Henderson, op.cit. (1981) stated, "These estimates from the Annual Census of Production are slightly higher in terms of numbers employed and considerably higher in terms of number of units than estimates based on the Scottish manufacturing establishments register which does not cover units with less than eleven employees". Since the Census of Production was the basis of the output and capital expenditure figures, it was decided to maintain consistancy with this data source and accordingly the SCOMER figures were scaled up to coincide with the Census of Production data. It was found that for the years 1971, 1973, 1975, 1979, the ratio of the SCOMER figures to the Census of Production figures remained remarkably constant at approximately .64. Thus to yield a series consistent with the Census of Production data, the SCOMER figures were divided by .64.

D) Link Equation Block

The dependent variables in this block are Scottish consumption (SCONK) and the real wage bill in Scottish manufacturing (TWSMK) reported in £ million. The data for (SCONK) was obtained from the DSEMG, 'Consumers Expenditure in Scotland, 1961-1979', Research Paper 81/D/4 (October 1981), pp. 1-95. Sources and methods used in calculating the series can be found on pp. 1-7. Refer to table 26, 'Consumers' expenditure in Scotland (adjusted series) in constant 1975 prices', p. 15, for the actual series (1961-1979) used in SIMFOR. Total consumer expenditure is defined in the (SAS) as the sum of the expenditure on goods and services by households, other individuals and non-profit-making bodies serving persons, all of which are residents in Scotland. The total thus includes expenditure abroad by resident consumers and excludes expenditure in Scotland by residents of other regions of the U.K. or foreign residents.

(TWSMC) was obtained from the DSEMG, draft copy of the research paper 'Earnings in Scotland, 1959-1980', (1981). This variable measures total wages and salaries in Scotland for all employees in the manufacturing sector. See table 17(1), and 17(2) for the actual series TWSMC in current prices. A constant price series was derived by deflating TWSMC by the U.K. retail price index, (all items) 1975 = 100, found in Economic Trends, Central Statistical Office (CSO), HMSO.

(II) Scottish Domestic Demand Identity

DEM = (SCONK + STIK + PAGSK)

STIK = (STINMK + STIMK)

STIMK = SFIMK + SHIMK

where,

DEM = Scottish Domestic Demand.

SCONK = Total Scottish Consumption.

STIK = Total Investment in Scotland.

PAGSK = Public Authority Government Spending in Scotland.

STINMK = Scottish Non-Manufacturing Investment.

STIMK = Scottish Manufacturing Investment.

SFIMK = Foreign Manufacturing Investment in Scotland.

SHIMK = Home Manufacturing Investment in Scotland.

All of the above are reported in £ million and with the exception of (STINMK) and (PAGSK) have already been covered in this Appendix.

The series (STINMK) was derived from (STIK), the latter being obtained from the DSEMG, 'Investment in Scotland, 1961-1979', Research Paper 81/D/6 (Nov. 1981), see pp. 1-6 for sources and methods and p. 55 for the constant price total gross domestic fixed capital formation information.

(PAGSK) was found in DSEMG, 'Local Authority and Central Government Current Expenditure on Goods and Services in Scotland, 1961-1979', Research Paper 81/D/9 (n.d.), pp.

1-29. Refer to pp. 1-5 for the sources and methods of both local authority current expenditure on goods and services at current prices and central governments' current expenditure on goods and services at current prices. See also p. 6 for the sources and methods used to produce a constant (1975) price series on public authorities current expenditure on goods and services. The actual PAGSK data can be found in table 15, p. 29 for the period 1961-1977.

(III) Independent Variables

Note: Following are the definitions and sources and methods for the predetermined variables not already presented. See section (I) in this Appendix for the information pertaining to lagged dependent variables and Section (II) for information relating to the exogeneous variables PAGSK and STINMK.

A) Output Block

The independent variable in this block of equations was the proxy for world demand (WXV). This variable was a base weighted (1975) index and represented the volume of exports of manufactured goods for the major industrialized countries as a whole. This series was found along with sources and methods, in various issues of the *United Nations Monthly Bulletin of Statistics* and in the *United Nations Statistical Year Book*.

B) Investment Block

The independent variables in the foreign investment function included the output argument weighted by the cost of U.K. investment goods and the long-run expected rate of return: [JVE = (SIOP x WPUK/PIGUK x (IER x UKR)] and the argument for relative U.K. to European rates of return (RAT1) lagged one period.

WPUK is the index of U.K. wholesale prices of manufactured output (1975 = 100).

PIGUK is an index of the price of investment goods in the U.K. (1975 = 100).

IER is an index of U.K. to U.S. exchange rates, (1975 = 100).

UKR is the long-term yield on U.K. central government bounds (average yield to maturity on bonds with at least 12 years life in %/annum). The above four series were found along with sources and methods in various issues of the International Monetary Fund Publications, International Financial Statistics and International Financial Statistics Year Book.

RAT1 is the ratio of U.S. companies net earnings as a percentage of investment stock in the U.K., to U.S. companies net earnings as a percentage of investment stock in the EEC(6). These series along with the sources and methods were found in various issues of the U.S. Department of Commerce Publication, Survey of Current Business.

C) Employment Block

The independent variable TREND in the home employment equation was simply a time trend taken as a proxy of technological progress.

D) Link Equation Block

The total real wage bill in U.K. manufacturing (TWUKMK) and Scottish Personal Disposable Income (INC) net of the Scottish total real wage bill in U.K. manufacturing are the independent variables in this block. The series TWUKMK was reported in £ million and was found in Economic Trends, CSO, HMSO.

INC was defined in the (SAS) as total personal income (TPI) minus taxes paid on income, national insurance contributions, transfers abroad and taxes paid abroad. TPI was defined as including wages and salaries of employees plus employers' contributions, as well as self-employed income. Other items included are rents, dividends and net interest, national insurance benefits and other current grants from public authorities. These figures were reported in £ million and were found in DSEMG, 'Income in Scotland, 1960 to 1980', Research Paper 81/D/11 (Feb. 1982); see p. 2 for sources and pp. 4-10 for methods. Current price PDI figures can be found on p. 34, table 11. The constant price series was derived by deflating the INC series by the U.K. retail price index (all items).

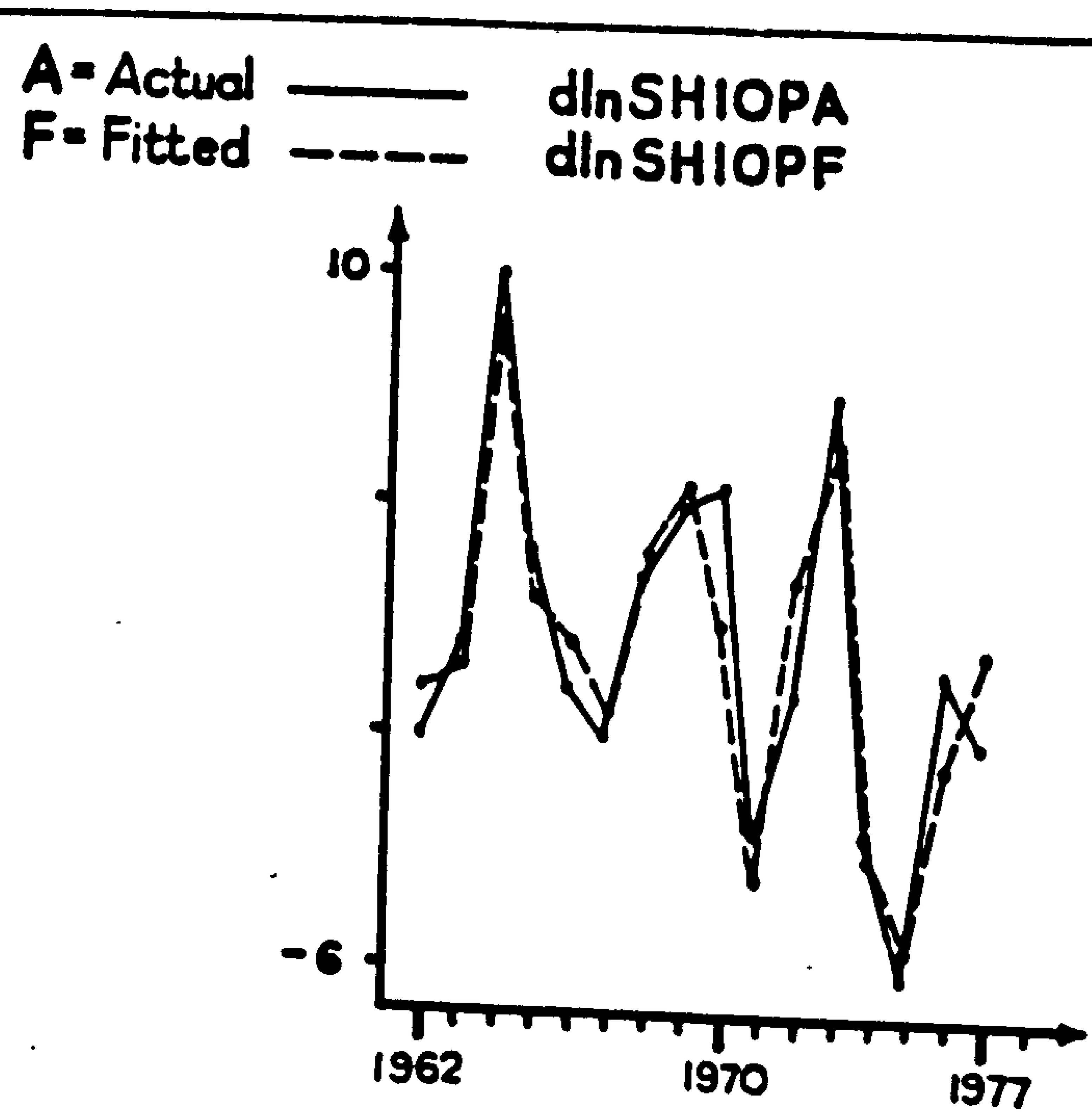
Appendix 4

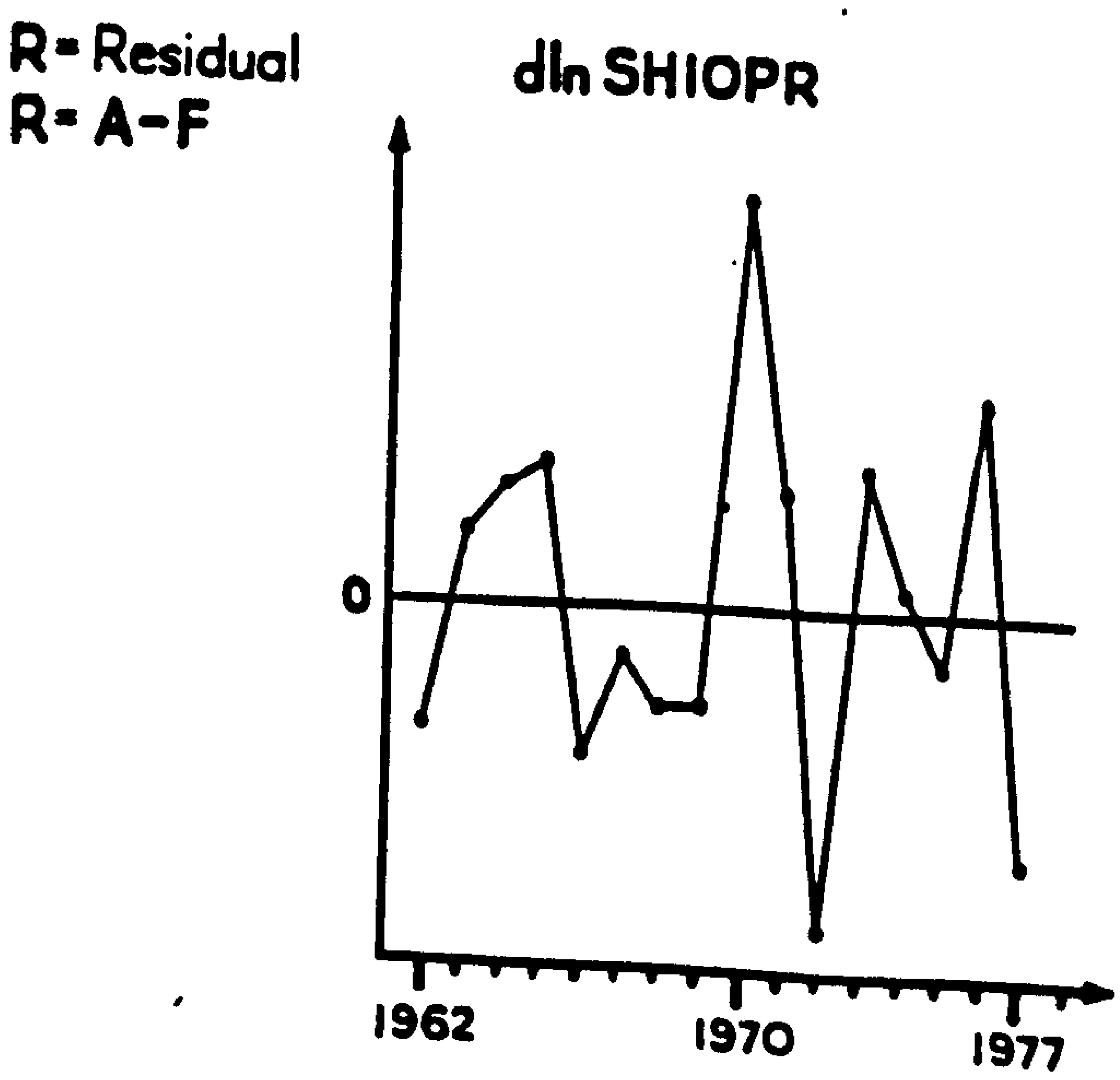
Ordinary Least Squares (OLS) Single Equation

Results to be used in SIMFOR

(1) Home Output (dlnSHIOP)

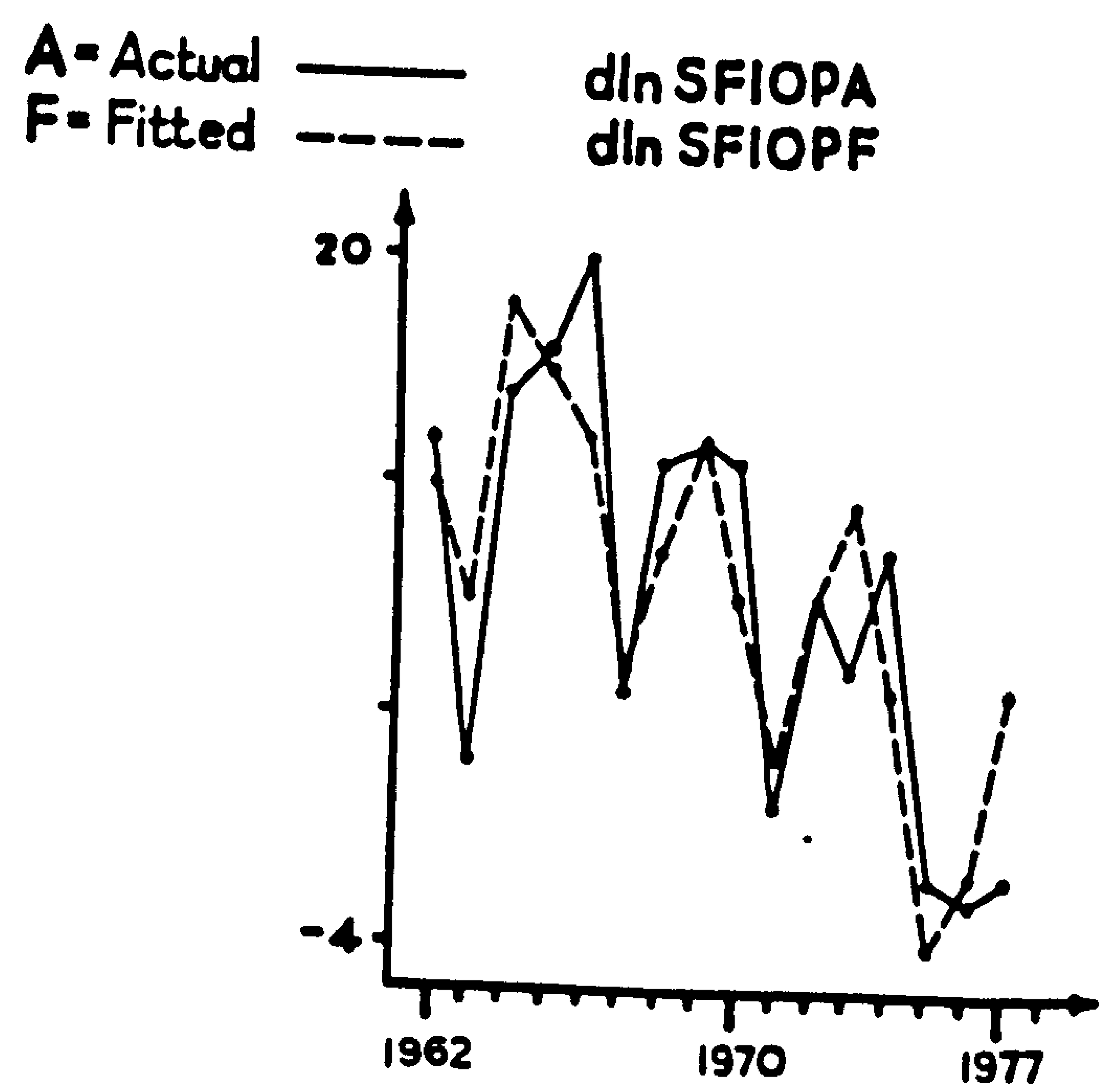
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-3.11	0.87	-3.54	.84		2.3	15.3
lnSHIOP(-1)	-0.59	0.14	-4.08		.79		
dlnDEM	1.22	0.24	5.07				
lnDEM(-1)	0.62	0.15	3.86				
dlnWXV	0.42	0.08	4.92				

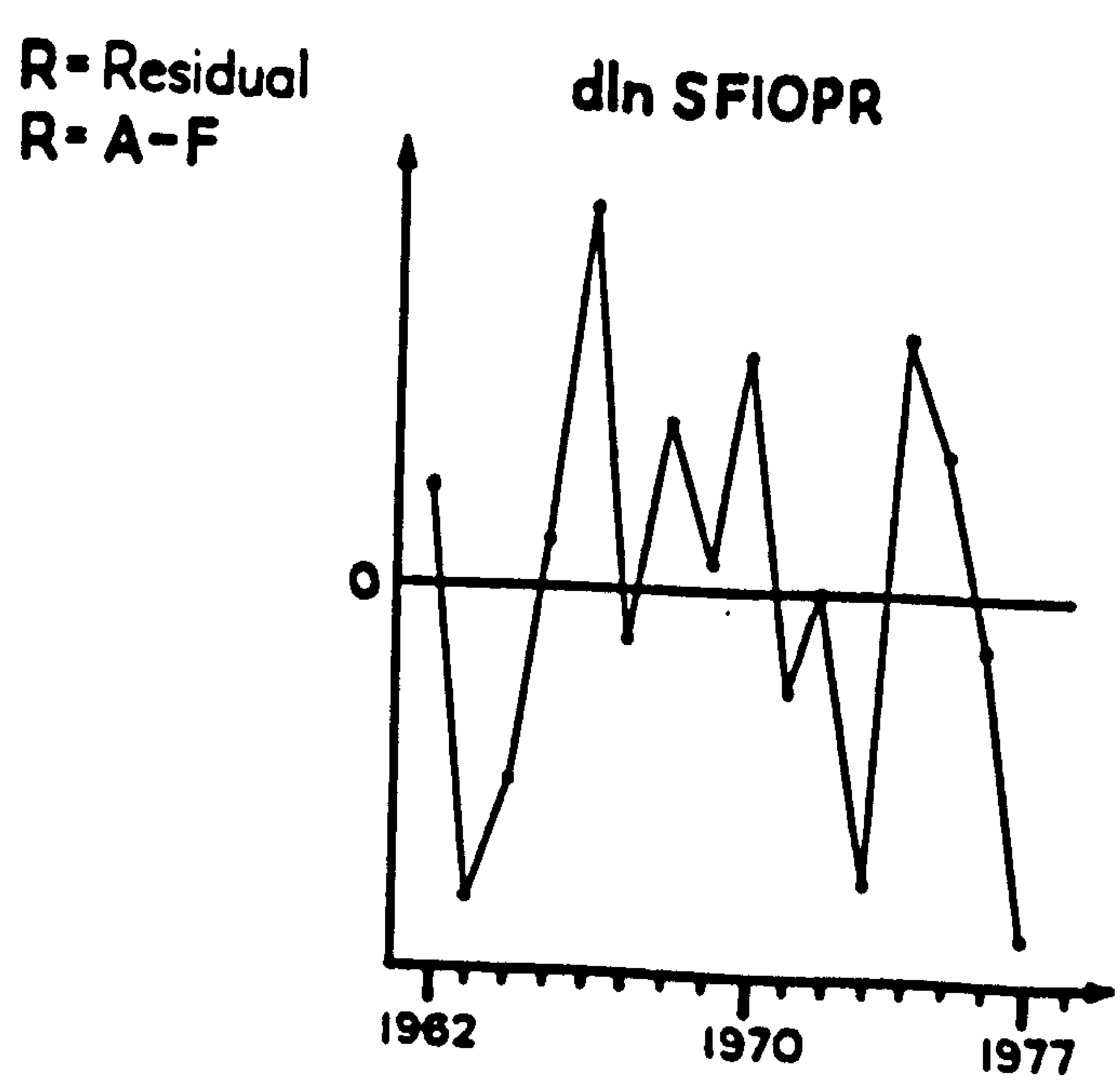




(2) Foreign Output (dlnSFIOP)

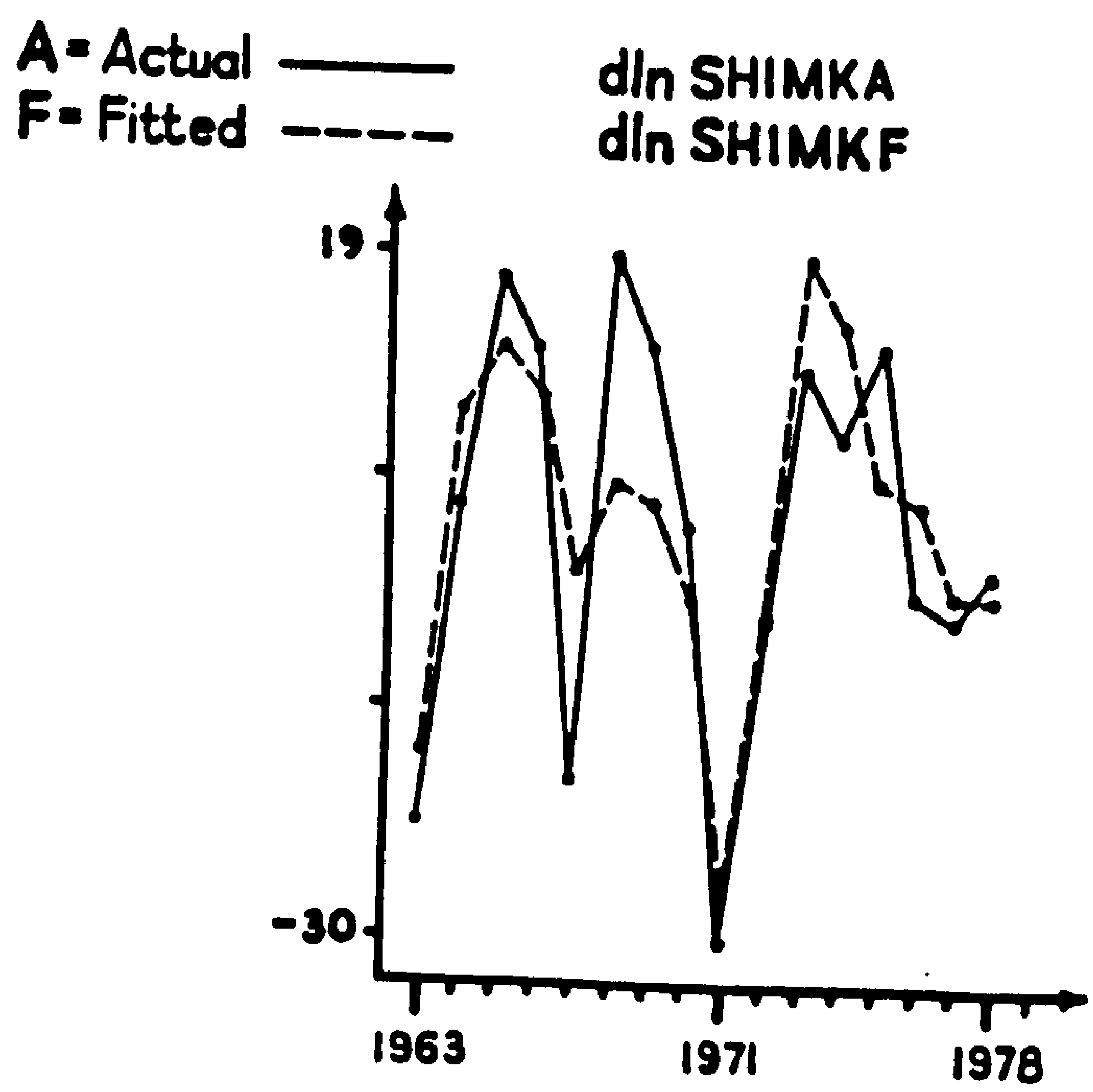
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-8.85	5.47	-1.61	.72		1.94	7.1
lnSFIOP(-1)	-0.30	0.15	-1.93		.61		
dlnDEM	1.34	0.61	2.18				
lnDEM(-1)	1.06	0.64	1.64				
dlnWXV	0.60	0.18	3.28				

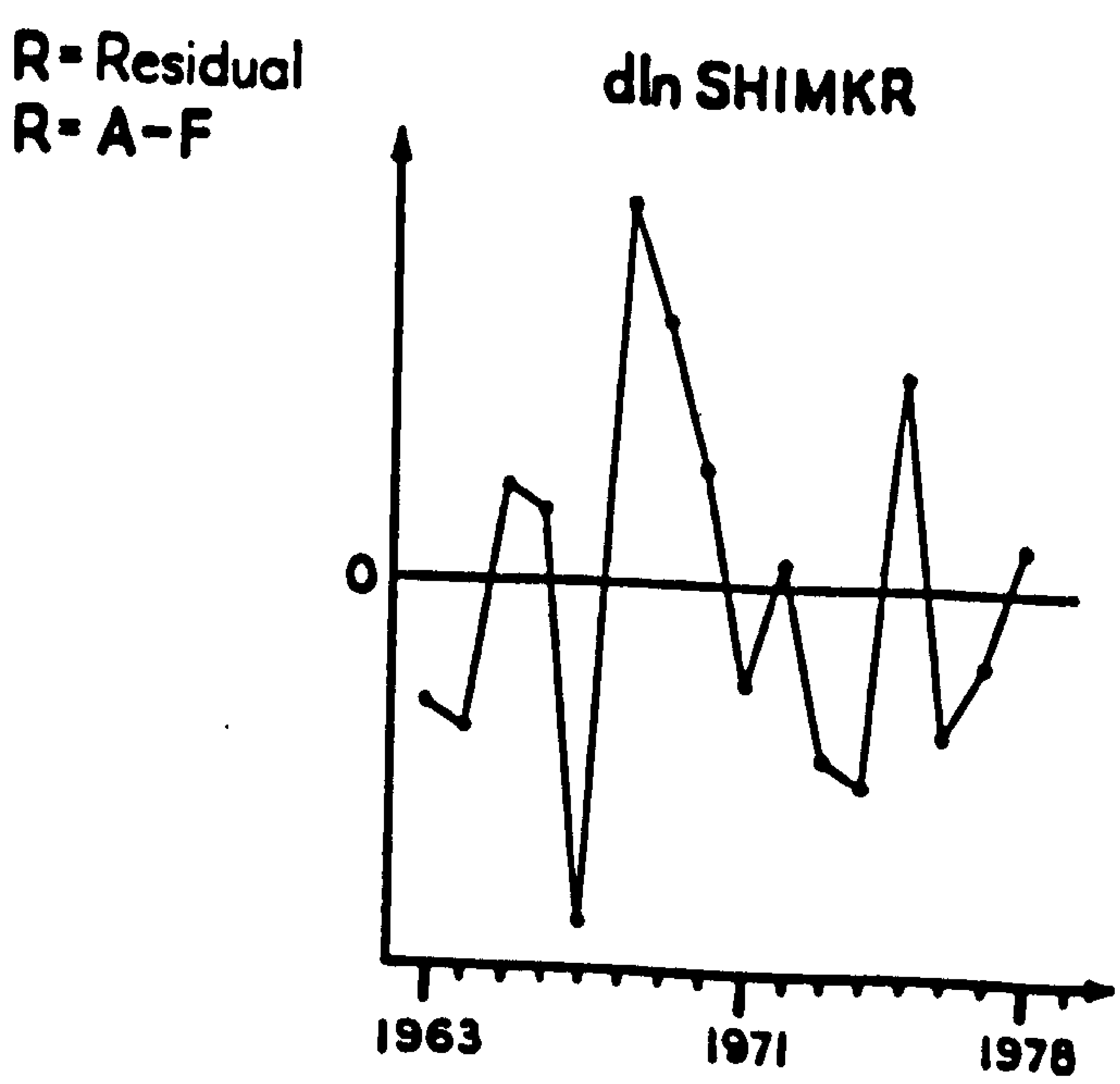




(3) Home Investment (dlnSHIMK)

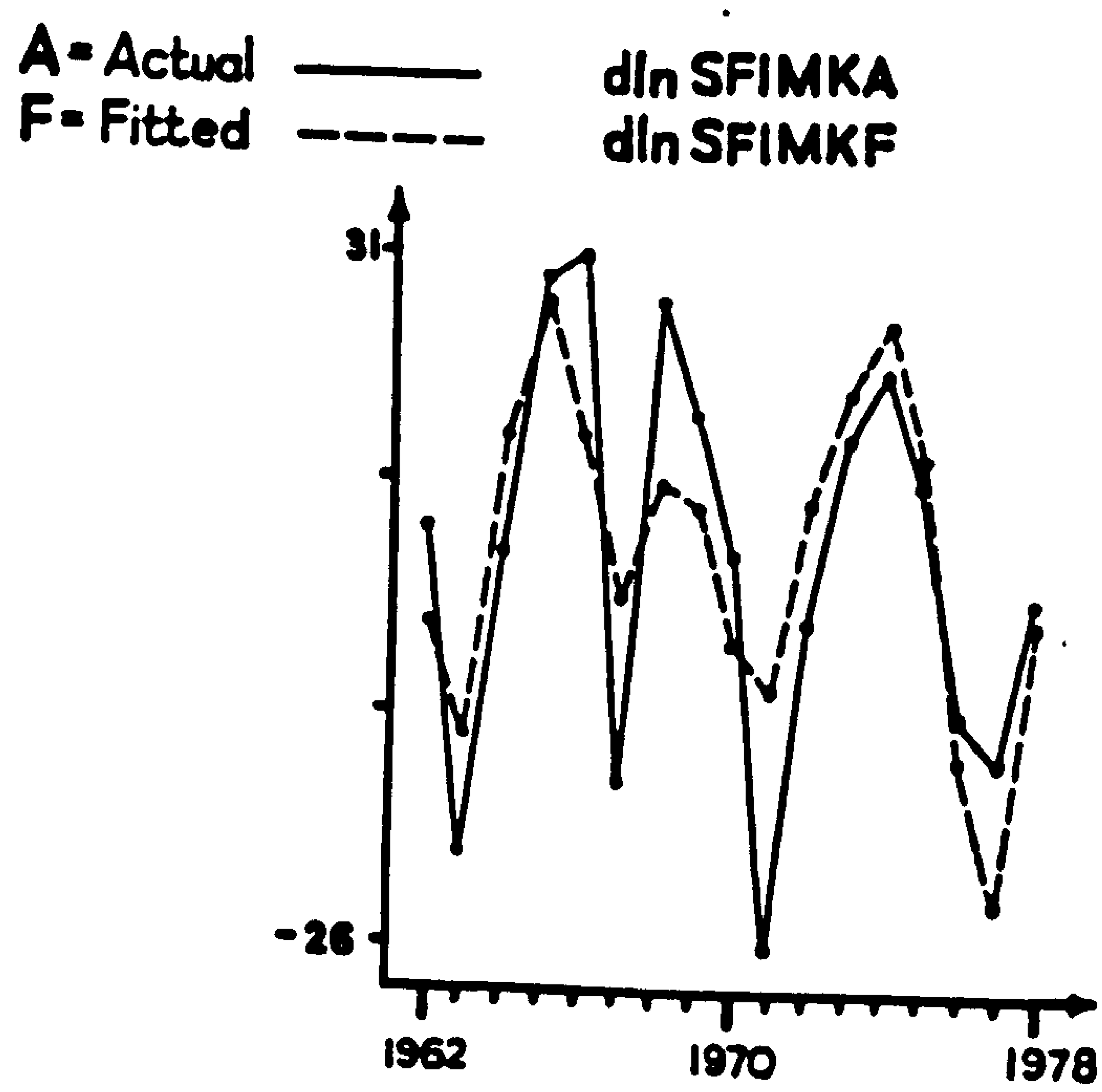
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	1.70	1.32	1.28	.75		2.1	12.3
lnSHIMK(-2)	0.82	0.13	-5.97		.69		
d^2lnFLEXACC	0.60	0.26	2.26				
lnFLEXACC	0.33	0.14	2.40				

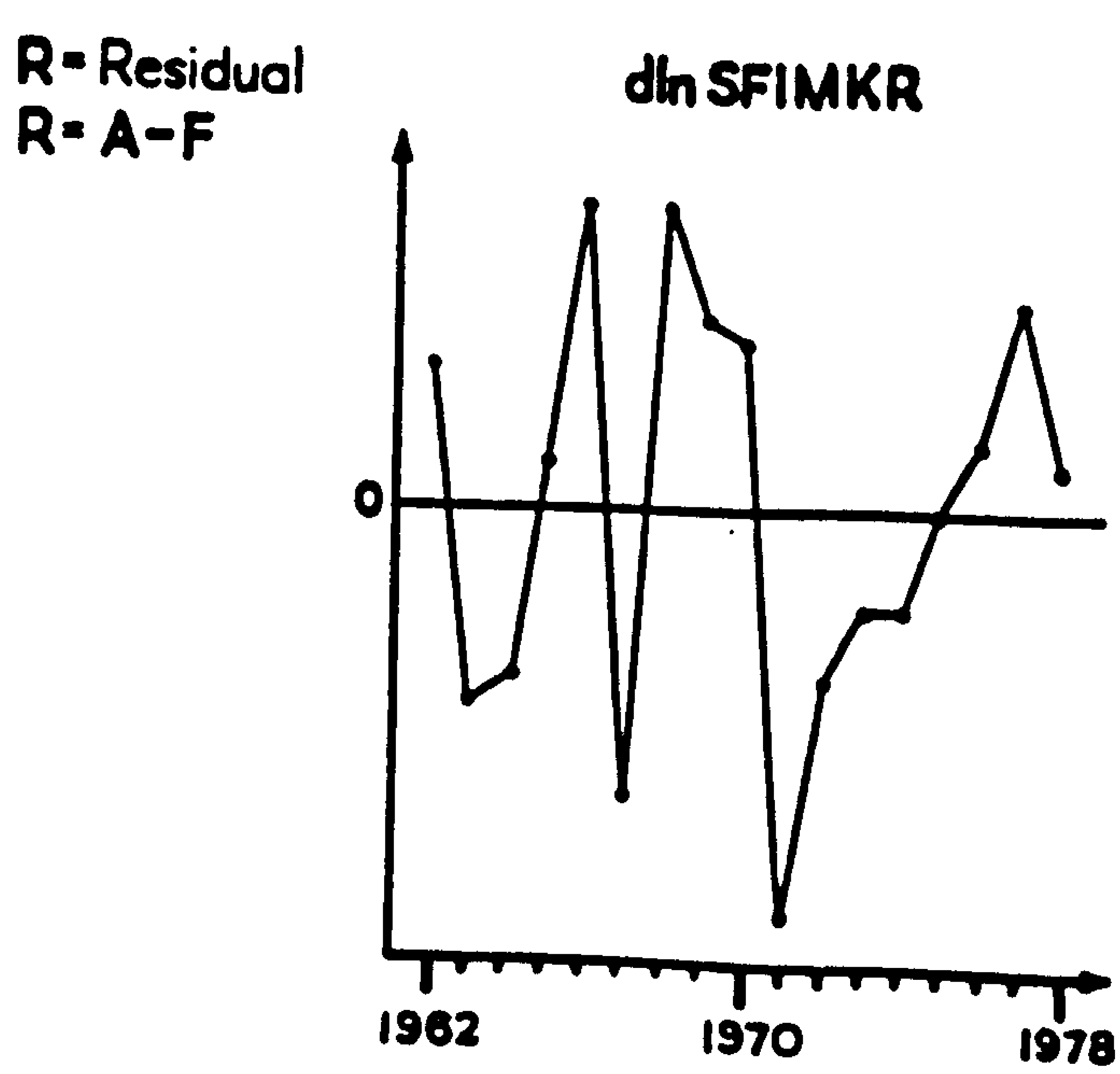




(4) Foreign Investment (dlnSFIMK)

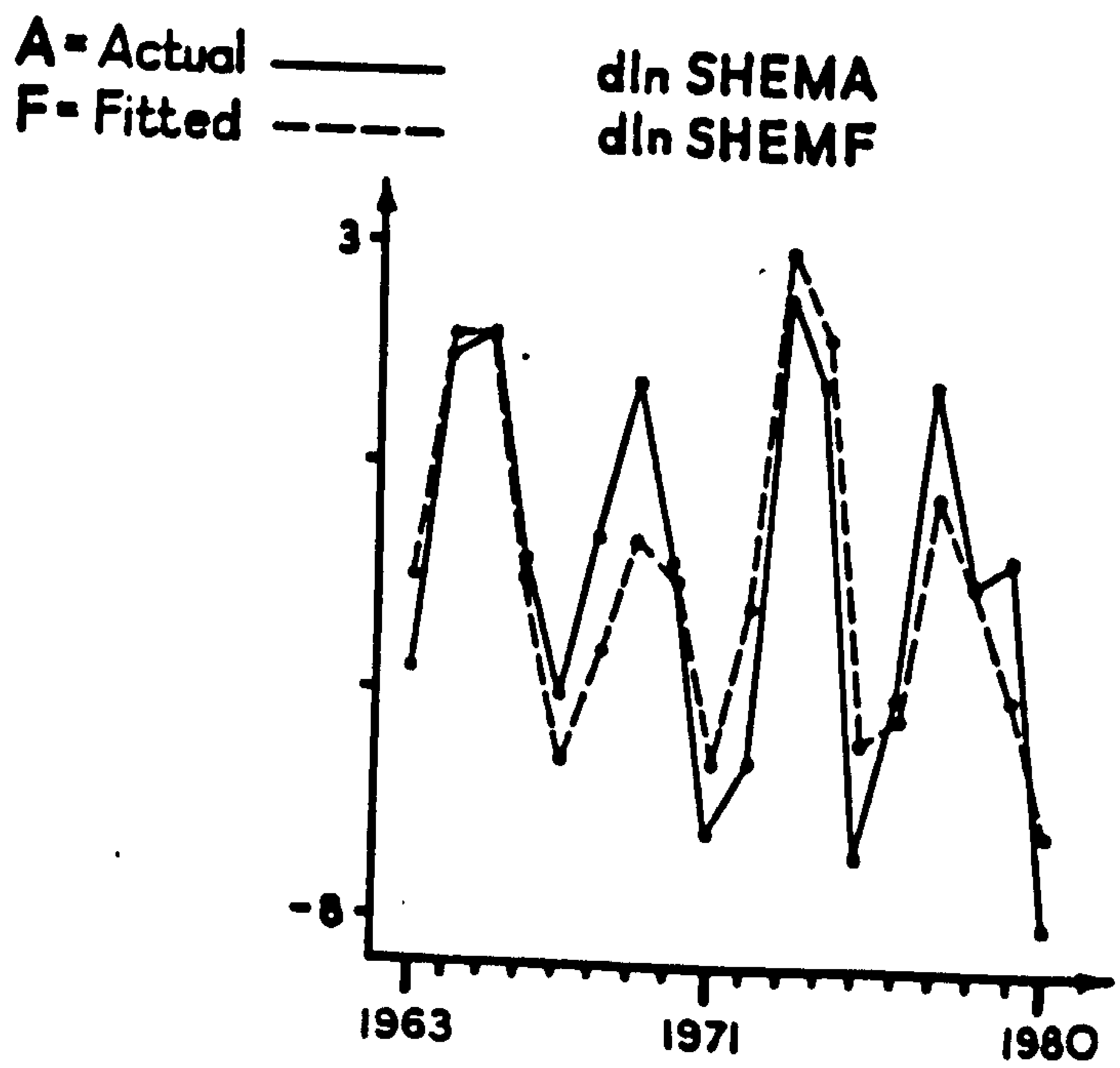
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-7.75	2.74	-2.82	.61		2.0	4.78
lnSFIMK(-1)	-0.57	0.31	-2.61		.48		
dlnJVE	0.50	0.30	1.65				
lnJVE	0.81	0.28	2.87				
RAT1(-1)	0.57	0.43	1.31				

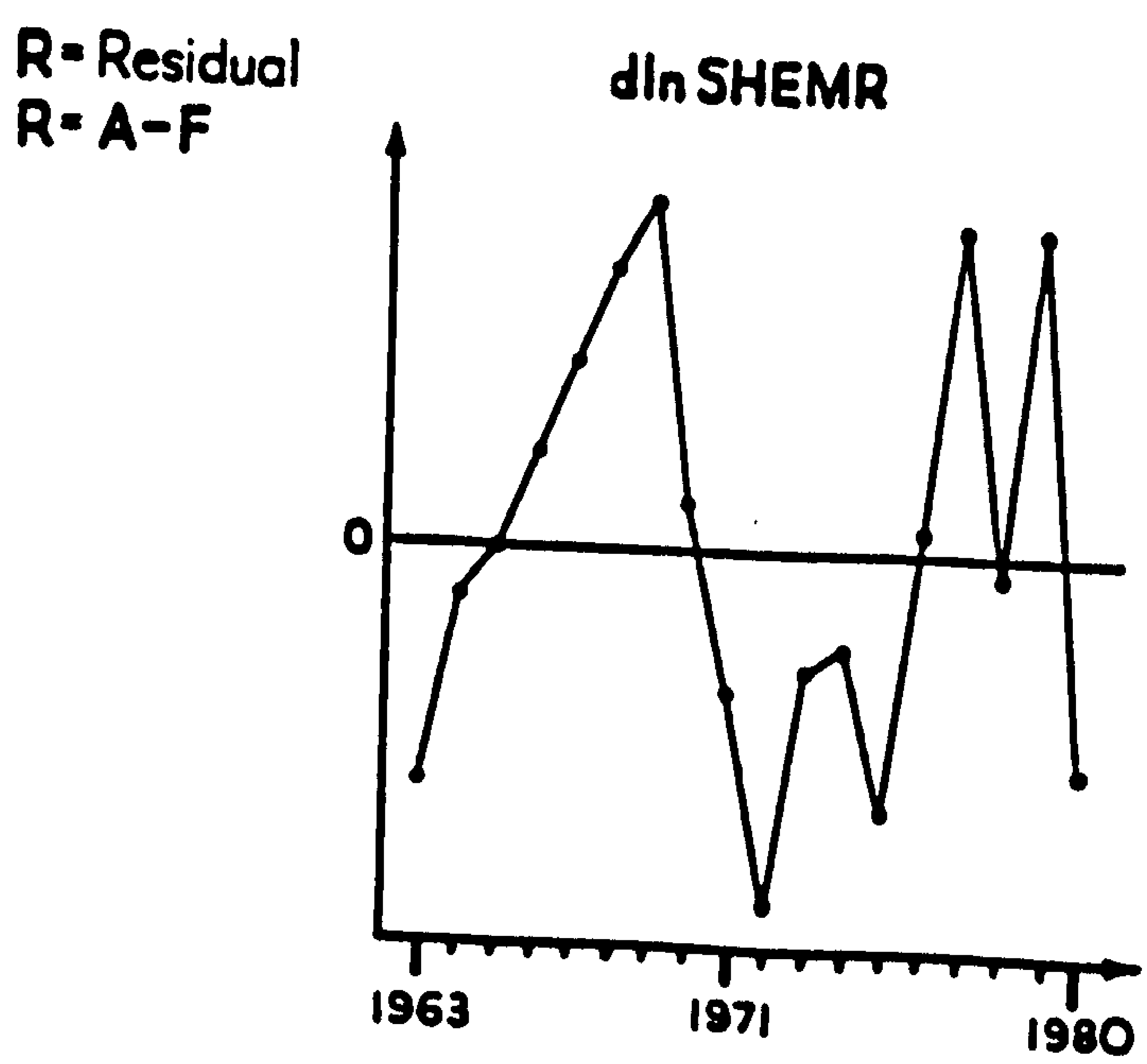




(5) Home Employment (dlnSHEM)

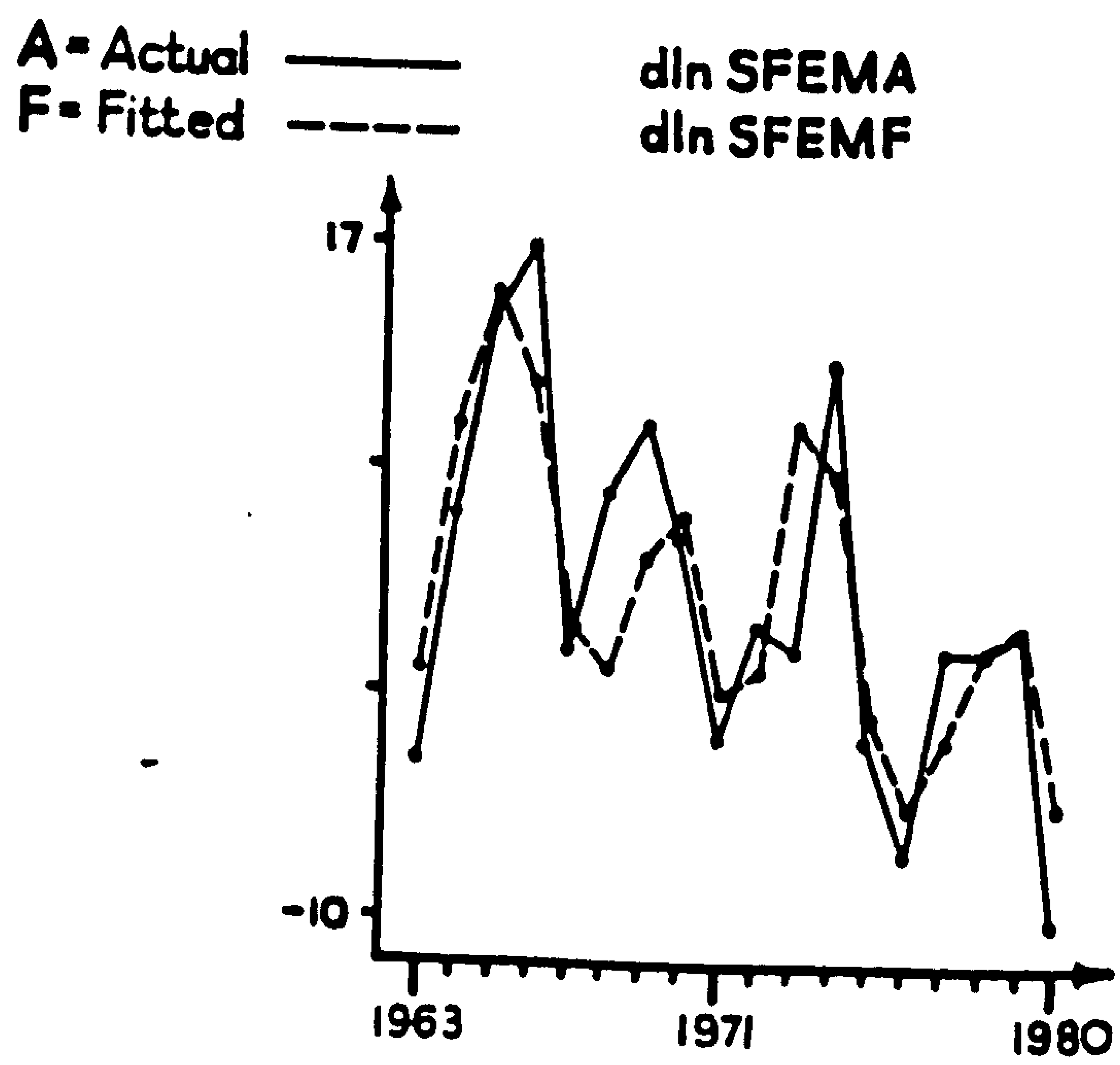
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	8.47	1.47	5.75	.78		1.3	11.7
lnSIOP	0.29	0.06	4.60		.71		
lnSHEM(-1)	-0.61	0.17	-3.42				
lnSHEM(-2)	-0.54	0.17	-3.46				
TREND	-0.02	0.004	-6.72				

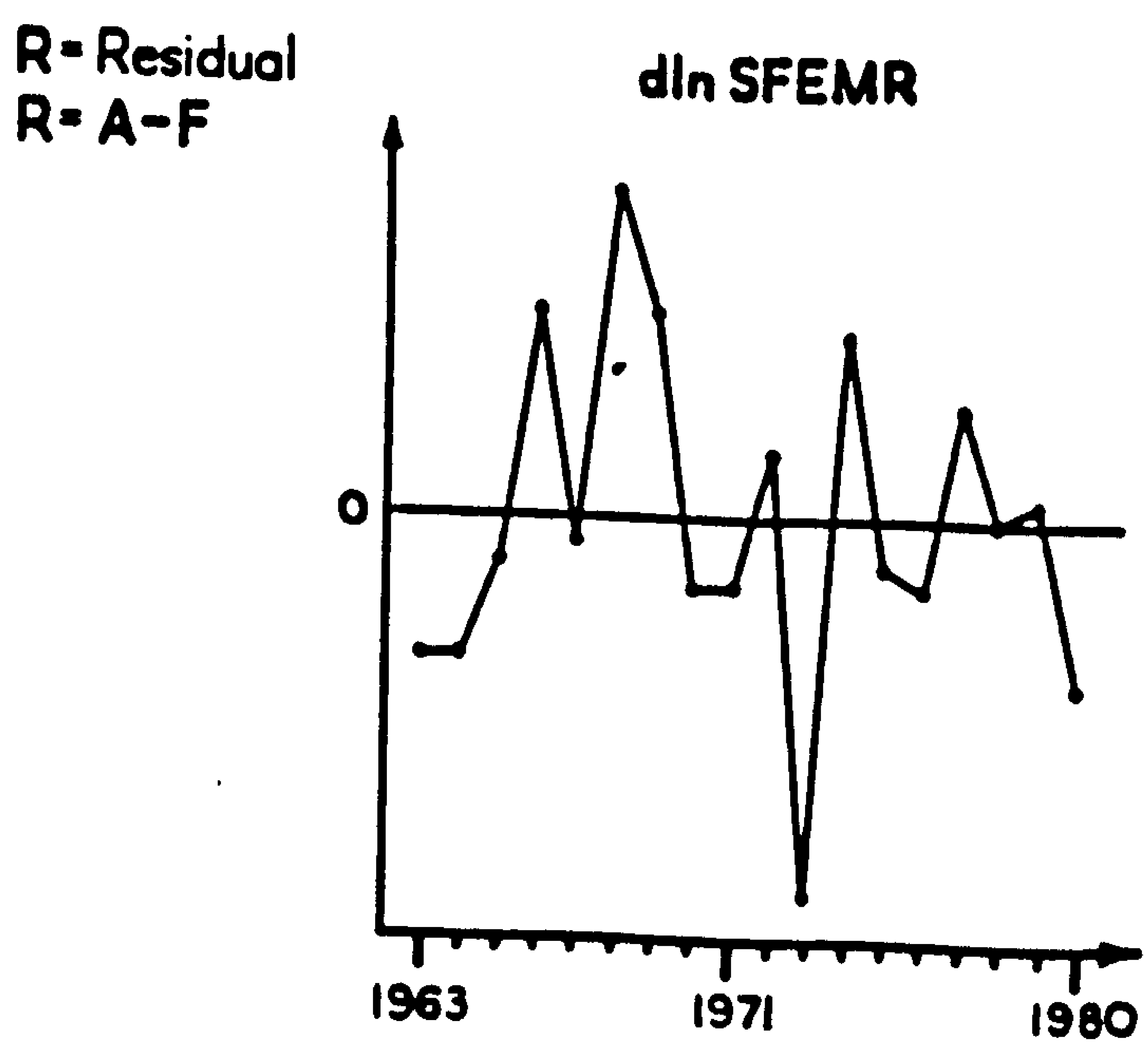




(6) Foreign Employment (dlnSFEM)

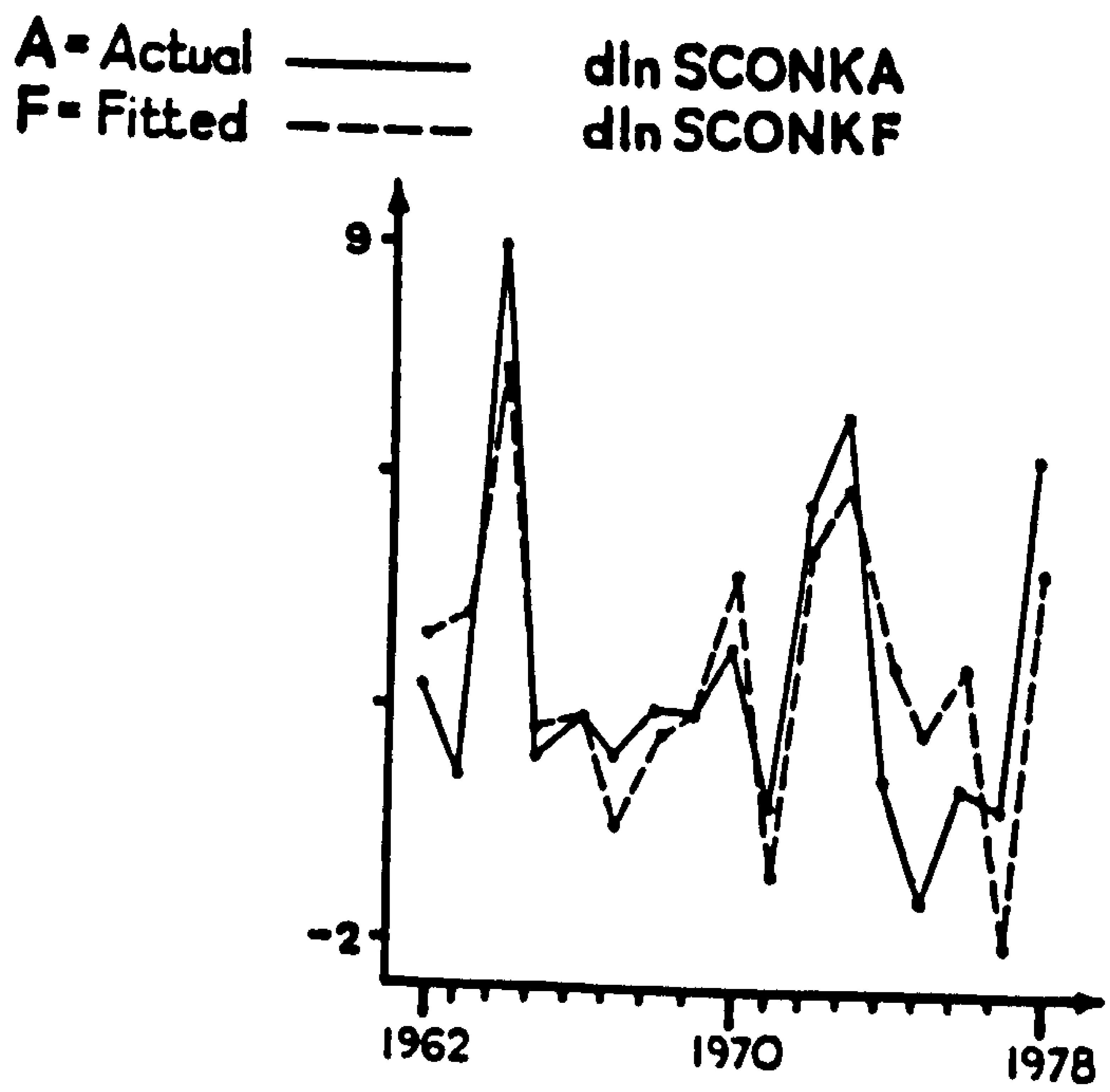
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	-2.11	0.64	-3.2	.70		2.12	10.2
lnSIOP	1.19	0.25	4.6		.63		
lnSFEM(-1)	-0.32	0.14	-1.68				
lnSFEM(-2)	-0.41	0.18	-2.32				

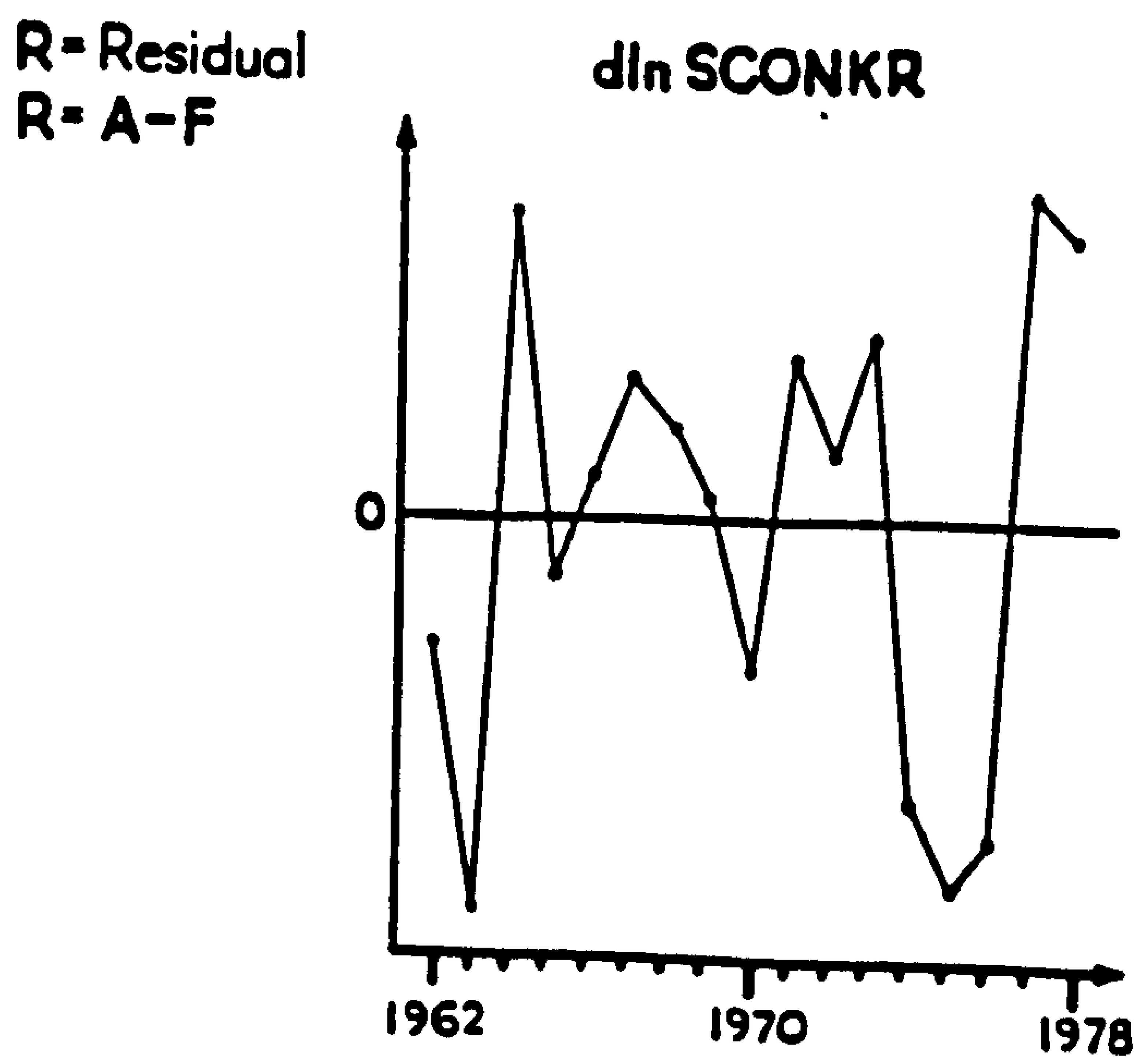




(7) Total Consumption (dlnSCONK)

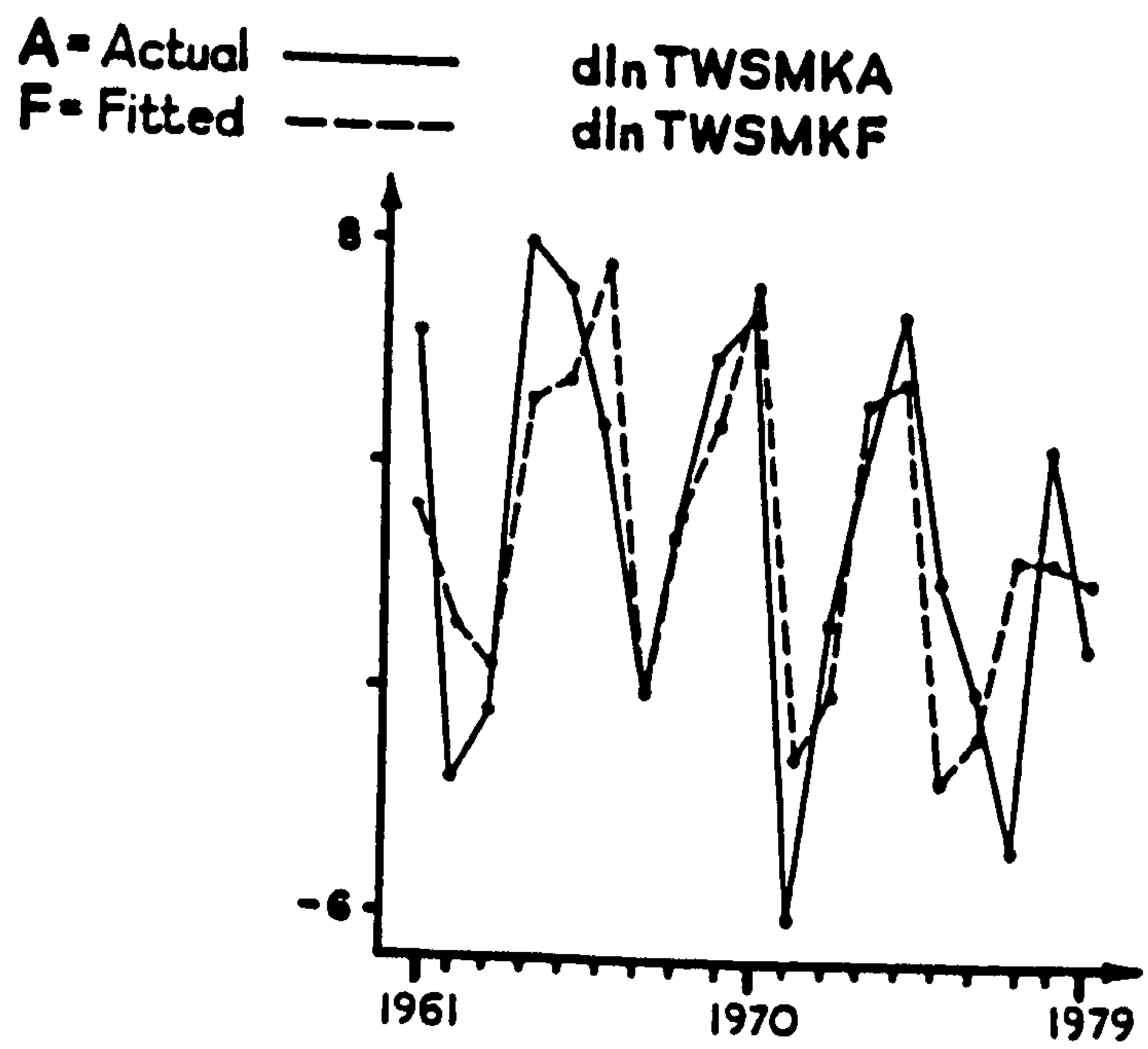
Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	2.28	0.84	2.7	.70		1.7	5.0
lnSCONK(-1)	-0.87	0.36	-2.4		.55		
dlnSPDIK	0.45	0.13	3.3				
lnSPDIK(-1)	0.42	0.14	2.8				
lnTWSMK	0.42	0.15	2.8				
lnTWSMK(-1)	-0.21	0.12	-1.7				

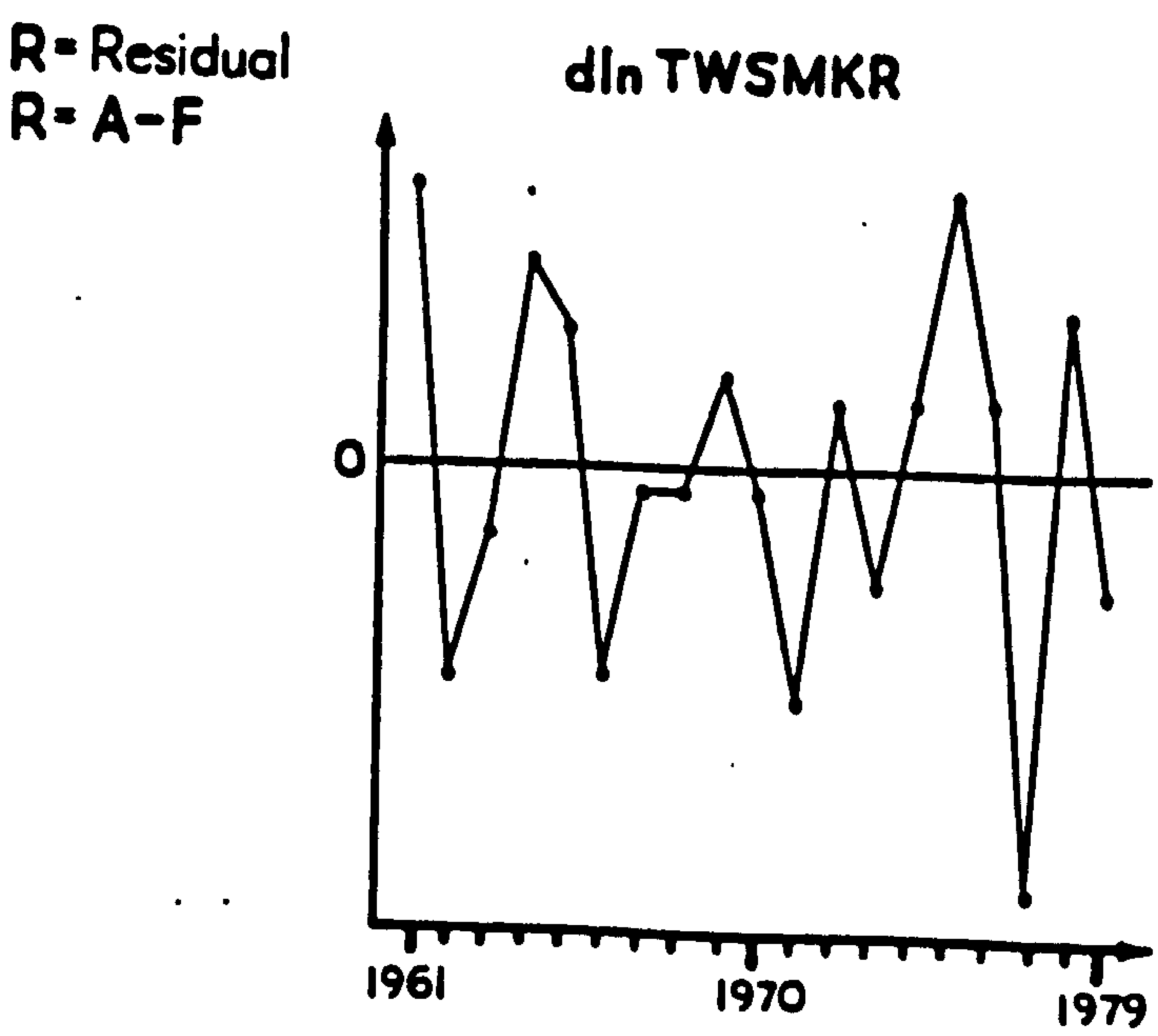




(8) Real Wage Bill (dlnTWSMK)

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	D.W.	F
C	0.01	0.008	2.23	.60		2.4	11.7
dlnTWUKMK	0.22	0.089	2.51		.54		
dlnSTEM	0.74	0.25	3.15				





Appendix 5

Table 1 Seasonally Adjusted Unemployment Rates in Scotland (%)

1959	4.0	1971	5.8
1960	3.6	1972	6.4
1961	3.1	1973	4.5
1962	3.8	1974	4.0
1963	4.8	1975	5.2
1964	3.6	1976	7.0
1965	3.0	1977	8.1
1966	2.9	1978	8.2
1967	3.9	1979	8.2
1968	3.8	1980	10.0
1969	3.7		
1970	4.2		

Note: The above rates exclude school leavers.

Source: Dundee Scottish Economic Modelling Group Research Paper 81/D/2 'Unemployment in Scotland, 1959-80', Department of Economics, Dundee University, p. 16.

Table 2 Capacity Utilization in Scottish Manufacturing

1959	91.67	1970	96.30
1960	95.17	1971	92.69
1961	93.22	1972	92.36
1962	91.30	1973	97.55
1963	89.67	1974	95.60
1964	93.95	1975	90.51
1965	97.11	1976	89.78
1966	97.27	1977	88.79
1967	93.66	1978	88.78
1968	92.96	1979	88.04
1969	96.60	1980	82.91

Note: The above index was calculated by the Dundee Scottish Economic Modelling Group who employed the Wharton School (peak-to-peak) method.

Source: Dundee Scottish Economic Modelling Group Research Paper 81/D/7, 'Capital Stock and Capacity Utilization in Scottish Manufacturing Industries, 1951-1978', Department of Economics, Dundee University, p.13.

Table 3 Total Net Migration from Scotland (Thous.)

1959	28.5
1960	34.6
1961	29.0
1962	33.9
1963	39.1
1964	39.1
1965	43.2
1966	43.1
1967	32.0
1968	23.9
1969	20.1
1970	21.7
1971	27.6
1972	10.7
1973	2.0
1974	19.0
1975	4.8
1976	9.8
1977	16.3
1978	14.6
1979	16.3

Source: SCOTAN Data Bank, Fraser of Allander Institute, University of Strathclyde, Glasgow.

Table 4 The Ratio of Scottish to Rest of U.K. Total Domestic Demand (%)

1961	10.59
1962	10.35
1963	10.10
1964	10.32
1965	10.24
1966	10.33
1967	10.31
1968	10.48
1969	10.60
1970	10.57
1971	9.99
1972	9.90
1973	10.00
1975	10.16
1976	10.25
1977	10.29

Note: See Appendix III, for the sources and methods of the various components of Scottish demand. The rest of U.K. figures were obtained from various issues the Central Statistical Office publication, Economic Trends.

Appendix 6

Detailed Results of the Principal Components of Instrumental Variable Estimation

- Number of Principal Components - 10

(1) Consumption (dlnSCONK)

Var.	Coeff.	S.E.	t	D.W.
C	2.52	1.16	2.16	1.89
lnSCONK(-1)	-0.90	0.47	-1.84	
dlnINC	0.44	0.15	2.82	
lnINC(-1)	0.41	0.17	2.30	
lnTWSMK	0.41	0.18	2.28	
lnTWSMK(-1)	-0.18	0.15	-1.22	

(2) Real Wage Bill (dlnTWSMK)

Var.	Coeff.	S.E.	t	D.W.
C	0.01	.009	1.37	1.91
dlnTWUKMK	0.30	0.11	2.65	
dlnSTEM	0.79	0.26	2.94	

3) Home Output (dlnSHIOP)

Var.	Coeff.	S.E.	t	D.W.
C	-2.81	0.93	-3.00	2.47
lnSHIOP(-1)	-0.56	0.15	-3.65	
dlnDEM	1.11	0.29	3.80	
lnDEM(-1)	0.57	0.16	3.42	
dlnWXV	0.43	0.09	4.56	

(4) Foreign Output (dlnSFIOP)

Var.	Coeff.	S.E.	t	D.W.
C	-7.40	6.00	-1.23	
lnSFIOP(-1)	-0.25	0.17	-1.40	1.76
dlnDEM	1.53	0.70	2.16	
lnDEM(-1)	0.88	0.71	1.24	
dlnWXV	0.61	0.20	3.04	

(5) Home Investment (dlnSHIMK)

Var.	Coeff.	S.E.	t	D.W.
C	1.73	1.43	1.20	2.2
lnSHIMK(-2)	-0.83	0.15	-5.51	
d^2lnACC	0.60	0.28	2.14	
lnACC	0.33	0.14	2.26	

(6) Foreign Investment (dlnSFIMK)

Var.	Coeff.	S.E.	t	D.W.
C	-7.56	3.83	-1.97	2.1
lnSFIMK(-1)	-0.43	0.27	-1.56	
dlnJVE	0.72	0.38	1.86	
lnJVE	0.76	0.39	1.95	
RAT1(-1)	0.45	0.50	0.91	

(7) Home Employment (dlnSHEM)

Var	Coeff.	S.E.	t	D.W.
C	8.29	1.56	5.28	0.82
lnSIOP	0.28	0.09	2.98	
lnSHEM(-1)	-0.59	0.19	-3.09	
lnSHEM(-2)	-0.58	0.20	-2.92	
TREND	-0.02	.005	-5.52	

(8) Foreign Employment (dlnSFEM)

Var	Coeff.	S.E.	t	D.W.
C	-2.25	0.74	-3.03	2.21
lnSIOP	1.23	0.30	4.04	
lnSFEM(-1)	-0.29	0.22	-1.30	
lnSFEM(-2)	-0.45	0.21	-2.11	

Appendix 7

Results of the Reestimated Structural Equations used in Policy Simulation

'SH2'

Real Wage Equation dlnTWSMK

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	0.02	0.008	2.39	.58		11.44	2.3
dlnTWUKMK	0.24	0.088	2.79		.53		
dlnSHEM	0.79	0.25	3.08				

Home output equation dlnSHIOP

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	-3.42	0.97	-3.51	.85			
lnSHIOP(-1)	-0.54	0.13	-3.91		.80	16.2	2.2
dlnDEM	1.23	0.23	5.27				
lnDEM(-1)	0.63	0.016	3.75				
dlnWXV	0.41	0.081	5.08				

Home Investment Equation dlnSHIMK

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	-0.12	0.004	-2.48	.58		5.6	2.8
lnSHIMK(-2)	-0.71	0.14	-3.66		.48		
d^2lnACC	0.49	0.36	1.60				
lnACC	0.46	0.25	1.83				

Home Employment Equation dlnSHEM

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	7.48	1.35	5.53	.79		12.7	1.35
lnSHIOP	0.36	0.07	5.11		.73		
lnSHEM(-1)	-0.56	0.17	-3.30				
lnSHEM(-2)	-0.56	0.16	-3.38				
TREND	-0.02	0.003	-6.93				

'SH3'

Home Output Equation dlnSHIOP

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	-3.86	1.15	-3.35	.87		19.0	
lnSHIOP(-1)	-0.45	0.12	-3.62		.83		2.0
dlnDEM	1.24	0.21	5.75				
lnDEM(-1)	0.64	0.18	3.48				
dlnWXV	0.40	0.073	5.55				

Home Investment Equation   dlnSHIMK

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	-0.38	-0.19	-1.93	.60		6.0	
lnSHIMK(-2)	-0.70	0.18	-3.91		.51		2.8
d^2lnLACC	0.55	0.31	1.77				
lnACC	0.50	0.20	2.38				

Home Employment Equation   dlSHEM

Var.	Coeff.	S.E.	t	R^2	$\bar{R}^2$	F	D.W.
C	7.14	1.24	5.7	.80			
lnSIOP	0.42	0.07	5.8		.74	13.5	1.4
lnSHEM(-1)	-0.59	0.17	-3.4				
lnSHEM(-2)	-0.54	0.16	-3.2				
TREND	-0.02	0.003	-7.2				

BIBLIOGRAPHY

ADAMS, F. G., BROOKING, C. G. and GLICKMAN, N. J. 'On the Specification and Simulation of a Regional Econometric Model: A Model of Mississippi', The Review of Economics and Statistics, Vol. 57 (1975).

AMANO, A. 'Specific Factors, Comparative Advantage and International Investment', Economica, Vol. 44 (1977).

ASHCROFT, B. K. and INGHAM, K. P. D. 'The Comparative Impact of U.K. Regional Policy on Foreign and Indigenous Firm Movements', Applied Economics, Vol. 14 (1982).

ASHCROFT, B. K. 'The Scottish Region and the Regions of Scotland' in Ingham, K. P. O. and Love, J. (Ed.) Understanding the Scottish Economy (Oxford: Martin Robertson, 1983).

BALL, R. J. and ST. CYR, E. B. A. 'Short-Term Employment Fluctuations in British Manufacturing Industry', Review of Economic Studies, Vol. 33 (1966).

BARKER, T. S. (Ed.), Economic Structure and Policy with Applications to the British Economy (London: Chapman and Hall, 1976).

BELL, D. N. F. 'Labour Utilization and Statutory Non-Wage Costs', The Fraser of Allander Institute Discussion Paper 16, University of Strathclyde (Feb. 1980).

BELL, D. N. F. and HART, R. A. 'The Regional Demand for Labour Services', Scottish Journal of Political Economy, Vol. 27, No. 2 (June 1980).

BELL, D. N. F. 'Regional Output, Employment and Unemployment Fluctuations' Oxford Economic Papers, Vol. 23, No. 1 (March 1981).

BELL, D. N. F. et. al. 'The Development of a Medium-Term Model for Scotland I: Projections to 1984'. The Fraser of Allander Institute Research Monograph Number 10, (1982).

BELL, D. N. F. Regional Econometric Modelling with Special Reference to Scotland, Ph.D. Dissertation, University of Strathclyde (July 1984).

BELL, F. W. 'An Econometric Forecasting Model for a Region', Journal of Regional Science, Vol. 7, No. 2 (1967).

BEGG, H. M., LYTHE, C. M. and MACDONALD, D. H. 'The Impact of Regional Policy on Investment in Manufacturing Industry, Scotland 1960-1971', Urban Studies, Vol. 13, (1976).

BEGG, H. M. and LYTHE, C. M. 'Regional Policy 1960-1971 and the Performance of the Scottish Economy', Regional Studies, Vol. 11 (1977).

BOATWRIGHT, B. D. and RENTON, G. A. 'An Analysis of United Kingdom Inflows and Outflows of Direct Foreign Investment', The Review of Economics and Statistics, Vol. 57 (1975).

BOS, H, C., SAUNDERS, M. and SECCHI, C. Private Foreign Investment in Developing Countries. A Quantitative Study on the Evaluation of Macro-Econometric Effects (Boston: Reidel, 1974).

BRECH, M. and SHARP, M. Inward Investment: Policy Options for the United Kingdom, (Chatham House Papers: Routledge & Kegan Paul, 1983).

BRECHER, R. A. 'Second Best Policy for International Trade and Investment', Journal of International Economics, Vol. 14 (1983).

BRECHLING, F. 'The Relationship Between Output and Employment in British Maufacturing Industry', Review of Economic Studies, Vol. 31 (July 1965).

BURGESS, D. F. 'On the Distributional Effects of Foreign Direct Investment', International Economic Review, Vol. 19, No. 3 (Oct. 1978).

BURNSIDE, A. M. and HENDERSON, D. S. 'The Revised Index of Industrial Production for Scotland, for the Period 1958-1970, Sources and Methods', E.S.U. Discussion Paper, No. 6 (Feb. 1980).

BUSINESS MONITOR, P. A. 1002. 'Annual Census of Production', Tables 20 and 21 (1973, 1975, 1977 and 1979).

CAVES R. E. 'International Corporations: The Industrial Economics of Foreign Invetment', Economica, Vol. 38 (Feb. 1971).

CENTRAL STATISTICAL OFFICE (CSO). Economic Trends (Various issues).

CHALLEN, D. W. and HAGGER A. J. Macroeconometric Systems, Construction, Validation and Applications (Macmillan

Press, 1983).

CHOW, G. C. Analysis and Control of Dynamic Economic Systems (John Wiley and Sons, 1975).

CHOW, G. C. and CORSI, P. (Ed.) Evaluating the Reliability of Macroeconomic Models (John Wiley and Sons, 1982).

CHOW, G. C. Econometrics (McGraw-Hill 1983).

COURBIS, R. 'The Regina Model: A Regional-National Model for French Planning', Regional Science and Urban Economics, Vol. 9 (1979).

COURBIS, R. 'Measuring Effects of French Regional Policy by Means of a Regional National Model', Regional Science and Urban Econmics, Vol. 12 (1982).

CROW, R. T. 'A Nationally Linked Regional Econometric Model', Journal of Regional Science, Vol. 13, No. 2 (1973).

CROW, R. T. 'Output Determination and Investment Specification in Macroeconometric Models of Open Regions', Regional Science and Urban Economics, Vol. 9 (1979).

DAS, S. P. and LEE, S. D. 'On the Theory of International Trade with Capital Mobility', International Economic Review, Vol. 20 No. 1 (Feb. 1979).

DAS, S. P. 'Effects of Foreign Investment in the Presence of Unemployment', Journal of International Economics, Vol. 11 (1981).

DAVIDSON, J. E. H., HENDRY, D. F., SRBA, F. and YEO, S. 'Econometric Modelling of the Aggregate Time-Series-Relationship between Consumer's Expenditure and Income in the United Kingdom', Economic Journal, Vol. 88 (1978).

DEI, F. 'Non-Traded Goods and Optimal Foreign Investments', Journal of International Economics, Vol. 9 (1979).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'A Manual/Non-Manual Division of Employees in Employment by Sex and Industrial Order: Scotland 1954-1980', Research Paper 81/D/1 (n.d.).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'Consumer's Expenditure in Scotland, 1961-1979', Research Paper 81/D/4 (October 1981).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'Investment in Scotland', 1961-1979' Research Paper 81/D/6 (Nov. 1981).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'Local Authority and Central Government Current Expenditure on Goods and Services in Scotland', Research Paper 81/D/9 (n.d.).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP . 'Income in Scotland, 1960 to 1980', Research Paper 81/D/11 (Feb. 1982).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'Earnings in Scotland, 1959-1980', draft copy of the Research Paper (1981).

DUNDEE SCOTTISH ECONOMIC MODELLING GROUP. 'Output in Scotland, 1958-1979', Research Paper 82/D/12 (n.d.).

DUNNING, J. H. International Production and the Multinational Enterprise (London: George Allen & Unwin, 1981).

ENGLE, R. F. 'A Disequilibrium Model of Regional Investment', Journal of Regional Science, Vol. 14, No. 3 (1974).

FAIR, R. C. Specification, Estimation and Analysis of Macroeconometric Models (Harvard University Press, 1984).

FIRN, J. 'External Control and Regional Development: the Case of Scotland', Environment and Planning, Vol. 7 (1975).

FORSYTH, D. J. U.S. Investment in Scotland (Prager, 1972).

GEHRELS, F. 'Optimal Restriction on Foreign Trade and Investment', American Economic Review, Vol. 61 (1971).

GLICKMAN, N. J. 'Son of the "Specification of Regional Econometric Models"', Papers and Proceeding of the Regional Science Association, Vol. 32 (1974).

GLICKMAN, N. J. Evaluation and Analysis of Regional Systems: Explorations in Model Building and Policy Analysis (New York: Academic Press, 1977).

GRANGER, C. W. T. and NEWBOLD, D. 'Spurious Regressions in Econometrics', _Journal of Econometrics_, Vol. 21 (1974).

GUCCIONE, A. and GILLEN, W. J. 'A Simple Disaggregation of a Neoclassical Investment Function', _Journal of Regional Science_, Vol. 12, No. 2 (1972).

GUCCIONE, A. and GILLLEN, W. J. 'A Metzler Type Model for the Canadian Regions', _Journal of Regional Science_, Vol. 14, No. 2 (1974).

HARVEY, A. C. _The Econometric Analysis of Time Series_ (Philip Alan, 1981).

HEATHFIELD, D. (Ed.). _Topics in Applied Econometrics_ (Macmillan, 1976).

HENDRY, D. F. 'Predictive Failure and Econometric Modelling in Macroeconomics: The Transactions Demand for Money' in Ormerod, P. (Ed.) _Economic Modelling: Current Issues and Problems in Macroeconomic Modelling in the U.K. and the U.S._, (Heinemann, 1979).

HENDRY, D. F. and MIZON, G. E. 'Serial Correlation as a Convenient Simplification, not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England', _The Economic Journal_, Vol. 88 (Sept. 1978).

HETHERINGTON, I. P. and HORN, M. E. 'Overseas-Owned Manufacturing Establishments in Scotland: Output, Investment and Employment', _Scottish Economic Bulletin_, No. 24 (Spring 1982).

HOLDEN, K., PEEL, D. A. and THOMPSON, J. L. _Modelling the U.K. Economy_ (Oxford: Martin Robertson, 1982).

HOOD, N. and YOUNG, S. 'The Geographical Expansion of U.S. Firms in Western Europe: Some Survey Evidence', _Journal of Common Market Studies_, Vol. 14, No. 3 (1976).

HOOD, N. and YOUNG, S. 'U.S. Investment in Scotland - Aspects of the Branch Factory Syndrome', _Scottish Journal of Political Economy_ Vol. 23, No. 3 (Nov. 1976).

HOOD, N. and YOUNG, S. 'European Development Strategies of U.S. owned Manufacturing Companies located in Scotland', _Report prepared for the Scottish Economic Planning Department_ (Edinburgh, 1980).

HOOD, N. and YOUNG, S. 'Foreign Direct Investment in Scotland: The European Dimension', Scottish Journal of Political Economy, Vol. 28, No. 2 (June 1981).

HOOD, N. and YOUNG, S. Multinationals in Retreat: The Scottish Experience (Edinburgh: Edinburgh University Press, 1982).

HOYT, H. One Hundred Years of Land Values in Chicago, (University of Chicago Press, 1933).

International Monetary Fund. International Financial Statistics and International Financial Statistics Year Book (various issues).

JEFFERSON, C. W. 'A Regional Econometric Model of the Northern Ireland Economy', Scottish Journal of Political Economy, Vol. 25. No. 3 (Nov. 1978).

JOHNSTON, J. Econometric Methods (McGraw-Hill, 1972).

JONES, R. W. 'International Capital Movements and the Theory of Tariffs and Trade', Quarterly Journal of Economics, Vol 81, No. 1 (Feb. 1967).

JORGENSON, D. W. 'Capital Theory and Investment Behaviour', American Economic Review, Papers and Proceedings, Vol. 53 (1963).

JUDGE, G. C., GRIFFITHS, W. E., HILL, R. C. and LEE, T. C. The Theory and Practice of Econometrics (John Wiley and Sons, 1980).

KELLY, C. M. 'Scottish Output in Sub-Sectors of Manufacturing Industry, Modelling in Relation to Expenditure Aggregates', ESU Discussion Paper No. 7 Scottish Office (Edinburgh, 1980).

KEMP, M. C. 'The Gain from International Trade and Investment: A Neo-Heckscher-Ohlin Approach', American Economic Review, Vol. 56 (Sept. 1966).

KLEIN, L. R. 'The Specification of Regional Econometric Models', Papers of the Regional Science Association, No. 23 (1969).

KLEIN, L. R. Econometric Models as Guides for Decision Making The Charles C. Moskowitz Memorial Lectures: No. 22 (New York: New York University, 1981).

KLOEK, T. and MENNES L. B. 'Simultaneous Equation Estimation Based on Principal Components of Predetermined Variables', Econometrica, Vol. 28

(1960).

LATHAM, W. R., LEWIS, K. A. and LANDON, J. H. 'Regional Econometric Models: Specification and Simulation of a Quarterly Alternative for Small Regions', Journal of Regional Science, Vol. 19, No. 1 (1979).

LEONTIEFF, W. The Structure of the American Economy, 1919-1939 (New York: Oxford University Press, 1951).

L'ESPERANCE, W. L., NESTEL, G. and FROMM, D. 'Gross State Product and an Econometric Model of a State', American Statistical Association Journal, Vol. 64 (1969).

LITTLE, J. M. D. and MIRRLEES, J. A. Project Appraisal and Planning for Developing Countries (London: Heinemann, 1974).

LYTHE, C., DEWHURST, J., PARRILLO, S., COX, M., GAUSDEN, R. 'Temptress III' Report to the Social Science Research Council, Department of Economics, University of Dundee (1981).

LYTHE, C. and MAJMUDAR, M. 'The Renaissance of the Scottish Economy' (London: George Allen & Unwin, 1982).

LUCAS, R. E. Studies in Business Cycle Theory (Oxford: Basil Blackwell, 1981).

MACDOUGALL, G. D. A. 'The Benefits and Costs of Private Investments from Abroad: A Theoretical Approach, Economic Record, Vol. 36 (1960).

MADDALA, G. S. Econometrics (McGraw-Hill, 1983).

MAJMUDAR, M. 'Government and the Scottish Economic Performance: 1954-1978', Scottish Journal of Political Economy, Vol. 30 (1983).

MAYES, D. G. Applications of Econometrics (Prentice-Hall, 1981).

MCDERMOTT, P. J. 'Multinational Manufacturing Firms and Regional Development: External Control in Scottish Electronics Industry', Scottish Journal of Political Economy, Vol. 26 (1979).

MCGILVRAY J. 'Construction of the 1973 Input/Output Tables for Scotland: A Summary of Experience', The

Fraser of Allander Institute Discussion Paper 20 (1981).

MOORE, B. and RHODES, J. 'Regional Policy and the Scottish Economy', Scottish Journal of Political Economy, Vol. 21 (1974).

NATIONAL INSTITUTE OF ECONOMIC AND SOCIAL RESEARCH, 'Listing of the Interim NIESR Model IV', Discussion Paper No. 28 (1974).

PARSONS, G. F. 'The Giant Manufacturing Corporations and Balanced Regional Growth', Area, Vol. 4 (1972).

PINDYCK, R. S. and RUBENFELD, D. L. Econometric Models and Economic Forecasts (McGraw-Hill, 1981).

SAVITT, J. H. Electric Energy Useage and Regional Economic Development, Electric Power Research Institute (Palo Alto, California, 1976).

SCHOFIELD, J. A. 'Macro Evaluations of the Impact of Regional Policy in Britain: A Review of Recent Research', Urban Studies, Vol. 16 (1979).

SCOTTISH ECONOMIC BULLETIN (SEB). 'The Index of Production for Scotland', No. 10 (Summer 1976).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Analysis of Industrial Production in Scotland by Market Sector', No. 11 (Winter 1977).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Relative Performance of Incoming and Non-Incoming Industry in Scotland', No. 13 (Autumn 1977).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Annual Gross Changes in Manufacturing Employment in Scottish New Towns and the Rest of Scotland, 1950-1970', No. 14 (Spring 1978).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Charts and Statistics, Employment in Scottish Manufacturing Industry: Analysis of Annual Components of Change by Region and Industry', No. 17 (Spring 1979).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Index of Industrial Production for Scotland - Rebasing to 1975', No. 19 (Autumn 1979).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Overseas Investment in Scottish Manufacturing Industry', No. 20 (Spring

1980).

SCOTTISH ECONOMIC BULLETIN (SEB). 'Charts and Statistics, Manufacturing Employment Estimates', No. 23 (Summer 1981).

SHARP, M. and BRECH, M. _Inward Investment: Policy Options for the United Kingdom_ (Chatham House Papers: Routledge & Kegan Paul, 1984).

SIMS, C. A. 'Macroeconomics and Reality', _Econometrica_, Vol. 48, No. 1 (Jan. 1980).

SIMS, C. A. 'Policy Analysis with Econometric Models', _Brookings Papers on Economic Activity_, Vol. 1 (1982).

THEIL, H. _Estimation and Simultaneous Correlation in Complete Equation Systems_, The Hague: Central Planning Bureau (mimeographed) (1953).

UNITED NATIONS. _Monthly Bulletin of Statistics_ (various issues).

UNITED NATIONS. _Statistical Year Book_ (various issues).

UNITED STATES DEPARTMENT OF COMMERCE. _Survey of Current Business_ (various issues).

WALLIS, K. F. (Ed.). _Topics in Applied Econometrics_ (Oxford: Basil Blackwell, 1979).