Superneutrality in Postwar Economies

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ABSTRACT

A structural vector autoregression is employed to estimate the real output level response to permanent inflation shocks. We identify the model by assuming that in the long run, inflation is a monetary phenomenon. Well-known economic theory is used to establish this identification restriction. The model is estimated for a sample of 16 countries from the larger pool based on data quality, existence of long uninterrupted series on output and inflation, and evidence that the country experienced permanent shocks to inflation and output. The VAR is estimated for each country separately. We find some evidence of nonsuperneutrality, particularly for some low inflation countries, but in general our results suggest that superneutrality describes well most of the postwar economies we study.

KEYWORDS: superneutrality, vector autoregression

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1 Introduction

A key issue in macroeconomics in the past thirty years concerns the concept of superneutrality. Most economists seem to agree that a one-time permanent change in the level of the money stock should have no long-run effect on real variables. This is often summarized with the statement that money is long-run neutral. By this long-run neutrality proposition, a change in the steady state growth rate of the money stock will cause an identical change in the steady state rate of inflation. However, there is a continuing theoretical dispute over the long-run effects of a permanent change in the growth rate of the money stock on real variables, and particularly on the capital-labor ratio, the level of real output, and to some extent on the growth rate of real output. The notion that a one-time permanent change in the rate of money growth has no long-run effect on these real variables has come to be summarized in the statement that money is long-run superneutral. In this paper we will take the 'long-run' qualifier to be understood throughout.

General equilibrium growth models of various stripes make opposite predictions about superneutrality. The main arguments have been made in the context of models where the rate of output growth is given exogenously. Within this class, simple versions of models with money and capital based on overlapping generations of consumers (with money demand motivated by the overlapping generations friction) predict that a one-time shift to a permanently higher rate of money growth will cause a one-time increase in the level of output. Models with money in the utility function and capital based on an infinitely-lived representative consumer predict, in simple versions, that a one-time shift to a permanently higher rate of money growth will have no effect on the level of output. A similar model with money demand motivated by a cash-in-advance constraint predicts, again in a simple version, that the permanently higher money growth rate will be associated with a lower level of output. Additional arguments have been made in the context of Romer-Lucas endogenous growth models. Here, a change in the steady state rate of inflation might have a permanent effect on the *growth rate* of output. Some results based on these models with a representative agent and money demand motivated by a cash-in-advance constraint predict that the one-time shift to a permanently higher rate of money growth will actually lower the output growth rate. Altogether, general equilibrium theories seem to suggest that plausible long-run effects on the level of output could be positive, zero, or negative; and that plausible effects on the rate of output growth may be negative.

In this paper, we conduct a statistical investigation of superneutrality in a large number of postwar economies. Our test imposes minimal structure and makes use of the idea that permanent shocks to nominal variables are necessary to test superneutrality propositions.[1] For each country we use a bivariate vector autoregression composed of the change in inflation and output growth, and we assume that inflation is a monetary phenomenon in the long run (that is, we assume money is neutral). We impose this assumption on the model with the long-run identifying restriction that the exogenous shock to output growth can have only temporary effects on the inflation rate. This identifying restriction effectively decomposes inflation into permanent and transitory components. Our identification scheme allows the effect of a permanent inflation shock on the level of output to be positive, zero, or negative. We therefore interpret our statistical model as a test of

[1] For an extensive discussion of this idea, see Fisher and Seater (1993).

superneutrality.

We collect annual data on inflation and output from a large pool of countries which meet the following criteria: (a) a data quality ranking of 'C-' or better from Summers and Heston (1991), and (b) at least 25 consecutive years of data on both time series. There are 58 countries that meet these two criteria in our sample. We divide these countries into a number of groups according to results from a standard battery of tests for nonstationarity. According to these unit root tests, 16 countries have experienced permanent shocks to inflation and the level of output. We estimate our VAR for these cases. For 11 of these 16 countries, the estimated long-run response of the level of real output to a permanent inflation shock is not significantly different from zero. For 4 of the remaining 5 countries, the long-run response is positive and statistically significant.[2] For the remaining country the point estimate of the long-run response is negative and statistically significant; this effect occurs for the country with the highest in-sample average inflation rate.[3] We note, more generally, that our estimated long-run response tends to be lower or negative for countries with high average inflation rates over the sample.

An additional 9 countries out of the 58 in our sample have experienced permanent shocks to inflation but not to the level of output according to standard tests. These results imply that the permanent inflation shocks did not have permanent effects on the level of output. Hence, these countries provide direct evidence of superneutrality.[4]

There are 31 countries that have not experienced permanent inflation

[2]The four countries are Germany, Austria, the UK, and Finland.

[3]This country is Argentina.

[4]By 'direct' we mean that it is not necessary to run a VAR to test for superneutrality in these cases.

shocks according to standard unit root tests. These countries are uninformative about superneutrality since they exhibit no evidence of permanent shocks to inflation. The remaining two countries are special cases which we discuss later.[5]

We interpret these results as suggesting that, broadly speaking, superneutrality seems to describe well the postwar experience for most of the countries for which our methodology can be applied. While our superneutrality results are only with respect to real output, we think this is the variable of greatest interest to many economists. To the extent that superneutrality is violated, we find that it is mostly on the positive side, with a permanent increase in inflation associated with a permanent increase in the level of output, and that this effect tends to occur for countries with lower average inflation in sample. This result is consistent with theories which predict Mundell-Tobin effects at low steady state inflation rates, but where the effect dissipates at higher steady state inflation rates.[6]

We also have results bearing on the question of whether the long-run *rate of growth* of output might be affected when the steady state rate of inflation increases, as it can be in endogenous growth models. In our framework, tests of this hypothesis require that there be permanent shocks to the *growth rate* of output as well as permanent shocks to inflation. For only one of the 58 countries do we find unit root test results that support this joint hypothesis. According to our tests, almost every country that experienced permanent inflation shocks did not experience permanent changes in output growth. Hence these results provide considerable direct evidence in favor of

[5]Theoretical results in Fisher and Seater (1993) are particularly useful for interpreting the evidence for these countries.

[6]See Azariadis and Smith (1993) for an example of a theory that makes predictions of this type.

superneutrality with respect to output growth rates.[7]

Other empirical work related to the superneutrality question has typically either focused on a time series analysis of a single country or studied the determinants of growth in a cross-sectional analysis for a large number of countries. Among the time series studies, our work is most closely related to Fisher and Seater (1993) and King and Watson (1992), who use the notion of permanent shocks to devise tests of neutrality and superneutrality propositions. King and Watson (1992) find evidence of nonsuperneutrality for the postwar U.S. using differenced output and twice differenced money in a bivariate vector autoregression. We note, following Fisher and Seater (1993), that neutrality is necessary but not sufficient for superneutrality, and we take advantage of this fact in our test by assuming money growth is reflected only in the inflation rate in the long run. An advantage to our specification is that it uses well-established macroeconomic theory and avoids trying to select the 'correct' definition of money.[8]

Fisher and Seater (1993) also provide discussions of other time series studies. They interpret Geweke (1986) and Lucas (1980) as providing evidence in favor of neutrality but as being uninformative with regard to superneutrality. They also interpret Kormendi and Meguire (1984) as providing evidence of neutrality for 43 countries and superneutrality for 4 countries, again based on the notion that permanent shocks are necessary to test these propositions.

The large literature on the determinants of real output growth based

[7]We find evidence of permanent shocks to output growth in four countries. Three of these are uninformative regarding superneutrality. The fourth is one of our special cases.

[8]The King and Watson (1992) evidence may be sensitive to the definition of money. An advantage to their approach is the broad range of identification assumptions considered, but this does not seem practical for our study which examines a large number of countries.

on analyses of a cross-section of countries has been summarized by Levine and Renelt (1992). While some authors have reported that inflation is negatively related to output growth in such regressions, Levine and Renelt (1992) conclude that such inferences are fragile.

In the next section of the paper, we contrast the various results that have been obtained in general equilibrium models with money on the question of superneutrality. We then present our statistical model and, in the following section, we present our data and implementation. The subsequent section discusses the results, and the final section provides summary comments.

2 Superneutrality

In this section, we outline four general equilibrium theories, each of which illustrates a different conclusion on the question of superneutrality. We sketch these theories not to provide a comprehensive review but simply to motivate our test as well as our identification scheme.[9] As is well known, general equilibrium models do not easily admit equilibria in which money has value, and therefore the general conclusion from the theoretical literature is that results depend to a large extent on the way in which a demand for real balances is motivated.[10]

We begin by illustrating a version of the Mundell-Tobin effect in an n-period overlapping generations model with money and capital.[11] In this economy, time runs from the infinite past to the infinite future. Overlapping generations of agents, identical except for birth dates, live for n periods and

[9] For a recent survey on superneutrality, see Orphanides and Solow (1990).

[10] As noted by Orphanides and Solow (1990), the comment of Stein (1970) has held up quite well: "My main conclusion is that equally plausible models yield fundamentally different results."

[11] For more detail on this model, see Bullard and Russell (1993).

maximize

$$U = \sum_{i=0}^{n-1} (1-\gamma)^{-1} \beta^i \left[c_t(t+i)^\eta \ell_t(t+i)^{(1-\eta)} \right]^{(1-\gamma)}$$

by choice of consumption, c, and leisure, ℓ. Here subscripts denote birthdates and parentheses denote real time. The parameter γ is the coefficient of relative risk aversion, $\beta = (1+\rho)^{-1}$ is the discount factor, where ρ is the net rate of time preference, and η is a parameter that controls the share of time devoted to market activity. The labor force grows at gross rate ψ. A large number of identical firms produce output using inputs of capital, $K(t)$, and labor, $L(t)$, according to

$$Y(t) = \lambda^{(t-1)(1-\alpha)} L(t) k(t)^\alpha$$

where $Y(t)$ is output and $k(t)$ is the capital-labor ratio. Here α is the capital share and λ is the gross rate of technological progress. The government provides high-powered money, $H(t)$, according to

$$H(t) = \theta H(t-1),$$

where $\theta > 1$ is the gross rate of money creation. Government consumption based on the revenue from money creation is endogenous, and the government uses the revenue to purchase goods at market prices without affecting the utility maps of the agents.

In any steady state of this model, output grows at the constant gross rate $\lambda\psi$. Agents can save by holding money or by renting capital to the firms, and an arbitrage condition equates the rate of return across all assets. A steady state may exist where agents hold the government-issued money voluntarily. At such a *monetary* steady state, the gross real rate of interest is given by

$$R = \lambda\psi\theta^{-1}$$

and the capital-labor ratio is given by

$$k(t) = \lambda^{t-1}\left[\frac{R - 1 + \delta}{\alpha}\right]^{\frac{1}{\alpha-1}}.$$

The comparative statics indicate that a one-time permanent increase in the gross rate of money creation, θ, will permanently raise the inflation rate, permanently lower the real rate of interest, permanently raise the capital-labor ratio, and permanently raise the level of output. The monetary steady state is a full Pareto optimum if $\theta = 1$. This corresponds to a Friedman rule where prices fall at a rate sufficient to make the rate of return on money equal to the growth rate of the economy. Positive rates of currency creation are therefore *welfare reducing.*

A second type of general equilibrium model with money and capital starts from somewhat different premises and reaches a different conclusion.[12] In this case we begin with a representative family which is growing over (continuous) time at net rate n. Money confers utility directly so that the family maximizes

$$W = \int_0^\infty u(c_t, m_t)e^{-\delta t}dt$$

by choosing consumption, c, and real balances, m. The function $u(\cdot)$ represents felicity at the instant t and δ is the rate of time preference. The family allocates savings between capital holdings and money holdings. The necessary conditions for an interior solution to this problem imply that the net real rate of interest is equal to the marginal product of capital which is

[12] For details on this model, see Sidrauski (1967).

given by

$$f'(k) = \delta + n.$$

Thus the real rate of interest is in the steady state independent of the growth rate of the money stock and of the inflation rate. A one-time permanent increase in the rate of growth of the money stock would have no effect on the capital-labor ratio, the level of output, or the output growth rate. Money is superneutral in this model. Positive rates of money creation are again welfare reducing, provided a technical condition on the utility function holds.

A third general equilibrium model begins with a discrete time formulation of an infinitely-lived representative agent's maximization problem

$$\max \sum_{t=0}^{\infty} \beta^t U(C_t)$$

where U is a standard utility function, C is consumption, and $\beta \in (0,1)$ is the discount factor.[13] The agent maximizes utility subject to a budget constraint

$$f(K_t) + \frac{M_{t-1} + \tau_t}{P_t} - C_t - K_{t+1} + (1-\delta)K_t - \frac{M_t^d}{P_t} = 0$$

and a liquidity or cash-in-advance constraint

$$\frac{M_{t-1} + \tau_t}{P_t} \geq C_t + K_{t+1} - (1-\delta)K_t$$

where K is capital, $f(\cdot)$ is a production function, $\delta \in (0,1)$ is the depreciation rate, P_t is the price level, M_{t-1} is beginning of period nominal money holdings, τ_t is additional money given to the agent at the beginning of time t, and M_t^d is the end-of-period money holdings of the agent. The agent again allocates asset holdings between capital and money.

[13] For details on this model, see Stockman (1981).

Since there is no growth in this model, the capital stock and the level of output are constant in the steady state. If the government issues money at gross rate θ according to

$$M_t = \theta M_{t-1},$$

the first order and market clearing conditions imply that

$$f'(K) = \frac{\theta[1-(1-\delta)\beta]}{\beta^2}.$$

Thus, the comparative statics indicate that higher rates of money creation (higher inflation rates in this model) imply a higher real interest rate, a lower level of the capital stock and a lower level of output. Inflation is again welfare reducing.

Finally, it is possible to analyze the effects of moving to a higher steady state inflation rate in a Lucas-Romer type endogenous growth model. The potential for important effects is magnified in these models because inflation might change the rate of output growth instead of merely the level. Gomme (1993) builds and simulates a model of this type with a representative agent and money demand motivated by a cash-in-advance constraint. Gomme's (1993) numerical calculations suggest that the effects of higher inflation on the output growth rate are negative in such a model, and we will take this as a working prediction for the purposes of this paper. We note, however, that Gomme (1993) predicts the growth rate effect will be small for the range of inflation rates we observe in our sample of 58 countries.[14]

We take these models seriously as representing the state of theoretical knowledge concerning superneutrality. We present these models in order to

[14]There is a large literature on other possible sets of assumptions (money in the production function, for instance) and the associated implications for inflation and growth, but the models sketched above provide examples with the starkest contrasts.

make several points concerning the nature of the claims they make about superneutrality. First, even though all the models involve general equilibrium, continuous market clearing calculations, they make sharply different predictions with respect to the effect of an increased inflation rate on output. This provides a natural motivation for a test to distinguish between the models on the basis of these differing predictions. Second, all of these models embody the long-run neutrality of money: In the steady state, the rate of inflation is determined by the rate of money growth. This helps motivate our maintained assumption that money is long-run neutral.[15] Third, in each case the arguments are couched in terms of steady state comparisons—one steady state with low money growth and low inflation versus another steady state with higher money growth and higher inflation. All ignore transition dynamics. Thus these arguments are best thought of as long run in nature, so that any imposition of monetary neutrality should only be in the long run. This is exactly what our identification assumption accomplishes. Finally, and perhaps most importantly, *all effects of higher money growth in these models come through higher inflation rates.* This is why we focus on inflation instead of money growth in our bivariate VAR.[16] We now turn to our test of superneutrality.

3 VAR identification

Blanchard and Quah (1989) develop a statistical model that decomposes output movements into permanent and transitory components. Our model performs a comparable decomposition for inflation. We use a bivariate time

[15]There is also considerable empirical evidence favoring this view.

[16]Our focus on inflation also has the side benefit of allowing us to sidestep the question of the definition of money.

series model consisting of the change in the rate of inflation, $\Delta\pi$, and the change in the logarithm of real output, Δy. In this framework, one shock is associated with permanent changes in inflation and one is restricted to have only temporary effects on inflation. The permanent inflation shock, ϵ^{π}, is attributed to permanent changes in the growth rate of the money supply following Milton Friedman's famous dictum that "inflation is everywhere and always a monetary phenomenon."[17] Friedman's statement is a reference to trend behavior in inflation, not a claim about every cyclical fluctuation. This permanent inflation shock will permanently affect the level of output if superneutrality is not a property of the macroeconomy. We estimate this long-run effect for all countries in our Group A, described in more detail in the next section. The temporary shock to inflation, ϵ^{y}, is permitted to have a permanent effect on output. For example, if the temporary inflation shock is an adverse aggregate supply disturbance that temporarily raises the inflation rate, output could permanently fall relative to its trend.

Equations (1) and (2) illustrate the moving average representation (MAR) of the bivariate time series model:

$$\Delta\pi_t = \theta_{11}(L)\epsilon_t^{\pi} + \theta_{12}(L)\epsilon_t^{y} \tag{1}$$

$$\Delta y_t = \theta_{21}(L)\epsilon_t^{\pi} + \theta_{22}(L)\epsilon_t^{y}. \tag{2}$$

Each lag operator has the general form of equation (3) with each θ_{ijk} a scalar parameter:

$$\theta_{ij}(L) = \sum_{k=0}^{\infty} \theta_{ijk} L^k, \tag{3}$$

for $i = 1, 2$ and $j = 1, 2$. The model is identified by two restrictions. First, we restrict the long-run multiplier for ϵ^{y} on π to be identically equal to zero

[17] Roberts (1993) uses a similar identifying assumption.

because this shock is not allowed to have a permanent effect on inflation. Restricting the sum of the parameters in the $\theta_{12}(L)$ lag polynomial to zero achieves this condition:

$$\theta_{12}(1) = \sum_{k=0}^{\infty} \theta_{12k} = 0. \tag{4}$$

If permanent movements in inflation are caused by permanent changes in money growth, the transitory inflation shock will primarily result from non-monetary disturbances.[18] Identification requires some assumption about the covariance between the two disturbances. Given that these shocks are thought to originate primarily from different sectors of the economy, our second restriction is that the disturbances are uncorrelated.

This model is easily estimated using Blanchard and Quah's (1989) method. If $\Delta x = [\Delta\pi, \Delta y]^T$ and $\epsilon = [\epsilon^\pi, \epsilon^y]^T$, the structural MAR in (1) and (2) can be written as

$$\Delta x_t = \theta(L)\epsilon_t, \tag{5}$$

where

$$\theta(L) = \begin{bmatrix} \theta_{11}(L) & \theta_{12}(L) \\ \theta_{21}(L) & \theta_{22}(L) \end{bmatrix}.$$

Pre-multiply (5) by $\theta(L)^{-1}$, under the assumption that $\theta(L)$ is invertible,[19] and premultiply the resulting expression by θ_0 $(= \theta(L)|_{L=0})$ to obtain the VAR representation,

$$\beta(L)\Delta x_t = u_t. \tag{6}$$

[18]The temporary shock to inflation could also account for monetary factors which have only temporary effects on inflation. We assume that this source of temporary inflation is less important.

[19]Lippi and Reichlin (1993) and Blanchard and Quah (1993) discuss many issues pertinent to non-invertibility.

The VAR coefficients, $\beta(L)$, are a function of the parameters from the structural MAR,

$$\beta(L) = \theta_0 \theta(L)^{-1}, \tag{7}$$

and the vector of VAR innovations, u_t, is a function of the structural disturbances and the contemporaneous parameters, θ_0:

$$u_t = \theta_0 \epsilon_t. \tag{8}$$

Long-run multipliers, $\theta(1)$, are related to the sum of VAR coefficients, $\beta(1)$, and the contemporaneous parameters according to

$$\beta(1) = \theta_0 \theta(1)^{-1}. \tag{9}$$

The covariance matrix of innovations is derived by assuming the covariance matrix for structural disturbances is the identity matrix[20]

$$\Sigma_u = \theta_0 \theta_0^T. \tag{10}$$

Solving (9) for θ_0, inserting this expression into (10) and simplifying yields

$$\beta(1)^{-1} \Sigma_u \beta(1)^{-T} = \theta(1)\theta(1)^T. \tag{11}$$

The VAR provides the information contained in the left side of this expression. Our assumptions for long-run multipliers and the covariance matrix for shocks imply that $\theta(1)$ is a lower triangular matrix. Hence, the Choleski decomposition of the left side of (11) identifies the parameters in $\theta(1)$. Then we obtain θ_0 from (9) and $\theta(L)$ from (7).

[20] Alternatively, we could normalize the diagonal elements in $\theta(1)$ to equal unity and estimate a diagonal covariance matrix for the structural shocks. These normalizations have no effect on our results.

Our primary purpose is to estimate the long-run response of output to a permanent one percentage point increase in inflation, e, which is derived from elements in the matrix of long-run multipliers,

$$e = \frac{\theta_{21}(1)}{\theta_{11}(1)}. \tag{12}$$

This long-run response is related to the long-run derivative that Fisher and Seater (1993) have investigated, although in their model money growth is not decomposed into permanent and temporary components. An advantage to our approach is that the empirical MAR provides structural information if the identifying assumptions are appropriate. Under this assumption, we can use the effects of the permanent inflation shock on output and inflation to assess the short-run and long-run consequences of a permanent increase in money growth. We are also able to use the empirical model to infer whether the temporary inflation shocks appear to be aggregate supply disturbances and to quantify their effects using variance decompositions.

4 Implementation

4.1 Data

The data are from the *International Financial Statistics* (IFS) data base. We use annual data on real gross domestic product and the gross domestic product deflator for each country. We begin with all of the countries listed on the data base and we apply two criteria to choose a subset of countries for which we argue our model may provide a reasonable test of superneutrality. Our first criterion is data quality. We remove countries from the sample that do not meet our minimum quality standard, which we define as a data

Country	Years	Grade	Country	Years	Grade
Argentina	1961-87	C	Australia	1960-92	A-
Austria	1964-92	A-	Belgium	1960-92	A
Bolivia	1961-85	C	Botswana	1964-91	C
Brazil	1963-91	C-	Canada	1960-92	A-
Chile	1961-92	C	Costa Rica	1960-91	C
Cyprus	1960-91	C	Denmark	1960-91	A-
Dom. Rep.	1963-91	C	Ecuador	1965-91	C
El Salvador	1960-92	C	Finland	1960-92	A-
France	1960-92	A	Germany	1960-92	A
Greece	1960-91	A-	Guatemala	1960-92	C
Honduras	1960-92	C	Iceland	1960-92	B+
India	1960-90	C	Indonesia	1964-92	C
Iran	1964-90	C-	Ireland	1960-90	A-
Italy	1961-90	A	Jamaica	1961-90	C
Japan	1960-90	A	Korea	1960-92	B-
Luxembourg	1960-92	A-	Malta	1960-89	C
Mexico	1960-91	C	Morocco	1964-91	C-
Netherlands	1960-92	A	New Zealand	1960-90	A-
Norway	1960-92	A-	Pakistan	1960-92	C-
Panama	1960-92	C	Paraguay	1960-91	C
Peru	1961-89	C	Phillipines	1960-92	C
Portugal	1966-91	A-	Singapore	1961-92	C
South Africa	1960-92	C-	Spain	1960-91	A-
Sri Lanka	1960-92	C-	Sweden	1960-92	A-
Switzerland	1960-92	B+	Syria	1963-91	C-
Tanzania	1965-91	C-	Thailand	1960-90	C-
Trin.-Tobago	1966-91	C	Tunisia	1968-92	C-
Turkey	1960-90	C	U.K.	1960-92	A
U.S.	1960-92	A	Venezuela	1960-92	C

Table 1: Countries, years of data, and data quality rating according to Summers and Heston (1991).

quality ranking of 'C-' or better from Summers and Heston (1991).[21] Our second criterion is that the country has a long continuous set of observations on the two time series. Since our identification scheme is based on a long-run restriction, we require enough data to plausibly claim that we can estimate a long-run phenomenon. We define the standard for the purposes of this paper as 25 years of annual observations. There are a total of 58 countries that meet these two criteria; these countries, the years of data available, and their data quality ratings are listed in Table 1.

4.2 Tests for nonstationarity

We denote the order of integration of a variable by $\langle x \rangle$, so that if x is integrated of order ℓ, we write $\langle x \rangle = \ell$. For our test of superneutrality to be applicable, the time series from a particular country must be characterized by permanent shocks to the inflation rate and to the level of output; that is, we require $\langle \pi \rangle = 1$ and $\langle y \rangle = 1$. We call the set of countries whose time series meet this criterion the 'Group A' countries.

In order to determine which countries belong in Group A, we apply augmented Dickey-Fuller regressions to test for unit roots in the two time series for each country.[22] We run a set of ten regressions for each variable specified as follows. The first five are run with a constant and 0, 1, 2, 3, or 4 lags. The second five are run with a constant, a deterministic trend, and 0, 1, 2, 3, or 4 lags. The adjusted Box-Ljung Q test statistic is calculated for serial correlation of orders 1, 2, 3, and 4 in each regression. We analyze the

[21] We use IFS data instead of data from Summers and Heston (1991) because the deflators on the IFS data base measure the changes in the price level that are actually experienced in a country. Deflators from the Summers and Heston (1991) data could be affected by international events that had little effect on a country's price index.

[22] Our methodology is a variation on that suggested by Cambell and Perron (1991).

Country	Var.	Lags	$\hat{\tau}_\mu$	$\hat{\rho}_\mu$	Lags	$\hat{\tau}_\tau$	$\hat{\rho}_\tau$
Argentina	y	1	-0.91	-1.54	1	-2.05	-7.41
	π	0	-1.99	-6.94	0	-2.79	-14.23
Australia	y	0	-2.52	-0.83	0	-0.87	-2.03
	π	1	-2.10	-5.70	1	-1.59	-4.72
Austria	y	0	-2.55	-0.92	0	-1.46	-2.61
	π	0	-1.91	-7.08	0	-2.12	-8.45
Chile	y	0	0.04	0.05	0	-1.53	-6.30
	π	1	-2.61	-7.28	1	-2.71	-7.77
Costa Rica	y	0	-1.94	-0.86	0	-0.74	-1.48
	π	0	-2.26	-9.43	0	-2.95	-14.59
Cyprus	y	0	-0.62	-0.65	0	-2.25	-9.29
	π	0	-2.18	-7.80	0	-1.93	-7.88
Finland	y	1	-1.58	-0.80	1	-0.92	-3.99
	π	0	-2.09	-9.28	0	-2.12	-9.42
Germany	y	0	-2.22	-0.95	0	-1.86	-4.19
	π	0	-2.25	-9.13	0	-2.19	-9.38
Iceland	y	1	-2.21	-1.32	1	-2.46	-9.21
	π	0	-1.63	-5.90	0	-1.29	-5.14
Ireland	y	1	0.33	0.11	1	-2.64	-9.07
	π	0	-2.18	-9.87	0	-2.00	-9.24
Japan	y	1	-2.47	-0.85	1	-1.77	-2.06
	π	0	-2.34	-9.69	0	-2.65	-12.35
Mexico	y	1	-2.52	-0.95	1	-0.99	-1.44
	π	0	-1.80	-5.76	0	-2.24	-11.75
Portugal	y	0	-2.50	-1.40	0	-2.32	-5.45
	π	0	-1.95	-5.54	0	-1.61	-5.82
Spain	y	1	-1.78	-0.65	1	-1.79	-1.88
	π	0	-2.31	-7.84	0	-2.11	-7.26
U.K.	y	1	-1.39	-0.81	1	-2.84	-10.56
	π	0	-2.15	-8.36	0	-2.02	-8.11
U.S.	y	0	-2.34	-1.04	1	-3.00	-9.17
	π	0	-1.87	-5.42	0	-1.48	-4.46

Table 2: Unit root test results for Group A countries. We fail to reject a unit root in either series by any of the four tests.

results beginning with the regressions with the maximum lag, checking the Q-statistics for significance at the 10% level. We proceed to the regression with the lag length reduced by one unless doing so means that one or more of the Q-statistics for that regression is significant, in which case we stay at the longer lag length. If this sequential procedure arrives at zero lags without finding any evidence of serial correlation in the augmented regressions, we use the (unaugmented) Dickey-Fuller regression to perform unit root diagnostics. This process leads us to choose a lag length of 0 or 1 in most cases. Once the lag length is decided, we examine the results from the Dickey-Fuller "t-test" for that regression at the 10% level (critical value -2.63 for $\hat{\tau}_\mu$ and -3.24 for $\hat{\tau}_\tau$) and for the normalized bias test at the 10% level (critical value -10.2 for $\hat{\rho}_\mu$ and -15.6 for $\hat{\rho}_\tau$). If both tests fail to reject a unit root for both inflation and output (with and without trend), we include the country in Group A. This process leads us to a set of 16 Group A countries. Table 2 summarizes these results for Group A countries.

Using a similar process, we are able to reject the hypothesis that $\langle\pi\rangle = 3$ for any country, and also that $\langle y\rangle = 3$ for any country. We are also able to reject the hypothesis that $\langle\pi\rangle = 2$ for every country except Peru, and we can reject the hypothesis that $\langle y\rangle = 2$ for all countries except Bolivia, El Salvador, Trinidad and Tobago, and Malta.

With this information in hand, we divide the countries not in Group A into three groups. The first is a group of nine countries where we find evidence of permanent shocks to inflation but not to output. We call these the Group B countries. The second is a group of 31 countries where we find no evidence of permanent inflation shocks. We call these the Group C countries. The two remaining countries are put in a special Group D. Tables

Country	Var.	Lags	$\hat{\tau}_\mu$	$\hat{\rho}_\mu$	Lags	$\hat{\tau}_\tau$	$\hat{\rho}_\tau$
Brazil	y	0	-3.22	-1.66	0	-0.45	-0.93
	π	0	-1.24	-3.66	0	-2.79	-11.39
Belgium	y	0	-3.58	-1.22	0	-1.67	-2.46
	π	0	-2.13	-7.61	0	-1.96	-7.15
Canada	y	0	-3.56	-1.11	0	0.05	0.11
	π	1	-2.30	-8.00	1	-2.10	-7.50
Denmark	y	0	-3.11	-1.45	0	-2.12	-5.11
	π	0	-1.18	-3.93	0	-1.56	-5.14
France	y	0	-6.22	-1.36	0	-1.84	-1.97
	π	1	-1.46	-3.27	1	-1.36	-3.08
Greece	y	0	-4.84	-1.76	0	-0.88	-1.18
	π	0	-1.71	-5.04	0	-2.66	-12.62
Italy	y	0	-3.06	-1.10	0	-1.79	-3.88
	π	0	-1.88	-6.02	0	-1.51	-5.58
Panama	y	0	-3.00	-1.66	0	-0.85	-1.85
	π	0	-2.47	-9.13	0	-2.16	-8.36
Sweden	y	1	-2.74	-1.30	1	-1.43	-2.73
	π	0	-2.16	-9.53	0	-1.73	-8.79

Table 3: Unit root test results for Group B countries. A unit root in inflation cannot be rejected by any test, but a unit root in the level of output is always rejected by one test, $\hat{\tau}_\mu$.

Country	Var.	Lags	$\hat{\tau}_\mu$	$\hat{\rho}_\mu$	Lags	$\hat{\tau}_\tau$	$\hat{\rho}_\tau$
Peru	y	1	-2.38	-2.60	1	-0.90	-2.48
	$\Delta\pi$	0	-0.72	-4.41	0	-1.22	-7.55
Bolivia	Δy	0	-1.99	-7.30	0	-2.56	-11.04
	π	1	4.74	25.80	1	3.67	24.18
	$\Delta\pi$	0	-2.16	-16.71	0	-3.05	-23.49

Table 4: Unit root test results for Group D, which consists of two special cases. A unit root in the change in inflation cannot be rejected for Peru, while a unit root in output growth cannot be rejected for Bolivia. The root in inflation for Bolivia appears to be explosive, but $\langle\pi\rangle = 2$ is rejected.

Country	Lags	$\hat{\tau}_\mu$	$\hat{\rho}_\mu$	Lags	$\hat{\tau}_\tau$	$\hat{\rho}_\tau$
Botswana	0	-4.01	-20.44	0	-4.31	-24.10
Dom. Rep.	0	-1.25	-5.11	0	-3.29	-17.11
Ecuador	0	-1.81	-6.43	0	-4.00	-20.76
El Salvador	0	-2.83	-12.30	0	-4.27	-26.17
Guatemala	0	-3.07	-14.70	0	-4.55	-27.37
Honduras	0	-2.89	-13.72	0	-3.48	-18.97
India	1	-3.67	-25.42	2	-3.68	-31.73
Indonesia	1	-13.26	-15.25	3	-5.01	-20.51
Iran	0	-3.35	-15.60	0	-3.60	-18.47
Jamaica	0	-2.43	-9.99	1	-4.00	-23.26
S. Korea	0	-2.29	-9.98	0	-3.22	-15.73
Luxembourg	0	-4.74	-26.54	0	-4.66	-26.64
Malta	0	-2.72	-12.24	0	-2.79	-12.98
Morocco	0	-4.44	-23.20	0	-4.55	-24.65
Netherlands	0	-2.55	-11.50	0	-3.30	-15.69
New Zealand	0	-3.15	-16.57	0	-3.01	-17.25
Norway	0	-2.54	-11.97	0	-2.43	-11.67
Pakistan	0	-2.55	-11.24	0	-2.56	-11.78
Paraguay	0	-2.03	-7.57	0	-3.27	-18.23
Phillipines	0	-4.05	-22.40	0	-4.38	-25.20
Singapore	0	-2.76	-12.46	0	-2.68	-12.43
S. Africa	0	-1.96	-6.53	0	-3.10	-16.90
Sri Lanka	0	-2.91	-13.38	0	-3.46	-19.07
Switzerland	0	-2.75	-13.23	0	-2.88	-14.04
Syria	0	-3.25	-16.14	0	-3.86	-22.36
Tanzania	0	-1.48	-4.65	0	-3.35	-16.92
Thailand	0	-2.86	-13.47	0	-2.85	-13.88
Trin. and Tob.	0	-2.94	-13.86	0	-3.03	-14.46
Tunisia	0	-3.48	-16.33	0	-3.36	-16.24
Turkey	1	-1.91	-6.50	1	-4.16	-20.68
Venezuela	0	-3.45	-18.09	0	-5.16	-30.21

Table 5: Unit root test results for inflation only, Group C. A unit root in inflation is rejected by at least one test in all cases.

3, 4, and 5 present the results for Groups B, C, and D.

5 Results

5.1 Group A countries

We use data from each of the countries in Group A to empirically address the superneutrality question. Our statistical model identifies permanent and transitory shocks to inflation using the VAR. The VAR lag specifications were selected by the modified likelihood ratio statistic of Sims (1980). In some cases, detrending of one or both variables in the VAR was necessary. We decided whether to detrend a variable using the following procedure. We ran a set of five regressions for each time series. The regressions had a constant, a trend, and 0, 1, 2, 3, or 4 lags as explanatory variables. For each regression, we calculated the Box-Ljung Q test statistic for serial correlation at orders 1, 2, 3, and 4. We began interpreting the output by looking at the regression with the most lagged dependent variables. If the Box-Ljung tests indicated serial correlation of any order for the regression with one less lag, we stayed at the longer lag length. Otherwise we proceeded to the regression with one less lagged dependent variable. Once we decided on a lag length via this process, we examined the t-statistic on the trend variable. If it was significantly different from zero, we concluded that the variable needed to be detrended before being put in the VAR.[23]

We begin with a discussion of the long-run response of output to a permanent inflation shock. This response (and the associated impulse response

[23] The number of lags in the VAR and the detrended variables are as follows: Argentina 2; Australia 3, Δy detrended; Austria 1, Δy detrended; Chile 2; Costa Rica 1, Δy detrended; Cyprus 1; Finland 4; Germany 1, Δy detrended; Iceland 1, Δy detrended; Ireland 2; Japan 4, Δy detrended; Mexico 5, Δy detrended; Portugal 3, Δy and $\Delta \pi$ detrended; Spain 1; United Kingdom 2; United States 1, Δy detrended.

function) is the primary focus of our test. The estimated long-run response and the associated 90% confidence bounds are displayed graphically in Figure 1.[24] In this figure, the countries are in increasing order of in-sample average inflation on the horizontal axis.[25] The point estimate of the long-run response is marked by a short horizontal line associated with each country, and the width of the 90% confidence interval is marked by the length of the straight vertical line for each country. For 11 of the 16 Group A countries, the estimated 90% confidence interval includes zero, and based on this result we conclude that superneutrality provides a good description of the postwar experience in these countries. For four countries, Austria, Germany, Finland, and the United Kingdom, we conclude that superneutrality is violated, and that a permanent increase in inflation is associated with a positive, permanent, and statistically significant increase in the level of output. One country, Argentina, experienced on average a statistically significant and permanent negative level effect on output in response to permanent inflation shocks. We note that, with a 90% confidence level and 16 countries, we expect to find one or two statistically significant estimates based on sampling variation alone.

In Figure 2, we summarize the sense in which higher in-sample average inflation seems to be associated with lower point estimates of the long-run response of output to a permanent inflation shock. Here the natural logarithm of inflation is indexed on the horizontal axis, and our point estimates of the long-run response are indexed on the vertical axis. The downward

[24]The confidence bounds are obtained using Runkle's (1987) bootstrap procedure with 1000 replications using random draws (with replacement) from the actual residuals.

[25]The in-sample average inflation rates for the 16 Group A countries are Argentina 145.6%, Australia 6.9%, Austria 4.8%, Chile 83.7%, Costa Rica 15.0%, Cyprus 5.8%, Finland 7.8%, Germany 4.0%, Iceland 26.0%, Ireland 8.8%, Japan 5.1%, Mexico 29.2%, Portugal 14.8%, Spain 10.6%, United Kingdom 8.0%, United States 5.0%.

sloping line in the figure is a fitted regression line used to visually summarize the relationship. The regression line crosses zero at a point that corresponds to about a 43% annual inflation rate. We conclude that our point estimates tend to be higher for countries with lower in-sample average inflation rates.

Some economists may believe that permanent inflation shocks obtain from adverse supply disturbances. The central bank may off-set these shocks by permanently raising the money growth rate thus raising inflation to a permanently higher level. Similarly, the monetary authority may allow inflation to permanently fall following a beneficial supply disturbance. This story, however, predicts a negative relationship between permanent movements in inflation and output, a prediction that is not supported by most of our point estimates.

Next we turn to a discussion of the impulse response functions. Figures 3, 4, and 5 present three sets of impulse response functions in the set of 16 Group A countries. We report standardized responses, whereby the impulse responses of each variable are divided by the standard error for that variable's residual. Figure 3 presents the results for Germany, one of the four countries with a positive and statistically significant long-run response.[26] Here inflation rises initially and remains permanently higher following a permanent inflation shock. The level of output also rises and remains permanently higher following such a shock. In the face of a temporary inflation shock, the initial response of inflation is positive and significantly different from zero, but ultimately the response is zero, reflecting our identifying assumption. The level of output falls in response to a temporary inflation shock. This last impulse response, which is common across all 16 countries

[26]The results for Germany are qualitatively unchanged if the sample is truncated in 1989, the year before German reunification.

in Group A, leads us to characterize the temporary inflation shock in the model as an adverse supply disturbance.[27]

Most countries do not display the positive and statistically significant long-run output response to a permanent inflation shock that Germany does. More typical results are like those presented in Figure 4, which displays impulse response functions for the United States. Here the responses of inflation to a permanent inflation shock, inflation to a temporary inflation shock, and output to a temporary inflation shock are qualitatively similar to the German case presented in Figure 3. But the output response to a permanent inflation shock is now statistically significant only at a short horizon.

Figure 5 displays the impulse response functions for a high inflation country, Chile. In this case the response of inflation to a permanent inflation shock is positive and statistically significant, and the response of output to a temporary inflation shock is negative and statistically significant; both these responses are consistent with the analogous functions plotted in Figures 3 and 4. The response of inflation to a temporary inflation shock is significant only in the second year and is eventually zero by the identifying restriction. Output responds in a negative but not quite statistically significant way to a permanent inflation shock at moderate to long horizons.

Comparing Figures 3, 4, and 5, then, we conclude that these countries differ primarily in the way output responds to a permanent inflation shock. This theme holds across the impulse response functions for the remaining 13 Group A countries. These functions are plotted in Appendix A. A summary

[27]This result is interesting in the context of Faust and Leeper (1994). They discuss inference problems associated with aggregating different kinds of structural disturbances. One would not expect this empirical finding for each country if the temporary shock were subject to these aggregation problems.

of the variance decompositions for the Group A countries is provided in Tables 6 and 7.[28]

5.2 Groups B, C, and D

Our VAR test of superneutrality is valid only for countries that have experienced both permanent shocks to inflation and permanent shocks to the level of output. Of the 42 countries not in Group A, a few are informative regarding superneutrality even though our test cannot be applied. This is because some have experienced, according to our unit root diagnostics, permanent shocks to inflation but no permanent shocks to the level of output. We interpret this as direct evidence of superneutrality.[29] The nine Group B countries fit into this category. If we combine the evidence from Groups A and B, we conclude that superneutrality describes well the postwar experience of 20 out of the 25 countries in these two groups.

There are 31 Group C countries for which we cannot claim evidence of permanent inflation shocks. These countries are uninformative regarding superneutrality, because we cannot infer the response to policy changes that did not occur.[30]

Finally, there are two special cases which we categorized in Group D. The first of these is Peru, for which we find $\langle \pi \rangle = 2$ and $\langle y \rangle = 1$. We follow Fisher and Seater (1993) and interpret this as direct evidence for

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[28] We provide results based on the permanent inflation shock because the effects of this shock are our primary concern. The point estimate for the variance explained by the temporary shock is equal to 100 less the point estimate of the variance explained by the permanent shock. Similarly, the lower 90 percent confidence bound can be calculated by subtracting the upper bound for the permanent shock from 100, and the upper bound by subtracting the lower bound for the permanent shock from 100.

[29] We follow Fisher and Seater (1993) in this interpretation. Again, by 'direct' we mean that it is not necessary to devise a test to come to this conclusion.

[30] We again follow Fisher and Seater (1993) in this interpretation.

Country	Horizon 1	2	4	8	16
Argentina	28	24	36	36	36
	(2,66)	(2,60)	(8,71)	(7,72)	(7,72)
Australia	17	14	17	9	7
	(0,64)	(1,64)	(2,67)	(4,56)	(3,55)
Austria	57	54	54	53	53
	(51,86)	(18,83)	(16,83)	(15,83)	(14,83)
Chile	0	0	14	19	19
	(0,37)	(0,41)	(4,65)	(3,70)	(2,72)
Costa Rica	12	23	29	31	32
	(0,52)	(1,62)	(2,68)	(1,70)	(1,71)
Cyprus	12	7	6	5	5
	(0,60)	(1,49)	(1,47)	(0,48)	(0,47)
Germany	61	53	48	46	45
	(26,88)	(20,82)	(15,79)	(12,78)	(11,78)
Iceland	0	0	0	0	0
	(0,38)	(0,39)	(0,41)	(0,42)	(0,43)
Ireland	7	8	17	18	19
	(0,42)	(0,46)	(1,58)	(1,61)	(1,62)
Japan	79	65	55	54	55
	(13,100)	(9,95)	(7,91)	(6,93)	(5,93)
Mexico	46	33	28	19	15
	(2,93)	(2,87)	(3,85)	(4,85)	(7,86)
Portugal	8	3	6	10	10
	(0,65)	(2,57)	(3,67)	(3,72)	(3,76)
Spain	48	43	41	39	39
	(2,92)	(2,88)	(2,86)	(1,86)	(1,86)
United Kingdom	46	46	45	45	45
	(11,78)	(11,77)	(9,79)	(8,80)	(7,81)
United States	21	8	4	2	1
	(0,63)	(2,40)	(2,32)	(1,32)	(1,31)

Table 6: Percent of output variance attributed to a permanent inflation shock. The 90 percent confidence bounds are in parentheses below each point estimate. The horizon is in years.

Country	Horizon 1	2	4	8	16
Argentina	98 (85,100)	97 (86,99)	95 (81,99)	95 (82,99)	96 (82,100)
Australia	70 (17,99)	88 (48,98)	93 (66,99)	93 (72,99)	96 (80,100)
Austria	61 (21,88)	83 (62,94)	92 (81,97)	96 (90,99)	98 (95,99)
Chile	93 (66,100)	89 (62,99)	95 (81,100)	96 (86,100)	98 (91,100)
Costa Rica	84 (40,99)	91 (65,100)	95 (78,100)	97 (87,100)	98 (93,100)
Cyprus	99 (79,100)	99 (84,100)	100 (91,100)	100 (95,100)	100 (97,100)
Germany	61 (28,88)	85 (69,95)	93 (86,98)	97 (93,99)	98 (96,100)
Iceland	93 (53,100)	95 (70,100)	97 (83,100)	99 (91,100)	99 (96,100)
Ireland	89 (57,99)	88 (60,99)	91 (75,99)	95 (84,99)	97 (91,100)
Japan	7 (0,73)	35 (8,85)	38 (11,84)	75 (50,93)	85 (61,97)
Mexico	28 (1,89)	12 (4,66)	41 (18,75)	61 (36,87)	67 (43,94)
Portugal	64 (13,99)	82 (46,98)	87 (61,97)	92 (73,98)	95 (82,99)
Spain	37 (2,91)	52 (17,93)	72 (44,96)	87 (73,98)	94 (88,99)
United Kingdom	23 (1,72)	30 (2,74)	73 (57,87)	84 (71,93)	92 (82,97)
United States	80 (43,99)	91 (70,99)	95 (84,100)	97 (90,100)	99 (95,100)

Table 7: Percent of inflation variance attributed to a permanent inflation shock. The 90 percent confidence bounds are in parentheses below each point estimate. The horizon is in years.

superneutrality akin to the countries in Group B. Intuitively, if $\langle y \rangle = 1$ and $\langle \pi \rangle = 2$, output may be a function of the change in the rate of inflation, but it cannot be a function of the level of inflation because that would imply $\langle y \rangle = 2$. The second country is Bolivia, for which we find $\langle \pi \rangle = 1$ and $\langle y \rangle = 2$. We again follow Fisher and Seater (1993, p. 404), who argue that the long-run derivative is finite in this case only if their $\gamma(1) = 0$. This condition is violated for the Bolivian data,[31] and thus we conclude that superneutrality is rejected for Bolivia. If we add Peru and Bolivia to our findings for Groups A and B, we conclude that superneutrality describes well the postwar experience of 21 of the 27 countries that are informative on this question.

5.3 Implications for endogenous growth models

There is also the question of the effects of higher inflation on output *growth rates.* As noted above, we are able to reject the hypothesis of a unit root in output growth for all of the countries in Groups A and B; these countries did experience permanent inflation shocks according to our tests. Thus these 25 countries provide considerable direct evidence in favor of superneutrality *with respect to output growth rates.* This result is in contrast to some recent claims that output growth rates are negatively related to inflation.[32] If we include the Group D countries, then Peru also provides direct evidence of superneutrality with respect to output growth (since $\langle y \rangle = 1$), while Bolivia provides evidence against. We conclude that 26 of the 27 countries that

[31] If the sum of the coefficients on $\Delta\pi$ in the $\Delta^2 y$ equation is equal to zero, then $\gamma(1) = 0$. We are able to reject this hypothesis for Bolivia.

[32] See, for instance, DeGregorio (1993) and Fischer (1991). We interpret our finding as consistent with Gomme (1993), who estimates small effects of inflation on real output growth rates in a simulation exercise. In addition, our finding is consistent with the 'fragility' results of Levine and Renelt (1992).

are informative on this question provide evidence in favor of superneutrality with respect to output growth rates.

6 Summary

King and Watson (1992) have noted that little progress has been made on testing superneutrality and related classical propositions since the Lucas-Sargent rational expectations critique of the 1970s. In this paper we have presented a test of superneutrality using minimal structure based on the notion of permanent shocks to inflation. Our statistical model assumes that money is long-run neutral (which is a necessary condition for superneutrality) but allows the effects of permanent inflation shocks on the level of output to be positive, zero, or negative. General equilibrium theories of money exist which are consistent with all three possibilities. We apply our test to a set of countries which meet our standards with respect to data quality and provide enough data to constitute a long run, and which also show evidence of having experienced permanent inflation and output shocks. The 16 countries in this set are labelled Group A.

Our general result is that superneutrality seems to provide a good description of the postwar experience for most of the Group A countries. To the extent that superneutrality is violated, it is typically on the positive side, a permanent increase in inflation being associated with a permanent increase in the level of output. We do find evidence of a statistically significant negative long-run response of the level of output to a permanent inflation shock for one country. Our point estimates of the long-run response of output to a permanent inflation shock are negatively related to the average in-sample inflation rate of the Group A countries. That is, we tend to estimate high long-run responses for relatively low inflation countries, and zero or negative responses for relatively high inflation countries.

Our nine Group B countries experienced permanent shocks to inflation but no permanent shocks to the level of output. We interpret this as direct evidence of superneutrality. We also find two additional special cases, one of which provides evidence for and one of which provides evidence against superneutrality. If we add these results to those from Group A, we conclude that long-run superneutrality provides a good description of the experience of 21 of 27 countries that are informative on this question.

Some results from endogenous growth models with money demand motivated via a cash-in-advance constraint suggest that a permanently higher inflation rate would permanently lower the output growth rate. We interpret all 25 countries in our Groups A and B as providing evidence against this view. These countries have experienced permanent shocks to inflation but no permanent shocks to output growth.

In the four theoretical frameworks sketched to motivate our test, inflation is always welfare reducing, and thus there seems to be little question of the right policy choice in a world of homogeneous agents and no alternative distortionary tax. To the extent that we find high estimates of the long-run response of the level of output to a permanent inflation shock for low inflation countries along with zero or negative estimates for high inflation countries, our results could be interpreted as lending support to recent work by Azariadis and Smith (1993), as their model predicts Mundell-Tobin effects at low steady state inflation rates which then dissipate at higher steady state inflation rates.

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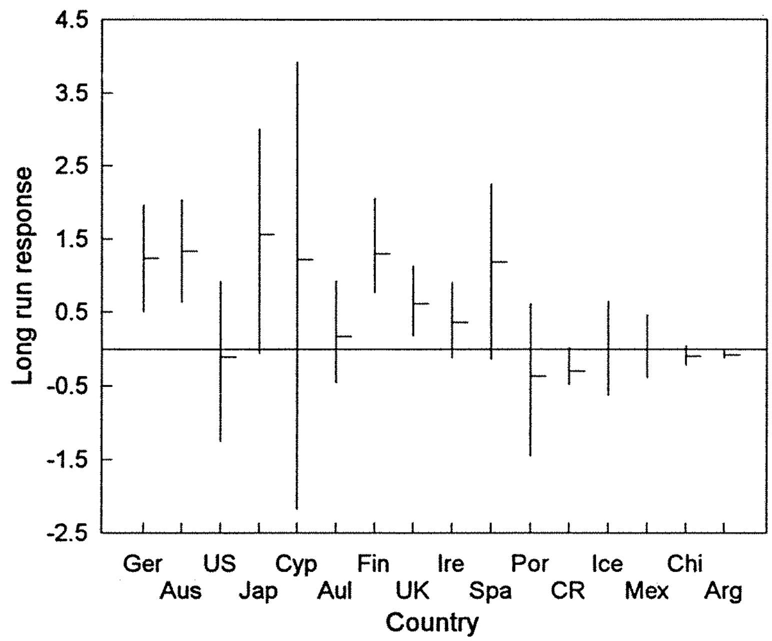
Figure 1



Countries in order from lowest to highest average inflation.

Figure 2

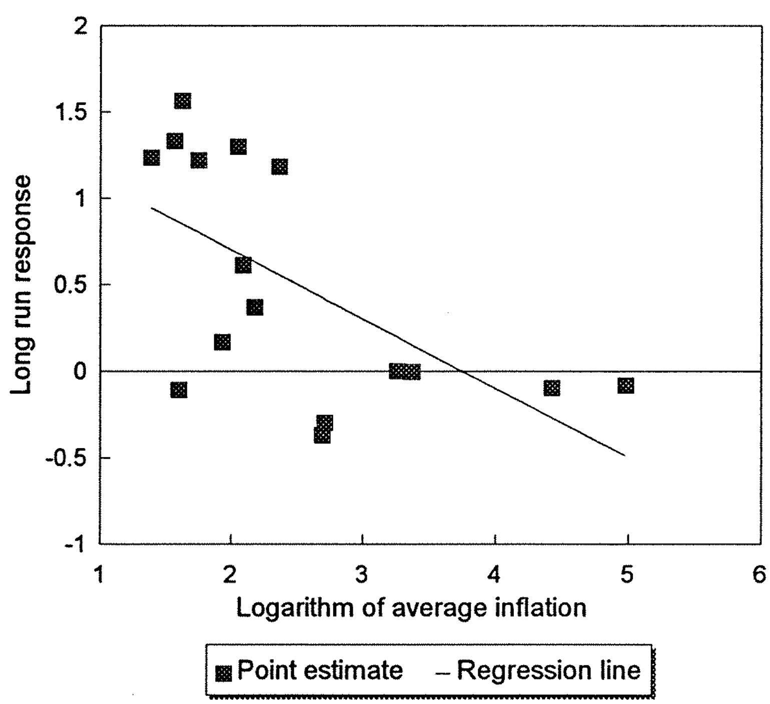


FIGURE 3

Germany, 1960-92

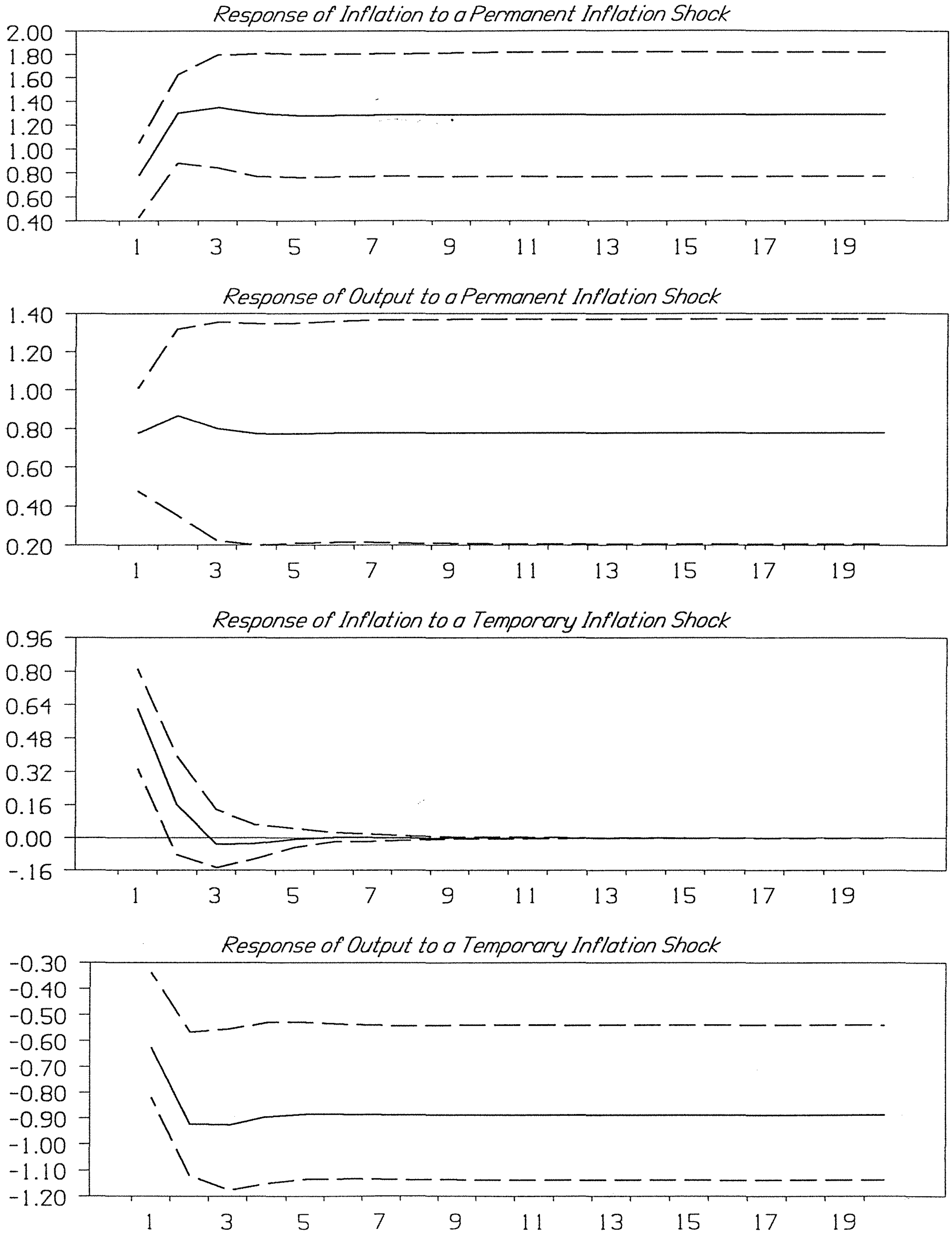


FIGURE 4

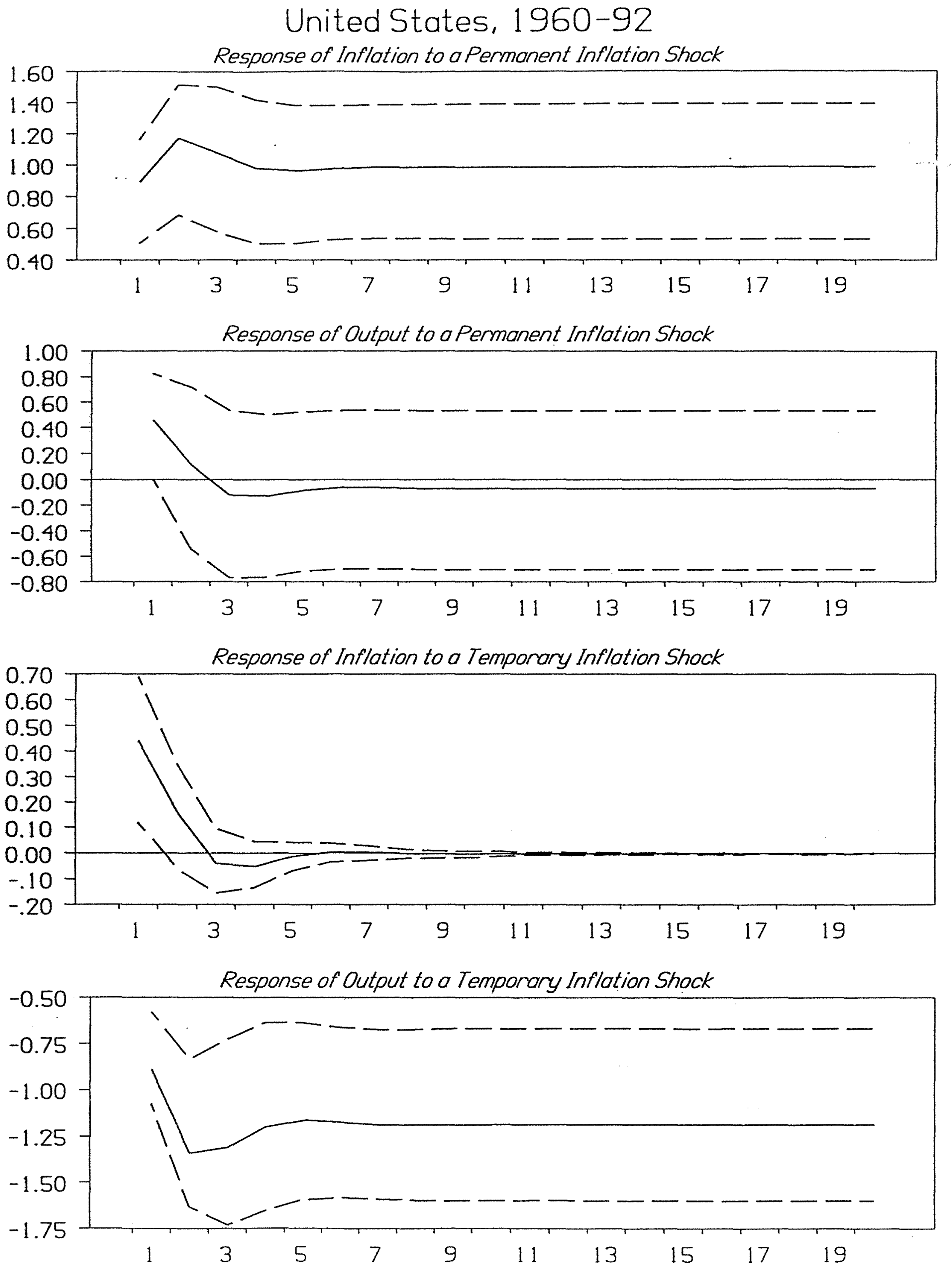
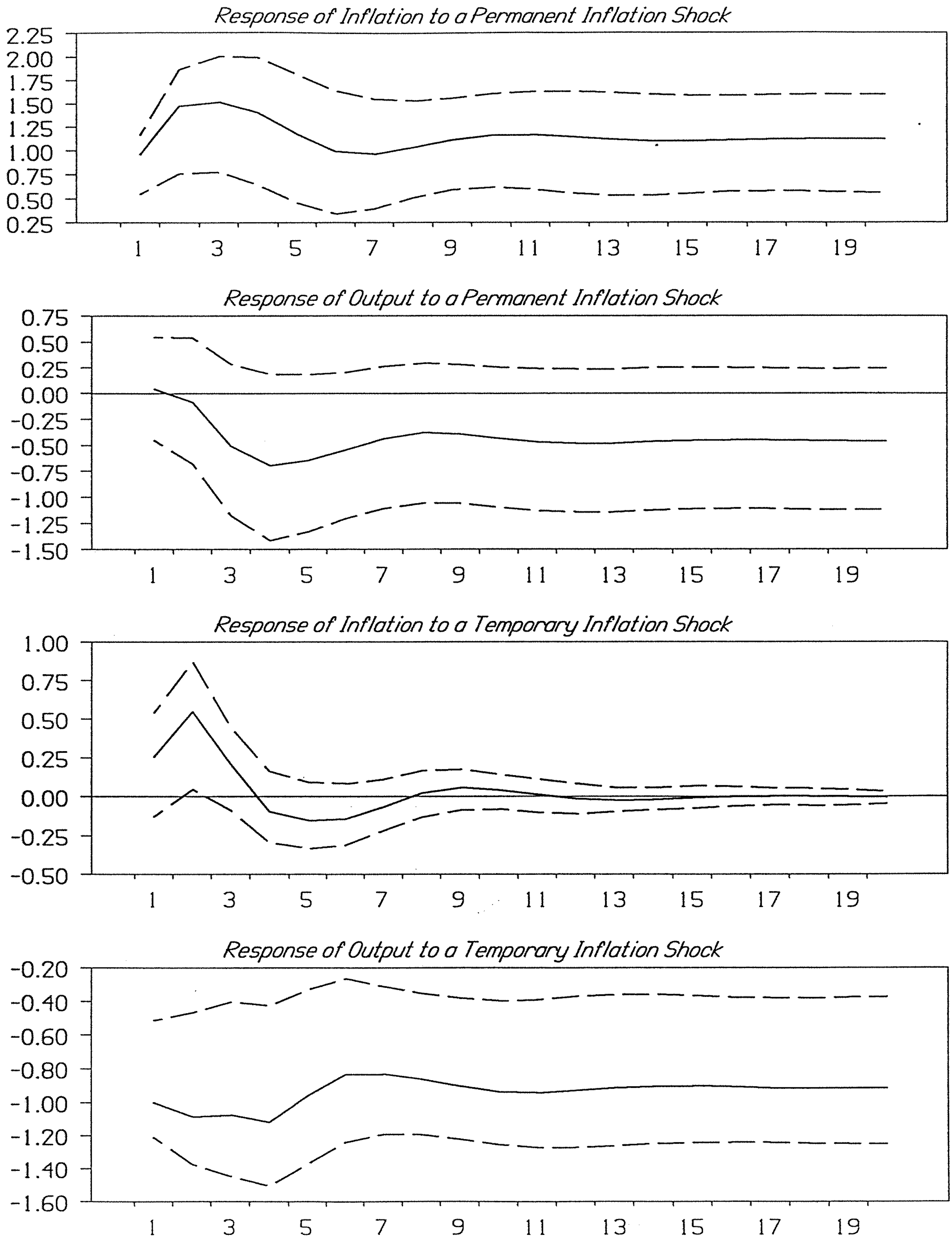

United States, 1960-92
Response of Inflation to a Permanent Inflation Shock
1.60
1.40
1.20
1.00
0.80
0.60
0.40
1 3 5 7 9 11 13 15 17 19
Response of Output to a Permanent Inflation Shock
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
1 3 5 7 9 11 13 15 17 19
Response of Inflation to a Temporary Inflation Shock
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-.10
-.20
1 3 5 7 9 11 13 15 17 19
Response of Output to a Temporary Inflation Shock
-0.50
-0.75
-1.00
-1.25
-1.50
-1.75
1 3 5 7 9 11 13 15 17 19

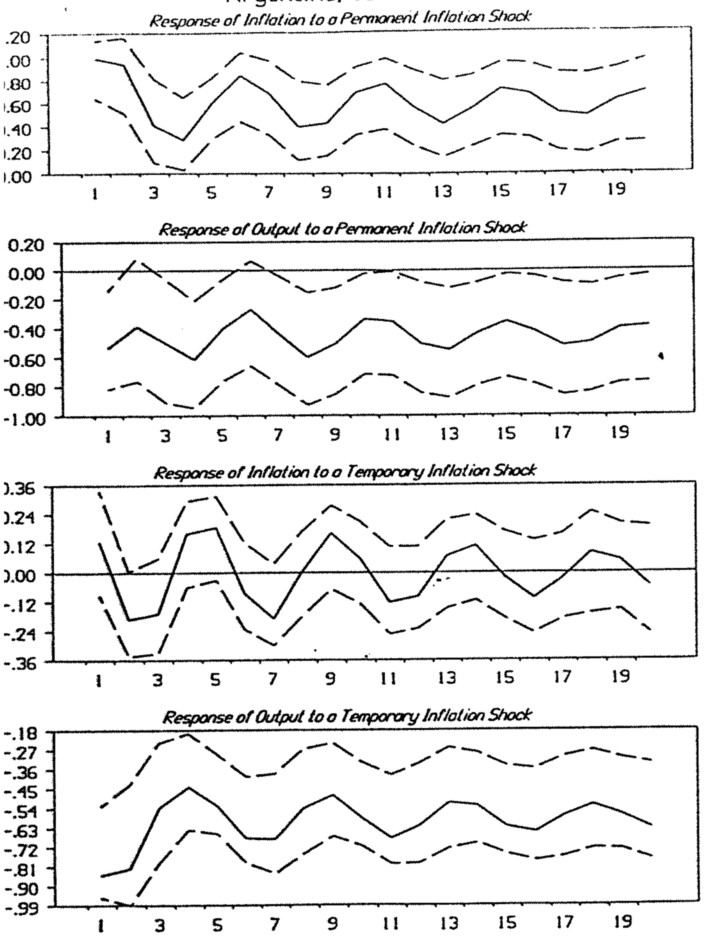
FIGURE 5

Chile, 1961-92

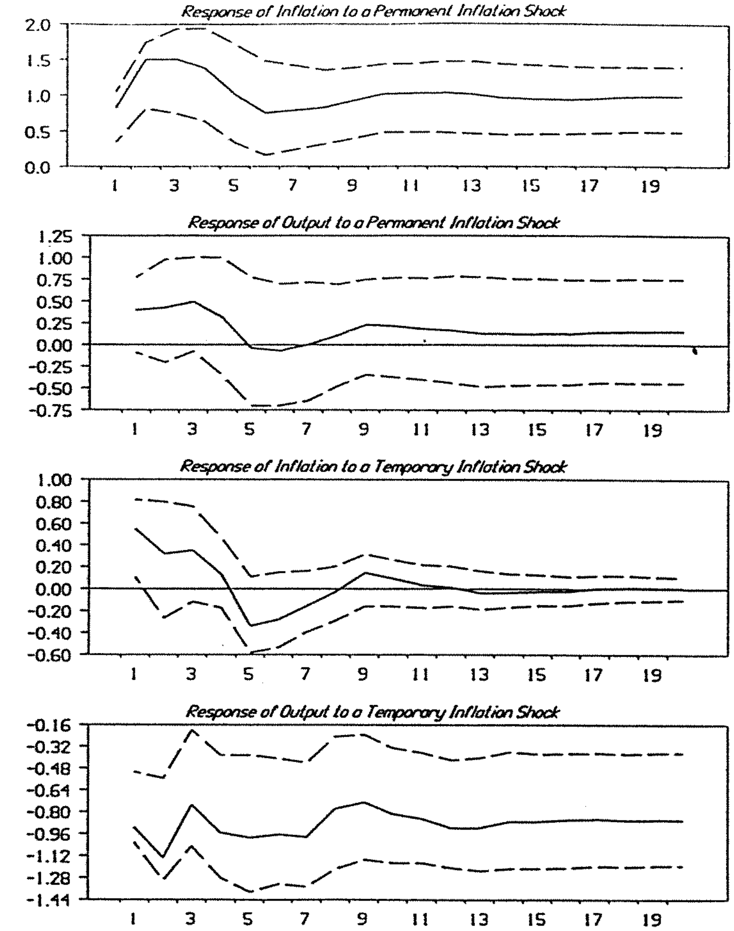


APPENDIX A

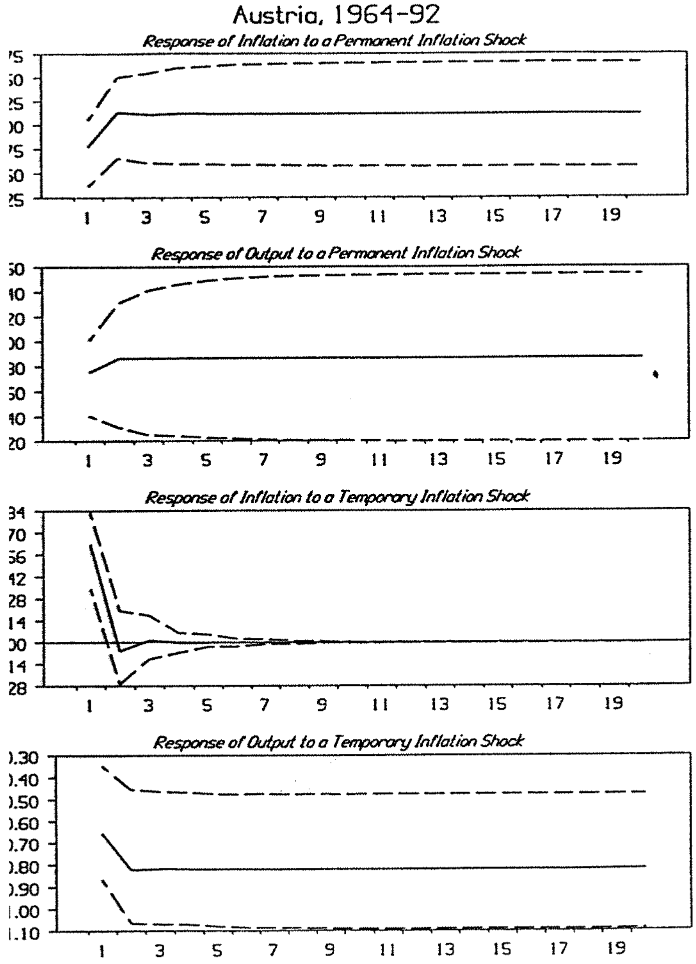
Argentina, 1961-87



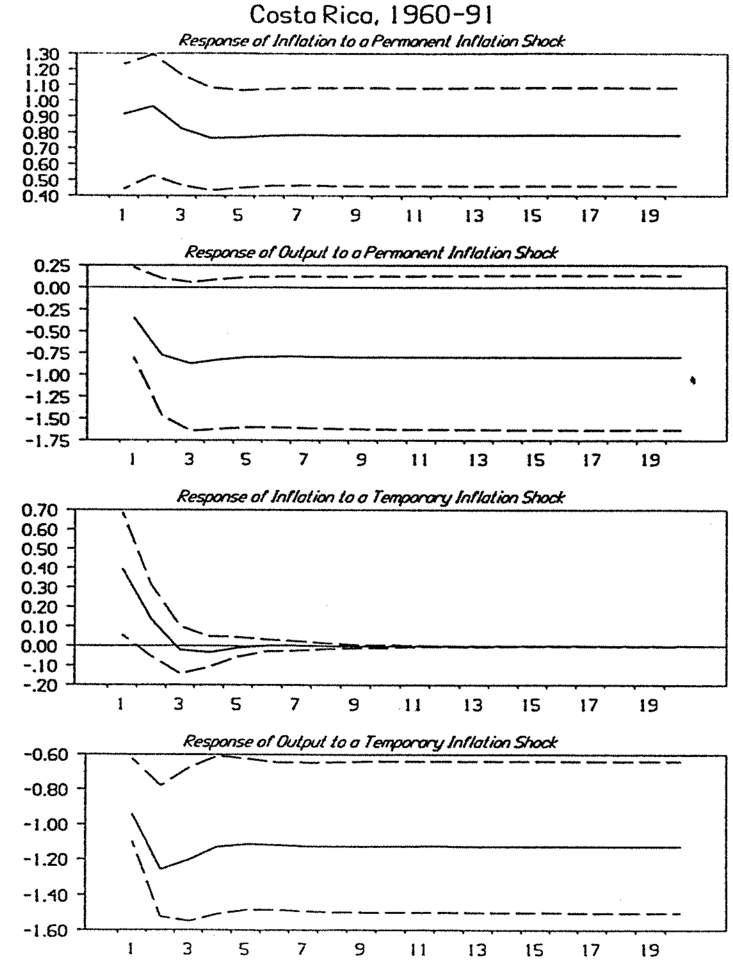
Australia, 1960-92



Austria, 1964-92

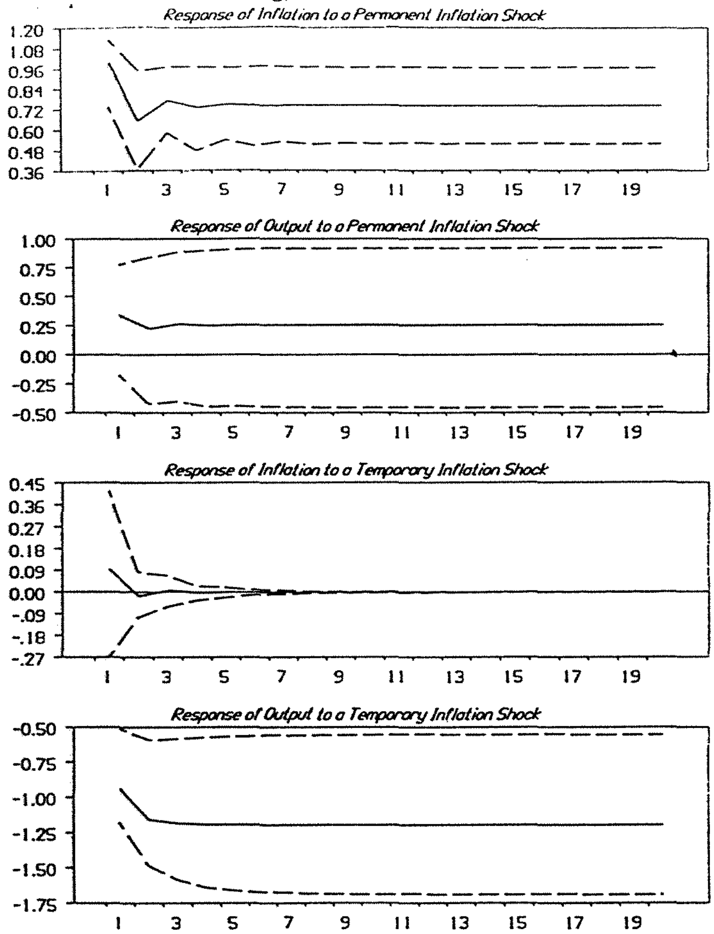


Costa Rica, 1960-91

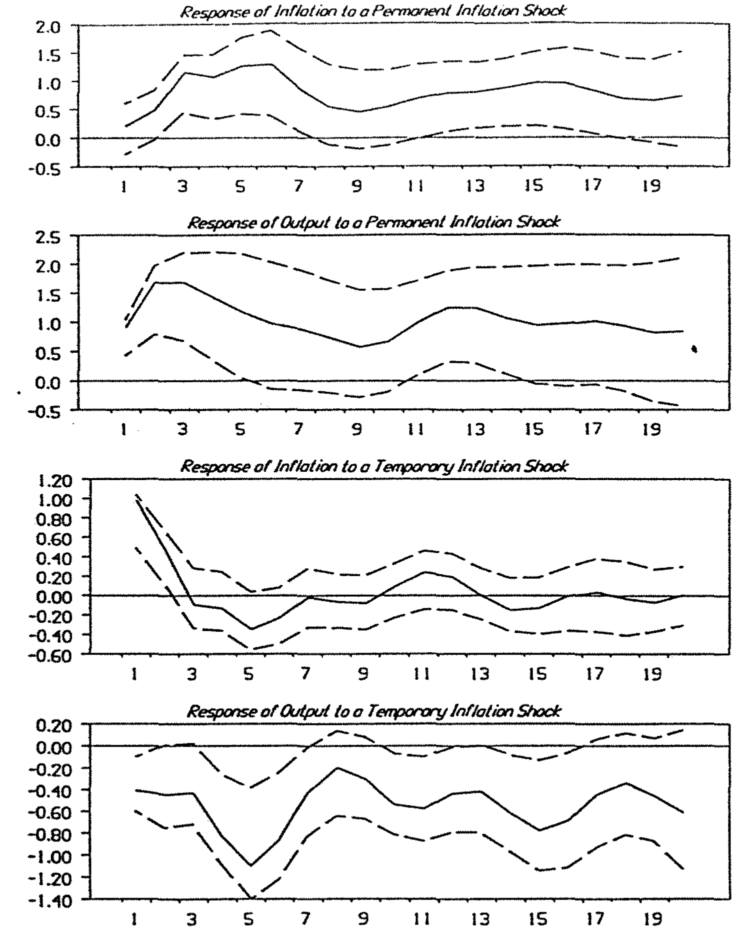


APPENDIX A

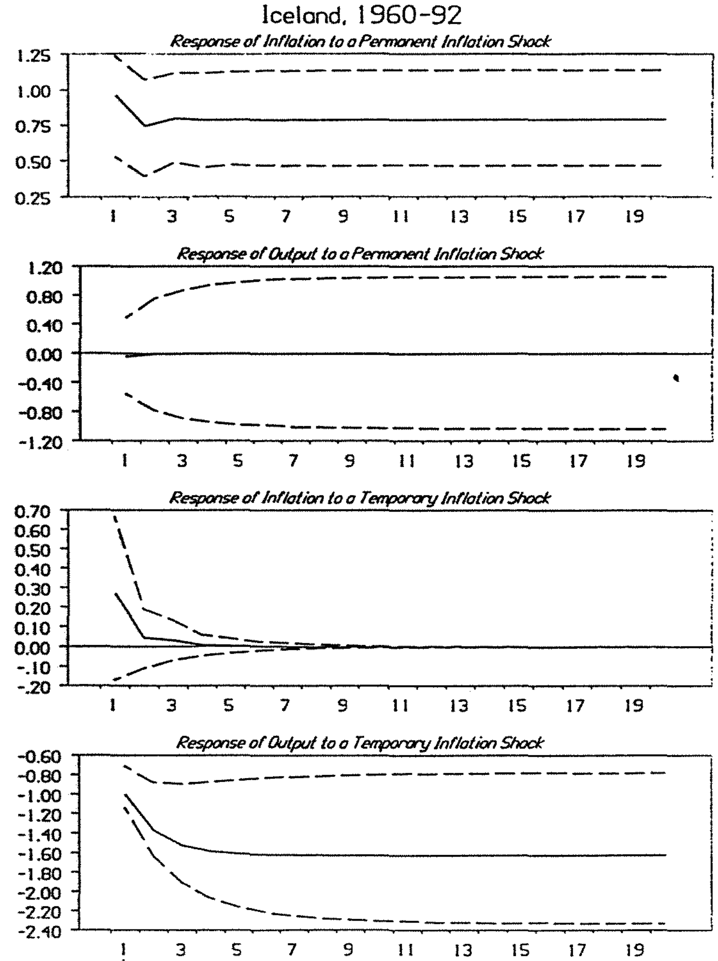
Cyprus, 1960-91



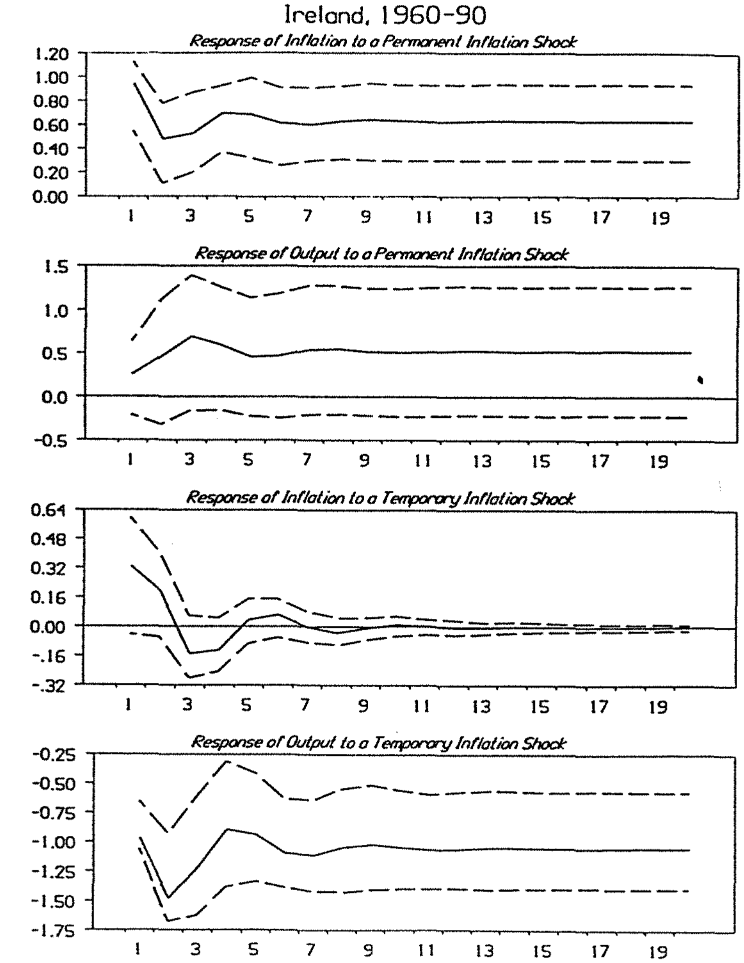
Finland, 1960-92



Iceland, 1960-92

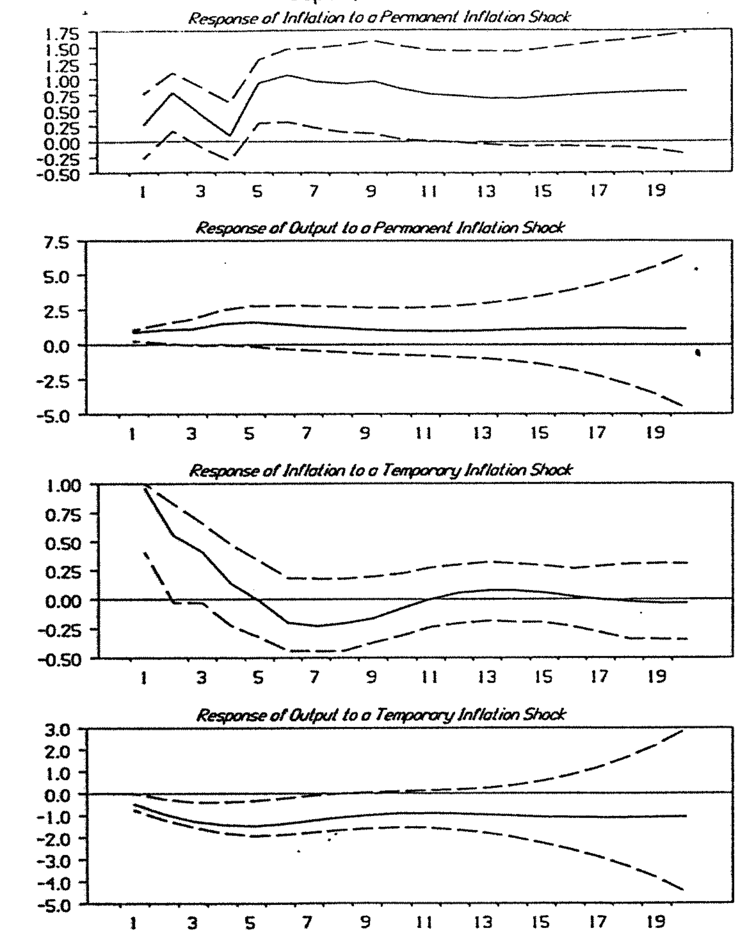


Ireland, 1960-90

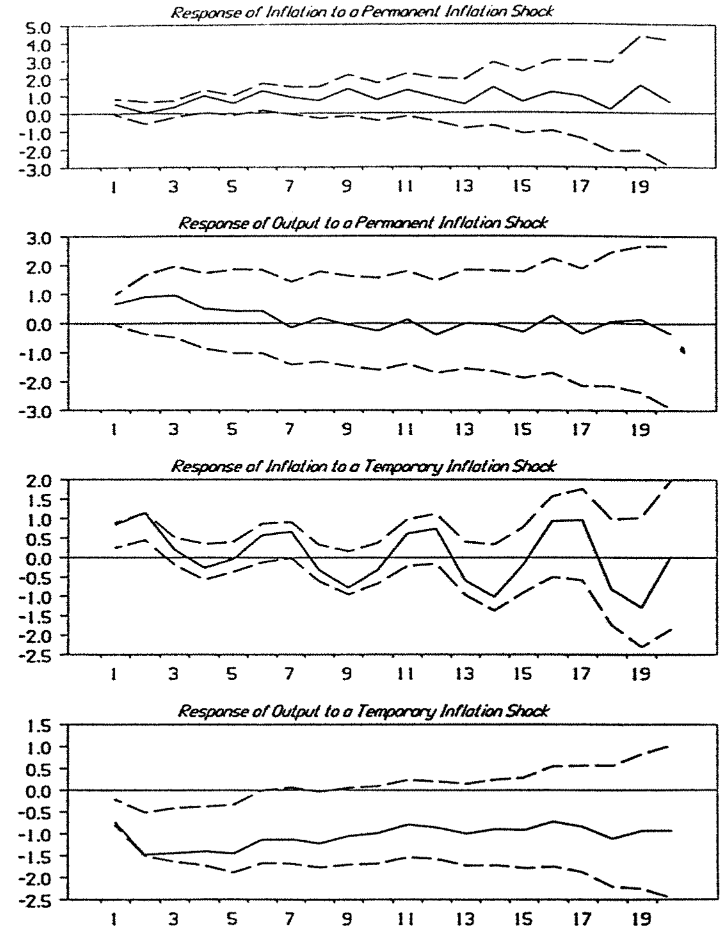


APPENDIX A

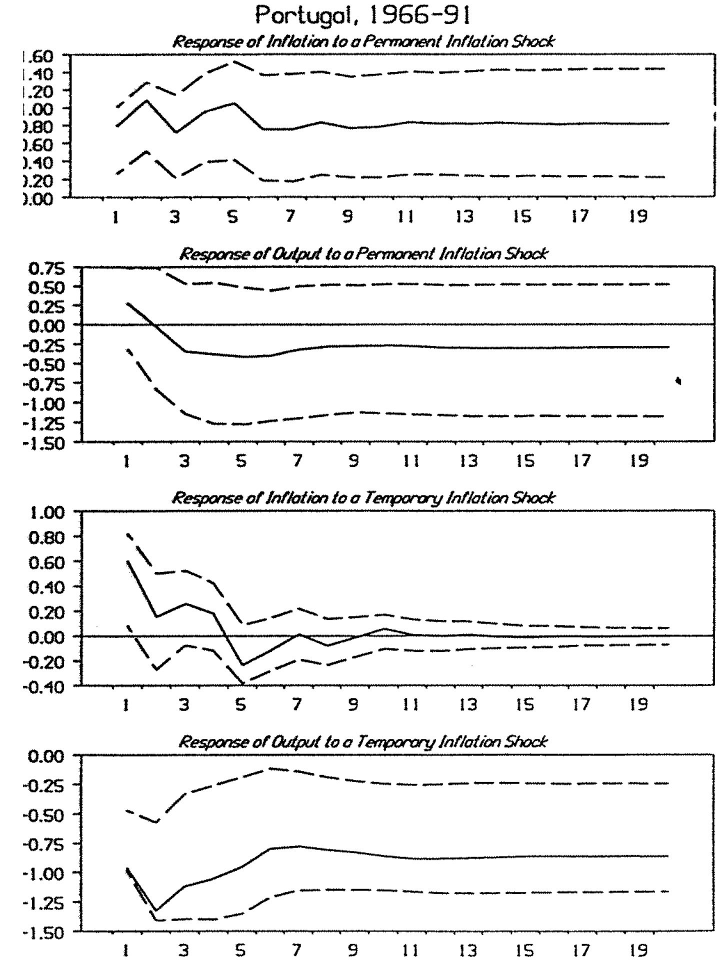
Japan, 1960-90



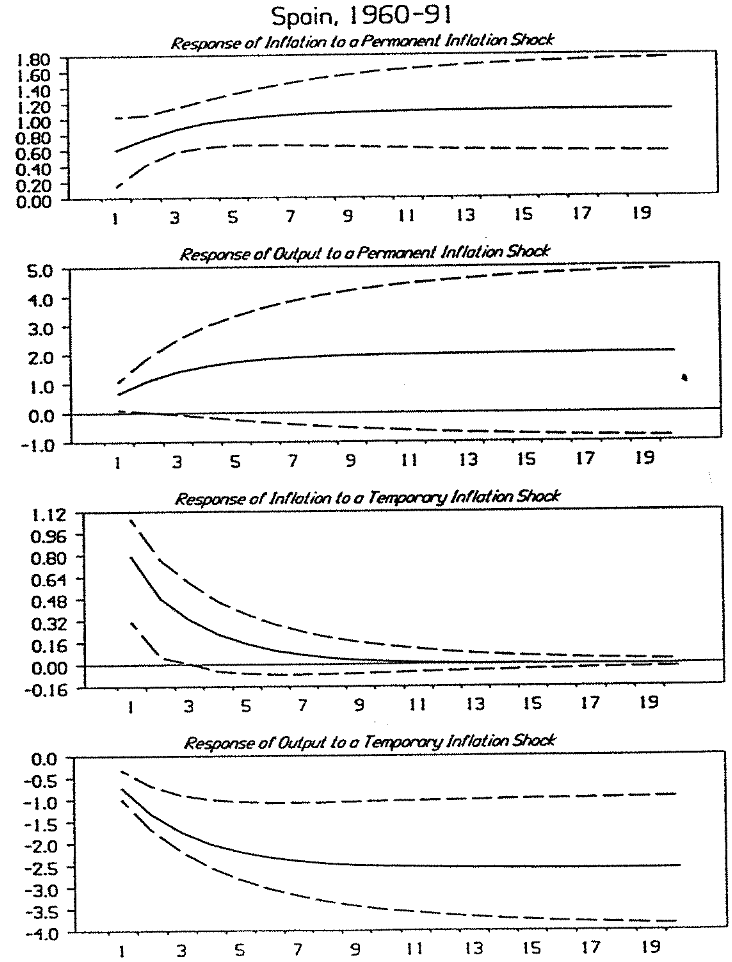
Mexico, 1960-91



Portugal, 1966-91



Spain, 1960-91



APPENDIX A

United Kingdom, 1960-92