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Econometric modelling of private investment in Argentina. 1978-1990

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ABSTRACT

In this paper a parsimonious conditional model of private fixed investment in Argentina is developed for the 1978-1990 period. The set of information contains, besides investment, income, the rate of interest, and public investment. All variables are measured quarterly.

In specifying the model, the econometric approach known as "general-to-particular" methodology is followed. Issues of cointegration, empirical model design and evaluation, and exogeneity are addressed.

The empirical model has constant, well determined parameter estimates. This feature may be surprising given the huge macroeconomic instability and the enormous difficulties faced by economic policy in eliminating the uncertainty prevailing during the period of analysis.

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RESUMEN

En este trabajo se estima un modelo condicional parsimonioso para la inversión privada fija en la Argentina durante el período 1978-1990. El conjunto de información contiene, además de la inversión, al ingreso, a la tasa de interés y a la inversión pública. Todas las variables están medidas trimestralmente.

Al especificar el modelo empírico se ha seguido el enfoque econométrico llamado metodología "de lo general a lo particular". Se abordan aspectos de cointegración, diseño y evaluación empíricos del modelo, y exogeneidad.

El modelo arroja estimaciones de los parámetros constantes y bien determinadas. Este rasgo puede sorprender dada la marcada inestabilidad macroeconómica del período, como así también en virtud de las grandes dificultades enfrentadas por los hacedores de política al intentar conjurar los profundos desequilibrios prevalecientes.

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1. Introduction.

In this paper a conditional model for private fixed investment in Argentina is estimated. In specifying the model, the so called "general-to-particular" econometric methodology (see Hendry and Richard, 1982, 1983; and Hendry et al., 1984) is followed. In this approach, econometric models are viewed as successive simplifications of the underlying real world process generating data. Test statistics become a very important part of the selection criteria since the error processes on empirical models are derived via the specification of the model and its associated estimation procedure. This approach permits the researcher to choose an empirical model which both embodies the economic theory and allows for the presence of any significant factors (such as lagged terms of the series) not fully specified by the postulated theoretical model. In this paper an error correction type model is estimated; as such, it provides an adequate description of the short-run behavior of private investment and possesses consistent and meaningful long-run properties.

In the present study the variable of interest is private fixed investment made by firms. To construct the empirical model not only were the general propositions of the theoretical analysis considered,[1] but also the institutional idyosincracies of the Argentine economy and the restrictions on the available data.

The model was estimated for 1978(3)-1990(4). One salient feature of the Argentine economy during this period was the presence of great macroeconomic instability which can be perceived in the huge volatility of the rate of inflation and the activity level. As in most Latin-American countries the period under consideration was characterized by a negative performance in economic indicators, associated with both the impact of the debt crisis at the beginning of the eighties and the subsequent adjustment efforts aimed at closing the deep disequilibria which took place. One of the most important consequences of the adjustment period was the decline in the investment rate, reflecting both the decline in foreign savings and the deterioration of fiscal conditions which forced a fiscal adjustment that took, in part, the form of a contraction in public investment. Furthermore, the phenomenon of capital

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[1]For recent surveys of the theoretical literature about investment, see Abel (1990), Hay and Morris (1991, ch. 12), Karakitsos (1992, ch. 5) and Serven and Solimano (1992).

flight was the counterpart of the processes of demonetization and retractionof domestic financial markets. This fact determined the scarcity of national savings available for investment which was added to the prevailing rationing of external credit.[2]

Economic theorists have found it difficult to explain patterns of investment spending. Rather than proving its superiority over the others, each one of the existing models picks up only part of a complex reality. Indeed, there are several conditions that influence the way economists think about investment, for instance: the degree of certainty/uncertainty, expectations, technology, market structure, the relevance of market clearing/rationing, etc. This difficulty in isolating the effective determinants of investment expenditure from a theoretical point of view is added to that found in empirical testing of macroeconomic functions.

In neoclassical models of fixed private investment, the desired capital stock depends on the level of output and on the user cost of capital (which in turn depends on the price of capital goods, the real interest rate, and the depreciation rate). In an intertemporal setting the neoclassical view leads to think investment as a function of current and future expected levels of output and user cost of capital.[3] Lags in decision-making and delivery create a gap between the actual and desired stocks, giving rise to an investment equation. In the presence of convex adjustment costs, the intertemporal neoclassical model reproduces Tobin's "q" theory (see, e.g., Tobin and Brainard [1977]), in which investment is seen to depend on the ratio of the market value of capital relative to its cost.[4]

An alternative view is given by the disequilibrium approach which works in the Keynesian tradition. According to this, firms may be facing current and expected future sales constraints, an important departure from the neoclassical assumption of continuous market-clearing. Thus, investment depends both on profitability and on the prevailing sales constraints. The latter permits to explain the commonly observed larger and more rapid

[2]For a general account of the evolution of the Argentine economy under this high inflation context, see -among others- Frenkel (1989) and Heymann (1986). Regarding the savings-investment-growth problem, see Fanelli et al. (1990).

[3]For a neoclassical firm (which is not demand-constained) output is endogenous and a function of relative prices. Thus, in a 'strict' neoclassical (intertemporal) approach investment decisions depend only on (actual and future expected) relative prices. Among the prices to be considered are the cost of capital services, product prices and wage rates. The latter may be rationalized in the context of the interrelated demands for capital and labor as long as relative factor prices indirectly appear as a determinant of the optimal capital stock, and thus of investment. As higher wage rates can have both income and substitution effects, the sign of the total effect is a priori ambiguous.

[4]Derivation of Tobin's theory from the neoclassical approach to investment requires usual recognition that it is the marginal rather than average "q" that matters.

responses to changes in output than to changes in the user cost of capital.[5]

Another stylized fact regarding investment is its high sensibility with respect to current -as opposed to future expected- income. This fact, which might be surprising since changes in income may be transitory and it is costly to adjust capital, can be explained as a myopic or a short-run behavior, the latter being the result of a rational attitude of investors in presence of uncertainty and credit rationing. According to the explanation focusing on the latter, firms may be unable to carry out an investment project even when it passes the test of profitability, and so investment spending may depend on the firms' current cash flow rather than on the discounted marginal productivity of capital.[6]

As regards uncertainty, the difficulties faced by firms in forecasting expected returns might lead them to rely on current sales changes, confering a volatile pattern to investment even in the face of no shifts in "fundamentals".[7] An important stream of neoclassical investment theory refers to irreversibility under conditions of uncertainty.[8] Irreversibility arises because capital is industry- or firm-specific and therefore cannot be used elsewhere, so that investment expenditures are considered to be sunk costs. In this case the optimal investment rule must take into account the opportunity cost of delaying investment. The sign of the relationship between uncertainty and investment is not unambiguous but usually thought to be negative. Moreover, rational inertia is a valid conclusion in this context.[9] This inertia provides a rationalization to the inclusion of some lagged terms of the dependent variable in the conditional model, in addition to the existence of lags in decision-making, and delivery and installment of capital goods.

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[5]In the case of developed countries, empirical findings of this relatively higher speed of adjustment are mentioned in Karakitsos (1992, ch. 5), who also states that the neo-classical model when estimated on relative prices alone performs very badly. In this vein, see Serven and Solimano's (1992) comments on some empirical studies for developing countries.

[6]This statement depends on firms being hampered by inadequate access not only to bank lending but to all sources of external finance. Besides providing reasons for credit quantitative constraints (controls on interest rates and endogenous rationing due to market imperfections originating in assymetric information, adverse selection and incentive problems), Jaffe and Stiglitz (1990) analyze why raising funds in the capital markets by firms may not substitute for bank credit.

[7]In this regard, Keynes pointed out the key role of the "animal spirits" of private investors as he thought that any rational assessment of the return on investment was bound to be highly uncertain.

[8]Dixit (1992) and Pyndick (1991) provide accessible introductions to this literature.

[9]Thus, a, say, decline in the interest rate which raises the present value of a project might be unable to augment private fixed investment if that reduction is not great enough to compensate for the uncertainty associated with future profits.

The real rate of interest is a frequently cited variable which measures the cost of financing the investment project or the oportunity cost of the applied funds. There are obvious difficulties in measuring the ex ante real rate due to the exigence of knowing by which mechanism expectations of inflation are formed. Consequently, the ex post rate of interest both in real and nominal terms may be an inadequate proxy for the user cost of capital. Instead, in an inflationary environment an increase in the nominal rate of interest reflects -at least partially- compensation given by borrowers to lenders for the erosion in the real value of both floating-interest debt and short-term fixed interest rate debt (so that the conditions under which it will be refinanced may change in a substantial way).[10] As Dreizzen (1985) shows, by applying to this case the analysis of financial fragility owed to Minsky (1977, among others), higher nominal interest rates could lead to a severe deterioration in borrowers' financial position and hence to a reduction in private investment.[11]

Another important relative price is the expected real exchange rate. One reason to analyze the effects of exchange rates on investment in Latin America is that the portfolio decision between real physical and foreign financial assets, associated to the "capital flight" phenomenon, plays a crucial role in determining the investment decision (see, among others, Fanelli et al. [1990]). Unfortunately, there are many effects of the real exchange rate having opposite signs, as is apparent in the theoretical paper by Lizondo and Montiel (1989) which analyzes both the demand and the supply of capital goods. This theoretical ambiguity turns problematic the interpretation of the variable at issue. As is the case with interest rates, there is also the problem of identifying the mechanisms by which expectations are formed in the foreign exchange market.

Some partial effects of exchange rates on investment that have appeared in empirical studies for Argentina are to be mentioned here.[12] First, Ahumada (1994) finds an encompassing model for total exports which includes hysteresis effects of the real exchange rate and argues that this fact reveals the relevance of some degree of inertia in private investment due to sunk private

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[10]See Balacco (1992) for evidence of association between the nominal interest rate and the rate of inflation.

[11]The nominal rate of interest can also be rationalized as an explanatory variable because of the inflation non-neutrality of the tax codes (see Abel, 1990). In this paper, the effects of taxes and subsidies on investment are neglected.

[12]It is worth noting that some of the effects of exchange rates on aggregate investment operate through the level of output, as is the case with the demand side effects emphasized in the literature on contractionary devaaluation (surveyed by Krugman and Taylor, 1979) and some transmission mechanisms working on the supply side (such the increased real price of imported imputs for domestic goods, the rise in the price of working capital due to increased interest rates, and real wage resistance). These effects are captured by using income as an explanatory variable.

fixed investment in the exporting sectors (as in some models working in the issue of irreversible investment with uncertain future real exchange rates). On the other hand, based on the fact that imported capital goods represent a great proportion of total investment, there could be a positive association between the relative price of capital goods and the real exchange rate, and hence an adverse effect of the real exchange rate on investment. The positive effect of the real exchange rate on the relative price of capital goods is partly illustrated by Chisari et al. (1992) for periods of overshooting in exchange rates like those of 1975-76 and 1989. Nevertheless, except for such periods, the relative price of capital goods remained remarkably stable.

Finally, in developing countries it is usual that a significative part of investment expenditures in infrastructure (roads, ports, communication networks, etc.) originate in the public sector. Moreover, public investment is usually seen as complementary to private investment in Latin America, as emphasized by the "three-gap" models (see Bacha [1990] and Fanelli et al. [1987]).[13] In the case of Argentina such a relationship has been tested for in Chisari et al. (1989) using annual data for 1970-89.[14] Since this effect does not seem to operate instantaneously, it would be reasonable to expect one or some lagged terms of public investment in the private investment function. If that is the case, the existence of a relationship of complementarity between public and private investment does not prevent the existence of a contemporaneous effects such as the "crowding-out" effect.

Given the former theoretical considerations, institutional factors and data restrictions, a data set is formed by including proxies for fixed business investment, current income, the nominal interest rate and public investment.[15] Other variables, as (nominal and real) exchange rates, real interest rates, inflation rates and real wages were considered but found of no statistical significance in the estimation of the investment function.

The rest of this paper is organized as follows. Section 2 describes the data set and analyzes its properties. Section 3 contains the estimate of an

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[13]Some models of endogenous growth (e.g. Barro, 1990) emphasize the role of public expenditures which promote growth through the development of both public services (such as education, health, and research and development) and infrastructure. As long as private fixed investment depends positively on growth, these models permit to capture the issue of complementarity.

[14]The elasticity estimated in that paper (some value between 1 and 1.5) is congruent with the one found in the cross-country study by Barro (1989). Instead, Bebczuc (1994) finds a negative relationship for Argentina in the period 1962-1993 (using also annual data). Greene and Villanueva (1992) review some empirical studies on this issue for different countries.

[15]Since this data set includes proxies to aggregate variables as private fixed investment, income and public investment, the true short-run relationships between them can be obscured by the presence of marked changes in relative prices which may deteriorate the statistical quality of the estimates of those variables (about this effect, see Olivera, 1976). The inclusion of the nominal rate of interest as a regressor could be useful to neutralize this effect on the relationship between private fixed investment and the remaining explanatory variables.

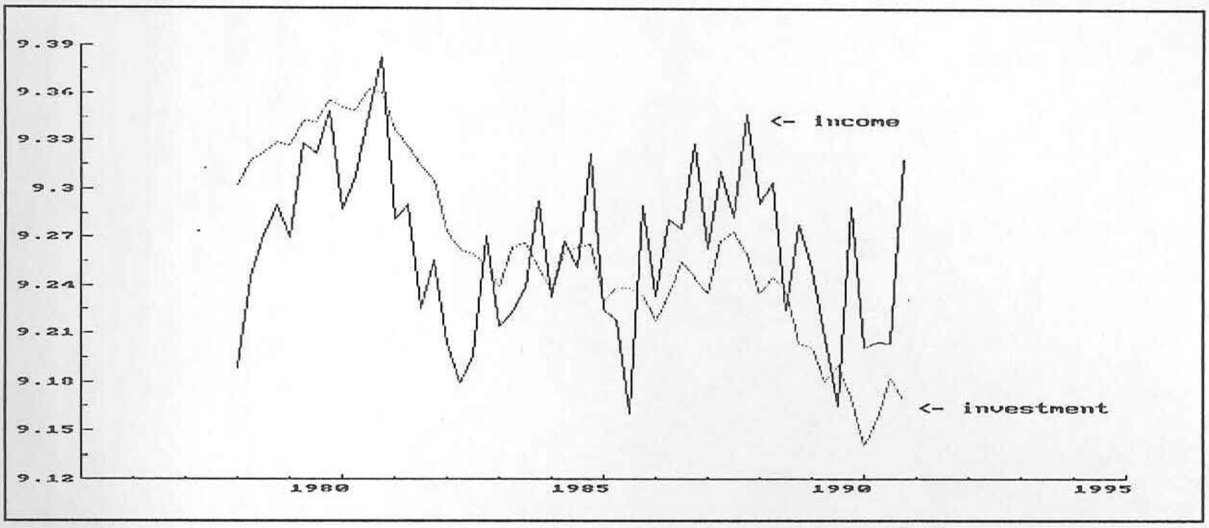

FIG. 2.1. Logarithm of gross private fixed investment and GDP (matched means and ranges).

investment function for Argentina during the period of analysis. In section 4 exogeneity and invariance issues are addressed. Finally, conclusions are stated in Section 5.

2. The data set and its properties.[16]

The data set is quarterly, not seasonally adjusted, for the Argentine economy over the period 1978(3)-1990(4). The reason of the end date is that there is no available quarterly information about fixed investment (**i**) and income (**y**) from 1991 on. All variables have been logarithmically transformed. To measure **i** and **y** the national accounts statistics published by the Central Bank of Argentina have been used. In relation to investment, the available data distinguish between several types of gross fixed investment (buildings, machinery and equipment, vehicles) and inventory accumulation. Investment in buildings is the only component to be decomposed between private and public expenditure. Thus, in order to isolate fixed business investment as much as possible, **i** is defined as gross total fixed investment minus gross public

[16]The econometrics and graphs were done with PCGIVE 7 (see Doornik and Hendry, 1992).

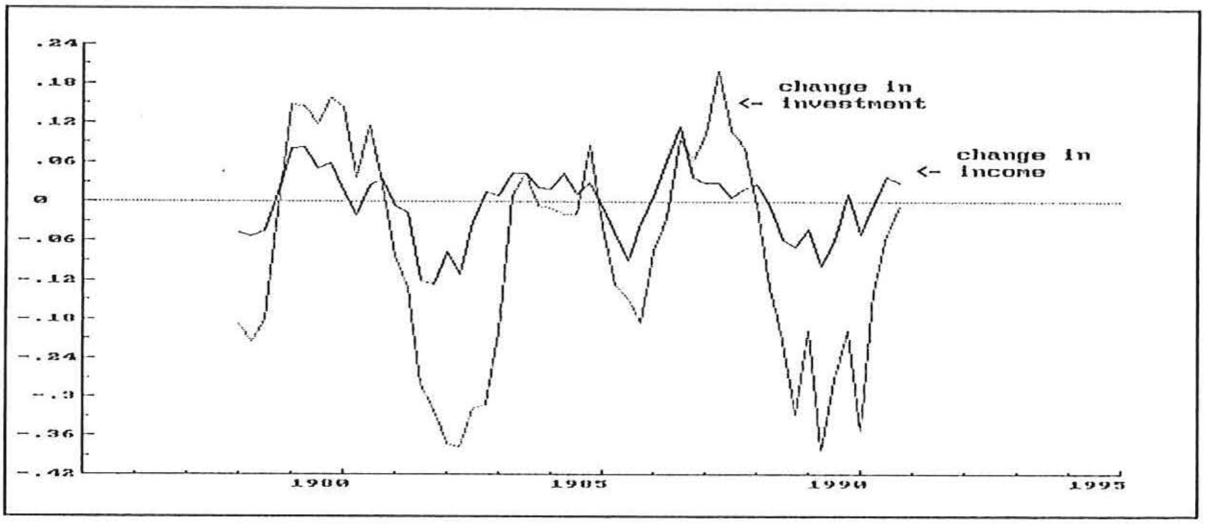

FIG. 2.2. Annual first differences of i and y.

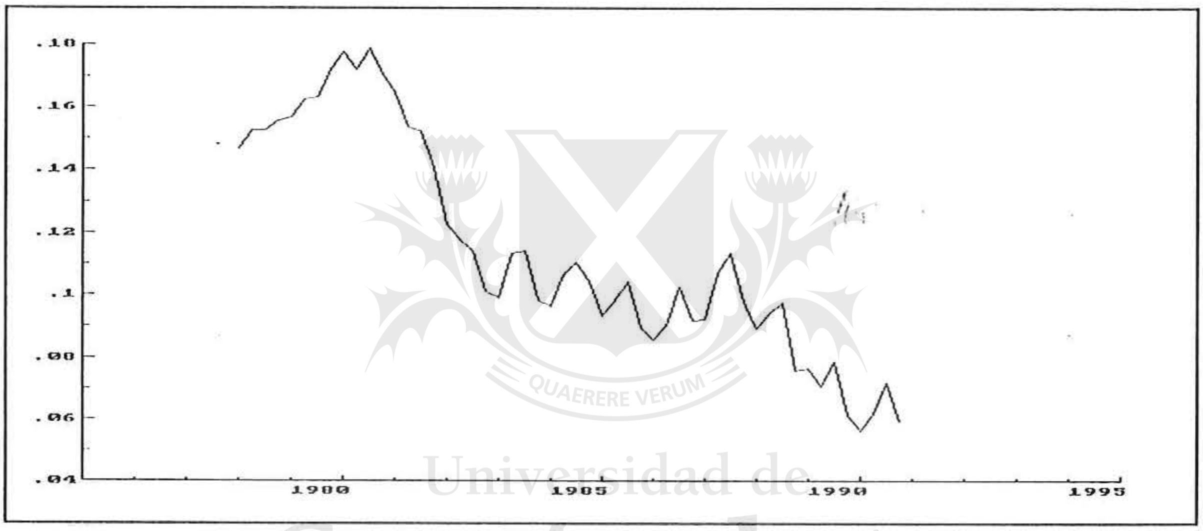

FIG. 2.3. Private gross fixed investment-GDP ratio (in natural units).

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investment in buildings.[17] As far as income is concerned the GDP is used.

[17]Although it will be desirable to model the data generation process of private fixed investment alone, the available annual information permits to conclude that -despite of its huge absolute fluctuations- public investment remained a relatively constant proportion (between 50% and 60%) of total investment, at least until the late eighties. See the information about government expenditure provided by Dirección Nacional de Programación Presupuestaria del Ministerio de Economía: Sector público. Esquema de Ahorro-Inversión-Financiamiento: 1961-1986, 1988; see also Chisari et al. (1992).

Furthermore, it is worth noting that i includes the expenditures in residential structures. This constitutes an important drawback of the proxy presented here. Notwithstanding, annual estimates of gross investment in residential structures for 1978-1989 reported by Hofman (1991) are a relatively stable proportion (around one third) of gross total investment.

Finally, a recent revision of the national accounts (at present available only anually) implies an investment-income ratio much higher than that present in the "old" statistics. However, this change arises mainly from an upward revision of residential structures as results from hitherto not used

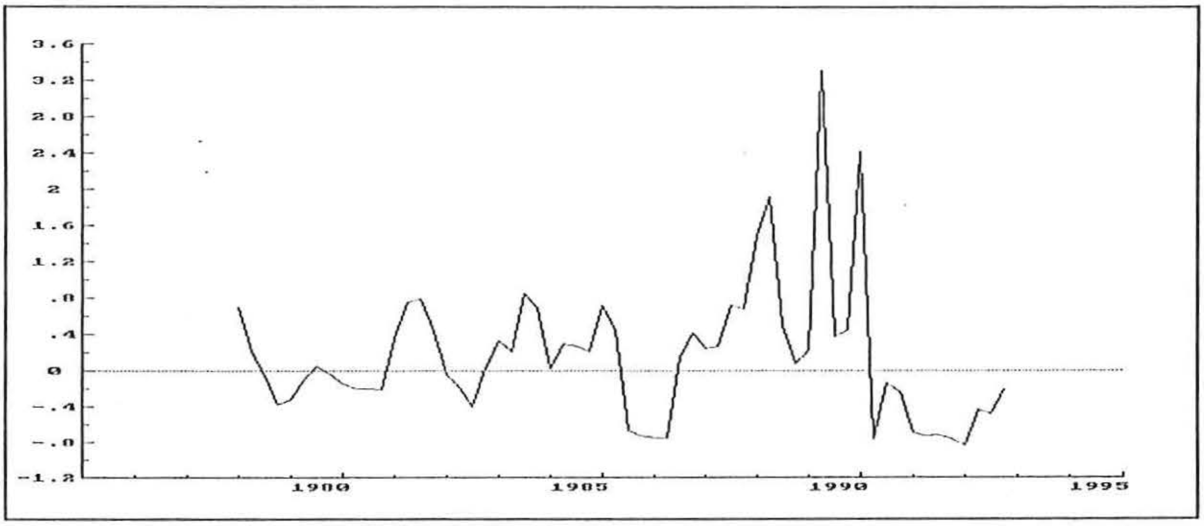

FIG. 2.4. Logarithm of the nominal borrowing rate of interest.

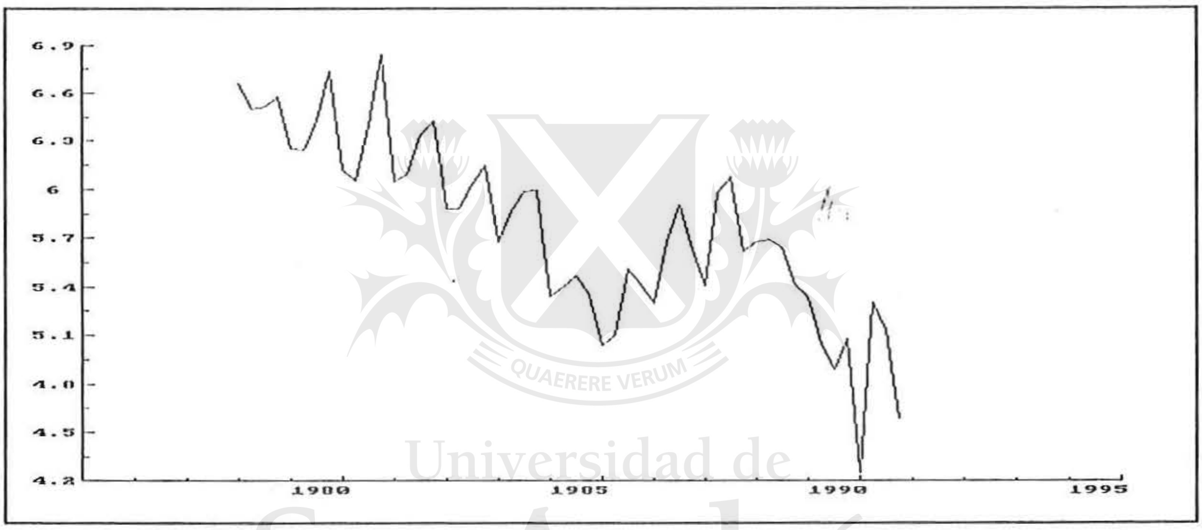

FIG. 2.5. Logarithm of gross public investment in buildings.

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Both variables are measured at 1970 market prices.

In the case of r borrowing rates for 30-days loans (in %) provided by FIEL -until 1979(4)- and CEPAL (using data from the Central Bank and other sources) -from 1980(1) on- were used.

First some basic properties of the data will be considered. Figure 2.1 shows the behavior of i and y over time and Figure 2.2 graphs their annual first differences, $\Delta_4 i_t = i_t - i_{t-4}$ and $\Delta_4 y_t = y_t - y_{t-4}$. As we can see, i has experienced fluctuations of greater amplitude than y, which may be explained by the high degree of uncertainty perceived, and/or financial constraints faced, by private investors. Moreover, i exhibits a decline not shared by

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data (originating in population censuses and households' expenditure surveys). For this reason, the evolution of fixed business investment does not seem to be greatly affected by the "new" national accounts (see Cetrángolo y Kacef, 1993).

Table 1
Univariate Statistics for Testing Unit Roots
1978(3) - 1990(4)

Variable	DF	ADF(#)	DFΔ	DFSI	ADFSI(#)	DFΔ_4
i	-1.36	-1.21(4)	-6.66**	-3.11	-1.28(2)	-2.05*
y	1.21	-0.35(4)	-12.06**	-0.16	-0.05(1)	-2.98**
ig	-0.96	-1.37(4)	-9.00**	-3.27	-1.87(1)	-3.45**
r	-0.47	-0.47(0)	-8.81**	0.04	-0.27(1)	-3.97**

Note: (#) Maximum lag used for eliminating autocorrelation.
(*) Reject the hypothesis of a unit root at the 1% significance level.
(**) Reject the hypothesis of a unit root at the 5% significance level.

y -which remained stagnant-, implying that the private fixed investment-GDP ratio has fluctuated significantly and tended to decline over the period, as shown in Figure 2.3. In fact, after averaging 16% in the first seventies, this ratio increased to peaks of over 18% during some quarters in the late seventies. This was partly the result of the implementation of a stabilization programme (the "tablita") in December 1978 which produced disinflation and a recovery of the activity level. The abrupt end of the "tablita" in March 1981 and the ocurrence of the debt crisis in 1982 determined a marked decrease of that ratio to around 10%. Another stabilization programme, the Austral Plan -launched in June 1985-, brought the private investment-GDP ratio from near 8% to almost 11% during 1987. That ratio then fell continuously to 6% at the end of the series.

The comments in the precedent paragraph suggest the convenience of including **r**, in addition to **y**, as an explanatory variable of **i**. This can be checked by comparing Figures 2.2 through 2.4. The latter shows the evolution of the borrowing rate of interest. In addition, in order to test the existence of a relationship of complementarity between public and private investment, a proxy for the former (**ig**, operationalized as gross public investment in buildings, provided by the national accounts) was included in the information set. This variable is shown in Figure 2.5.

It is not obvious from Figure 2.1 that there exists a long-run equilibrium relationship between **i** and its possible explanatory variables, so that there is a stationary linear combination of them. If this is the case, they are cointegrating variables. To test for this, first of all it is essential to identify the order of integration of each variable.[18] And to do

[18]A non-stationary variable which needs to be differenced d times to be stationary is said to be integrated of order d. A variable x_t that is integrated is said to have a unit root in its autoregressive representation, which simply refers to the unit coefficient on x_{t-1} in the formula defining an

this the existence of a unit root in the univariate representations of the individual series is tested for. The first two columns in Table 1 show the values of Dickey-Fuller (DF) and the augmented Dickey-Fuller (ADF) statistics[19] for **i**, **y**, **ig**, **r**, and the DF of their corresponding (quarterly) first differences (DFΔ).[20] The results clearly indicate that there are no grounds for rejecting the null (unit root) hypothesis at the usual significance levels, so that all variables can be considered integrated of order one.[21]

As all these variables are measured quarterly it may be important to determine their order of seasonal integration. Table 1 also shows the values of the Dickey-Fuller seasonal integration (DFSI) test and its augmented version (ADFSI)[22] for each variable, as well as the DF of their corresponding annual first differences (DFΔ_4). These DFSI and ADFSI results are not significantly negative, so the null hypothesis of seasonal integration of first order of all variables cannot be rejected. The DFΔ_4's confirm this because their values do not lead to reject that the annual first differences of all variables are I(0).

The reason behind the tests of integration is that trends in variables (whether deterministic or stochastic) may give rise to spurious regressions and uninterpretable statistics and, in general, make regression results extremely difficult to evaluate. Differencing the series successively until stationarity is achieved may not be an ideal solution because it produces the loss of the long-run properties. The desirability of models which combine both short run and long run properties leads to reconsider the measurement of variables in levels. Consequently, a commonly used approach is to test whether there exists cointegration between **i**, **y**, **ig** and **r**. Given that it is not rejected that the individual series be I(1), it will be evaluated if there

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integrated process.

[19]While the DF test does not take account of possible autocorrelation in the error process, the ADF test handles this by including as many lagged left-hand side variables as necessary to prevent such situation.

[20]The tests were carried over the same period as that corresponding to the final conditional model (3.1) shown below.

[21]In the case of the rate of interest, recursive estimates of the ADF(1) (using monthly data of the lending interest rate between June 1976 and December 1991) shown in Ahumada (1992b) permit to conclude that the **r** series is I(1) until mid-1989 and I(0) from then on. Instead, the same method applied to the present data do not lead to reject the hypothesis that **r** has always been I(1). The difference between these two results may originate in the frequency with which data are measured and the behavior of the spread. In his turn, looking at the DF value of the lending interest rate (measured monthly), Balacco (1992) found **r** to be stationary between June 1984 and January 1991.

[22]According to Charemza and Deadman (1992), neither of these tests is strictly appropriate as they provide only a 'rough and ready' simplification of the Dickey, Hasza and Fuller's (1984) test, modified by Osborn et al. (1988).

exists some non-trivial function of them which is I(0).[23] To do this the Engle-Granger static regression is estimated. As the **r** coefficient proved to be not significative,[24] the result is the following:

$$
(2.1) \qquad i_t = \underset{(4.301)}{-4.742} + \underset{(0.476)}{0.959}\, y_t + \underset{(0.045)}{0.504}\, ig_t
$$

$R^2=0.803$ $\quad\sigma=15.27\%$ $\quad DW=1.17$ $\quad T=50$ $\quad k=3$ $\quad ADF(0)=-4.48$

The R^2 value, the estimated coefficients and the ADF test provide evidence in favor of cointegration. The **y** coefficient is near the expected value of one and the **ig** coefficient is positive like those found in some previous studies cited in section 1, but in this case clearly lower than one. Furthermore, the ADF(0) of the residuals in (2.1) is -4.48, permitting to reject the null hypothesis of no cointegration at the 1% level. The same conclusion is achieved when noting that a simple rule of thumb proposed by Banerjee et al. (1986), which requires that the value of the cointegration Durbin-Watson statistic -calculated for the residuals in (2.1) and here equal to 1.18- be greater than the R^2 coefficient in that equation, is satisfied.

As will be seen later, the parsimonious model of private fixed investment (derived from a general-to-specific approach) will include an error correction mechanism implying the long-run relationship between **i**, **y** and **ig** specified in (2.1). This fact brings additional support to the existence of an attractor of the temporal trajectories of these series. Since the intercept in (2.1) is not significative and reduces the adjusted R^2, the error correction term of the conditional model will not include a constant.

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3. A Model of Private Investment.

In this section a conditional model of Argentine private fixed investment is estimated following the general-to-particular approach. In addition to income, we include **r** and **ig** as explanatory variables. Table 2 presents the estimates for an unrestricted autoregressive-distributed lag (ADL) model. The period chosen reflects the fact that any model estimated prior to 1978(3) showed parameter instability. This phenomenon is consistent with the usual assertion about the existence of a structural break in the Argentine economy during the late seventies.

The ADL model in Table 2 exhibits no departure from the nulls of white-

[23]If they were not cointegrated, any linear combination of them would drift anywhere, and hence no long-run relationship would exist between these series.

[24]A measure of domestic savings based on the national account statistics also proved to be not significative.

Table 2
The Unrestricted Dynamic Model Estimates for
Private Investment: 1978(3)-1990(4) (*)

Left-hand side variable is i_t

Method: OLS. T=50 k=24 R^2=0.986 σ=5.49% DW=1.91

$FAR_{1-1}(1,25)$=0.02 $FAR_{1-4}(4,22)$=2.66 $Chi^2(2)$=0.04

$FARCH_{1-4}(4,18)$=0.05 FRESET(1,25)=0.08

VIT=0.07 JIT=3.86 Chow F(10,18)=1.39

	j = lag					
	0	1	2	3	4	5
i_{t-j}	-	0.772 (0.181)	0.046 (0.187)	-0.141 (0.199)	0.517 (0.209)	-0.358 (0.170)
y_{t-j}	0.881 (0.466)	-0.252 (0.489)	0.492 (0.383)	0.169 (0.357)	-1.381 (0.446)	0.203 (0.393)
r_{t-j}	-0.002 (0.001)	0.0004 (0.001)	-0.001 (0.001)	-0.0002 (0.001)	0.001 (0.002)	0.001 (0.001)
ig_{t-j}	0.047 (0.057)	-0.009 (0.061)	-0.009 (0.053)	0.049 (0.051)	0.089 (0.065)	-0.065 (0.069)
Constant	-0.490 (4.484)					

(*) Usual standard errors are below the estimates, σ is the percentage residual standard deviation, T the number of observations and k the number of coefficients. FAR_{i-j} tests for *i*th to *j*th order autocorrelation. Chi^2 tests for residual normality. $FARCH_{i-j}$ tests for autoregressive conditional heteroscedasticity. FRESET tests for the omitted square of the fitted dependent variable. VIT tests for variance instability and JIT tests for joint instability. Chow F tests for parameter constancy over a ten-quarter forecast period.

'F' and 'Chi' denote distributions under the null and subscripts indicate the relevant alternative.

noise and innovation disturbances, as well as of parameter constancy within sample. Recursive Chow tests (provided by the PCGIVE 7 version and not shown here) do not cross the critical values from the F-distribution at the 5% probability level.

This configuration provides a statistically acceptable point of departure to search for a parsimonious conditional investment function. However, the static long-run equation corresponding to the model in Table 2 does not show well determined long-run coefficients. Instead, the long run equilibrium for i derived from the Engle-Granger static regression (2.1) will

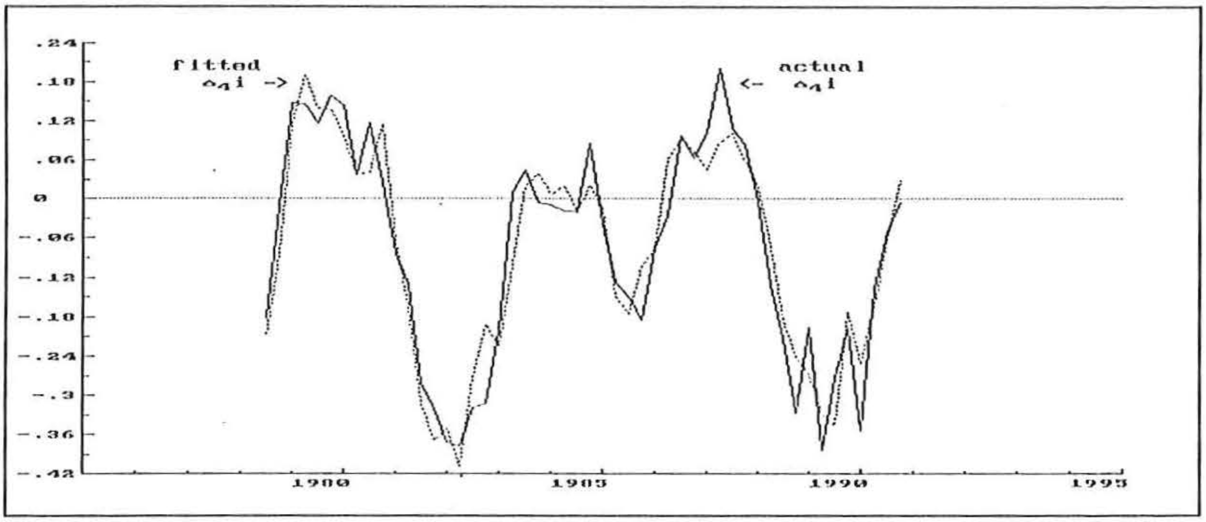

FIG. 3.1. Equation (3.1): Actual outcomes and fitted values over the whole sample.

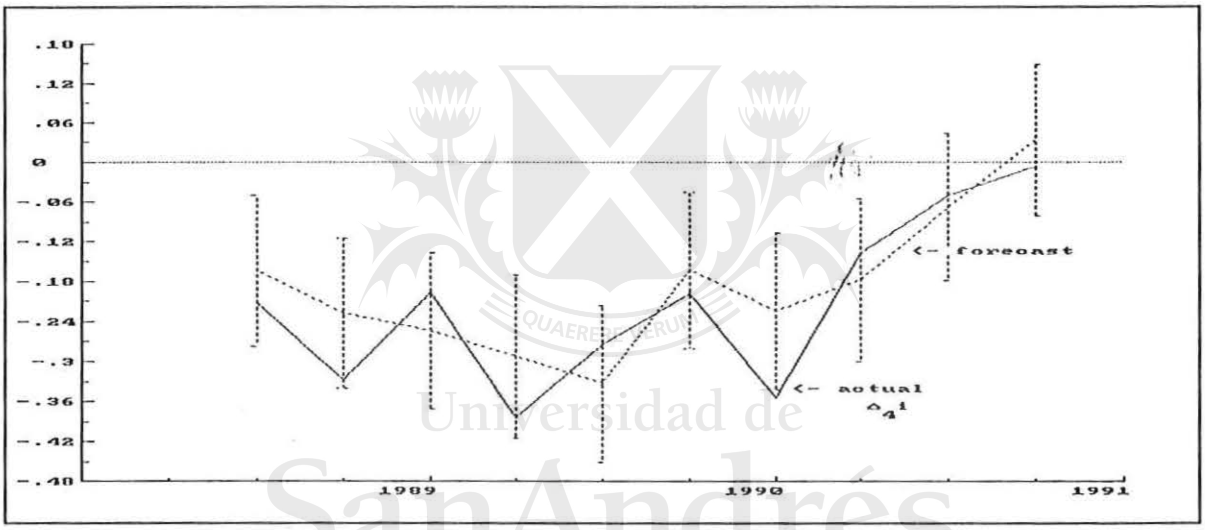

FIG. 3.2. Equation (3.1): One-step ahead forecast values of $\Delta_4 i$ with $\pm$ 2 forecast standard errors.

be used.[25] Furthermore, the only lags which proved to be significant are the first and the fourth, providing evidence in favor of a model relating variables measured in their annual first differences.[26]

Looking at the unrestricted model in Table 2, the regressors that do not seem to be significative are next eliminated. Various orthogonalizing

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[25]As the γ coefficient in the error correction term is not exactly one, it may be seen as implying an auxiliary hypothesis of measurement errors, which unfortunately cannot be tested for because a proxy for the latter is not available. See Darnell and Evans (1990).

[26]The investment functions estimated by Driver and Moreton (1991) are of the same type.

transformations were carried out on the model to create growth rates, the error correction term, and so on. Reestimating that model gives:[27]

$$(3.1)\quad \Delta_4 i_t = \underset{(0.299)}{-0.611} + \underset{(0.061)}{0.629}\, \Delta_4 i_{t-1} + \underset{(0.195)}{1.282}\, \Delta_4 y_t - \underset{(0.014)}{0.050}\, \Delta_4 r_t - \underset{(0.063)}{0.125}\, (i_{t-4} - 0.959\, y_{t-4} - 0.504\, ig_{t-4})$$

T=50 k=5 R^2=0.898 σ=5.59% DW=2.02

$FAR_{1-1}(1,44)$=0.01 $FAR_{1-4}(4,41)$=2.05 $Chi^2(2)$=0.38

$FARCH_{1-4}(4,37)$=0.81 FHET(8,36)=0.62 FRESET(1,44)=0.15

VIT=0.06 JIT=0.98 Chow F(10,35)=1.39

where FHET tests for heteroscedasticity arising from the squares of the regressors. The block of 7 restrictions imposed on the general ADL model was tested for and not rejected by a global F test ($F_{NIN}(7,26)$=1.77).

Like the model in Table 2, the model (3.1) exhibits no departure from the nulls of white-noise and innovation disturbances, and parameter constancy. Figure 3.1 shows actual outcomes of equation (3.1) over the whole sample. The performance is remarkable given the great variability of i and its explanatory variables over the period. Note that σ is slightly above 5% and similar to that of the unrestricted ADL model.

Figure 3.2 plots the actual and forecast values for $\Delta_4 i$ with 95% confidence intervals within a ten-quarter forecast sub-period. Although the value for 1990(1) lies outside the confidence interval, the Chow F test confirms the validity of the conditional model (3.1).

To further evaluate the stability of the model parameters several tests based on recursive least squares estimation have been conducted. The estimated coefficients are constant; most of them, which relate to exogeneity analysis, are shown in Figures 4.1 to 4.5. There is a gain of significance over time for all variables, with the rate of interest becoming significant only at some point between 1985 and 1987, and the error correction term only toward 1987. The $\Delta_4 i_{t-1}$ term reflects the presence of inertia which can be rationalized by the effects of adjustment costs and/or uncertainty. Furthermore, the constant is negative and may be capturing the impact of some

[27] Since the explanatory variables are included due to their role in determining i indirectly (i.e. via their influence on the optimal capital stock, which has to be differenced once to give rise to any investment variable), it may be surprising that both i and its regressors appear differenced once instead of -say- the former being differenced once and the latter being differenced twice. However, it must be noted that i is a series of gross investment expenditure figures, so that the desired i becomes a function of the capital stock, which indirectly makes investment a function of the level of its explanatory variables (see Hay and Morris, 1991).

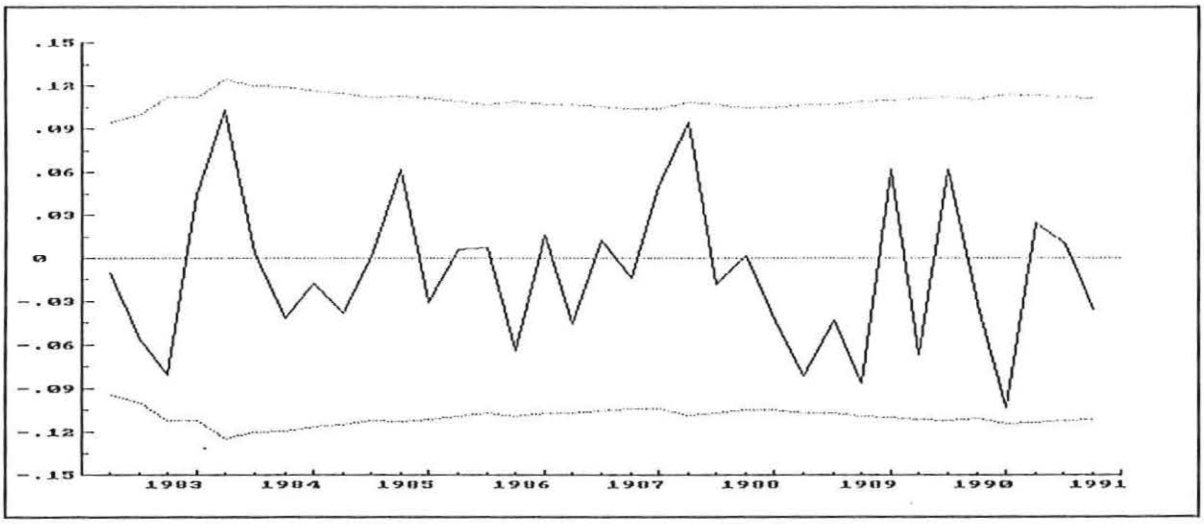

FIG. 3.3. Equation (3.1): One-step residuals with ± 2 equation standard errors.

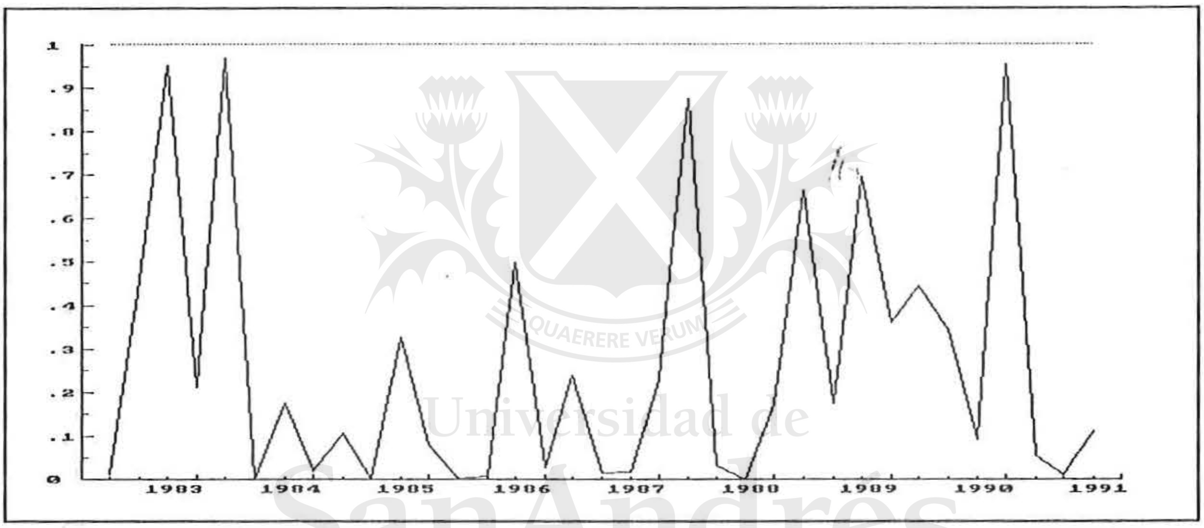

FIG. 3.4. Equation (3.1): Sequence of one-step Chow-statistics.

exogenous variables during this period of great macroeconomic instability.[28]

It is worth noting the high impact elasticity for income (1.282), which is larger than the long-run equilibrium elasticity (0.959). This implies that private investment over-reacts to an expansion in **y** and then adjusts downward to its long-run equilibrium level through a stable path. Adjustments of **i** to departures from its long-run equilibrium are slow, as shown by an error correction coefficient of 0.125, providing further evidence of adjustment costs and/or uncertainty.

Since the error correction includes also a proxy of public investment,

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[28]The intercept also plays a role in the long-run equilibrium of the model.

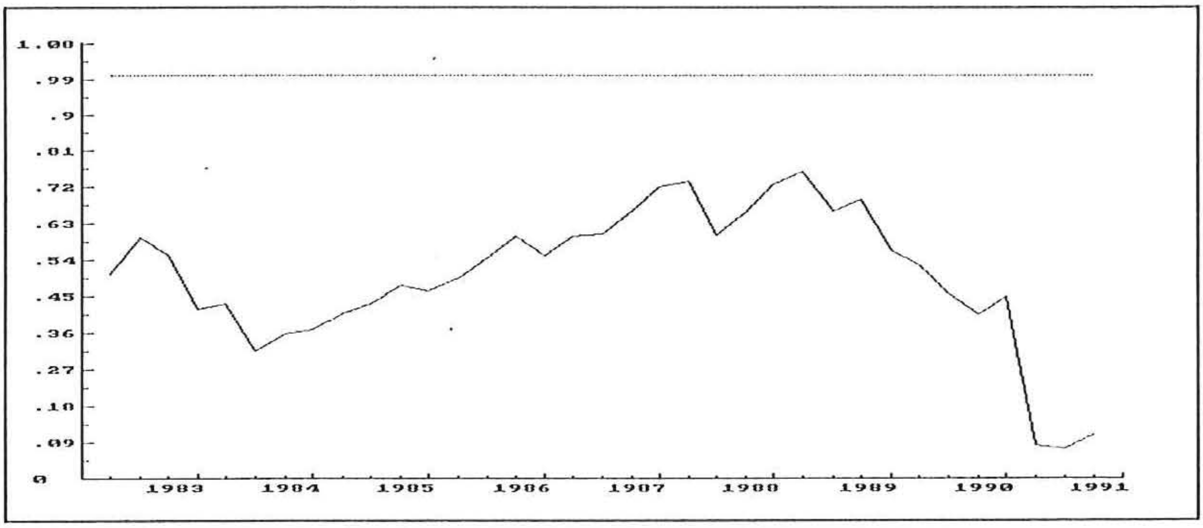

FIG. 3.5. Equation (3.1): Sequence of break-point Chow-statistics.

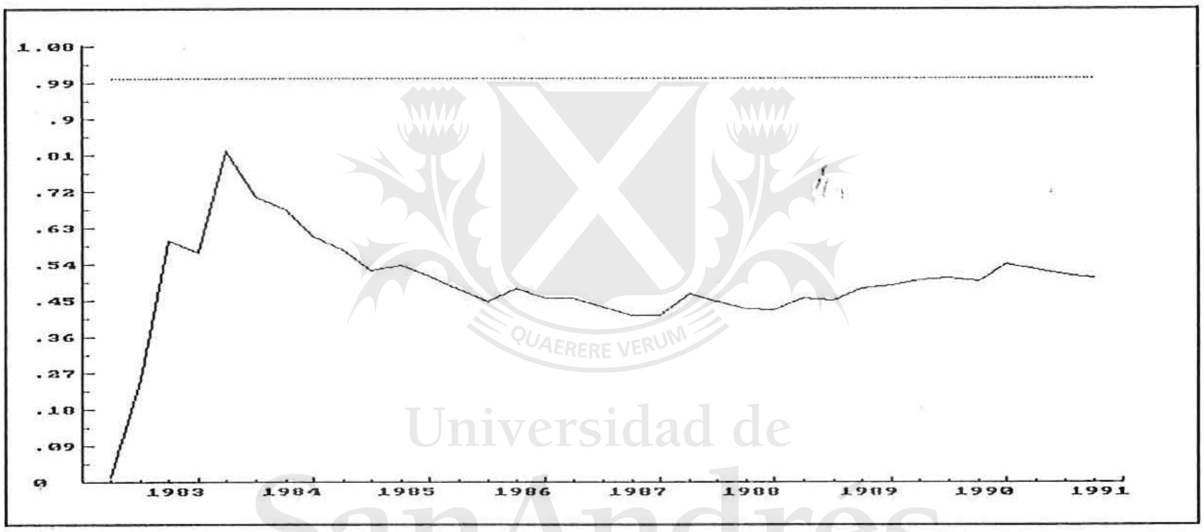

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FIG. 3.6. Equation (3.1): Sequence of forecast Chow-statistics.

equation (3.1) favors the hypothesis of long-run complementarity between private and public investment. The lagged reaction involved implies that this hypothesis does not prevent impact effects of public investment which may be partly captured by the rate of interest ("crowding out") and the income terms.

Furthermore, the term concerning the nominal rate of interest has a minus sign and may be capturing the adverse effects of inflation on private investment due to an increase in financial fragility generated, in turn, by the erosion of the real value of firms' debt (rather than a neoclassical user cost of capital effect).

Figure 3.3 records the sequences of one-step residuals and corresponding calculated equation standard errors. The residual standard error is remarkably stable, given the large changes in data correlation structure. Finally, none

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Econometric modelling of private investment in Argentina. 1978-1990

Marcelo Sánchez

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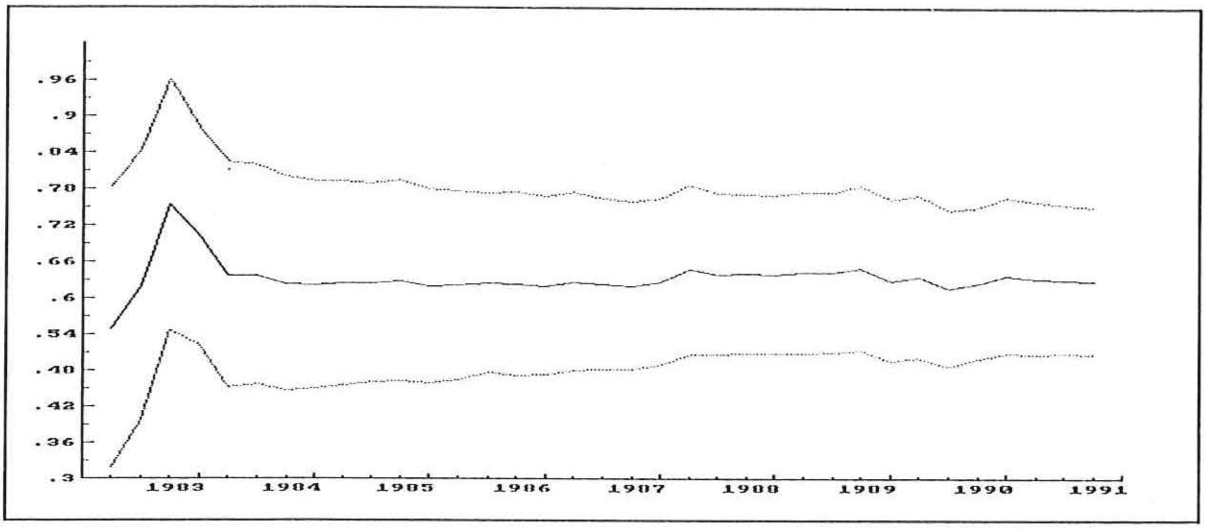

FIG. 4.1. Equation (3.1): Recursive estimation of the coefficient of $\Delta_4 i_{t-1}$.

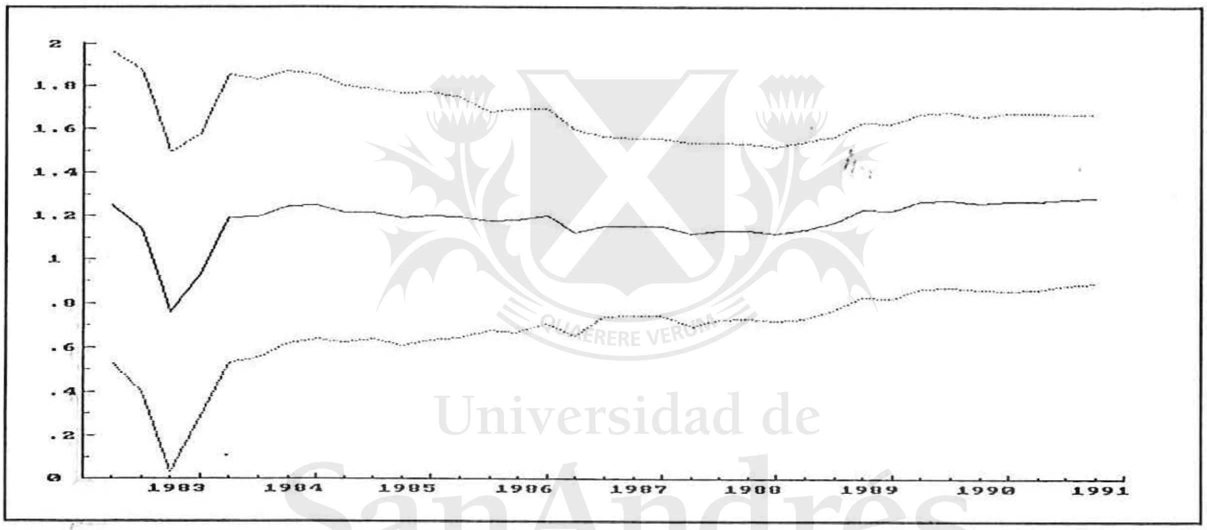

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FIG. 4.2. Equation (3.1): Recursive estimation of the coefficient of $\Delta_4 y$.

of the Chow statistics shown in Figures 3.4 to 3.6 passes the critical values from the F-distribution at the 5% probability level. The stability obtained suggests the validity of the conditional model.

In order to continue the evaluation of this model, the next section analyzes the issue of exogeneity.

4. <u>Exogeneity and Invariance.</u>

The literature considers several definitions of exogeneity, two of which are of special relevance here: weak exogeneity (**WE**) and super exogeneity (**SE**) (see Engle <u>et al.</u>, 1983). **WE** sustains conditional inference and requires that

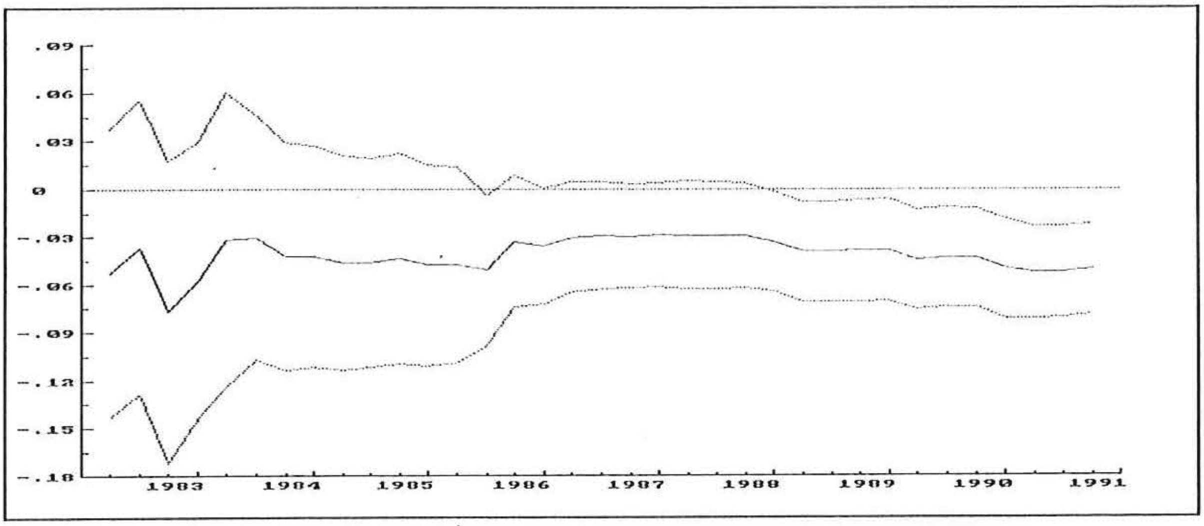

FIG. 4.3. Equation (3.1): Recursive estimation of the coefficient of $\Delta_4 r$.

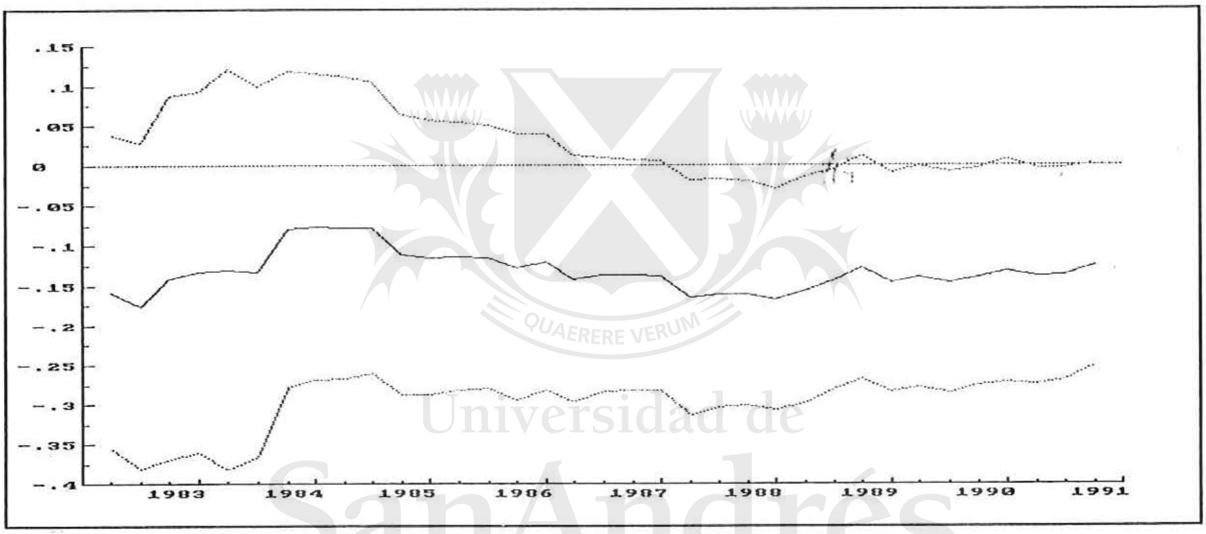

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FIG. 4.4. Equation (3.1): Recursive estimation of the error correction parameter.

the parameters of interest in a conditional model can be efficiently analyzed without specifying the marginal model for the potentially exogenous variables. **SE** is weak exogeneity combined with the invariance of the parameters of interest to a class of interventions that alter the marginal model, so that the parameters of the conditional model remain constant under a regime change (see Hendry, 1992). Thus, finding **SE** implies **WE**, and demonstrating **SE** relies on showing that the parameters of the conditional model remain constant even though the marginal model changes.

Figures 4.1 through 4.4 show that the coefficients in (3.1) are constant. Given the observed constancy in the parameters of the conditional model (3.1), testing for **SE** requires specifying non-constant marginal models

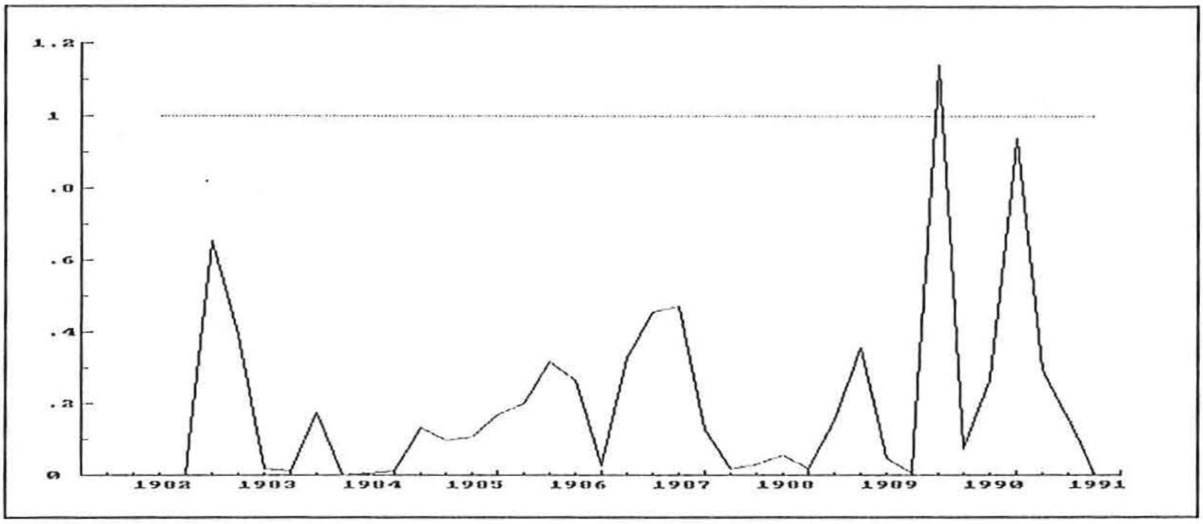

FIG. 4.5. Equation (4.1): Sequence of one-step Chow-statistics when intervention dummies are excluded.

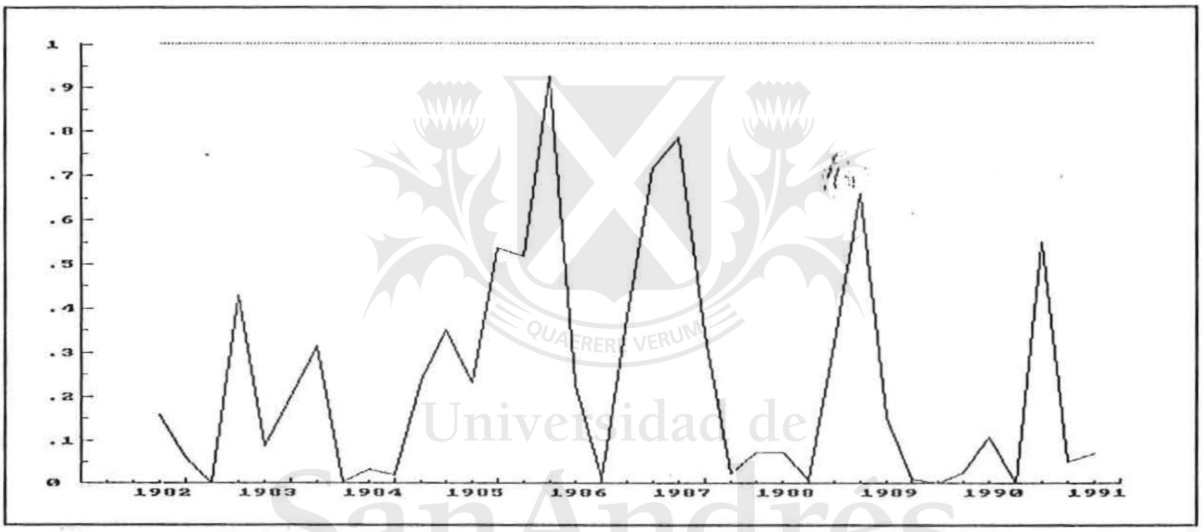

FIG. 4.6. Equation (4.1): Sequence of one-step Chow-statistics when intervention dummies are included.

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for income and the rate of interest.

Estimating over 1978(3)-1990(4), the following autoregressive model for income is obtained:

(4.1)
$$\Delta_4 y_t = \underset{(0.004)}{0.007} + \underset{(0.110)}{0.910}\,\Delta_4 y_{t-1} - \underset{(0.030)}{0.115}\,\mathbf{D81(3)} - \underset{(0.031)}{0.108}\,\mathbf{D82(2)} - \underset{(0.030)}{0.097}\,\mathbf{D89(2)} - \underset{(0.031)}{0.092}\,\mathbf{D90(1)}$$

T=50 k=8 R^2=0.745 σ=2.92% DW=2.00

$FAR_{1-1}(1,42)$=0.01 $FAR_{1-4}(4,39)$=0.61 $Chi^2(2)$=1.39

$FARCH_{1-4}(4,35)$=0.73 FHET(8,34)=0.67 FRESET(1,42)=1.10

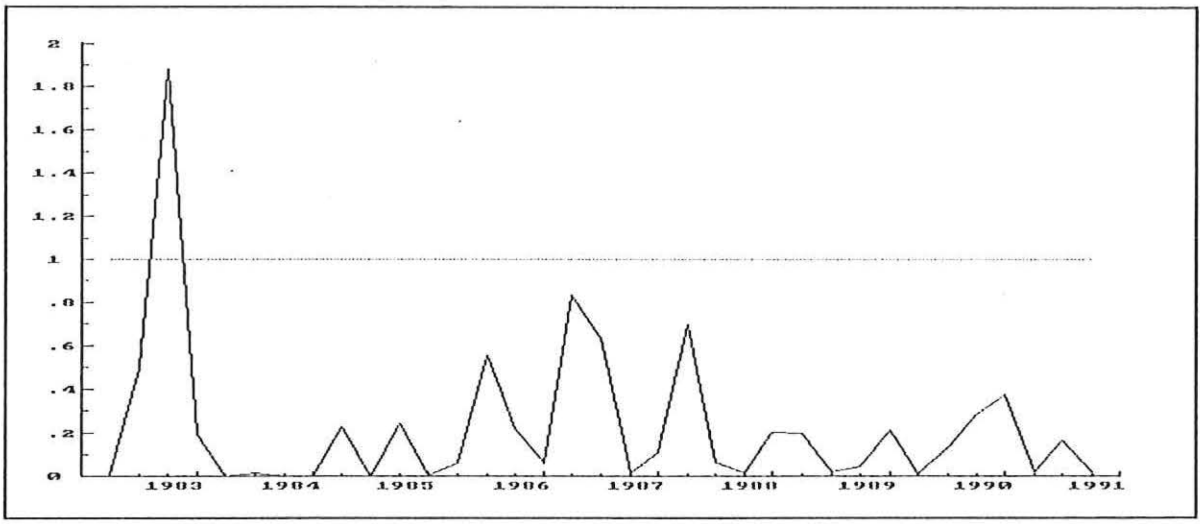

FIG. 4.7. Reversed regression for $\Delta_4 y$: Sequence of one-step Chow-statistics.

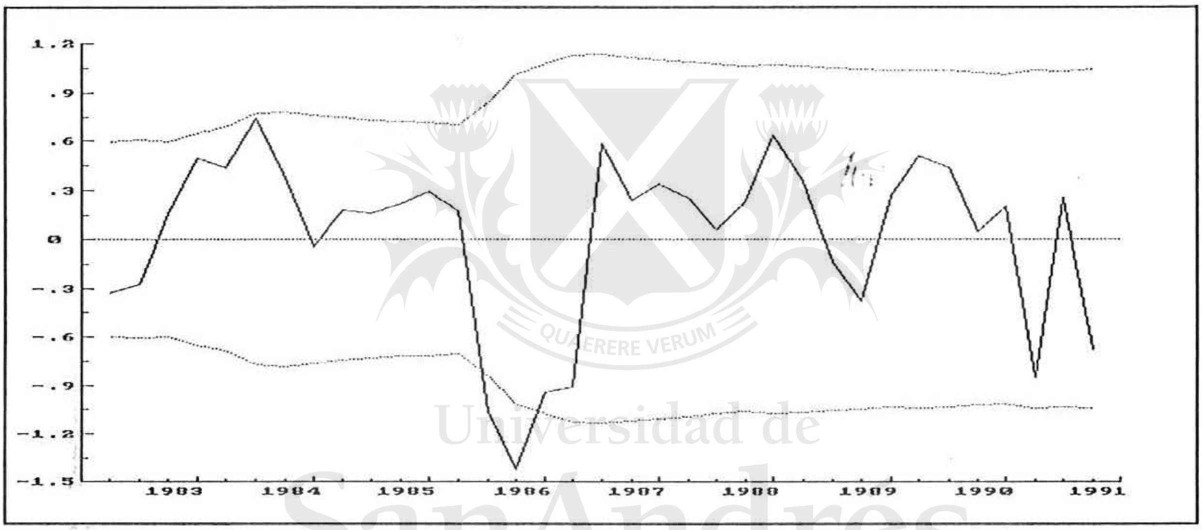

FIG. 4.8. Reversed regression for $\Delta_4 r$: One-step residuals forecast values with $\pm$ 2 equation standard errors.

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This is a well specified, stable marginal model for income. Its stability depends on including a set of intervention dummies -in quarters 1981(3), 1982(2), 1989(2) and 1990(1)- which were not necessary for achieving stability in the model (3.1). Instead, these dummy variables are crucial for the stability of (4.1). This is evident from the sequences of Chow-statistics shown in Figures 4.5 and 4.6, where the first excludes the dummies while they are included in the second.

The joint occurrence of structural breaks in the process of the conditioning variable $\Delta_4 y$ and constancy of the coefficient of this variable in the private fixed investment function indicate invariance with respect to the set of interventions in the sample period. Following Engle and Hendry (1993), to show this the dummy variables in model (4.1) were added to

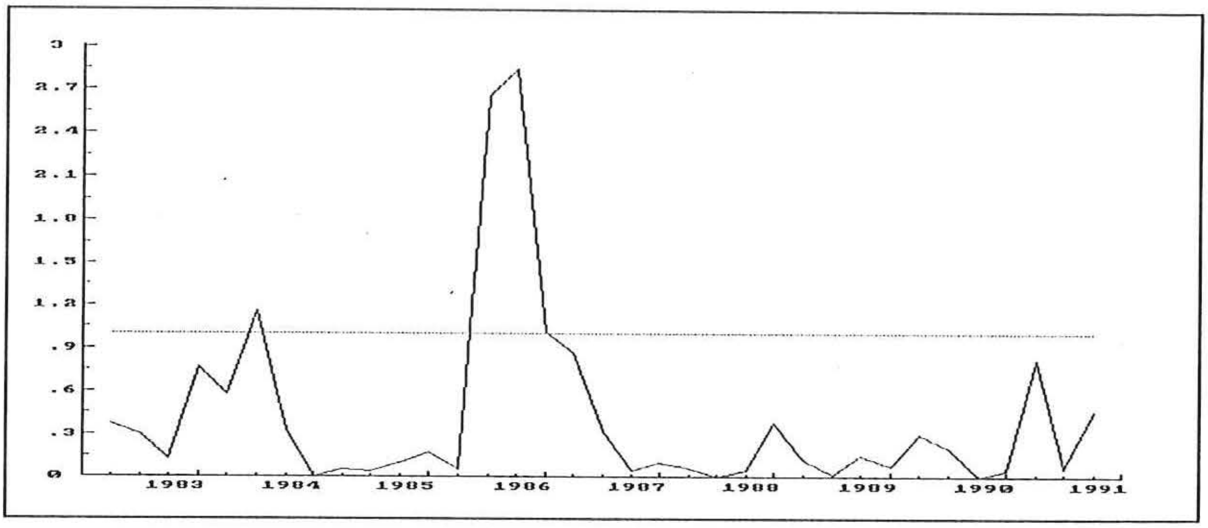

FIG. 4.9. Reversed regression for $\Delta_4 r$: Sequence of one-step Chow-statistics.

equation (3.1) and they proved to be not jointly significative (F(4,41)=1.54). This result suggests that income is super exogenous in the conditional model (3.1). A test of weak exogeneity by adding the lagged error-correction term to (4.2) (see Urbain, 1992) has also been performed. The t-value is -0.902, which corroborates the exogeneity of income with respect to the long-run parameters.

As with income, non-constant autoregressive marginal models for the rate of interest have been tried out. Nevertheless, in the case of **r** it was not possible to achieve a model with the goodness of fit and the stability properties of (4.1) by the use of intervention dummies.[29] These facts could lead to the conclusion that the marginal process of **r** exhibited structural instability during the period.

A final aspect of exogeneity is "non-invertibility". Since the parameters of interest in model (3.1) were stable, the presence of "regime shifts" which alter the correlation structure of the variables implies that the coefficients of the reversed models cannot be constant. With respect to the reversed regression for **y**, it is seen that, although it predicts well, the critical value of the recursive one-step Chow statistics is crossed as shown in Figure 4.7. This fact provides evidence in favor of instability and hence of super exogeneity of **y**. However, as the equation disturbances in the reversed model are autocorrelated ($FAR_{1-1}(1,44)=6.54$ and $FAR_{1-4}(4,41)=6.01$), the estimation results can be seriously affected (see Hendry, 1992).

Finally, let's consider the reversed model for **r**. Figure 4.8 shows one-step residuals with ± two equation standard errors and Figure 4.9 graphs the one-step Chow statistics of this regression. The instability is evident, which

[29]A better fit to an univariate representation of **r** was obtained by Ahumada (1992a) using monthly data for 1977-1988.

is consistent with finding super exogeneity for r in (3.1). As with y, however, the presence of autocorrelation cannot be rejected ($FAR_{1-1}(1,44)=9.26$ and $FAR_{1-4}(4,41)=2.71$). Furthermore, the reversed model for r predicts well, but in this case it may be attributed to the high residual standard error (σ=52.26%).

5. Concluding remarks.

This study on private fixed investment finds a relationship that passes the usual misspecification tests and remains stable over major policy changes from 1978(3) to 1990(4). The model focuses on just three explanatory variables: income, the borrowing nominal interest rate and public investment in buildings. Not only does it represent adequately the short-run dynamics of private investment, but also the "long-run equilibrium" is estimated.

The validity of the conditional model (3.1) supports the adequacy of some of the transmission channels discussed in section 1. Further research is needed to adress the relative quantitative importance of the different effects found to be consistent with the conditional model. The high income elasticity of private fixed investment provides support alternatively to the hypotheses of myopic behavior or short planning horizons due to uncertainty and/or credit rationing faced by firms. The significance of the nominal borrowing rate of interest also favors the idea of credit rationing rather than that of a strong neoclassical effect coming from changes in the user cost of capital.[30] Furthermore, a proxy for public investment enters significatively the error correction term; the (long-run) effect of this variable on private fixed investment is positive but small when compared to previous evidence for Argentina (cited in section 1). Finally, the significance of the lagged endogenous variable, together with the evidence in favor of a model in the annual first differences of all variables, supports the hypotheses of adjustment costs and/or uncertainty.[31]

This paper addresses exogeneity issues and applies several tests. The coefficients of the explanatory variables in the conditional investment function appears as constant. Consequently, the empirical non-constancy of the univiariate marginal model for income implies the super exogeneity of this variable in the investment function. An implication of super exogeneity is

[30]One may think that the exogeneity of r also favors the former hypothesis rather than the latter. The interpretation of r given in this paper does not mean that cost-of-funds variables are insignificant when applied to the Argentine evidence, but that r may not be considered to be measuring such a variable.

[31]The importance of uncertainty and imperfections in financial markets emphasized here with respect to private fixed investment is consistent with the interpretation given by Galiani and Sánchez (1994) to the results contained in their empirical study of consumers' expenditure in Argentina.

that the reversed regressions of the conditional model for its explanatory variables must be non-constant. This seems to be the case the case in Argentina for income and, to a larger extent, of the interest rate.

As super exogeneity for income and interest rate is demonstrated for the classes of interventions occurred during the period, some statistically valid policy analysis can be made. In so far as government actions affect income and the interest rate, economic policy can (and will) influence the behavior of private investment. One such action, public investment in buildings, is explicitly included in the model (3.1) within an error correction term lagged four quarters. This lagged reaction implies that the relationship of complementarity between private and public investment does not avoid contemporaneous effects on private investment via interest rates ("crowding out") or income.

It is worth noting that the adverse shocks (and especially the occurrence of the debt crisis) which took place during this period have had a dramatic impact in terms of pessimistic expectations and an unstable economic climate. The recovery of investment rates and growth prospects will require a reversion of the depressing state of entrepreneurial expectations and, associated to this, the application of policies which succeed in stabilizing the economy. However, as results from equation (3.1), private fixed investment exhibits a high degree of inertia which can be rationalized by the existence of adjustment costs and/or uncertainty. In consequence, the success of economic policy in fostering investment via the reduction of inflation (and hence of the nominal interest rate) and the recovery of the activity level may be conditioned by inertia in investment decisions. Furthermore, although sound fiscal and monetary policies will contribute to relieve the financial position of firms via lower interest rates, it is also apparent that there is a need for an explicit credit policy aimed at reducing the pervasive imperfections prevailing in financial and capital markets. More detailed discussion of the policy implications of the present model requires specifying the policy at hand and analyzing the concrete mechanisms by which it influences income and the interest rate.

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