WPS0709

An Empirical Macroeconomic Model for Policy Design

The Case of Chile

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A model focusing on the design and evaluation of macroeconomic policy is applied to Chile.

This paper — a product of the Macroeconomic Adjustment and Growth Division, Country Economics Department — is part of a larger effort in PRE to design applied macroeconomic models for the evaluation of macroeconomic policies. Copies are available free from the World Bank, 1818 H Street NW, Washington DC 20433. Please contact Susheela Jonnakuty, room N11-039, extension 39074 (79 pages, with figu. s, graphs, and tables).

Serven and Solimano construct, estimate, and simulate a macroeconomic model for Chile. This model allows aggregate supply and demand factors to interact in determining such key economic variables as inflation, the real wage, the real exchange rate, real output and employment, and the current account balance.

The model ensures the consistency of different aggregates by imposing the relevant budget constraints on the fiscal sector, the central bank, and the balance of payments. To this consistent framework, the model adds behavioral equations with sound analytical foundations.

Serven and Solimano use model simulations to explore the effects of domestic policies and external shocks (like a balanced-budget fiscal expansion, a policy of increased growth in minimum wages, a fall in world copper prices, and an oil price shock). These simulations help illustrate the effects of economic policies and external factors that shape current policy discussions in Chile.

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1. Introduction

The design and implementation of macroeconomic policies requires, among other things, a clear understanding of the rules of macroeconomic behavior and the budget constraints that relate macro variables. The development of empirical macroeconomic models incorporating an adequate representation of such relationships may be a useful tool for policy-makers and scholars interested in macroeconomic policy. In the past fifteen years, empirical macro modelling has suffered two lines of criticism: on the one hand, traditional macroeconometric models have been criticized on the grounds that their theoretical underpinnings are weak and because of their lack of solid microfoundations. A second line of criticism focuses on the fact that the "structural" parameters of econometric models are in fact not policy-invariant and therefore their use may lead to potentially misleading model-based policy prescriptions and evaluation. This paper takes the view that in spite of the validity of some of these criticisms, there is still room for theoretically-grounded, empirically relevant, macroeconomic modelling.

Macro modelling may be very useful in three respects. First, it provides a conceptual framework organized around accounting identities and behavioral relationships that can help in the understanding of macroeconomic problems. Second, empirical macro models provide a quantitative tool for assessing the orders of magnitude of the impact of different policies on the main variables that are of interest in the conduct of macroeconomic policy. And third, the models can help assess the consistency between targets of macro policy such as low inflation, external balance and sustainable growth, the setting of policy instruments for monetary, fiscal and exchange rate policy and the level of certain key relative prices such as the real exchange rate, the real interest rate and the real wage.

In this paper we set up a macroeconomic model for an open economy in which both aggregate demand and aggregate supply play a role in the determination of the key macroeconomic variables -- output, employment the rate of inflation, the real exchange rate and the real interest rate. The model is estimated with annual data for the Chilean economy and used for the

simulation of macro policies in the 1990s.

The analytical model considers the goods market, the labor market, and assets markets. Goods market clearing determines the real exchange rate. Among the components of goods demand, private consumption and investment as well as exports and imports are endogenously determined. Aggregate demand depends on current and permanent income, the real interest rate and fiscal parameters; and on the real exchange rate and foreign demand. Aggregate supply of domestic goods depends on real wages and also on the real exchange rate, due to the use of imported intermediate inputs in the production process.

In turn, the labor market need not clear in the short run, due to wage inertia. The wage-exchange rate-price mechanism is also an important part of the model. In particular, our framework intends to capture the impact of wage indexation and exchange rate rules on the dynamics -- and, especially the inertia -- of inflation.

Finally, the model ensures consistency by explicitly incorporating three crucial constraints for the conduct of macroeconomic policy: the fiscal constraint, the balance of payments, and the money supply identity.

The plan of the paper is as follows. Section 2 provides an overview of the Chilean economy in the 1980s in order to set the stage for understanding some macro policy choices envisaged for the 1990s. The analytical structure of the model is presented in section 3. The results of the econometric estimation are presented in section 4. In section 5 the model is used to perform a set of policy simulations for the period 1990-1995. A base simulation is constructed in order to have a benchmark case to which compare the policy simulations. The paper closes with some final remarks in section 6.

2.   The Chilean Economy in the 1980s: An Overview[1]

The behavior of the Chilean economy during the eighties can be characterized by three clearly distinguished periods. The first one was

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[1] This section draws from Solimano (1990a).

associated with an exchange rate based stabilization program following the
fixing of the exahange rate from mid-1979 to mid-1982. In that period
inflation sta:.ilization was pursued through the management of exchange rate
policy, and an unsustainable debt-led boom in economic activity developed,
fueled by external borrowing. A second period comes in 1982-1983 where a
severe recession and a financial crisis set in associated with previous policy
mistakes and adverse external shocks. Finally, after 1984 emerges a period of
recovery and growth based in strong export performance and the recovery of
investment in a context of macroeconomic stability, impaired at the end of the
1980s by an unwarranted demand expansion.

2.1   Exchange rate based stabilization: 1979-82

This period is characterized by a failed attempt at exchange rate-based
stabilization that begins in June 1979 when, after a moderate stepwise
devaluation, the exchange rate was fixed for an undetermined period of time in
order to curb inflationary expectations and bring domestic inflation to
international levels. The absence of fiscal imbalances and a low (and
uniform) tariff structure were regarded as strong backers of the exchange rate
policy. Ultimately, the experiment had to be abandoned in June 198ᵼ   ᵢen the
exchange rate was finally devalued in the midst of a severe recession and
worsened extern:.l conditions.

This period was one of booming economic activity, rising real wages and   ⸝
overexpanding financial intermediation in a context of heavy foreign
borrowing. Severe misalignments in some key relative prices and foreign and
domestic overindebtedness rendered the economy particularly vulnerable to
adverse external and internal shocks. In fact the real exchange rate
appreciated and unsustainable current accounts deficits developed -- up to
14.5% of GDP in 1981 -- as exports started to be squeezed and imports boomed.
In turn, high domestic real interest rates, mainly in 1981, seeded an incoming
financial crisis as the path of internal debt accumulation by domestic firms ·
and households with the financial system (the counterpart of heavy foreign

borrow'ng) reached unsustainable levels.

2.2   The crisis of 1982-83

During 1982-1983, the Chilean economy experienced a severe recession as
a consequence of negative external shocks and previous domestic policy
mistak⌐s[2]. After an attempt to correct the large external imbalance developed
in 1981, through tight money and high real interest rates (without devaluing
the exchange rate), by mid-1982 the government changed its policy and decided
to correct the exchange rate overvaluation by a series of discrete
devaluations followed by a crawling peg. Fiscal and monetary policies were
clearly restrictive to support the exchange rate policy and reduce domestic
absorption. As a result of these policies and the external shocks, GDP fell
by around 1J percent in 1982-83, imports were cut by half in real terms in
those two years, investment collapsed and open unemployment rates climbed to
nearly 20 percent. The sharp drop in economic act'vity during 1982-83 was
complicated by the financial situation of many indebted firms as they started
to face the conjunction of large debts and depressed demand. As a result, the
financial sector was in a very fragile shape with an important part of the
loans of the major financial institutions becoming non-performing. The
banking crisis further curtailed the supply of domestic credit in the economy,
forcing ultimately the Central Bank to intervene several financial
institutions and undertake massive rescue operations and, in some cases,
liquidation.

2.3   The period of recovery and growth after 1984

A phase of recovery and growth takes place after 1984. In 1984-89 GDP
grew at an impressive 6.3 per year, and inflation averaged 20.4 percent per
annum, a low level for Latin American standards. In addition, such growth has
taken place in the context of reduced reliance on external savings (see the

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[2] There is an already vast literature on that period for the Chilean case,
see Arellano (1988), Corbo (1985), Edwards and Edwards (1987), Foxley (1982).

reduction in the current account deficits in Table 1) and consolidation of internal financial stability. Looking at this performance some important questions arise: First, what are the sources of growth in the Chilean economy in this period? Is the current growth record sustainable over time? What

Table 1. Macroeconomic Indicators for Chile: 1980-89

	GDP growth (%)	Inflation rate (%)	Fiscal Deficit[a] % of GDP	Current Account Deficit (%)	Real Exchange Rate (1980=100)	Real Interest rate (%) (90-365 days)	Terms of Trade (1980=100)	Average Real Wages	Real Minimum Wages .
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1980	7.8	31.2	-3.1	7.1	100.0	8.4	100.0	100.0	100.0
1981	5.5	9.5	-1.7	14.5	90.9	13.2	84.3	108.9	115.7
1982	-14.1	20.7	2.3	9.5	108.8	12.1	80.4	108.6	117.2
1983	-0.7	23.1	3.8	5.7	135.6	7.7	87.5	97.1	94.2
1984	6.3	23.0	4.0	10.7	144.1	8.4	83.2	97.2	80.7
1985	2.4	? .4	6.3	8.3	179.4	8.2	78.5	93.5	76.4
1986	5.7	17.4	2.8	6.5	175.5	4.1	79.0	95.1	73.6
1987	5.7	21.5	0.1	4.3	170.8	4.2	83.0	94.7	69.1
1988	7.4	12.7	1.7	0.8	181.9	4.6	100.0	101.0	73.4
1989	10.0	21.1	-3.0	3.0	177.5	6.8	105.0	102.9	79.7

Source: Boletín Mensual Banco Central de Chile. Various Issues.
CEPAL (1989) Informe Preliminar de la Economia de America Latina, el Caribe. Naciones Unidas.
[a] minus indicates surplus.

explains the fact that the recovery of economic activity in Chile has been non-inflationary (by Latin American standards) in circumstances that the exchange rate has depreciated over 45 percent, in real terms, in the last six years and a financial crisis led monetary authorities to reshuffle major financial intermediaries? To which extent the benefits from higher growth have been shared by labor and other low income groups?

2.3.1 Sources of recovery and growth after 1984

An important fact that table 2 shows is that the recovery in Chile since 1984 has been driven mostly by exports and investment, rather than by consumption growth. In fact, the average rate of growth of total exports has been 8.9 percent per year in the period 1984-89 whereas the rate of growth of aggregate consumption has averaged 4.2 per year over the same period. Investment has been growing at an average rate of 25 percent per year though with large fluctuations over the period; nevertheless, this percentage is strongly affected by 1984 and 1989, when the growth in gross investment seems to reflect, to a considerable extent, the building up of inventories. Anyway, as a share of GDP, investment has recovered from a low of 13.6% in 1984 to 22 percent in 1989. Moreover, exports also have increased their share of GDP while the share of total consumption has declined.

What explains the rapid increase in exports, investment and growth in the last six years? Exchange rate policy has played a preeminent role in the expansion of exports and import competing activities in that period. A higher and relatively stable real exchange rate has increased the profitability of

Table 2. Sources of growth in Chile: 1984-89

	Consumption		Investment		Exports		Imports		GDP
	rate of growth (%)	share of GDP (%)	rate of growth (%)	share of GDP (%)	rate of growth (%)	share of GDP (%)	rate of growth (%)	share of GDP (%)	Growth (%)
1984	1.3	87.4	75.4	13.6	6.8	24.3	16.5	25.3	6.3
1985	-1.0	83.5	-6.7	13.7	6.9	29.1	-11.1	26.3	2.4
1986	3.8	81.6	14.3	14.6	9.8	30.6	9.6	26.8	5.7
1987	3.8	79.0	25.8	16.9	8.8	33.5	17.1	29.4	7.7
1988	9.0	75.8	8.5	17.0	6.1	37.4	12.1	30.2	7.4
1989a/	8.1	77.0	32.6	22.0	14.8	29.0	26.3	28.0	10.0

Source: The World Bank
            estimate

producing for external markets – a factor captured mainly by non-copper exports. The increase in the basic tariff rate[3] from 10 percent to 20 percent (whose anti-export bias was more than offset by the real depreciation) and indirect tax reimbursement for exports have also contributed to the expansion of the tradable goods sector in general. In addition, the existence of idle capacity (until 1987) and the ample availability of labor also contributed to the expansion of export and import competing activities.

Besides the positive impact of supportive macroeconomic policies and a competitive real exchange rate on the very rapid expansion of non-traditional exports in Chile (fresh fruit, fish, paper, timber) this process is also related to institutional factors and structural change carried out in the sixties and seventies. The CORFO (Croporación de Fomento de la Producción, plan of fruit growing (1968) and the afforestation activities of 1966-73 were two initiatives that boosted agricultural development and also the ability to export in these areas. The agrarian reform of 1965-73 also contributed, in spite of transitional problems, to help modernize the agricultural sector from the latifundios (quasi-feudal) structure. Moreover, after 1974 a new process of land redistribution, sale by tender and auctioning -- starting from the structure left after the agrarian reform process -- took place, giving rise to a more active land market that was needed to support a more competitive environment in agriculture.[4]

Total investment has been stimulated by various factors[5]. Besides the recovery of public investment, the reduction in real interest rates undoubtedly contributed to the recovery of private investment. A monetary policy of real interest rate targets, conducted in the context of a financial market characterized by the extensive use of indexed financial instruments,

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[3] Specific import duties were imposed on some products where evidence of dumping was found.

[4] See ECLA (1990) for a further discussion of these issues for the case of Chile.

[5] An econometric analysis of the behavior of private investment in Chile during the eighties is carried out in Solimano (1989).

was the chief mechanism behind the interest rate policy.[6] Tax incentives seem to have played also an important role in the recovery of private investment in Chile, as the tax rate on corporate incomes was reduced from 46 percent to 10 percent; in addition, reinvested profits received a preferential tax treatment over dividends.

The average rate of growth of GDP in the Chilean economy was 8.7 percent during 1988-89 (10 percent in 1989). That exceedingly high growth record seems to reflect, to a considerable extent, two elements: the first is related to an improvement in external conditions in the form of high copper prices (a positive terms of trade shock) observed since 1987, and the second is a political business-cycle feature, namely the adoption of a highly expansionary monetary policy in the second half of 1988 -- M1 grew nearly 50 percent in that period -- as a plebiscite over the permanence of the military regime was to take place in October of that year. In addition, given the traditional lags in the effects of monetary policy on real economic activity, the stimulative effects of the late 1988 monetary expansion were largely felt also in 1989. Moreover, the presidential and parliamentary election of December 1989 was preceded by a rather lax monetary stance that rapidly resulted in an acceleration of inflation in the last quarter of 1989. Therefore an attempt to maintain a pace of growth that reflects, to a large extent, cyclical elements, over a more extended period of time, would sooner or later conflict with other targets of macroeconomic policy like maintaining low inflation and the preservation of external balance. In that perspective, since December 1989 the central bank is tightening monetary policy in order to cool down growth. The actual deceleration in growth during 1990 has been sharp and the forecasts for 1990 predict a rate of GDP growth of around 1-2% for the year (down from 10% in 1989).

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[6] According to Fontaine (1988), the level of the real interest rate was determined on the basis of two criteria: to provide a real return to domestic financial assets competitive with the return of financial instruments abroad, so to avoid capital flight and, second, the real interest rate should be consistent with a real cost of credit that does not hamper the recovery of investment.

2.3.2 Why the adjustment of relative prices and the financial crisis was non-inflationary in Chile?

An interesting issue mentioned before is the non-inflationary adjustment of the Chilean economy, in spite of a large real depreciation of the exchange rate -nearly 45 percent since 1984 (see table 1) -- and the turnaround of a serious financial crisis that required massive Central Bank intervention.

Two explanations may be advanced in this regard.[7] First, the series of devaluations starting in 1982 were accompanied by de-indexatio.. of wages; thus a real depreciation did not require a permanent acceleration in inflation in order to reduce real wages. In addition, the increase in the rate of unemployment, reaching levels over 20 percent in 1982-83 and remaining fairly high until 1987, acted as a "labor market-deterrent" for workers attempting to recover the level of real wages squeezed after the crisis of 1982. With ample slack in the labor market, firms were not forced to bid up for additional labor through higher wages (mainly for less skilled labor, where unemployment concentrated) a factor that prevented an acceleration of inflation coming from the wage side during the adjustment process. Clearly in Chile the "classical" price-wage-exchange rate spiral resulting from an attempt to modify the real exchange rate while maintaining wage indexation and monetary accommodation was absent. However the "Chilean way" was not costless in terms of economic activity and real wages, though the costs were tilted towards the first phase of the adjustment process.

A second factor refers to the fiscal situation. In Chile, like in other highly indebted countries, the strain on the public sector accounts resulting from the crises of 1982-83 centered mainly (but not only) on the quasi-fiscal deficit (central bank budget). The deterioration stemmed both from the increase in the domestic currency value of servicing the external debt after 1982, and of the rescue program of troubled financial institutions and conglomerates set-up by the Central Bank. These adverse quasi-fiscal shocks have been non inflationary for two main reasons: first the non-

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[7] See Corbo and Solimano (1990) for an econometric analysis of inflation and stabilization in Chile during the last two decades.

financial public sector in Chile ran a surplus in its primary deficit during this period, transferring part of it to the central bank to cover its new losses. Second, the rescue operations of troubled financial institutions were carried out by issuing interest bearing liabilities of the central bank rather than by issuing high powered money. The issuing of interest-bearing liabilities by the Central Bank was directed to finance debt-relief schemes for borrowers of the banking system, to the purchase of risky loans by the Central Bank with a (generous) repurchase obligation on the part of banks' shareholders and to the recapitalization and subsequent sale (financed with government credit and subsidies) of intervened banks to small investors (the "capitalismo popular" scheme)[6]. It is noteworthy to recognize that the whole scheme of reshuffling the banking system involved placing large amounts of central bank bonds in the market. That required, of course, a corresponding increase in demand for such assets. The rapid recovery of the Chilean economy since 1984 in terms of growth of output, certainly was instrumental in that regard (also because it helped increase private savings). In a medium-term perspective, however, these new Central Bank interest-bearing liabilities constitute a "latent inflationary pressure" that can be triggered if other "non-monetary" sources of central bank revenues deteriorate in the future.

2.3.3 Incidence of the costs of adjustment and the benefits of recovery and growth

A key and difficult question is the social distribution of the costs and benefits of the macroeconomic adjustment. Table 2 shows that average real wages recovered their 1980s level just in 1988 and that minimum wages in real terms were still 20 percentage points below their 1980 level and 35 points under their 1982 level. That suggests that labor, and particularly low wage groups, paid a significant share of the costs of adjustment in Chile. In turn, the benefits for labor of the recovery after 1984 have taken more the form of an employment increase rather than real wage growth. The step from

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[6] See Larraín (1989) for a detailed account of the management of the Chilean financial crises.

functional to personal income distribution is hard to make, particularly in the case of Chile because of the absence of comprehensive information on income distribution in this period. However, actions like the cut in some items of social spending e.g., pension payments, and the squeeze on public sector wages suggest that middle-low income groups also suffered in the adjustment process. The incidence of the costs of adjustment on high income groups is less clear since their income tax rates were reduced. Asset transfers in the privatizations that took place after 1985 and the granting of subsidies to the financial sector provide some clues that high-income groups were shielded, in part, from the costs of adjustment.

3.   The Analytical Model

In this section we set up a simple aggregate model for the Chilean economy. We basically use an open economy IS-LM framework, extended to incorporate the supply side and the labor market. We consider one single domestic good[9] that can be used for consumption, investment, and exports, and whose market must clear at every instant; goods market equilibrium determines the real exchange rate and real output. In contrast, the labor market need not clear in the short run due to wage rigidity.

The presentation of the model will start with the components of aggregate demand and aggregate supply for domestic goods. Then we will turn to the labor and assets markets, and provide a simplified representation of the behavioral model. We close the discussion with the budget constraints of the economic actors.

The Goods Market

Let us turn first to the demand side of the goods market. Aggregate demand for domestic goods is the sum of public and private consumption and

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[9] This may seem odd in view of the important role of copper in the Chilean economy. The model assumes that copper is produced only for exports, and that the production volume is exogenous. However, copper revenues will be endogenously determined by prices and exchange rates (see below).

investment, plus net exports.

The private consumption equation is based on the assumption that there are two groups of consumers: the first group is liquidity constrained (they cannot borrow in capital markets against their future income), so that their consumption depends on current real disposable income[10], Yd. The other consumers (e.g. the wealthy, and upper-middle income groups) are unconstrained, and determine their consumption according to the life cycle-permanent income hypothesis (Hall, 1978); thus, their current consumption depends on past consumption and on the unanticipated change to permanent income, which can be summarized also by current disposable income. Aggregate consumption C_{pr} is the sum of consumption of the constrained and unconstrained consumers; hence it depends on both current income and lagged consumption:[11]

(1) $C_{pr} = C_{pr}(Yd, C_{pr,-1})$

Real disposable income is defined as:

(2) $Yd = [p \cdot Y - T - e \cdot FFP]/p_c$

where Y is real output, p is the domestic price level, T are taxes, e is the nominal exchange rate (units of domestic currency per unit of foreign exchange), p_c is the consumption deflator, and FFP is net factor payments abroad (in foreign currency terms), which are given by profit remittances PR plus interest payments on net foreign debt:

(3) $FFP = PR + i^* \cdot (FD-RE)$

with FD and RE denoting foreign debt and foreign reserves, respectively.

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[10] For recent evidence that the role of liquidity constraints in consumption is more important in countries with relatively less developed capital markets (as most LDCs), see Jappelli and Pagano (1990).

[11] We have omitted, just for simplicity, two possible extensions: first, the distribution of income between wage earners and profit recipients could be another determinant of consumption spending (Diaz-Alejandro, 1965). Second, the ex-ante real interest rate could also affect private consumption -- although the direction of this effect is theoretically (and empirically) ambiguous. In our empirical work we could not identify either of these two effects.

Private fixed investment is determined along the lines of the standard cost-of-adjustment model (Hayashi, 1982). Thus, investment depends on Tobin's Q, the ratio of the market value of installed capital to its replacement cost. However, because of market imperfections, firms may find themselves rationed in financial and/or goods markets; hence, we must also allow for a direct effect of current profits and demand conditions[12] on investment. Demand conditions are measured by the degree of capacity utilization in the economy Y/Yp, where Yp denotes potential or full-capacity output. In turn, with variable production inputs (labor and materials) optimally adjusted, current profits can be shown to depend only on the degree of capacity utilization. In summary, private investment can be expressed[13]

$$(4) \qquad I_{pr} = I_{pr}(Q, \; Y/Yp)$$

In turn, Tobin's Q depends on anticipated profits and the real interest rate[14], r. As before, profits are summarized by the degree of capacity utilization, Y/Yp:

$$(5) \qquad Q = q(r, \; Y/Yp)$$

Government consumption, C_g, and public investment, I_g, are considered policy determined variables so they are exogenously given.

Real copper exports X_{cop} are exogenous; in turn, non-copper exports X_{nc} are endogenously determined. They depend on the price of competing foreign goods relative to the price of the domestic good ep^*/p, and on the level of

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[12] For a formal proof that when the firm faces sales constraints the optimal investment rule depends on both Tobin's Q and goods demand, see Precious (1985).

[13] For notational simplicity, all behavioral equations are written as static. However, in their empirical implementation we will allow for dynamic effects.

[14] More precisely, Tobin's Q can be shown to equal the present value of future unit profits, discounted at the real rate of interest plus the depreciation rate of capital, $(r+\delta)$. Under static expectations, this equals current profits divided by $r+\delta$. In turn, with profits described by the degree of capacity utilization (as argued above), Tobin's Q can be expressed as in (5).

world demand Y^*:

(6) $\qquad X_{nc} = \dot{x}(ep^*/p, Y^*)$

Real imports depend on the tariff-inclusive relative price of importables in terms of domestic goods, $ep^*_a(1+t)/p$, where p^*_a is the world price of importables, and on the level of output Y:

(7) $\qquad M = m(ep^*_a(1+t)/p, Y)$

Equating output to aggregate demand, we have:

(8) $\qquad Y = C_{pr} + C_g + I_{pr} + I_g + \Delta stk + X_{cop} + X_{nc} - M$

where Δstk denotes inventory investment, which is exogenously determined.

On the supply side, we assume that output is produced according to a constant returns to scale technology that uses labor, capital and imported materials. Assuming profit maximization, we can write the supply function as

(9) $\qquad Y/Yp = y^*(w/p, ep^*_a/p, \mu)$

where w is the nominal wage rate, p^*_a is the foreign-currency price of imported materials[15], and μ is a productivity parameter. Solving for p, we can write the inverse supply function as

(9') $\qquad p = p(w, ep^*_a, \mu, Y/Yp)$

which expresses the price of domestic goods p as a (variable) markup over unit variable costs, with the markup rate increasing with the degree of capacity utilization Y/Yp[16]. Moreover, equation (9') must be homogeneous of degree one in input prices.

Finally, the change in the level of capacity output is related to the

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[15] Here we are assuming, only for notational simplicity, that the world price of foreign materials in terms other importables is constant.

[16] Notice that in principle this markup specification would be consistent with either perfect or imperfect competition in the goods market.

path of the capital stock:

(10) $\Delta Y_p/\dot{Y}_p = \Delta K/K$

and the capital stock changes over time according to net investment:[17]

(11) $\Delta K = (I_{pr}+I_g) - \delta K$

The Labor Market

Because of wage stickiness, the labor market need not clear in the short run. Labor supply equals the labor force L^*; actual employment is always determined by labor demand. The specification of the latter follows from profit maximization; hence, labor demand is related to the real wage w/p and the level of output Y:

(12) $L = l(w/p, Y)$

The rate of unemployment is defined as

(13) $u = 1 - L/L^*$

The labor market is completed with an equation describing the rate of change of the average nominal wage w. The latter depends on four factors. First, the rate of change of the consumer price index $\Delta p_c/p_c$, reflecting inflationary expectations and/or the existence of wage indexation. Second, the rate of change of the minimum wage $\Delta wmin/wmin$, which affects the average wage directly through a "composition effect" (since a fraction of the workers earns the minimum wage) and also through an indirect "relative wage" effect, which links the whole structure of wages to the minimum wage. Third, the degree of slack or excess supply in the labor market measured by the rate of unemployment u, along the lines of a Phillips curve specification. Finally, wage growth depends also on labor productivity g_{yl}. Formally,

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[17] Here we are making the simplifying assumption that public and private investment are equally 'efficient' in increasing productive capacity.

(14) $\Delta w/w = v(\Delta p_c/p_c, \Delta wmin/wmin, u, z_{y1})$

The Money Market

We use a very simplified representation of assets markets. There are three assets in the economy: money, domestic interest-bearing assets[18], and a foreign bond; the latter two assets are imperfect substitutes. Moreover, we assume that there are barriers to capital mobility; hence, the private sector cannot adjust instantaneously its holdings of foreign assets[19]. In addition, we assume that the nominal exchange rate is fixed (or managed by the authorities).

We can summarize portfolio equilibrium by considering the money market. Formally, real money demand h depends on the nominal interest rate i, the level of output Y, and the foreign interest rate, i^*, adjusted by the expected rate of devaluation of the exchange rate, Δlne^*. Hence money demand is

(15) $h = h(i, Y, i^* + \Delta lne^*)$

Letting H denote the nominal money stock, money market equilibrium implies

(16) $H/P = h(i, Y, i^* + \Delta lne^*)$

or, solving for the domestic nominal interest rate,

(16') $i = i(H/p, Y, i^* + \Delta lne^*)$

In turn, the domestic real interest rate r is equal to the difference between the nominal interest rate i and the anticipated inflation rate π^e:

(17) $r = i - \pi^e$

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[18] The domestic asset implicitly includes public debt and the claims on the capital stock -- i.e., holdings of equity. This amounts to assuming that domestic debt and equity are perfect substitutes (up to a constant risk premium).

[19] This assumption ensures that at every instant the money stock is predetermined; however, we could eliminate it without any analytical complication. Also, we could allow explicitly for a parallel foreign exchange market without major difficulties (other than empirical).

Price Definitions

The model is completed with two equations describing the consumption and investment deflators. Both consumption and investment are assumed a composite of domestic goods and imports. Hence their implicit deflators can be expressed

(18) $\quad p_c = p_c(p, \ e \bullet p^*_m(1+t))$

(19) $\quad p_k = p_k(p, \ e \bullet p^*_m(1+t))$

where p_k is the investment deflator; further, both p_c and p_k must be homogeneous of degree one in p and $e \circ p^*_m(1+t)$.

Finally, the national accounts nominal income-expenditure identity can be written

(20) $\quad p \bullet Y = p_c \bullet (C_{pr} + C_g) + p_k \bullet (I_{pr} + I_g) + p_{stk} \bullet \Delta stk + e \bullet (p^*_{cop} \bullet X_{cop} + p^* X_{nc} - p^*_m M)$

where p^*_{cop} is the world price of copper, which is exogenously given; equation (20) is used to determine the deflator of inventory investment p_{stk}.

A Simple Graphical Representation of the Model

We can provide a simple graphical representation of the model by reducing it to three equations depicting aggregate supply, aggregate demand, and the current account balance, all in terms of the real exchange rate, real output, and for given values of the remaining variables. First, a semi-reduced form for aggregate demand AD can be obtained by replacing equations (1) through (7), (16'), and (17) through (19), into (8):

(21) $\quad AD = AD(ep^*/p, \ H/ep^*, \ a_d)$

where $a_d \equiv \{C_g, \ I_g, \ TD, \ t, \ [FD-RE]/p^*, \ PR/p^*, \ Y^*, \ i^*, \ \Delta lne^*, \ p^*/p^*_m, \ X_{cop}, \ p^*_{cop}/p^*_m,$ $\pi^*, \ C_{pr-1}\}$, and in arriving at (21) we have used the fact that $H/p = (H/(ep^*))(ep^*/p)$.

Letting $e_R \equiv ep^*/p$ denote the real exchange rate, and for given a_d and

given real money stock in terms of foreign goods $H/(ep^*)$[20], the AD schedule is depicted in Figure 1 as an upward sloping line in the real exchange rate-real output space (e_R, Y), reflecting the assumption that a real depreciation of the exchange rate raises aggregate demand -- that is, the positive effect of a real depreciation on net exports dominates its negative effect on real disposable income and consumption, which is due to the increase in the value in terms of domestic goods of foreign debt servicing payments, and in the decrease in the value in terms of consumption goods of a given disposable income in terms of domestic goods[21].

The position of the AD schedule is determined by the values of the real money stock $H/(ep^*)$ and the other variables included in a_d (i.e., all the variables other than e_R that affect aggregate demand) [22].

In turn, the aggregate supply schedule AS is just given by (9), rewritten here as

(22) $AS = AS(ep^*/p, w/(ap^*), a_s)$

where $a_s \equiv \{\mu, Y_p, p^*_a/p^*\}$, and we have used the fact that $w/p = (ep^*/p)(w/(ep^*))$. Thus, for given a_s and given real wage in terms of foreign goods, the aggregate supply schedule is downward sloping in Figure 1, reflecting the fact that a real depreciation increases the relative price of imported materials (as well as the product wage w/p for given $w/(ep^*)$) and

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[20] Here we are making the important assumption that anticipated inflation and depreciation are predetermined.

[21] In Solimano (1986) a macro model of a devaluation is set up and parameterized with Chilean data. The main result is that a real depreciation turns out to be contractionary in the short run followed by an expansion in output and employment in the medium to long run. A real depreciation may affect adversely absorption also via a cut in investment due to higher cost of imported capital or because of a reduced access to credit by firms overindebted in dollars. See Serven and Solimano (1990) for a full review of the effects of a real depreciation on investment.

[22] Note also that the inclusion of lagged consumption in a_d gives rise to a distinction between short run and long run equilibrium. The short run AD schedule will be shifting over time as the economy approaches a stationary equilibrium. In our empirical model this is more so, as other lagged endogenous variables (e.g., exports or the real exchange rate) would also be included among the determinants of aggregate demand.

thus reduces output supply. A step beyond would be to insert the laws of
motion of the nominal wage and the capital stock (equations (11) through (14))
in (22), bringing out the dynamics of aggregate supply -- and allowing for a
distinction between the short run and long run aggregate supply schedules.

Finally, the current account deficit measured in terms of domestic goods
CA is given by

$$(23) \qquad CA = (e/p) \cdot [i^*(FD-RE) + PR - FTR + p_a^* M - p_{cop}^* X_{cop} - p^* X_{nc}]$$

where FTR are net foreign transfers; the term $(e/p) \cdot [p_a^* M - p_{cop}^* X_{cop} - p^* X_{nc}]$ is
the resource deficit. Inserting equations (6) and (7) in (23) we get:

$$(24) \quad CA = CA(Y, ep^*/p, i^*, [FD-RE]/p^*, FTR/p^*, X_{cop}, Y^*, p^*_{cop}/p^*, p^*_a/p^*)$$
$$= CA(Y, ep^*/p, a_{ca})$$

Setting the right-hand side of (24) equal to zero, we obtain the CA
locus in Figure 1, which represents the combinations of output and the real
exchange rate that yield a balanced current account for given values of all
the other variables. The locus slopes upward, due to the fact that an
expansion in output raises imports and hence the resource deficit, and must be
compensated with a real depreciation in order to maintain the current account
in equilibrium. Points above the CA locus correspond to current account
surplus; points below correspond to current account deficit.

The domestic goods market clears when aggregate supply and demand are
equal; in Figure 1, this happens at point E. In the figure we have assumed
that E also corresponds to a balanced current account; hence, at E the economy
is in full macro equilibrium: the levels of the real exchange rate and output
are consistent with both internal balance[23] (aggregate demand = aggregate
supply) and external balance (equilibrium in the current account).

Of course, the meaning of "internal and external balance" in our

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[23] A related issue is that of the stability of internal equilibrium. A
sufficient condition for static stability is that the aggregate demand schedule
be upward sloping, as assumed here. The dynamic stability under rational
expectations of a model similar (but somewhat simpler) to ours is examined in
Serven (1991).

framework must be qualified: on the one hand, internal balance may occur with unemployment in the short run. On the other hand, external balance may be consistent with a sustainable deficit in the current account, and not necessarily with a zero deficit.

The functioning of the model can be seen by performing a simple comparative static exercise, such as an increase in public spending that shifts down and to the right the aggregate demand schedule in Figure 1(a) (dotted line). The new short term equilibrium would be at E' where the real exchange rate appreciates and the level of output increases (assuming output is below full capacity). At E', however, there is now a deficit in the current account which has to be financed either through an increase in external borrowing and/or running down international reserves.

Another exercise of interest is a devaluation (i.e., an increase in e). Of course, if a nominal devaluation is to have an impact on real variables, it must not be accommodated by proportionate increases in nominal wages and the nominal money stock; otherwise, as is clear from (21) and (22), real variables would be completely unaffected, while p, w and H would all rise in the same proportion as the nominal exchange rate.

In Figure 1(b), we depict the effects of a devaluation holding constant the nominal money stock and the nominal wage. From (21) and (22) it is clear that both the real money stock and the real wage in terms of foreign goods must fall, and thus the AS and AD schedules shift upwards; the CA schedule is unaffected. Hence the outcome is a real depreciation and a current account surplus; however, the effect on real output is in principle uncertain, although if the adverse impact on interest rates and hence on investment demand is not too large, output should be expected to rise, as represented in E' in the figure.

Let us consider the determination of the rate of inflation by looking at the dynamics of aggregate demand and aggregate supply. This is useful for addressing problems of inflation stabilization and to examine the inflationary effects of wage indexation and exchange rate rules and money growth, and in

particular the issue of inflation inertia.

We can illustrate these issues as follows. First, equating aggregate demand with aggregate supply,

$$AD(\ ep^*/p,\ H/(ep^*),\ a_d)\ =\ AS(\ ep^*/p,\ w/(ep^*),\ a_s)$$

and solving for the rate of change of the price level π, we have

(25) $\pi\ =\ a\ (\Delta w/w)\ +\ b\ (\Delta e/e)\ +\ c\ (\Delta H/H)\ +\ v$

where $a+b+c=1$, v is a function of the rates of change of a_s and a_d, and foreign prices have been assumed constant. For given v, the rate of inflation is a weighted average of the rate of wage inflation, the rate of devaluation and the rate of change in the money supply; in turn, inflation may rise or fall due to the effects of supply and demand shocks (the v term).

We can use (25) to illustrate the effects of the wage formation process and exchange rate rules on inflation. Assuming a linear functional form for the rate of change in nominal wages we can write equation (14) as:

(26) $\Delta w/w\ =\ (1-\beta)\bullet\pi_c\ +\ \beta\bullet(\Delta wmin/wmin)\ -\ \gamma\bullet u$ $0 < \beta < 1$

where π_c is the rate of change of the consumption deflator; $\gamma > 0$; and for simplicity we have ignored productivity growth. Hence the rate of change in average nominal wages is a function of consumer inflation, the rate of change in minimum wages, and the rate of unemployment. Let us assume that the minimum wage is indexed to current and past inflation:

(27) $\Delta wmin/wmin\ =\ (1-\theta)\pi_c\ +\ \theta\pi_{c,-1}\ +\ k$ $0 < \theta < 1$

where k is an exogenous minimum wage shock. Replacing (27) in (26), we can write

(26') $\Delta w/w\ -\ \pi_c\ =\ \beta k\ -\ \beta\theta\ (\pi_c\ -\ \pi_{c,-1})\ -\ \gamma u$

which implies that, given k, the real consumption wage can only be reduced by accelerating inflation (as long as $\theta > 0$) or through unemployment. On the other hand, from (18) we can write $\pi_c\ =\ \lambda\pi\ +\ (1-\lambda)(\Delta e/e)$, where $0 < \lambda < 1$ is the share

of domestic goods in the consumption basket. Finally, let us assume that money growth and nominal depreciation partially accommodate inflation; hence $\Delta e/e = \eta\pi$, and $\Delta H/H = \Phi\pi$ where $0<\eta,\Phi<1$. With all these ingredients, we can rewrite (25) as

(28) $\pi = \alpha\pi_{-1} - \gamma'u + v'$

where $\alpha \equiv D^{-1}a\beta\theta[\lambda+(1-\lambda)\eta]$, $\gamma' \equiv D^{-1}\gamma$, $v' \equiv D^{-1}(v+\beta k)$, and $D \equiv 1-b\eta-c\gamma-a(1-\beta\theta)[\lambda+(1-\lambda)\eta]>0$. Equation (28) shows that inflation depends on three factors: lagged inflation, unemployment, and exogenous supply, demand, and minimum wage shocks. In particular, the degree of inflation inertia is measured by α. Hence, as can be directly verified, the larger the weight of minimum wages in average wages β, the larger their backward indexation θ, and the more accommodating money and exchange rates are (i.e., the larger Φ and η), the more persistent inflation is. In particular, with full accommodation ($\eta=\Phi=1$), (28) reduces to

(28') $\pi = \pi_{-1} - (a\beta\theta)^{-1}\gamma u + (a\beta\theta)^{-1}(v+\beta k)$

so that current inflation fully reflects past inflation, irrespective of the degree of backward indexation θ; however, the larger θ, the more costly in terms of unemployment it is to reduce inflation below its past level.

Budget Constraints

The behavioral model is completed with the budgetary identities of the different economic actors -- that is, the private, public, and external sector. These ensure the consistency between stocks and flows in the model, which is necessary for the simulations to be of any practical interest.

One important issue is the appropriate degree of disaggregation of the public sector. Normally, for the purposes of macroeconomic analysis, it would suffice to consider the consolidated financial and nonfinancial public sector -- that is, including the Central Bank. However, in the Chilean case the recently introduced autonomy of the Central Bank creates some unusual fiscal

problems, due to the large stock of Central Bank debt to the private sector, and to an equally large stock of foreign-currency denominated liabilities of the Government with the Central Bank. In order to keep close track of the fiscal implications of these two issues, we choose to consider these two agents separately.

To adapt the budget identities to the Chilean institutional context, we must take into account two facts. First, most domestic currency financial instruments (with the obvious exception of the money stock) are indexed to the price level. The interest actually paid on such instruments is given by a market determined 'real' interest rate applied to the actualized (i.e., according to inflation) principal of the instrument.

Second, the way in which the nonfinancial public sector (more precisely, the central government) services its main liability with the Central Bank (which has the form of a dollar-denominated Treasury note held by the latter) is somewhat special. The liability originates from the consolidation of past transfers to cover the Central Bank's operating losses. Interest on the Treasury note accrues at a rate equal to LIBOR plus a fixed spread. However, the actual interest payment by the government is only 2 percent of the principal; the remaining interest accrued is capitalized. Moreover, the government can also make anticipated amortization payments to reduce the principal of the note[24].

Keeping these issues in mind, we can now describe the budget constraints of the model. First, the identity of the external sector is just the Balance of Payments, which in terms of foreign currency can be written

(29) $P_m^* \cdot M - (P^* \cdot X_{nc} + P_{cop}^* \cdot X_{cop}) - FTR + (PR + i^* \cdot [FD-RE]) = DFI + \Delta[FD-RE]$

Here DFI is direct foreign investment; all variables (with the exception of real imports M and real copper and non-copper exports X_{cop} and X_{nc}) are measured in foreign currency (dollar) terms. The left-hand side of the

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[24] For example, in 1990 the government made an amortization payment of US $ 230 million.

equation is the current account deficit described before; the right-hand side is the capital account balance. Again, the term in square brackets FD-RE represents <u>net</u> foreign debt.

In turn, the budget constraint (in nominal terms) of the nonfinancial public sector can be written

(30) $(p_c \cdot C_g + GTR_{cb} + OE + r \cdot p \cdot [b_g + dc_g] + e \cdot i^* \cdot [FD_g - CSF])$

$\qquad - (TD + TI + OR + CUR) + p_k \cdot I_g$

$\qquad = p \cdot (\Delta dc_g + \Delta b_g) + e \cdot \Delta FD_g - e \cdot (TBAmort + \Delta CSF)$

The first two lines of (30) represent the public deficit. The first term in brackets represents current expenditures; the second, current revenues. Here TD and TI respectively denote direct and indirect tax revenue in nominal terms; CUR represents nominal revenue from copper production (i.e., the pre-tax operating surplus of the public copper company); OR and OE are other current revenues and expenditures[25], expressed in nominal terms; CSF is the 'Copper Stabilization Fund', which we describe below; and GTR$_{cb}$ is a transfer to the Central Bank, also expressed in nominal terms, which corresponds to the interest paid on the Treasury note held by the Bank. Letting TB denote the principal of the note (in dollars), GTR$_{cb}$ is determined according to

(31) $\qquad GTR_{cb} = \alpha \cdot e \cdot TB$

where α is a given parameter (currently equal to 2 percent, as explained above). In turn, copper revenues are related to copper prices and exchange rates by the following equation:

(32) $\qquad CUR = (e \cdot P^*_{cu} - ß \cdot P) \cdot Y_{gcu}$

where ß is a cost parameter, and Y_{gcu} denotes the volume of public copper production. Thus, nominal production costs are assumed to rise one for one

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[25] OR includes basically nontax revenues of the government and the operating surplus of public enterprises other than the copper company. In turn, OG mainly involves transfers and subsidies to the private sector.

with domestic prices.[26]

The bottom.line of the public sector's budget constraint reflects the change in the net liabilities of the nonfinancial public sector. Here dc_g and b_g are the net domestic credit from the Central Bank[27] and net public debt held by the private sector, respectively, and they are defined in _real_ terms; hence, the corresponding interest payment is determined by the real interest rate times the _adjusted_ value of the principal, where the latter is determined by the price level. In turn, FD_g is net foreign debt of the nonfinancial public sector.

The last two items in the right-hand side of (30) are somewhat unusual and deserve separate comment. First, TBAmort represents the amortization payment made by the government on the foreign currency-denominated Treasury note held by the Central Bank[28]; its amount is arbitrarily determined by the government. The principal TB evolves over time according to

$$(33) \qquad \Delta TB = i^* \bullet TB - (GTR_{cb}/e) - TBAmort$$

so that if no amortization is paid, then the change in the principal plus the current transfer received by the Central Bank add up exactly to $i^* \bullet TB$, i.e., the (spread-inclusive) world interest rate[29] times the principal of the Treasury note.

In turn, CSF is the 'Copper Stabilization Fund', expressed in dollars[30]. It represents a government account at the Central Bank to which a fraction of copper revenues is deposited whenever the copper price exceeds a

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[26] Actually, part of the operating costs of CODELCO correspond to copper purchases and thus are related to copper prices. For simplicity, we ignore this in (32).

[27] According to the new regulations in Chile, the Central Bank is forbidden from lending to finance public deficits. Hence, Δdc_g cannot be positive.

[28] Notice that such note is _not_ included in dc_g.

[29] As described above, i^* would equal LIBOR plus a fixed spread.

[30] Again, the copper fund is _not_ included in net credit from the Central Bank dc_g.

specified upper bound, and from which withdrawals can be made when the price falls below a likewise specified lower bound. In summary, we can write:

$$(34) \qquad \Delta CSF = \Phi \cdot P^*_{cu} \cdot Y_{gcu}$$

where $\Phi < 1$ (and not necessarily positive), and its precise value depends on the world price of copper relative to the specified upper and lower bounds[31].

Finally, we have the Central Bank's budget identity:

$$(35) \qquad e \cdot i^* \cdot (FD_{cb} - RE) - r \cdot p \cdot (dc_g + dc_{pr}) - GTR_{cb} + e \cdot i^* \cdot CSF =$$
$$\Delta HB + e \cdot \Delta(FD_{cb} - RE) - p \cdot \Delta(dc_g + dc_{pr}) + e \cdot (TBAmort + \Delta CSF)$$

The top line of the equation is the operating loss of the Central Bank, with dc_{pr} denoting <u>real</u> net credit to the private sector[32]; thus, the loss equals the interest paid on net foreign liabilities minus the interest received on net domestic assets (excluding the Treasury note), minus the transfer from the government, plus the interest paid to the latter on the Copper Fund.

The bottom line again denotes the change in the net liabilities of the Central Bank which finances its net operating loss. It comprises the increase in the money base HB, and in net foreign indebtedness, the decline in net domestic assets, and the payments received from the government for deposit to the Copper Fund and for amortization of the Treasury note[33].

In the model, the monetary base is related to the money stock H by the money multiplier μ, which is assumed exogenous:

$$(36) \qquad H = \mu \cdot HB$$

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[31] Alternatively, we could have defined dc_g as <u>net</u> of the copper fund CSF and of the Treasury note TB. The approach used in the text intends to highlight the important role of these two items in the Central Bank-Central Government link.

[32] Net, in particular, of domestic debt of the Central Bank held by the private sector. Thus, in the Chilean case dc_{pr} is negative.

[33] Obviously, if the operating loss is zero and if there are no government payments to the Copper Fund or for amortization of the Treasury note, the equation collapses into the standard money supply identity.

To conclude the presentation of the budget identities[34], it may be instructive to consider briefly the budget constraint of the consolidated public sector, including the Central Bank. Summing (30), and (35), this can be written

$$(36) \quad p_c \bullet C_g + OE + r \bullet p \bullet [b_g - dc_{pr}] + e \bullet i^* \bullet [FD_g + FD_{cb} - RE]$$
$$- (TD + TI + OR + CUR) + p_k \bullet I_g$$
$$= p \bullet \Delta[b_g - dc_{pr}] + e \bullet \Delta[FD_g + FD_{cb} - RE] + \Delta HB$$

where $(FD_g + FD_{cb} - RE)$ and $p \bullet (b_g - dc_{pr})$ respectively are the _net_ foreign and domestic debt of the overall public sector. Using the money market equilibrium condition (16) along with (33), and after some well known manipulations, we can rewrite (36) in compact form as

$$(36') \quad def + r \bullet b + [r^* + (\Delta e_R / e_R)] \bullet f = \Delta b + \Delta f + (1/\mu) \bullet [\Delta h(.) + \pi \bullet h(.)]$$

where $def \equiv [p_c \bullet C_g + OE - (TD + TI + OR + CUR) + p_k \bullet I_g]/p$ is the primary deficit of the overall public sector in real terms; $b \equiv b_g - dc_{pr}$ is the real domestic debt stock; $f \equiv (e/p) \bullet [FD_g + FD_{cb} - RE]$ is the real value of the net external debt stock of the public sector in terms of domestic goods; $r^* \equiv i^* - \pi^*$ is the foreign real interest rate; e_R denotes the real exchange rate, as before; and $h(.)$ is the money demand function (15).

The left-hand side of (36') is the inflation-adjusted deficit of the overall public sector, which includes the real primary deficit plus real interest payments on domestic and foreign debt; observe that the real interest rate relevant for foreign debt is the world real interest rate _plus_ the rate of depreciation of the real exchange rate[35] $\Delta e_R / e_R$. The adjusted deficit must

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[34] In principle, the model would also include a budget constraint for the private sector. However, such equation can be shown to be a linear combination of the budget constraints of the other sectors and the National Accounts income-expenditure identity (20), and thus it need not be considered explicitly.

[35] Obviously, with unrestricted access to foreign and domestic financial markets, the optimal financial strategy of the public sector would be to diversify its sources of financing only if $r = r^* + \Delta e_R / e_R$. This has been emphasized by Buiter (1989).

be financed by increasing the real stocks of foreign and/or domestic debt, or by seigniorage revenues (the last term on the right-hand side).

In order to ensure that public debt will not eventually grow without bound, we must require that real interest payments on the debt stock be met by future primary surpluses and seigniorage revenues (where the latter include the increase in real balances plus the inflation tax revenue)[36]. In terms of the model, this can be done by imposing simple fiscal (or quasi-fiscal) policy rules, such as assuming that increases in debt service are matched in every period by tax increases (as in, e.g., McKibbin and Sachs (1990)). While this can be easily done, it would unnecessarily limit the ability of the model to explore some quite realistic scenarios of 'sustained' fiscal imbalance. A more flexible approach is to allow for arbitrary fiscal imbalances in the short to medium term, while imposing fiscal adjustment in the longer term.

4. Empirical Results

4.1 Preliminary Issues

The structural model summarized in the previous section consists of eleven estimable equations: four for the components of aggregate demand (private consumption, private investment, imports, and non-copper exports), three goods prices relationships (the inverse supply schedule, and the consumption and investment deflators), two labor market equations (for employment and nominal wages), and two asset markets relationships (for Tobin's q and the domestic interest rate).

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[36] Formally, integrating (35") under the assumption that debt does not explode in the long run, we can write the intertemporal budget constraint of the public sector as

$$b(t) + f(t) =$$
$$\int_t^\infty \exp\{-R(s)\} \bullet [(\Delta h(s)+\pi(s)\bullet h(s))/\mu - def(s)] \, ds + \int_t^\infty \exp\{R(s)-R^*(s)\}\bullet f(s) \, ds$$

where $R(s) \equiv \int_t^s r(v) \, dv$, $R^*(s) \equiv \int_t^s [r^*(v)+\Delta e_R(v)/e_R(v)] \, dv$. That is, the existing debt stock must equal the present discounted value of future primary surpluses plus seigniorage revenues, plus an additional term that adjusts for the discrepancy between domestic and foreign (real depreciation-adjusted) real interest rates.

As written above, the behavioral equations (with the only exception of that for private.consumption) contain no dynamics. However, in reality we must allow for the slow adjustment of the left-hand side variables to their 'target' levels. For example, decision and delivery lags in the case of investment, or slow market penetration in the case of exports, can account for substantial differences between the short- and long-run responses of investment or exports to their determinants. Thus, in our empirical equations we included lags of the dependent and/or independent variables to capture this lagged adjustment effects. In most cases, a standard cost-of-adjustment model proved sufficient.

In principle, efficient estimates of the model's parameters could be obtained from a joint estimation technique (e.g., three-stage least squares or full information maximum likelihood). However, the available sample (which includes fewer than 30 data points) is 'undersized', as the sample size falls short of the total number of predetermined variables in the model. In such context, the maximum likelihood estimator is not well defined (Sargan (1975)), nor is the 3SLS estimator (as the instrument matrix fails to have full column rank). Alternative system estimators based on instrumental variables have been proposed in the literature (see e.g., Swamy (1980)); each one of them results from a particular set of restrictions on the set of instruments employed in the estimation, and therefore can be interpreted as imposing implicit (and arbitrary) restrictions on the model's reduced form parameters (for a discussion, again see Swamy (1980)). However, the relative advantages of the alternative estimators are not entirely clear, as the comparisons of performance often rely on asymptotic arguments which by definition are of little interest in the context of small samples. Finally, the computation of some of the system estimators for undersized samples can be rather cumbersome (e.g., Brundy and Jorgenson (1971)).

On the other hand, joint estimation techniques pose the well-known problem that misspecification of any equation will 'contaminate' the rest of the model, leading to inconsistent estimates in all the equations.

In view of these facts, we decided to estimate the model using 2SLS equation by equation, with different sets of instruments for each equation[37]. In this manner, we avoid the problem of contamination - at the cost of some possible losses in efficiency, which in an undersized sample such as ours are not likely to be of great significance.

4.2 Estimation Results

The equations of the model were empirically estimated using annual data for the years 1960-1987. Overall, the estimated equations provide reasonably good fits; none shows any symptoms of serial correlation. All the parameter estimates carry the theoretically correct signs. In most equations we tested some specific parameter restrictions and, when not rejected, imposed them. Such constraints raise the precision of the estimates and also contribute to make the simulation results more easily interpretable. In some cases, the constraints are dictated by basic economic theory (e.g., behavioral rules for real variables should be homogeneous of degree zero in all nominal magnitudes), and their rejection would be a symptom of misspecification. In other cases, they make the dynamics of the model more reasonable (for example, when imposing a unit long-run elasticity of consumption with respect to disposable income).

Below we describe briefly each one of the empirical equations.

Goods Market

Private Consumption - As stated in (1), the estimated equation relates real private consumption to real disposable income and to lagged consumption; attempts to find a significant role for the real interest rate, credit availability, or income distribution, proved unsuccessful.

The selected equation is:

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[37] A possible extension of this procedure would be 3SLS with different instruments for each equation (Schmidt (1990)). Of course, this would again lead to inconsistent estimates in all equations if any one of the model's equations were misspecified.

(37) $\text{Log(Cpr)} = \underset{(-2.863)}{-0.069} + \underset{(5.757)}{0.578} \text{Log(Cpr(-1))}$

$+ \underset{(5.757)}{0.422} \text{Log(Yd)} - \underset{(-5.742)}{0.194} \text{D74}$

$R^2 = 0.964 \quad DW = 2.105 \quad h = -0.320$
$\text{Adj-}R^2 = 0.961 \quad F = 321.545$
Sample: 1961-87

2SLS, instruments = Log(Cpr(-1)), Log(Yd(-1)), Trend, D74.

The adopted specification incorporates the constraint of a unit log-run elasticity of consumption with respect to disposable income; the constraint was not rejected by the data.

The consumption deflator - The implicit price of consumption was assumed in (18) a weighted average of the prices of domestic goods and imports (with the latter adjusted for tariffs). We used a first-difference specification:

(38) $\Delta \text{LogPc} = \underset{(26.920)}{0.893} \Delta \text{LogP} + \underset{(26.920)}{0.107} \Delta \text{Log}[e \bullet P^*_M(1+t)] + \underset{(2.261)}{0.060} \text{d74}$

$R^2 = 0.9980 \quad DW = 2.271$
$\text{Adj-}R^2 = 0.9979 \quad F = 12004.61$
Sample: 1962-87

2SLS; instruments = $\Delta \text{LogP}(-1), \Delta \text{Log}[e \bullet P^*_M(1+t)](-1), \text{Log}(P^*_{cop}), \text{d74}$

The weights of domestic and import prices are constrained to sum to unity, and the regression constant is restricted to zero; neither constraint was rejected by the data[38].

Private fixed investment - As described in (4), private fixed investment is related to Tobin's Q (defined as the stock market index relative to the investment deflator) and the level of output relative to full capacity[39]. The estimated equation is of the lagged adjustment form, and is written in

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[38] Observe that a zero constant term amounts to ruling out a long-term trend in the relative price of consumption.

[39] Capacity output was constructed by the method of interpolation of peaks.

terms of the (real) share of private investment in GDP:

(39) $\text{Log(Ipr/Y)}^{\cdot} = \underset{(-4.556)}{- 1.437} + \underset{(2.996)}{0.124 \text{ Log(Q)}} + \underset{(2.008)}{0.795 \text{ Log(Y/YP)}}$

$+ \underset{(2.849)}{0.372 \text{ Log(Ipr(-1)/Y)}} - \underset{(-3.027)}{0.472 \text{ D72}}$

$R^2 = 0.7493 \quad DW = 1.723 \quad h = 0.947$
$\text{Adj-}R^2 = 0.7016 \quad F = 15.693$
Sample: 1962-87

2SLS; instruments $= \text{Log(Q(-1)), Log(Y(-1)/YP(-1)), Log(Ipr(-1)),}$
$\text{Log(P}^*_{cop}\text{), r(-2), Trend, i}^*\text{(-1), Log(Y}^*\text{(-1)), D72}$

Thus, in the long run the investment share rises more than one for one
with the degree of capacity utilization. In turn, the long-run elasticity of
investment with respect to Tobin's Q is about .2, somewhat smaller than that
obtained by Solimano (1989) from the estimation of a similar equation with
quarterly data.

The investment deflator - As in the case of consumption, the investment
deflator in (19) is a weighted average of the GDP deflator and the import
deflator. A first-difference specification proved adequate:

(40) $\Delta \text{LogPk} = \underset{(16.506)}{0.856 \, \Delta \text{LogP}} + \underset{(16.506)}{0.144 \, \Delta \text{Log}[e \bullet P^*_M(1+t)]} + \underset{(3.505)}{0.099 \, d7172}$

$R^2 = 0.9948 \quad DW = 2.059$
$\text{Adj-}R^2 = 0.9946 \quad F = 4581.25$
Sample: 1962-87

2SLS; instruments $= \Delta \text{LogP(-1)}, \Delta \text{Log}[e \bullet P^*_M(1+t)](-1), \text{Log(P}^*_{cop}\text{)}, d7172$

As before, the equation incorporates the constraints that the shares of
domestic and foreign prices sum to unity and that the constant be equal to
zero; both constraints were tested and not rejected by the data.

Non-copper exports - Real non-copper exports are assumed in (6) to depend on
their relative price eP^*/P - i.e., the ratio of foreign prices to the GDP
deflator -and on world demand Y^*, measured by real world imports from

developing countries; again we use a lagged adjustment specification. The estimated equation is:

$$(41) \quad \text{Log}(Xnc) = \underset{(-3.245)}{-1.492} + \underset{(12.565)}{0.814} \, \text{Log}(Xnc(-1))$$

$$+ \underset{(3.068)}{0.308} \, \text{Log}(e{\cdot}P^*/P) + \underset{(12.565)}{0.186} \, \text{Log}(Y^*) + \underset{(3.999)}{0.517} \, \text{D64}$$

$$R^2 = 0.9714 \quad DW = 1.983 \quad h = 0.047$$
$$\text{Adj-}R^2 = 0.9677 \quad F = 260.327$$
Sample: 1961-87

2SLS; instruments = $\text{Log}(Xn(-1))$, $\text{Log}(Y^*)$, $\text{Log}(P^*_{cop}(-1))$, $\text{Log}(e{\cdot}P^*/P)(-1)$, $i^*(-1)$, D64

The long-run elasticity of real exports with respect to world demand is constrained to one; the constraint was not rejected by the data. In accordance with other studies, our empirical results indicate considerable export inertia. The elasticity with respect to the real exchange rate is only .308 in the short run, but in the long run it rises to about 1.6.

Imports - Real imports depend on output and on their relative price, described by the import deflator times one plus the tariff rate divided by the GDP deflator. Again we used a lagged adjustment specification:

$$(42) \quad \text{Log}(M) = \underset{(-5.302)}{-2.353} + \underset{(6.983)}{1.004} \, \text{Log}(Y) - \underset{(-4.669)}{0.209} \, \text{Log}[e{\cdot}P^*_M(1+t)/P]$$

$$+ \underset{(2.346)}{0.198} \, \text{Log}(M(-1)) + \underset{(4.992)}{0.185} \, \text{D7781}$$

$$R^2 = 0.9577 \quad DW = 2.008 \quad h = -0.373$$
$$\text{Adj-}R^2 = 0.9500 \quad F = 124.42$$

Sample: 1961-87
2SLS; Instruments = $\text{Log}(M(-1))$, $\text{Log}(Y(-1))$, $\text{Log}(e{\cdot}P^*_M(1+t)/P)(-1)$, $\text{Log}(P^*_{cop})$, $\text{Log}[e{\cdot}PFn/P](-1)$, D7781

The estimated long-run elasticity of imports with respect to real GDP is about 1.2. The restriction that it be equal to one is not accepted by the data (t-statistic=2.7). In turn, the long-run relative price elasticity is about 0.25.

Aggregate supply - As noted above, the inverse supply schedule (9') can be viewed as the price equation of the model, with prices determined as a markup over variable cost, which in turn consists of wages and the cost of imported materials, and with the markup rate allowed to vary with the degree of capacity utilization. The selected specification imposes homogeneity of degree zero in nominal prices; thus the equation is written in terms of relative prices[40]:

$$(43) \quad Log(P/W) = \begin{array}{c} - \\ \end{array} \begin{array}{c} 0.627 \\ (-1.059) \end{array} + \begin{array}{c} 0.416 \\ (1.726) \end{array} Log(Y(-1)/YP(-1))$$

$$+ \begin{array}{c} 0.630 \\ (3.538) \end{array} Log(e \cdot PFm/P) - \begin{array}{c} 0.0214 \\ (-5.619) \end{array} Trend + \begin{array}{c} 1.630 \\ (---) \end{array} ln(1+r)$$

$$+ \begin{array}{c} 0.081 \\ (2.073) \end{array} D6465$$

$$R^2 = 0.9379 \quad DW = 2.20$$
$$Adj-R^2 = 0.9192 \quad F = 50.30$$
$$Sample: 1961-87$$

instruments = Log[Y/YP](-1), Log[e·PFm/P](-1), Log(P^*_{cop}),
Trend, ln(1+r), D6465

Here r denotes the indirect tax rate, whose coefficient was constrained to reflect full pass-through of indirect taxes (the constraint was not rejected by the data). Notice that the estimated equation can be rewritten

$$(43)' \quad lnP = ln(1+r) + .613 \ lnW + .387 \ ln(e \cdot PFm) + .255 \ ln(Y(-1)/YP(-1)) + \ldots$$

so that the cost share of labor is about 60%, and that of materials is 40%.

Our results have two important implications. First, changes in nominal input prices are immediately passed on to goods prices, without any adjustment lags. Second, demand pressure is reflected in prices only after a one-period lag; hence, given input prices, final goods prices are unaffected by output changes in the short run -- which, as we discuss below, has important consequences for the short-run inflation-output tradeoff.

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[40] We experimented with different dynamic specifications, to allow for some inertia in the adjustment of prices to nominal production costs; however, we were unable to identify any such effect.

The labor market

Employment - Employment is determined by labor demand, which, according to (12), is related to real output and to the real wage. Preliminary experiments showed that the dynamics were adequately captured by an error correction specification:

$$(44) \quad \Delta \text{Log } L = \underset{(2.584)}{0.184} + \underset{(2.446)}{0.222} \Delta \text{Log } Y - \underset{(-2.343)}{0.070} \text{Log}(L(-1)/Y(-1))$$

$$- \underset{(-2.157)}{0.050} \text{Log}(W(-1)/P(-1)) - \underset{(-5.287)}{0.075} D74\text{-}6,82\text{-}3 + \underset{(4.956)}{0.043} D8487$$

$$R^2 = 0.924 \quad DW = 2.369$$
$$\text{Adj-}R^2 = 0.902$$
$$\text{Sample: } 1962\text{-}87$$

2SLS; instruments $= \Delta \text{Log } Y(-1), \text{Log}[L(-1)/Y(-1)],$
$\text{Log}(e \cdot PFm/P)(-1), \text{Log}[W(-1)/P(-1)], i^*, \text{Dummies}$

The estimated short-run response of employment to output is only _bout .2; however, the long run elasticity is constrained to unity; the constraint was not rejected by the data. The long-run real wage elasticity (which can be interpreted as the elasticity of substitution) is about .7, although not significantly different from one.

Wages - As described earlier, the evolution of average nominal wages is related to that of consumer prices (summarized by the consumption deflator) and minimum wages, and to the unemployment rate. Attempts to introduce both current and past inflation along with minimum wage growth as explanatory variables proved unsuccessful due to the strong collinearity between one-period lagged inflation and current minimum wage growth -- which probably reflects the existence of formal or informal (partial) minimum wage indexation to past inflation in some portions of the sample. Faced with the two options of keeping either minimum wages or past inflation as regressors, we chose the former alternative, in order to retain the ability to explore the effects of minimum wage policies in the simulation model.

A first-difference specification along the lines of a Phillips curve proved adequate:.

$$(45) \quad \Delta Log\ W = \underset{(4.452)}{0.088} - \underset{(-2.051)}{0.239}\ U + \underset{(3.547)}{0.492}\ \Delta LogPc + \underset{(3.418)}{0.462}\ \Delta LogWmin$$

$$- \underset{(-3.071)}{0.133}\ D64 - \underset{(-5.705)}{0.417}\ D73 + \underset{(4.824)}{0.224}\ D76$$

$$R^2 = 0.9922 \quad DW = 2.131$$
$$Adj\text{-}R^2 = 0.9898$$
Sample: 1963-87

2SLS; instruments = $\Delta Log\ P_c(-1)$, $\Delta LogP_c(-2)$, $\Delta logWmin(-1)$, $U(-1)$, $Log(e \cdot PFm/P)(-1)$, Dummies

Since minimum wage growth was found to be strongly dependent on inflation, it is not used as an instrument in the estimation[41]. One feature of the estimated equation which is worth noting is that the constraint that the inflation and minimum wage coefficients sum to one is not accepted by the data. This has the important consequence that a permanent increase in inflation coupled with a nominal minimum wage increase such the real minimum wage is unchanged, will cause a decline (although a very small one) in the real average wage.

By excluding lagged inflation from the estimated wage equation, it may seem that we are eliminating one potentially important source of inertia in the wage-price system. However, what our empirical results really imply is that in the sample the observed wage inertia was largely due to inertia in the

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[41] An auxiliary regression of minimum wage growth on current and past inflation yields the following results:

$$\Delta Log\ Wmin = \underset{(-3.141)}{-0.043} + \underset{(13\ 794)}{0.696}\ \Delta LogPc + \underset{(13.794)}{0.304}\ \Delta LogPc(-1)$$

$$R^2 = 0.9792 \quad DW = 1.904$$
$$Adj\text{-}R^2 = 0.9775$$
Sample: 1963-87

2SLS; instruments = $\Delta Log\ P_c(-1)$, $\Delta LogP_c(-2)$, $\Delta logWmin(-1)$, $U(-1)$, $Log(e \cdot PFm/P)(-1)$, Dummies

adjustment of the minimum wage to inflation.

Assets markets

Money market - Asset equilibrium is summarized in (16') by an interest rate equation, which can be viewed as the money market equilibrium condition inverted to solve for the nominal interest rate. The latter is related to the depreciation-adjusted foreign interest rate, the real money stock (measured by M1 divided by the GDP deflator), and real output. We assume rational expectations and replace anticipated depreciation with its actual value, which is then treated as an endogenous variable:

$$(47) \quad i = \begin{array}{c} 0.020 \\ (0.296) \end{array} + \begin{array}{c} 0.075 \ (i^*+\dot{e}) \\ (3.528) \end{array} - \begin{array}{c} 0.578 \ Log(H/P) \\ (-4.552) \end{array}$$

$$+ \begin{array}{c} 0.578 \ Log(Y) \\ (4.552) \end{array} + \begin{array}{c} 1.691 \ D7576 \\ (11.483) \end{array}$$

$$R^2 = 0.9194 \quad DW = 1.968$$
$$Adj\text{-}R^2 = 0.9088 \quad F = 87.43$$
$$Sample: 1961\text{-}87$$

2SLS; instruments = $(i^*+\dot{e})(-1)$, $Log[H/P](-1)$, $Log(Y(-1))$, Trend, $Log(P^*_{cop})$, $Log(P^*_{cop}(-1))$, i^*, $Log(Y^*)$, D7576

Viewing the equation as the money market equilibrium schedule, it can be seen that we have imposed a unit elasticity of real money demand with respect to output; the constraint was tested and not rejected by the data. The semielasticities with respect to the domestic and foreign interest rates are about 1.73 and .13, respectively; the latter result is similar to that found by Edwards (1985) and Edwards and Kahn (1986).

Tobin's Q - As in Solimano (1989), Tobin's Q is assumed in (5) to depend on the degree of capacity utilization and on the ex-ante real interest rate. Experiments including the relative price of investment goods (measured by the investment deflator relative to the GDP deflator) were unsuccessful. Also, all our specifications performed very poorly when estimated on the full sample, probably due to the substantial changes experienced by Chilean financial

markets in the past two decades. We were forced to restrict the estimation to the post-Allende period; due to the scarcity of degrees of freedom, the results must be viewed as highly tentative.

(47)   Log(Q) =   1.314   +   5.188 Log(Y/YP)   -   1.015 r
                       (14.159)   (8.957)   (-2.918)

                    + 0.465 D8082
                       (4.525)

          R^2 = 0.9608 DW = 2.144
      Adj-R^2 = 0.94397F = 57.158
      Sample: 1976-86

    2SLS; instruments = Log[Y/YP](-1), r(-2), Log(Pcur), i*,
                        Log(Y^*(-1)), d8082

As before, we used the assumption of rational expectations to replace the ex-ante real interest rate with its ex-post counterpart. The results indicate that capacity utilization has a strong positive effect on Q, in accordance with the results obtained by Solimano. We also find a strong adverse effect of the real interest rate.

4.3   Some Implications

As we noted above, one feature of our empirical results which is worth emphasizing is the implied shape of the short-run aggregate supply schedule. This can be most easily illustrated by replacing equations (44) and (45) into (43), using the approximation U = (L'-L)/L' ≈ ln(L'/L), and assuming all foreign prices grow at the same rate. After some manipulations, we obtain the following semi-reduced form equation for inflation:

(48) π = .40 ΔlnWmin + .56 (Δlne + π^*) + .09 lnY + Z

where π is the domestic inflation rate (measured as ΔlnP), π^* is the foreign inflation rate (again measured as ΔlnP*), and Z is a linear combination of tax rates and predetermined variables. Thus, in the short run inflation depends on the rate of growth of the minimum wage and on the rate of change of the prices of foreign goods in domestic currency -- in turn given by the rate of

nominal depreciation plus the foreign inflation rate -- and also on the level of economic activity.

The important fact is that the coefficient on lnY is very small -- in other words, given the rate of growth of the minimum wage, the rate of nominal depreciation, and world inflation, a reduction in inflation in the short run can only be achieved at the cost of a **sharp** recession. More precisely, a ten percent decline in real output leads in the short run to a decline in inflation of less than one percent[42]. This result may help understand the developments in the Chilean economy in 1990, in which a sharp deceleration of economic activity has had only limited short-run success in bringing down inflation from the high levels that it had achieved as a result of the increase, in that year, of indirect taxes, minimum wages, and world oil prices.

Naturally, the precise form of the short-run inflation-output tradeoff depends, as we discussed before, on the policy rules according to which the minimum wage and the rate of nominal depreciation are determined. For example, if the nominal exchange rate is adjusted to keep the real exchange rate constant (i.e., Δlne $= \pi - \pi^*$), then inflation is given by:

$$\pi = .91 \, \Delta lnWmin + .20 \, lnY + k_1 \bullet Z$$

where k_1 is a constant. This has two interesting implications: first, the rate of inflation becomes very sensitive to changes in the nominal minimum wage. Second, the output cost of bringing down inflation becomes lower, although it still remains substantial: now a five percent decline in output is required to reduce inflation one percentage point. In other words, the aggregate supply schedule of the economy becomes steeper under the PPP rule.

5.   Out-of-sample Policy Simulations

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[42] It is apparent that equation (48) allows for an inflation-output tradeoff even in the long run, as the coefficients on the nominal minimum wage and on foreign prices fail to sum to one. This is due to our finding of non-neutrality in the nominal wage equation (44).

5.1   General Remarks

The empirical model was used to simulate the evolution of the Chilean economy under alternative assumptions about fiscal, exchange rate, and wage policies, as well as under different external conditions. The simulation scenarios were chosen to illustrate different aspects of the working of the model, and not necessarily because of their likelihood or realism.

In all the simulations, the external environment is exogenously given. This comprises the evolution of world demand Y^*, the foreign interest rate i^*, and the world prices of imports as well as those of copper and non-copper exports (P^*_M, P^*_{cop} and P^*, respectively). Real copper exports follow an exogenously given path. Similarly, profit remittances, net transfers from abroad and direct foreign investment are all exogenously projected in foreign currency terms. We also assume no debt conversions. The time path of the foreign debt stock is given exogenously, to reflect the limited availability of external financing. Finally, the interest rate on foreign debt is assumed to carry a 1 percent spread over LIBOR.

Among the fiscal variables, tariff rates are assumed to remain unchanged throughout the simulation period. In turn, the indirect tax rate also remains constant, after an initial increase in 1990 (see below). The items 'Other government revenues' and 'Other public expenditures' are assumed to remain constant as percentages of GDP. Copper revenues are endogenously determined, as we described above, although the volume of public copper production is exogenous. Real public investment grows at a constant rate throughout the simulation period. On the other hand, the public sector deficit is assumed to be entirely financed by foreign debt. No amortization on the Treasury note is paid after 1990.

This leaves as fiscal policy variables real public consumption and direct taxes. Because of the flexibility of the simulation model, their time paths can be either exogenously given (e.g., in terms of fixed real growth rates), or related to other endogenous variables according to appropriate policy rules (e.g., public consumption can be determined so as to achieve a

prescribed public savings/GDP ratio)[43]. Which of these alternatives is adopted depends on the specific simulation scenario under study.

The same applies to the remaining policy variables: the nominal exchange rate, the money stock, and the legal minimum wage. Their time path can also be specified either in the form of a given rate of growth, or according to a policy rule (e.g., a crawling peg for the nominal exchange rate).

In the monetary accounts, the money multiplier is assumed constant. Base money growth is specified exogenously, and foreign reserves are obtained from the Balance of Payments (as the aggregate foreign debt stock is exogenously projected). We also assume that the Central Bank's foreign debt stock remains constant; hence, its budget identity endogenously determines the time path of net credit (or, more accurately, net debt) to the private sector dc_{pr}.

To complete the simulation model, we must also specify the evolution of some other variables. These include the labor force, which is assumed to grow at a constant rate, and real inventory investment, which is assumed to remain constant as a ratio to real GDP throughout the simulation period.

Finally, it is important to note that in the simulations we assume static expectations for inflation and for nominal exchange depreciation. This has the advantage of enormously simplifying the solution of the model. Under rational expectations, it can be shown that in our model current endogenous variables would depend on the current and future anticipated values of all exogenous variables; thus the model would have to be solved using a 'multiple shooting' technique in order to find the convergent trajectory.

The model was simulated using 1989 as the base year. This introduces some complications, since 1989 was a 'boom' year -- particularly for investment and imports (and also non-copper exports), and also in terms of a spectacular increase in the accumulation of inventories. The boom could be

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[43] Of course, these degrees of freedom only exist for the near term. In the long run, the setting of the two variables has to satisfy the additional constraint of providing the primary budget balance required to avoid an explosive path for public debt, as we noted before. Since in the simulations below we are only concerned with the short to medium term, and since the simulated model is backward-looking, we need not concern ourselves with this problem here.

explained mainly by the stimulative monetary policies adopted in 1988, and perhaps also by anticipations of possible trade restrictions and/or of real depreciation.

To reflect the expected cooldown of the economy in 1990, we introduced a downward adjustment in the accumulation of inventories, which for the simulations is fixed at 0.3 percent of real GDP, down from 3.3 percent in 1989. This amounts to a once-and-for-all adverse shock to aggregate demand, which results in an economic slowdown in 1990; however, since in the empirical model some of the components of aggregate demand display substantial inertia (consumption, investment, exports), this may not eliminate completely the lagged effects of the 1989 boom.

In all the scenarios we assumed some monetary and fiscal adjustment in 1990. Direct taxes rise 1.5 percentage points of GDP in 1990, and the indirect tax rate rises 2 percent in the same year. Monetary policy is transitorily restrictive in those two years, with money growth proceeding at a constant rate thereafter. Similarly, the minimum wage is increased by 26 percent in 1990[44].

5.2   The simulation scenarios

Below we present the results of five simulation scenarios. The first one is a reference or 'base' scenario, which is mainly used as a benchmark for the purposes of comparison. The second and third scenarios simulate the effects of 'internal shocks': a fiscal expansion, and an increase in minimum wage growth, respectively. Finally, the fourth and fifth scenarios explore the effects of two adverse 'external shocks': a fall in copper prices, and an increase in oil prices. Although both represent terms-of-trade disturbances, the latter scenario adds to the picture the ingredients of a supply shock.

(i) The Base Scenario

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[44] This is the approximate equivalent in annual terms to the 40 percent increase that took place in May.

The base scenario represents a 'reference' case, and does not necessarily correspond to a 'most likely' scenario. Fiscal policy is assumed moderately restrictive: after the tax adjustment described above, direct taxes remain constant as a percentage of GDP, while real public consumption and investment rise at the constant rates of 1 and 4 percent per year, respectively[45].

The assumed time path of copper prices deserves some attention. The world price is assumed to fall about 15 percent in 1990, followed by an additional 10 percent fall in 1991. In 1992 it stays at this new value, and thereafter it grows at the assumed rate of world inflation (which throughout equals 5 percent). This amounts to a total fall of about 34 percent in the relative price of copper in terms of other foreign goods over the simulation period, from the very high levels achieved in 1989-90.

We also assume that the nominal exchange rate follows a 'crawling peg', to achieve a modest 1 percent real depreciation per annum. Finally, wage policy is summarized by the rate of change of the nominal minimum wage, which slows down gradually after 1990 (when it equals 26 percent), to reach 22 percent in 1991 and 20 percent per annum in 1992-95.

(ii) Internal shocks

Fiscal expansion

In this scenario we explore the consequences of a balanced-budget expansion in public consumption. In 1990-92 real public consumption rises by one percentage point of GDP per annum, relative to the base scenario; it then remains constant as a share of GDP. The expansion is entirely financed by a direct tax increase, so as to leave the public deficit/GDP ratio unchanged from its level in the base scenario. All other exogenous variables and policy rules are the same as in the base scenario, so that, in particular, the path of the real exchange rate is unchanged (by appropriately adjusting the nominal

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[45] This expansion of public consumption may seem too slow at first sight; however, it represents an expansionary change when compared with the recent trend, as public consumption declined in real terms in 1985-89.

rate of depreciation).

Minimum Wage Increase

This scenario investigates the consequences of a faster rate of minimum wage growth. We raise the latter to 25 percent in 1991-95; recall that in the base scenario the minimum wage rose by 22 percent in 1991 and at a constant rate of 20 percent in 1992-95. To avoid an excessive increase in inflation, and also to explore the impact of the higher wage growth on the real exchange rate, we assume the same nominal depreciation as in the base scenario. All other exogenous variables and policy rules are identical to those in the base scenario. In particular, it is important to emphasize that the time path of public consumption is left unchanged, so that we are implicitly assuming that the wage policy change refers mainly to the private sector's wage.

(iii) External Shocks

Fall in copper prices

This scenario is based on more pessimistic assumptions about the trajectory of the world price of copper. The latter is the same as in the base scenario for 1990, but in 1991 it is assumed to fall by 20 percent (compared with 10 percent in the base scenario), and in 1992 by a further 10 percent (it was unchanged in the base scenario). It then stays constant in 1993 at this level, and in 1994-95 rises at the world rate of inflation (5 percent). Overall, the assumed trajectory represents a 50 percent decline in the relative price of copper in terms of other foreign goods, about 15 percent more than in the base scenario.

We also assume that the adverse effect on public finances of the fall in copper revenues is partially offset by fiscal adjustment. In particular, public consumption declines with respect to the base scenario by half of the loss in copper revenues, so that only 50 percent of the latter is reflected in a fiscal imbalance. The remaining exogenous variables and policy rules are the same as in the base case.

Oil shock

In the final scenario we investigate the consequences of a permanent oil shock. We assume that the price of oil rises 13.3 percent[46] in 1990, and an additional 12 percent in 1991; thereafter, it rises at the world rate of inflation. In the long run, this amounts to about a 15 percent increase in the relative price of oil in terms of other foreign goods.

Oil is implicitly included in the model as part of the composite import commodity and also in the imported intermediate input. Thus, the oil price increase is reflected in an increase in the foreign-currency prices of aggregate imports and of imported materials. The former rises by a percentage determined by the share of oil imports in total imports, times the oil price increase. The latter rises by the share of oil in materials imports times the oil price increase.

Finally, to isolate the macroeconomic impact of the oil price shock, we assume that no macroeconomic adjustment measures are taken; in particular, the rate of nominal depreciation, and the time paths of the fiscal policy variables, are the same as in the base scenario. The remaining exogenous variables and policy rules are also unchanged.

5.3 Simulation Results

Base Scenario

The results of the base scenario are summarized in Table 5.1. The combined effect of the monetary and fiscal adjustment measures, along with the assumed fall in the demand for inventories, result in a drastic slowdown of the economy in 1990. Real GDP growth falls to 3.3 percent, while inflation rises to almost 30 percent due to the combined effect of the minimum wage increase, the accelerated rate of nominal depreciation required to maintain the real exchange rate, and also as a consequence of the 1989 boom (see equation (4.7)' above). Despite the slowdown, the current account balance

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[46] That is, a 40 percent increase during the last four months of the year, which amounts to 13.3 percent in annual terms.

shows a substantial deterioration, .rtly due to the assumed fall in copper prices. The budget surplus of the nunfinancial public sector also declines, while the inflationary push and the assumed real depreciation lead to a reduction in the real wage despite the increase in the minimum wage.

After the 1990 slowdown, there is a recovery. This is due to the combined effect of the inertia of aggregate demand -- in particular, exports and private investment are still growing at high rates --, to the absence of further contractionary tax increases, and also to the sustained real depreciation. The rate of growth of real GDP rises to 5.8 percent in 1991, and then declines gradually to stabilize around 4.8 percent, while inflation decelerates in 1991 -- due to the economic slowdown of 1990 -- and then remains around 17 percent. The current account deficit also narrows, to reach 4.3 percent in 1995. The public surplus is still falling in 1991-92 along with real copper prices, but starts to rise again when they bottom out; it reaches about 2.5 percent of GDP in 1994-95. In turn, the real wage rises by six percentage points over the simulation period, despite the assumed real depreciation.

Fiscal expansion

The results of this simulation can be more easily understood with the help of Figure 2. Assume that in the base scenario the economy started from the situation depicted by point A, at the intersection of the SS and DD schedules; hence, the CA schedule passing through point A corresponds to the current account deficit achieved in the base scenario. Now there is a fiscal expansion, and hence the DD schedule shifts to the right, to a position such as D'D' in the figure. If this were all, then the result would be an output expansion and a real appreciation relative to the base scenario, together with a current account deterioration; that is, we would reach a point such as B. However, since we have assumed that nominal depreciation is raised so as to keep the same real exchange rate path as in the base scenario, point B cannot be the final outcome; rather, the additional depreciation combined with

unchanged minimum wage growth leads to a fall in real wages (see equation (22) above)[47], that shifts the supply schedule to S'S'; thus, the final equilibrium must be achieved at point C, where the real exchange rate is unchanged at its initial value, and the output expansion is further increased to y_1.

The numerical results of the simulation appear in Table 5.2. The fiscal stimulus, which develops in 1990-92, raises GDP growth in those years by about 1.5 percentage points above its level in the base scenario; as the fiscal impulse comes to a halt in 1993-95, the economy slows down, with growth falling below its level in the base scenario; GDP growth eventually stabilizes at 4.3 percent. The additional demand pressure causes also a transitory inflation increase relative to the base scenario, which disappears in the long run as real growth slows down. The increased growth is reflected in the current account deficit, which shows a persistent deterioration relative to the base scenario. The external imbalance averages about 7 percent of GDP over the simulation period, and peaks at 7.7 percent in 1994; it eventually starts declining in 1995.

By construction, the real exchange rate and the public deficit remain unchanged at their values in the base scenario. In contrast, the additional inflation - given the path of the nominal minimum wage - leads to slower real wage growth, so that in 1995 the real wage is 1 percent lower than it was in the base scenario.

Minimum wage increase

The effects of the minimum wage increase are illustrated in Figure 3. With the given rate of nominal depreciation, the immediate consequence is an increase in the real wage (see (22) above), that shifts the SS schedule to the left. The result is a real appreciation, an output contraction, and a current

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[47] The additional depreciation with unchanged monetary growth also leads to a reduction in the real money stock (see (21) above), and hence to a contractionary shift of the DD schedule. We have ignored this to avoid cluttering the figure. The net result still is a rightward shift of the DD schedule.

account deterioration relative to the base scenario.

The numerical results appear in Table 5.3. They show a reduction in real GDP growth, which now falls after the transitory recovery of 1991; it eventually stabilizes at 3.7 percent in 1994-95. Inflation shows a parallel increase over its level in the base scenario; it averages about 18.5 percent at the end of the simulation period.

The real exchange rate stays now practically unchanged from its level in 1990; this amounts to a real appreciation of more than 6 percent in 1995 relative to the base scenario -- which is also the extent of the real wage increase in 1995. This leads to a significant current account deterioration despite the growth slowdown, with the external deficit now reaching 5.5 percent of GDP in 1995, compared with 4.3 in the base scenario. This is partly due to a worsening of the fiscal balance, which results mainly from the reduced real copper revenues that follow from the real appreciation; the fiscal surplus is now reduced to 1.9 percent of GDP in 1995, compared to 2.6 percent in the base scenario.

Copper price fall

As in the previous scenarios, we can use Figure 4 to illustrate the qualitative consequences of the copper price fall. The terms of trade deterioration relative to the base scenario shifts the CA schedule to the left, as now a more depreciated real exchange rate is required to keep the same current account deficit as in the base scenario. However, under our assumption of partial fiscal adjustment the aggregate demand schedule also shifts to the left to D'D', reversing part (but not all) of the external accounts deterioration through a fall in output and a real depreciation; this would take the economy to a point such as B in the figure. But to this we must add the reduction in nominal depreciation that is required to keep the real exchange rate unchanged, as assumed; together with the unchanged wage behavior, this implies a real wage increase that shifts the SS schedule to the

left, reducing output even further and preventing the real depreciation[48].
The final equilibrium would be at point C.

The numerical results of th simulation are summarized in Table 5.4.
The fall in copper prices forces a fiscal retrenchment starting in 1991, that
causes a persistent fall in GDP growth relative to the base scenario; the
growth decline averages about 0.8 percentage points in 1991-95. As public
expenditure is reduced, so is the pressure of aggregate demand, and hence
inflation shows a moderate reduction relative to the reference scenario --
which is also reflected in a somewhat higher real wage.

Since the fiscal adjustment does not fully offset the reduction in
copper revenues, the public surplus declines; by 1992, it has been almost
entirely wiped out. In 1995, the deterioration in public finances relative to
the base scenario amounts to almost 1 percent of GDP. The current account also
deteriorates; the external deficit now exceeds 7 percent of GDP in 1991-94,
and in 1995 it is more than two points higher than in the base scenario.

Oil price increase

The diagrammatics of this scenario are depicted in Figure 5. As in the
case of the copper price fall, the adverse terms of trade shock shifts the CA
schedule up and to the left, to CA'CA'. However, the oil shock is also an
adverse _supply_ shock, that shifts the SS schedule to the left, leading to a
real appreciation, a fall in output, and a further current account
deterioration. The final equilibrium is at a point such as B.

The numerical results for this simulation are summarized in Table 5.5.
The oil shock, which takes place in 1990-91, leads to an immediate slowdown in
economic activity: in 1990, real GDP growth falls by about 0.5 percent
relative to the base scenario, and by one percentage point in 1991-92.
Inflation rises in 1990-91 above its level in the reference scenario, but then
declines due to the economic deceleration; in 1995 it equals 17 percent,

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[48] Symmetrically with the fiscal expansion scenario, the reduced nominal
depreciation together with unchanged money growth raises real balances,
moderating the contractionary shift of the DD schedule.

compared with 17.4 in the base scenario. As in the wage increase scenario, higher inflation. combined with unchanged nominal depreciation lead initially to a real appreciation, that is later partially reversed. However, in 1995 the real exchange rate has appreciated by over 4 percent relative to the reference scenario.

As a consequence of the terms of trade shock and of the real appreciation, the current account suffers a sharp deterioration, with the deficit peaking at 6.9 percent of GDP in 1991, and remaining above 6 percent throughout the simulation period. As before, the real appreciation has also the effect of reducing real copper revenues, and the fiscal surplus declines relative to the base scenario. The real wage also declines, due to the erosion caused by increased inflation with an unchanged minimum wage growth, and to the additional unemployment (relative to the base scenario) generated by the reduction in growth.

6. Final Remarks

In this paper we have constructed, estimated, and simulated a macroeconometric model for Chile. The model allows for the interaction of aggregate supply and demand factors in the determination of the key macroeconomic variables, such as real output and employment,.inflation, the real exchange rate and the real wage, and the current account balance. It ensures the full consistency of the different macro aggregates, by imposing the relevant budget constraints on the fiscal sector, the Central Bank, and the Balance of Payments. To this consistent framework, the model adds a set of behavioral equations with sound analytical foundations.Thus, the model provides a potentially useful tool for the design and evaluation of macroeconomic policy.

The behavioral equations were empirically estimated using annual data for Chile. The results are in general quite encouraging: the model tracks the observed values of the endogenous variables with a high degree of accuracy, and its qualitative properties are well in line with the predictions of

macroeconomic theory.

The model was simulated to explore the effects on the evolution of the economy of different internal and external disturbances: a balanced-budget fiscal expansion, a policy of increased minimum wage growth, a fall in world copper prices, and an oil price shock. These simulations attempt to illustrate the effects of domestic policies and external shocks that shape the current policy discussion in Chile.

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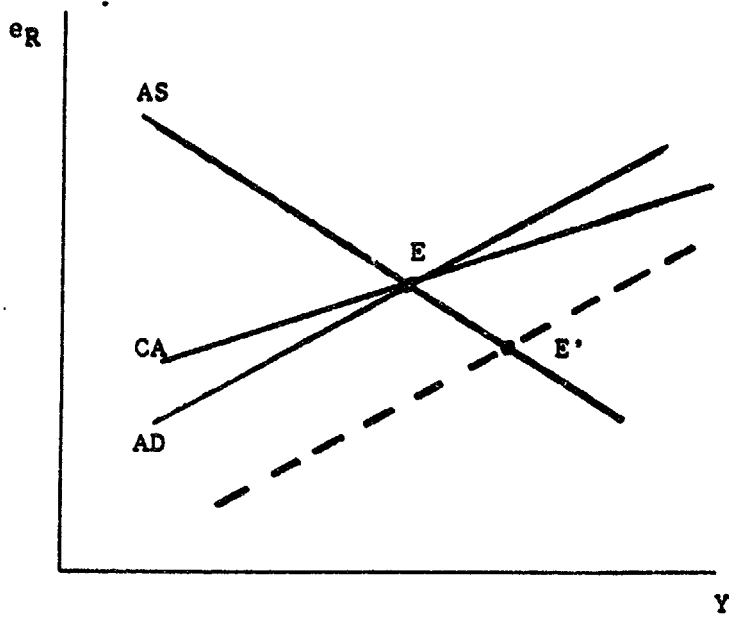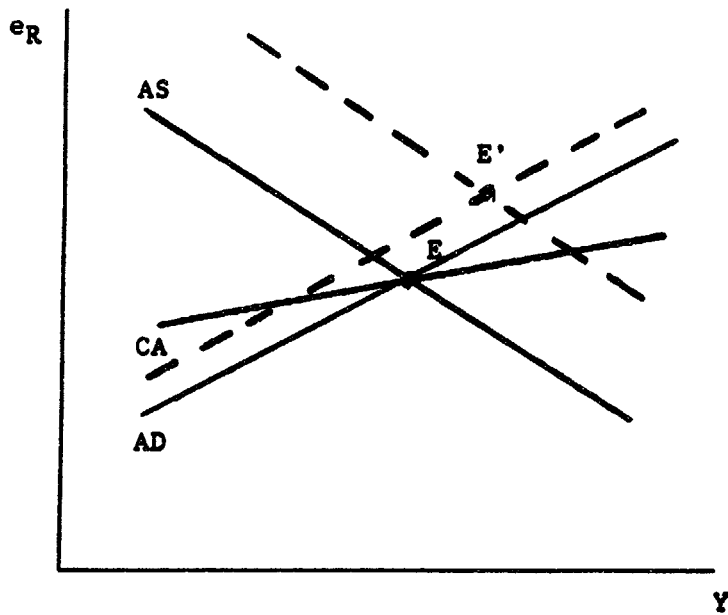
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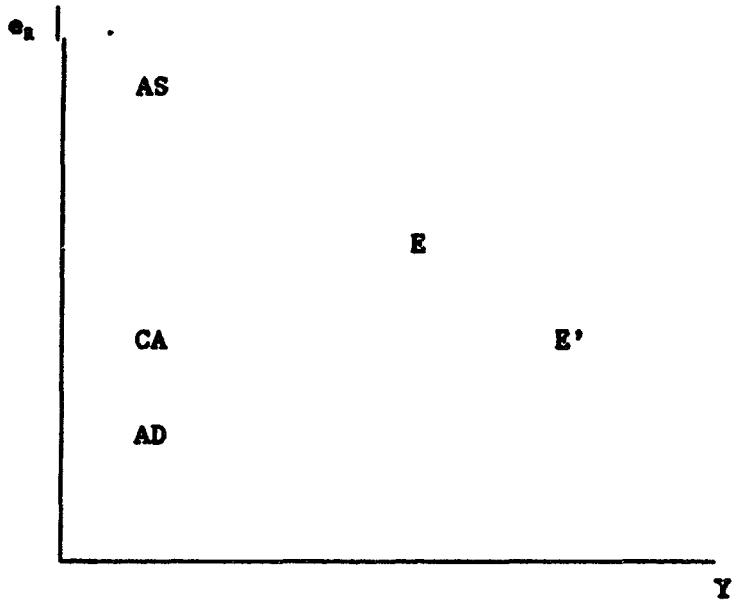
(a) A Fiscal Expansion
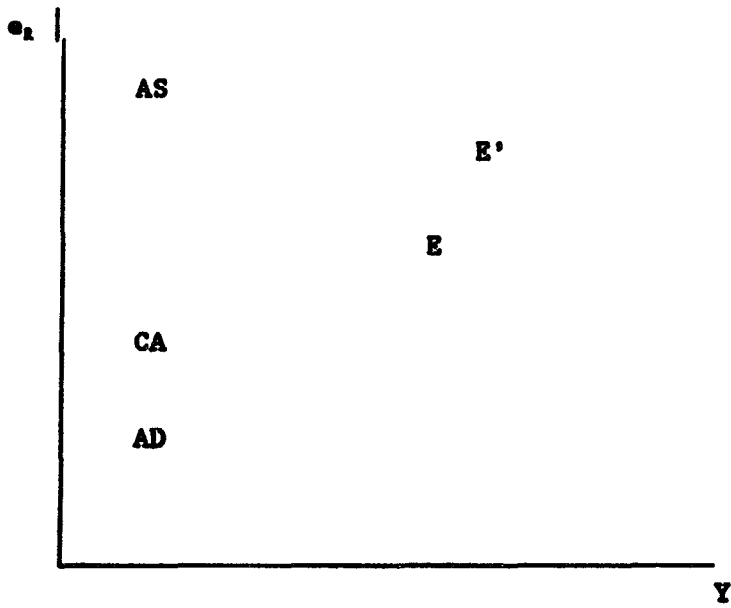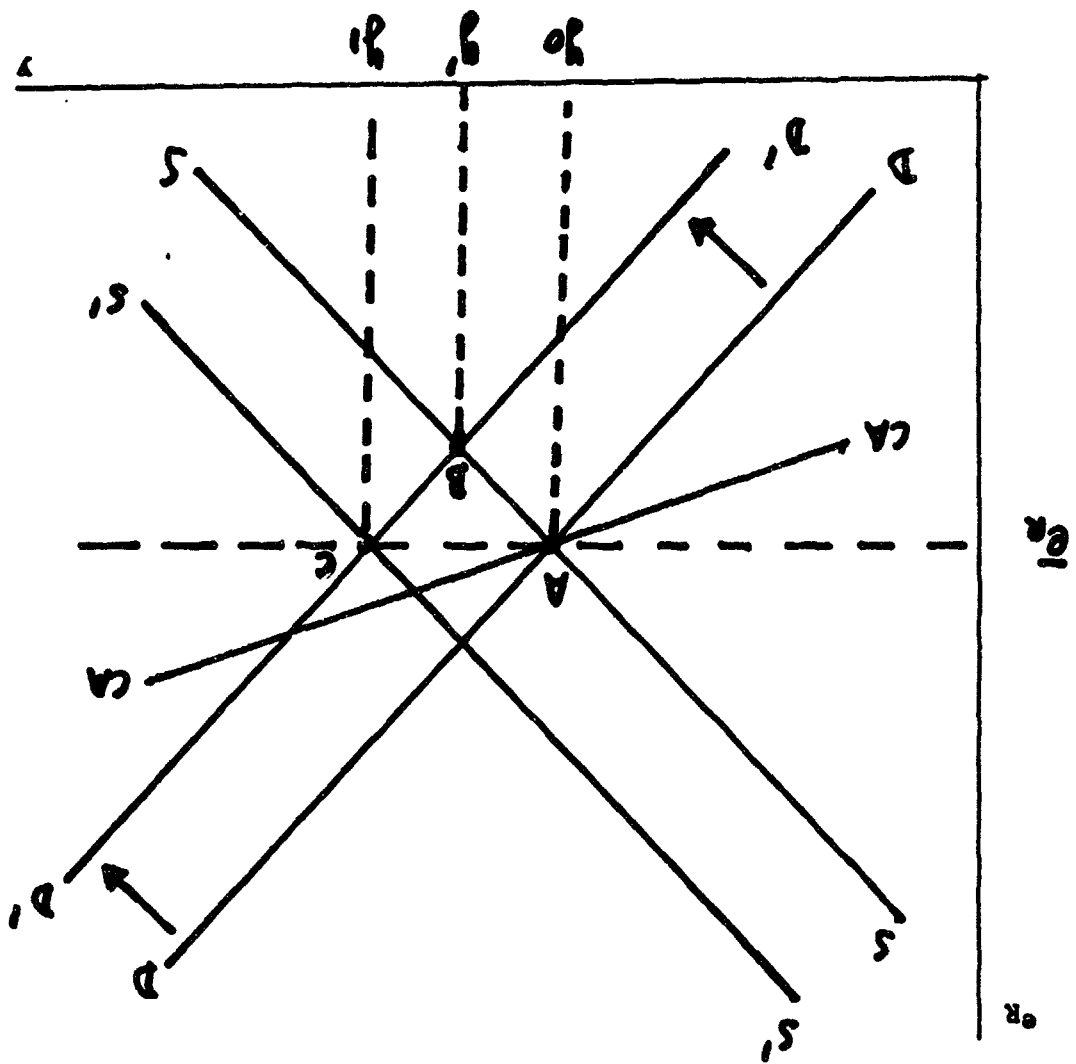

(b) Devaluation

Figure 1

(a) A Fiscal Expansion

(b) Devaluation

Table 5.1

Simulation results 1990-95:   Base Scenario

Year	Real GDP Growth	Inflation Rate[a]	Curr. Account Deficit[b]	Nfps Deficit[c]	Real Exch. Rate[d]	Real Wage[e]
1989[f]	10.0	13.3	3.0	-2.9	100.0	100.0
1990	3.3	29.6	5.3	-2.5	101.0	97.8
1991	5.8	15.3	5.5	-2.0	102.0	100.2
1992	5.6	16.4	5.4	-1.9	103.0	101.8
1993	5.3	17.0	5.0	-2.2	104.1	103.4
1994	4.7	17.3	5.3	-2.4	105.1	105.0
1995	4.8	17.4	4.3	-2.6	106.2	106.9

Notes: a - GDP Deflator
b - As percentage of GDP
c - Deficit of the non-financial public sector, as percentage of GDP
d - Increase means depreciation
e - In terms of the consumption deflator
f - Actual values

Table 5.2

Simulation results 1990-95: Fiscal Expansion

Year	Real GDP Growth	Inflation Rate[a]	Curr. Account Deficit[b]	Nfps Deficit[c]	Real Exch. Rate[d]	Real Wage[e]
1989[f]	10.0	13.3	3.0	-2.9	100.0	100.0
1990	4.7	29.8	5.7	-2.5	101.0	97.8
1991	7.5	16.9	6.6	-2.0	102.0	99.7
1992	7.1	18.4	7.3	-1.9	103.0	100.6
1993	5.3	18.7	7.2	-2.2	104.1	101.7
1994	4.3	17.6	7.7	-2.4	105.1	103.6
1995	4.3	17.3	6.9	-2.6	106.2	105.9

Notes: a - GDP Deflator
b - As percentage of GDP
c - Deficit of the non-financial public sector, as percentage of GDP
d - Increase means depreciation
e - In terms of the consumption deflator
f - Actual values

Figure 3
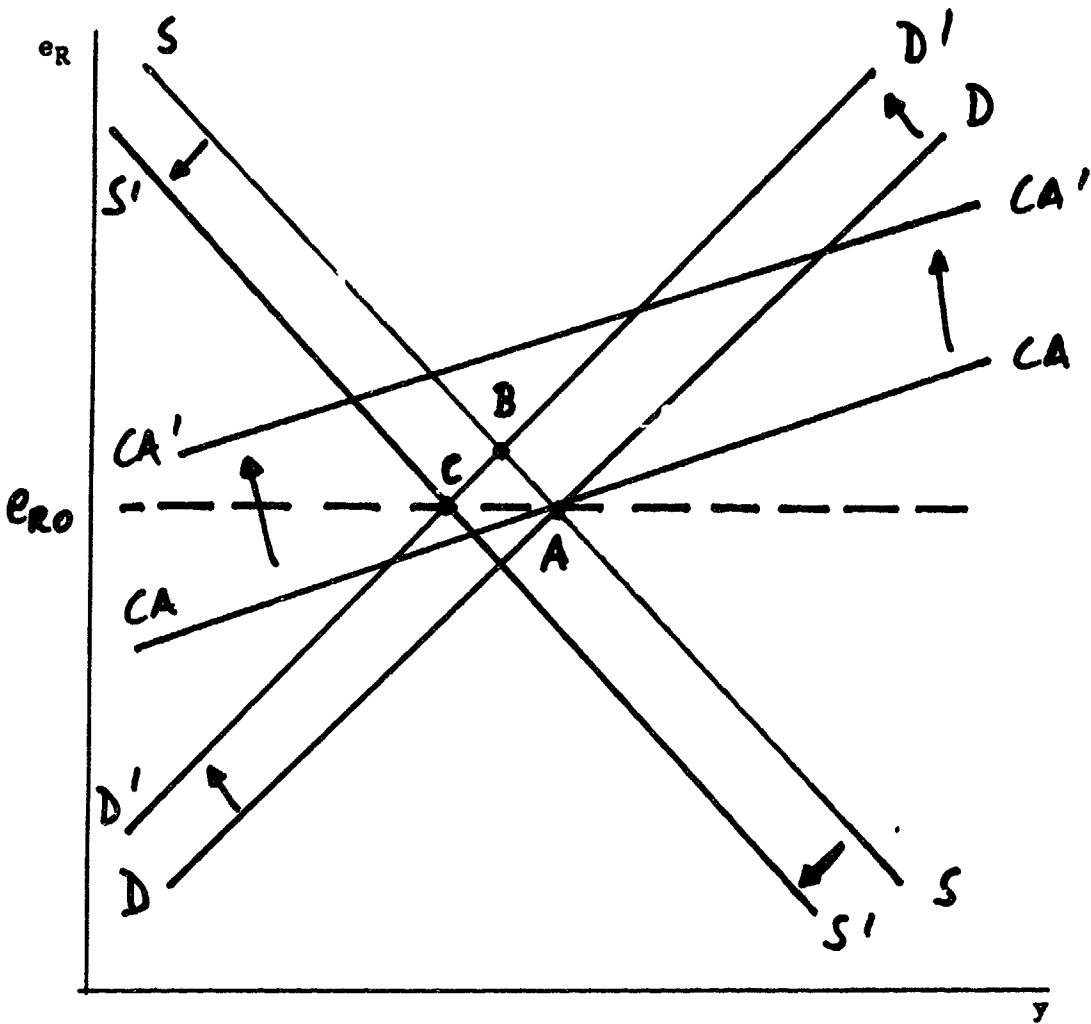
The 'minimum wage increase' scenario
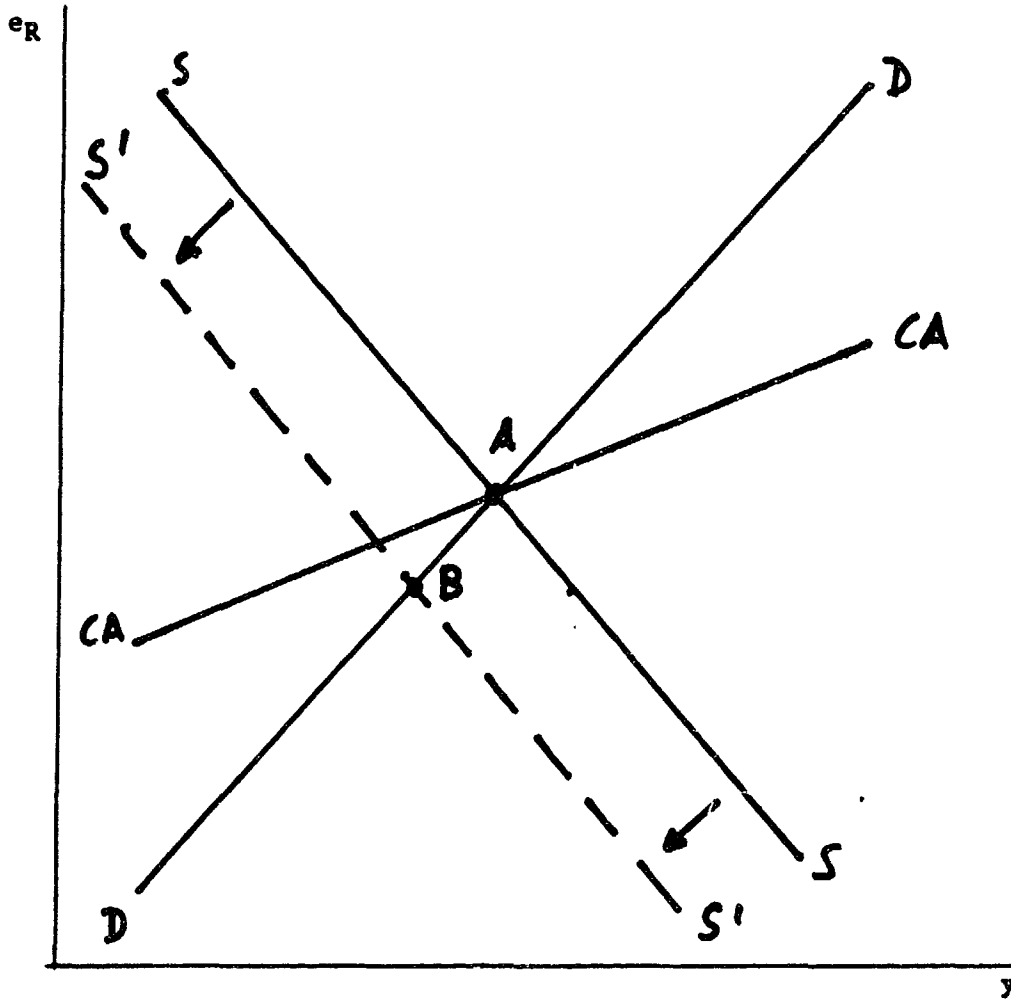
Table 5.3

Simulation results 1990-95:   Minimum Wage Increase

Year	Real GDP Growth	Inflation Rate[a]	Curr. Account Deficit[b]	Nfps Deficit[c]	Real Exch. Rate[d]	Real Wage[e]
1989[f]	10.0	13.3	3.0	-2.9	100.0	100.0
1990	3.3	29.6	5.3	-2.5	101.0	97.8
1991	5.6	16.4	5.6	-1.9	101.1	100.8
1992	5.1	18.1	5.7	-1.6	100.6	103.4
1993	4.5	18.6	5.6	-1.7	100.2	106.1
1994	3.7	18.7	6.2	-1.8	100.0	108.9
1995	3.7	18.6	5.5	-1.9	99.9	112.0

Notes: a - GDP Deflator
         b - As percentage of GDP
         c - Deficit of the non-financial public sector, as percentage of GDP
         d - Increase means depreciation
   e - In terms of the consumption deflator
         f - Actual values

Figure 4

The 'copper price fall' scenario

Table 5.4

Simulation results 1990-95: Copper price fall

Year	Real GDP Growth	Inflation Rate[a]	Curr. Account Deficit[b]	Nfps Deficit[c]	Real Exch. Rate[d]	Real Wage[e]
1989[f]	10.0	13.3	3.0	-2.9	100.0	100.0
1990	3.3	29.6	5.3	-2.5	101.0	97.8
1991	5.0	15.2	6.5	-1.4	102.0	100.2
1992	4.8	15.5	7.1	-0.1	103.0	102.1
1993	4.7	16.0	7.0	-1.0	104.1	104.0
1994	4.3	16.5	7.4	-1.2	105.1	105.8
1995	4.5	16.7	6.4	-1.5	106.2	107.7

Notes:　a - GDP Deflator
　　　　b - As percentage of GDP
　　　　c - Deficit of the non-financial public sector, as percentage of GDP
　　　　d - Increase means depreciation
　　　　e - In terms of the consumption deflator
　　　　f - Actual values

Figure 5

The 'oil shock' scenario
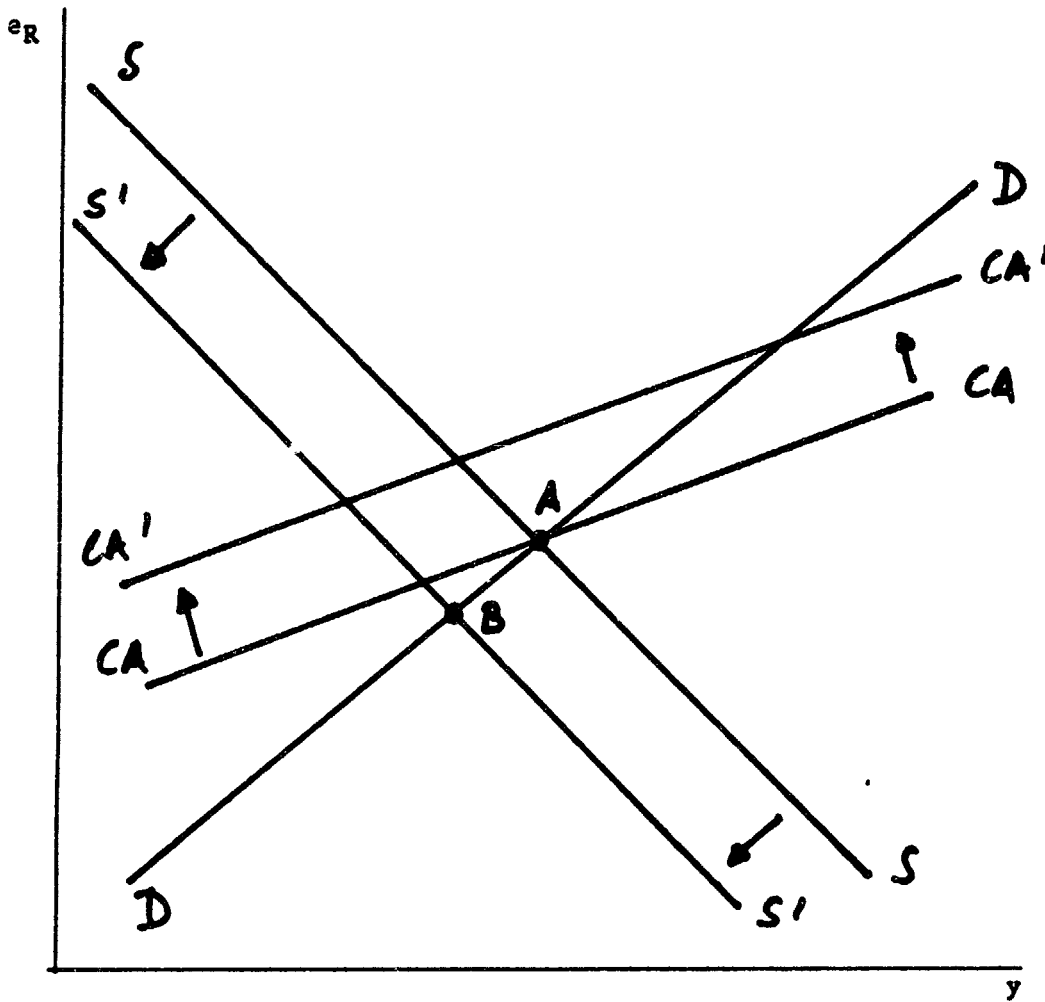
Table 5.5

Simulation results 1990-95: Oil Shock

Year	Real GDP Growth	Inflation Rate[a]	Curr. Account Deficit[b]	Nfps Deficit[c]	Real Exch. Rate[d]	Real Wage[e]
1989[f]	10.0	13.3	3.0	-2.9	100.0	100.0
1990	2.9	33.7	5.8	-2.1	97.9	96.1
1991	4.8	18.1	6.7	-1.3	96.5	97.2
1992	4.5	15.9	6.9	-1.2	97.9	98.8
1993	4.3	16.5	6.6	-1.5	99.2	100.4
1994	3.9	16.9	6.9	-1.7	100.6	102.1
1995	4.1	17.0	6.0	-1.9	101.9	103.8

Notes: a - GDP Deflator
   b - As percentage of GDP
   c - Deficit of the non-financial public sector, as percentage of GDP
   d - Increase means depreciation
   e - In terms of the consumption deflator
   f - Actual values

SIMULATION RESULTS 1990-95
REAL GDP GROWTH
DOMESTIC SHOCKS

REAL GDP GROWTH

FISCAL EXPANSION

BASE SCENARIO

WAGE INCREASE

YEAR
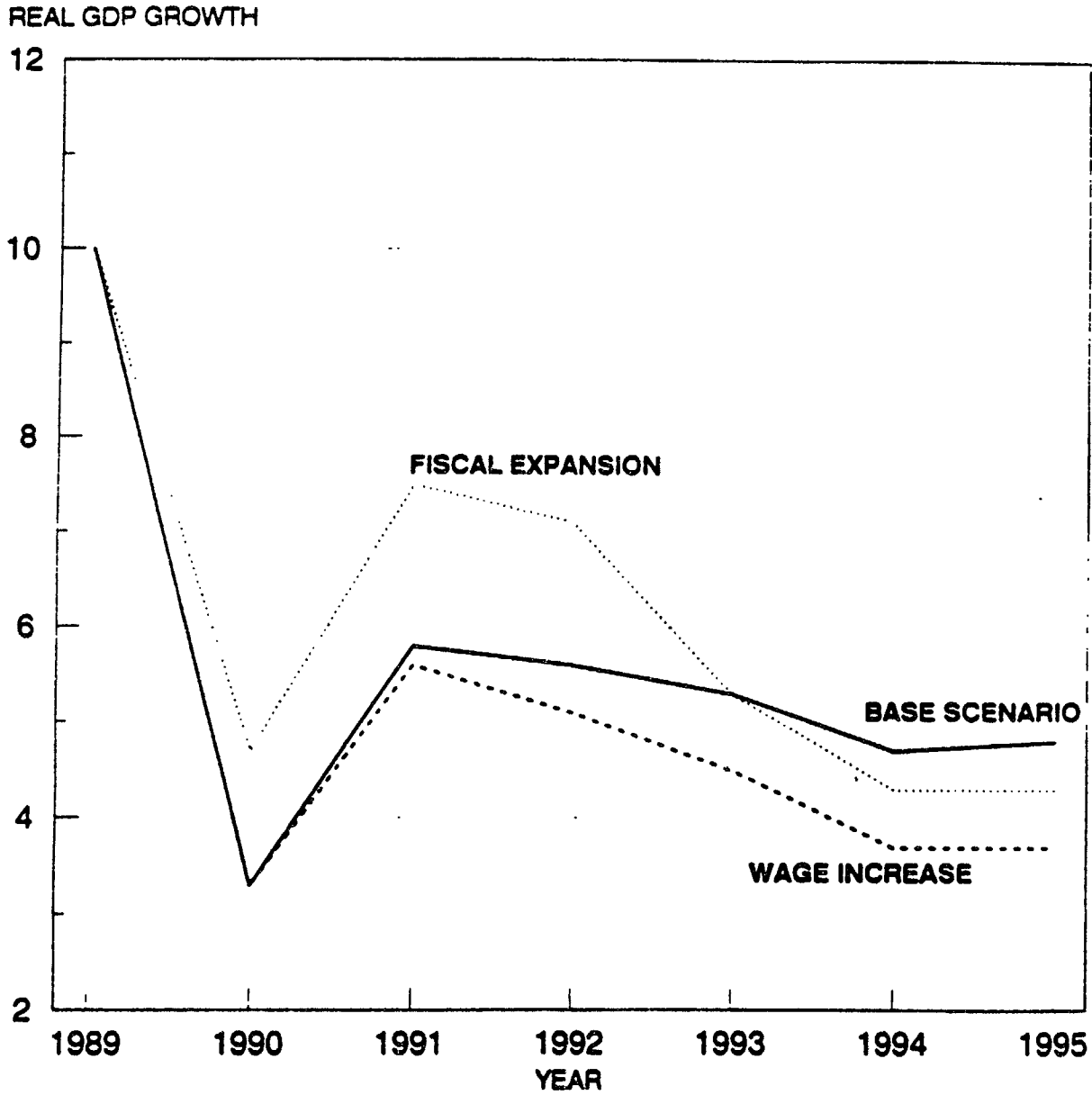
SIMULATION RESULTS 1990-95
INFLATION RATE (GDP Deflator)
DOMESTIC SHOCKS
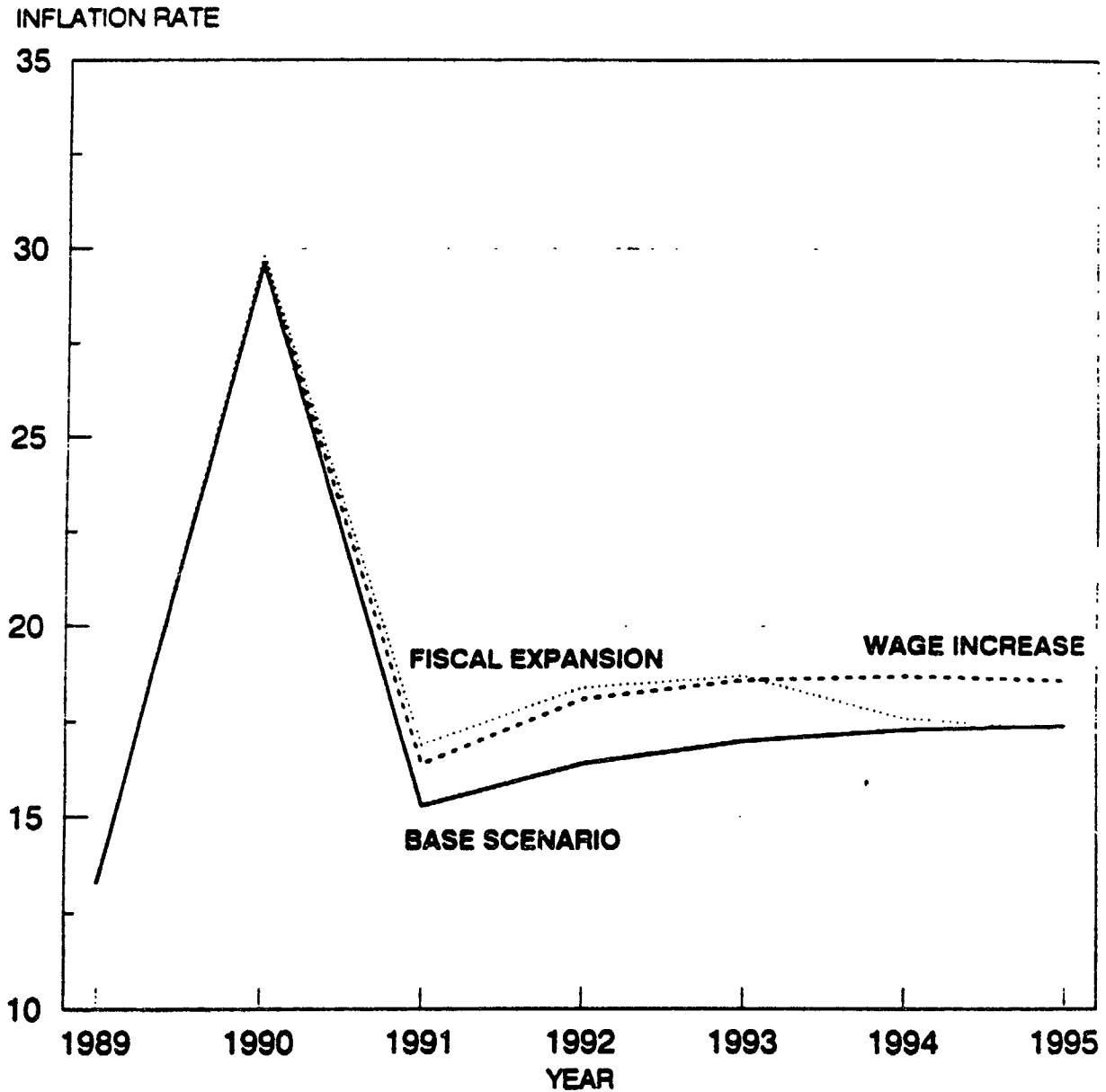
SIMULATION RESULTS 1990-95
CURRENT ACCOUNT DEFICIT/GDP
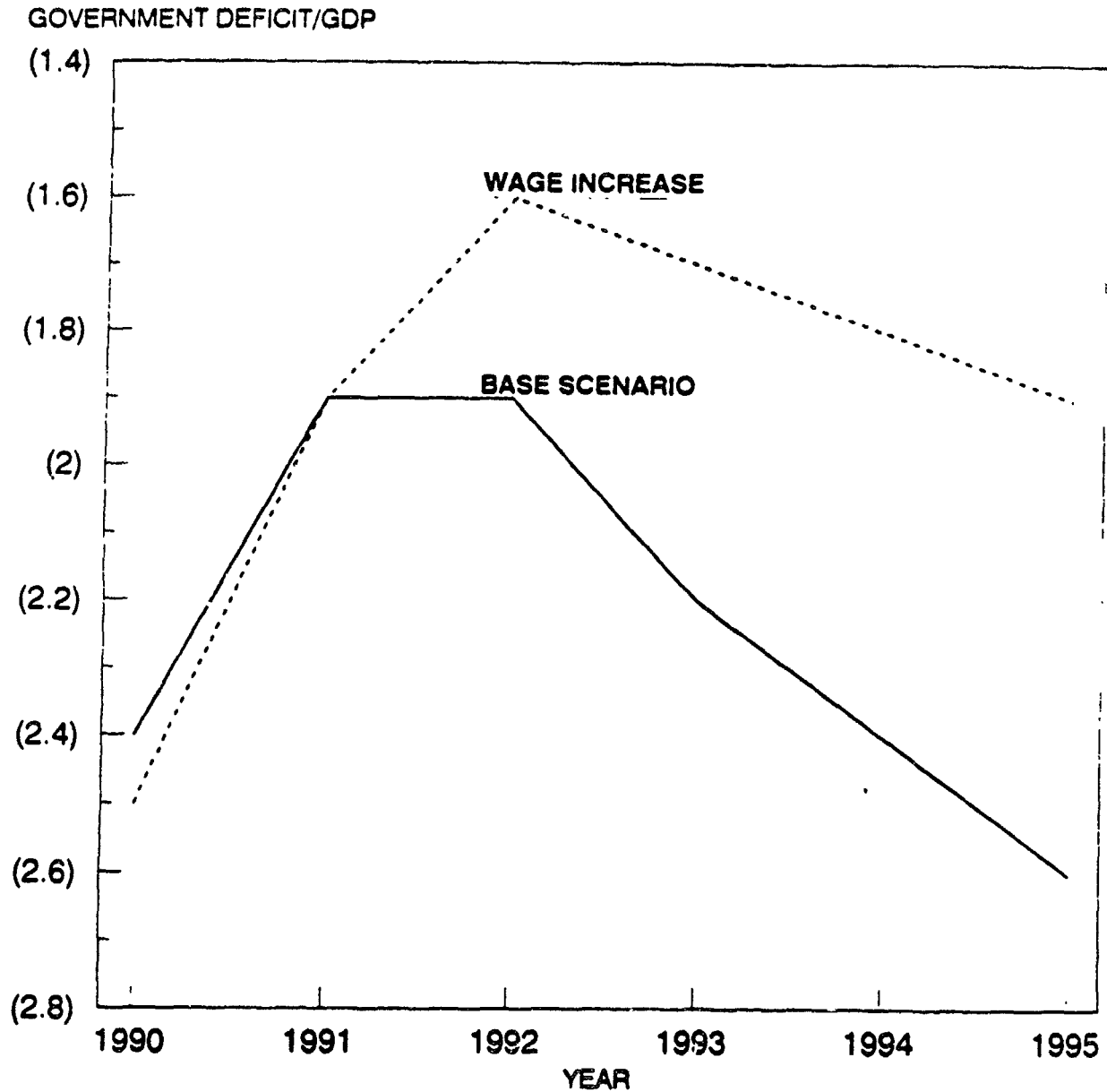## DOMESTIC SHOCKS
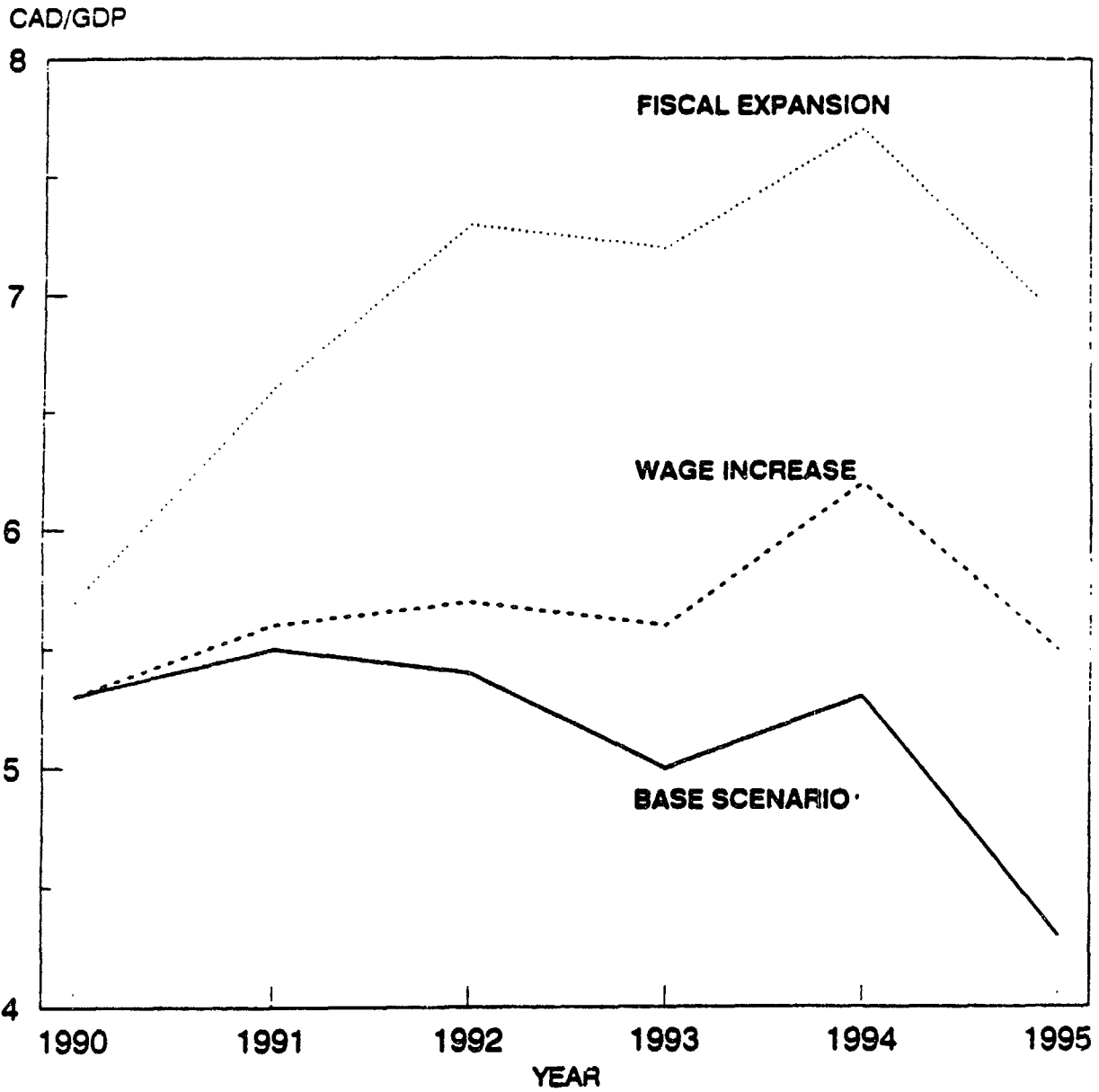
CAD/GDP

FISCAL EXPANSION

WAGE INCREASE

BASE SCENARIO

YEAR

DEC-3-90 FQ
S-MRES WX1
CAD.DRW

SIMULATION RESULTS 1990-95
GOVERNMENT DEFICIT/GDP
DOMESTIC SHOCKS

GOVERNMENT DEFICIT/GDP

WAGE INCREASE

BASE SCENARIO

YEAR

DEC-3-90 FQ
SIMRES WK1
GDEF DRW

SIMULATION RESULTS 1990-95
REAL EXCHANGE RATE
DOMESTIC SHOCKS
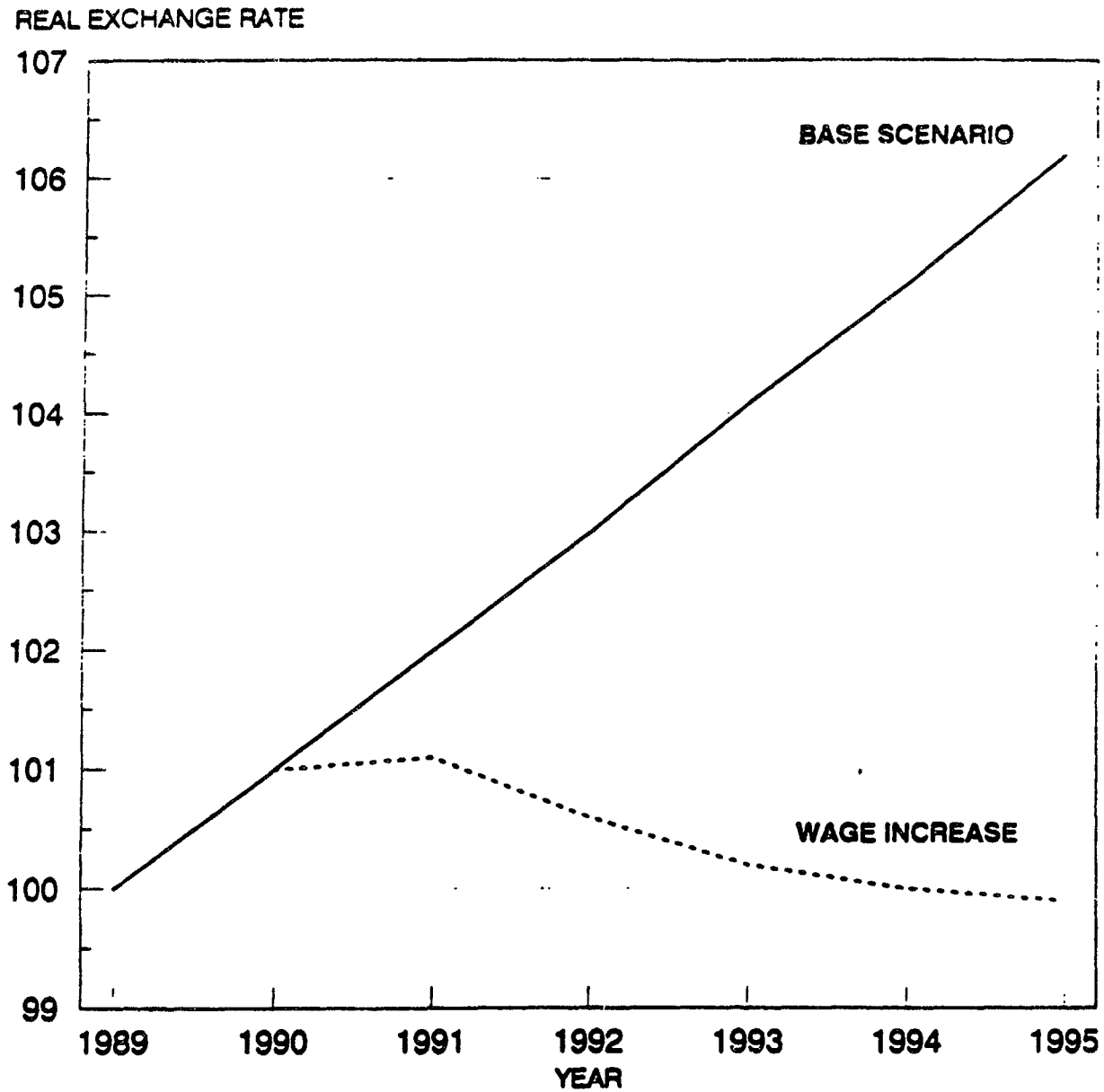
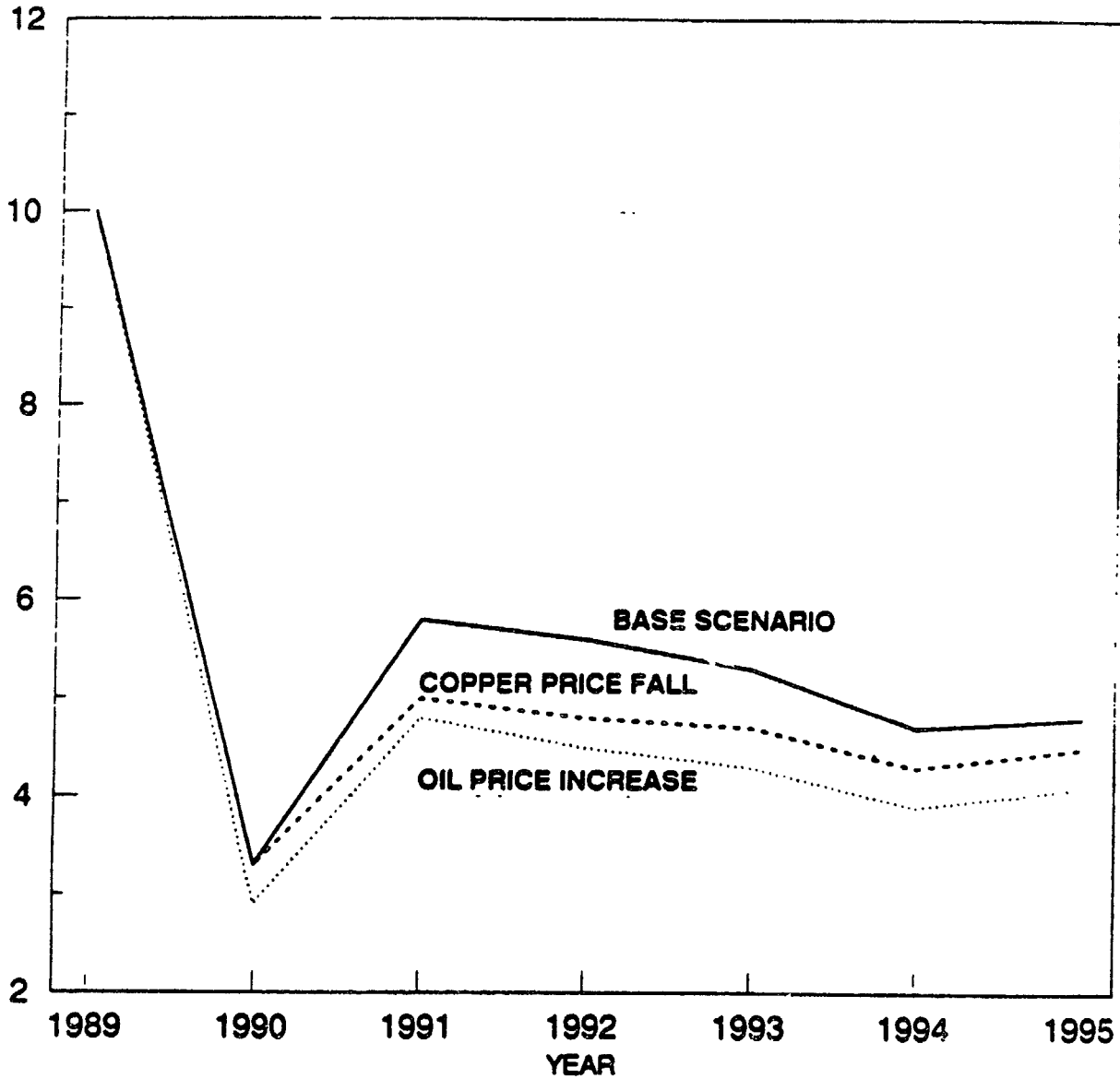# SIMULATION RESULTS 1990-95
REAL WAGE
DOMESTIC SHOCKS
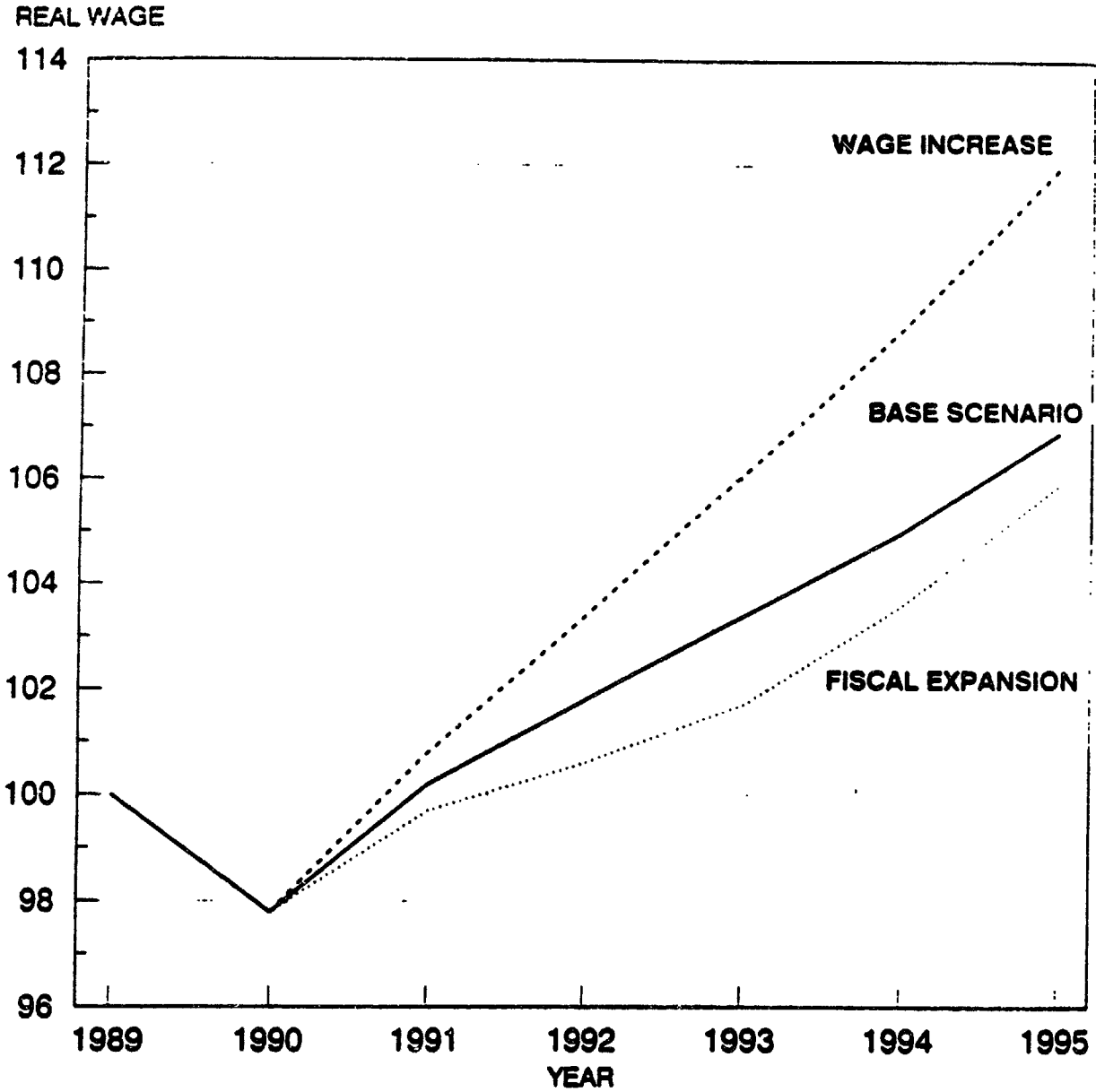
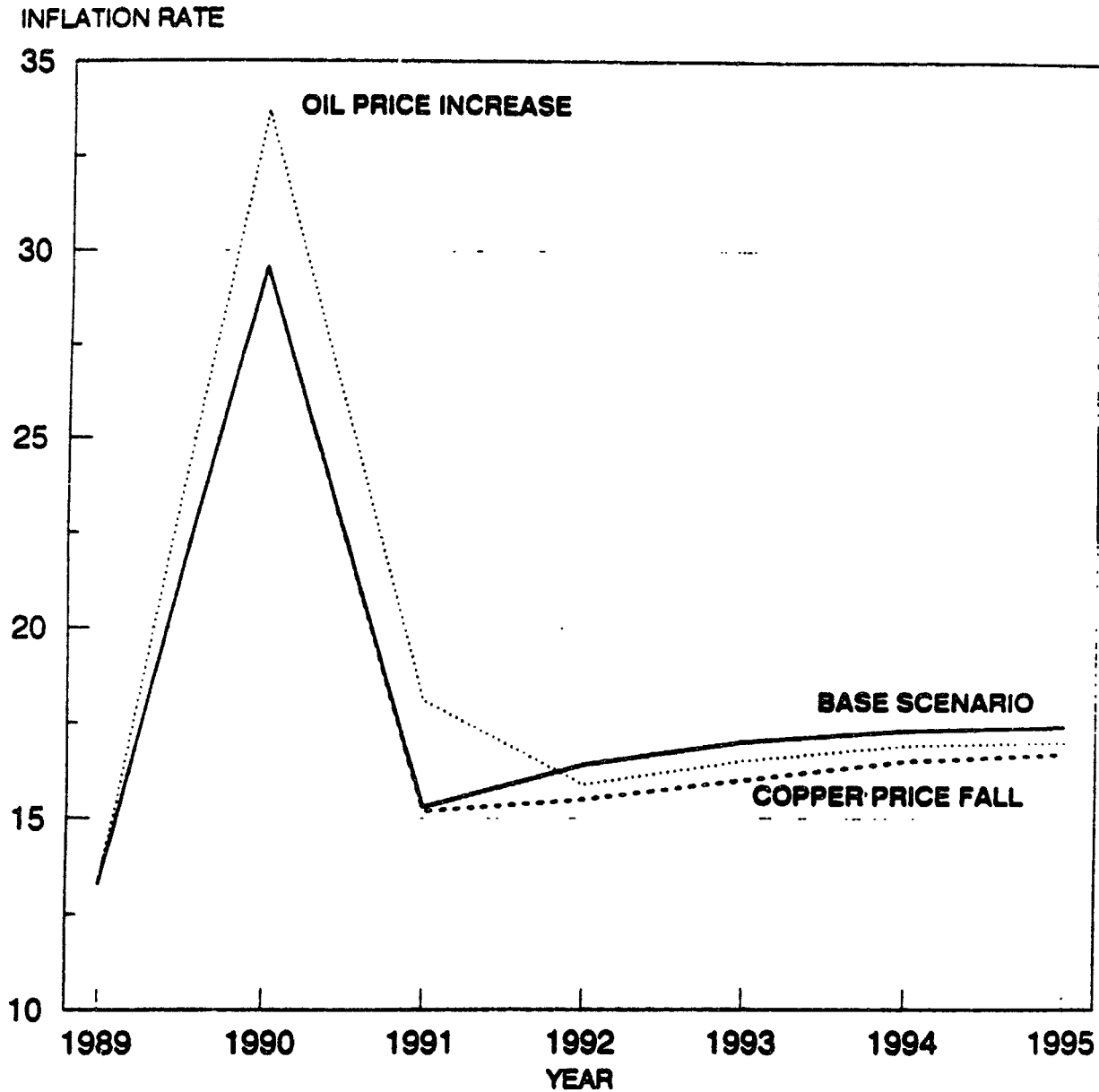# SIMULATION RESULTS 1990-95
REAL GDP GROWTH
EXTERNAL SHOCKS

REAL GDP GROWTH

BASE SCENARIO

COPPER PRICE FALL

OIL PRICE INCREASE

YEAR

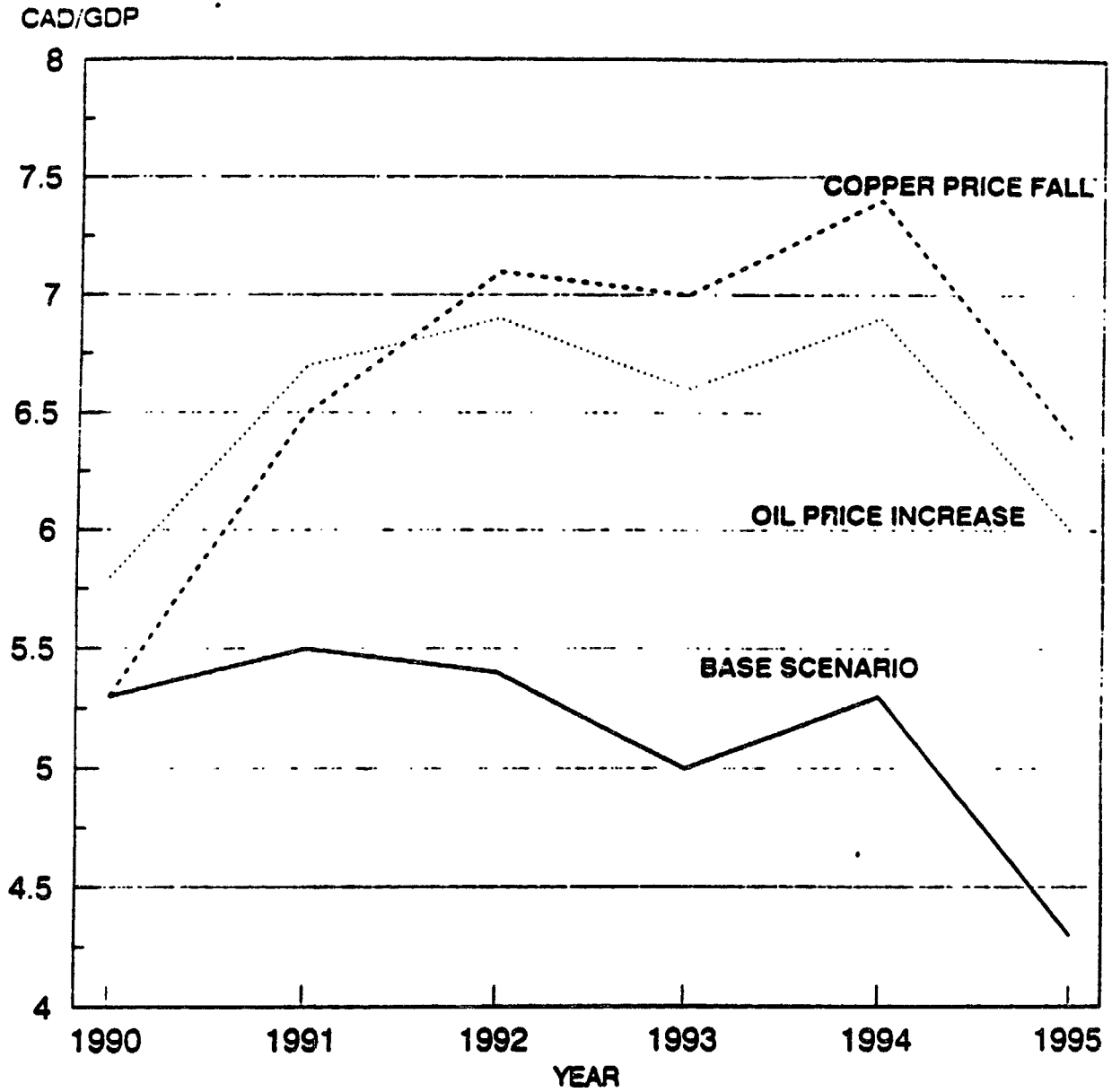# SIMULATION RESULTS 1990-95
INFLATION RATE (GDP Deflator)
EXTERNAL SHOCKS

SIMULATION RESULTS 1990-95
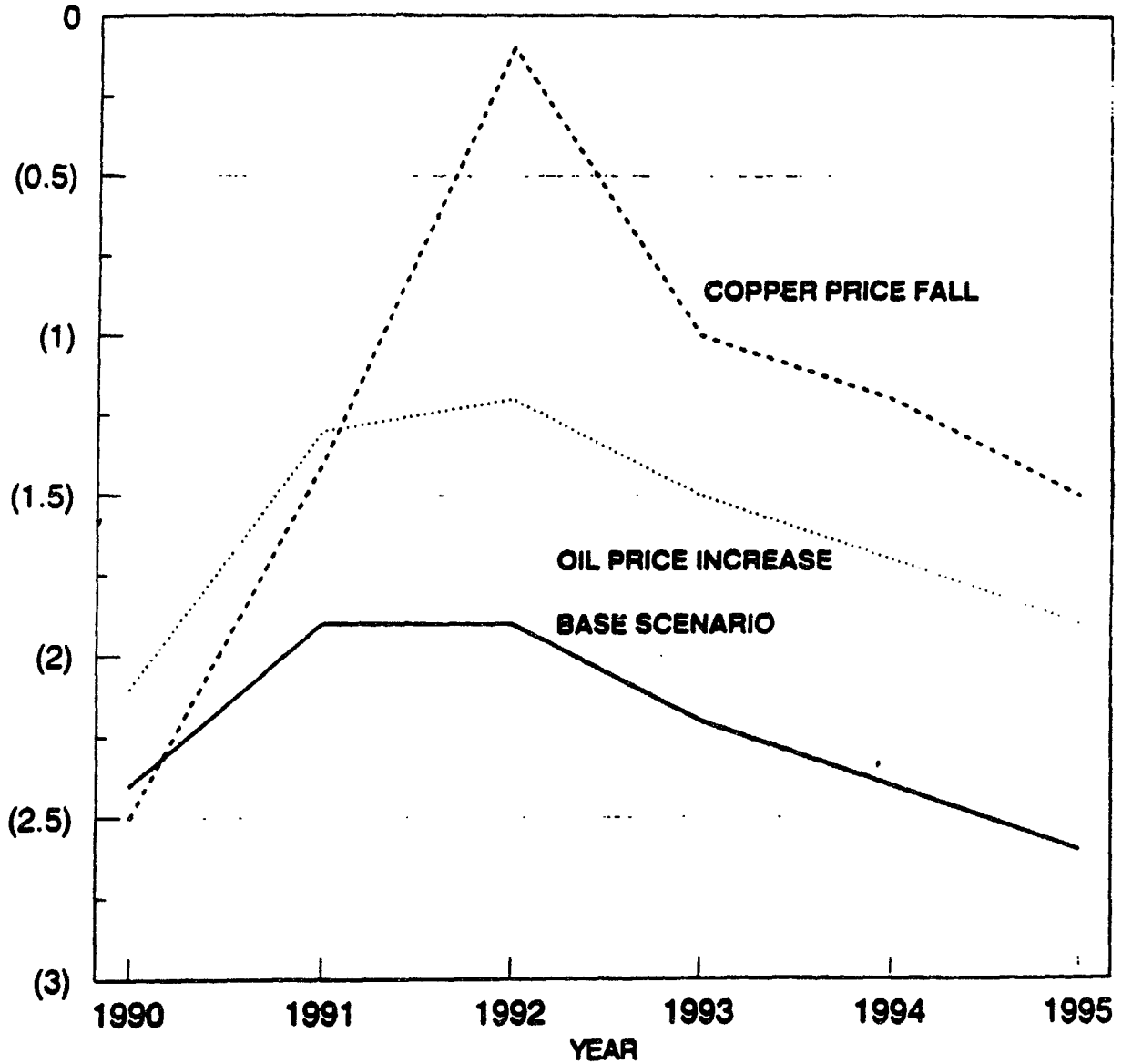# CURRENT ACCOUNT DEFICIT/GDP
EXTERNAL SHOCKS

SIMULATION RESULTS 1990-95
GOVERNMENT DEFICIT/GDP
EXTERNAL SHOCKS

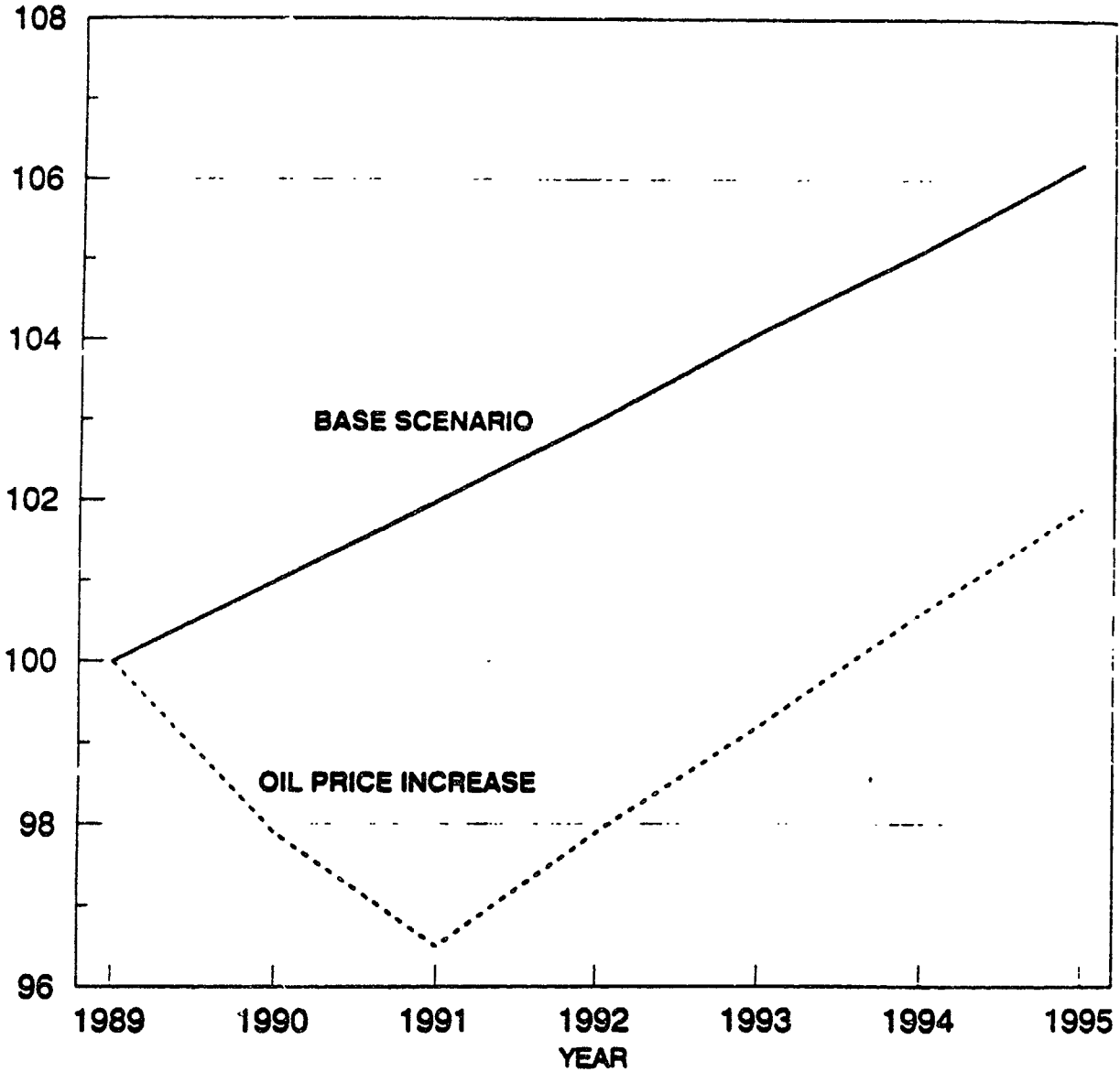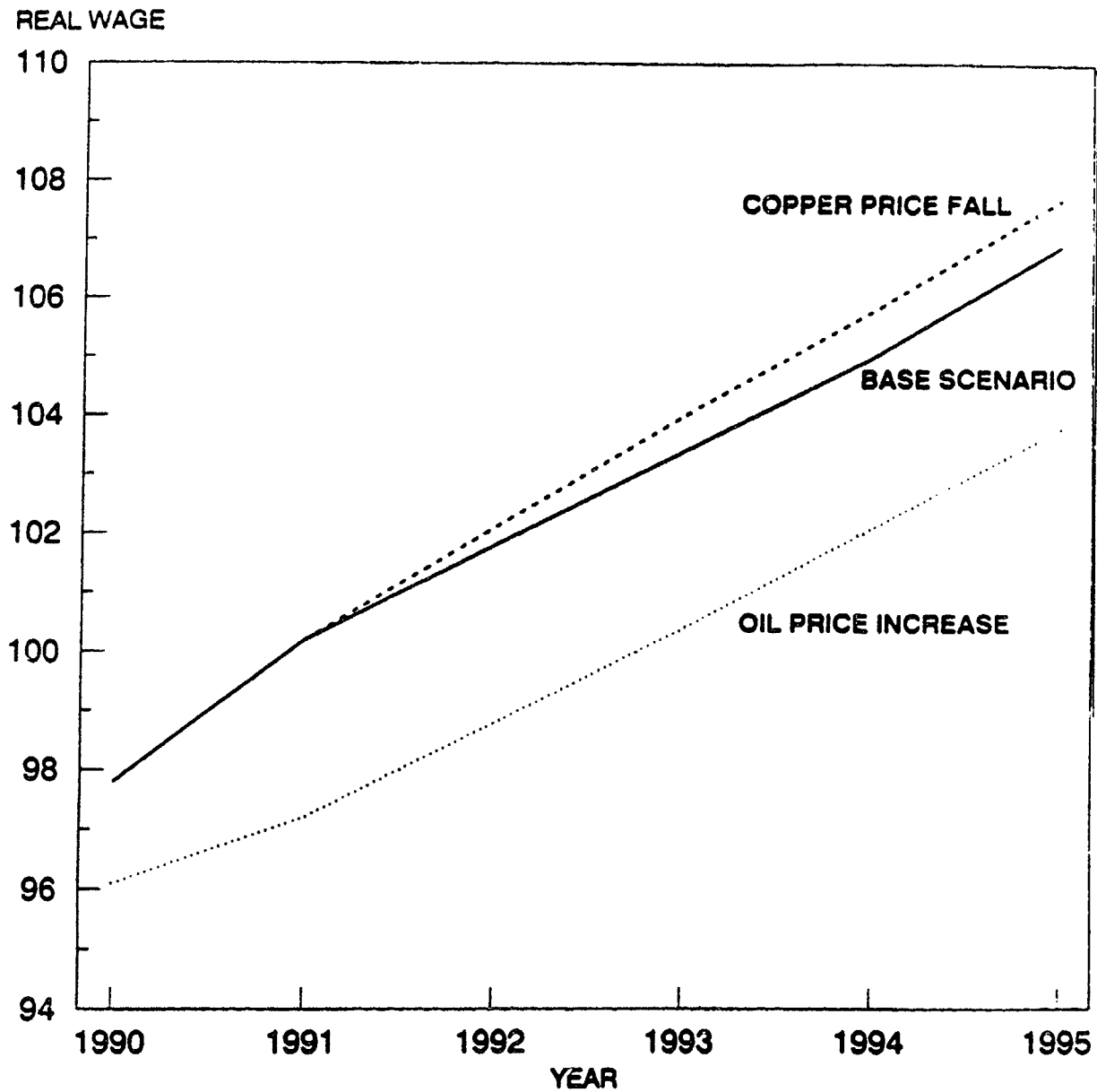# SIMULATION RESULTS 1990-95
REAL EXCHANGE RATE
EXTERNAL SHOCKS

SIMULATION RESULTS 1990-95
REAL WAGE
EXTERNAL SHOCKS

REAL WAGE

COPPER PRICE FALL

BASE SCENARIO

OIL PRICE INCREASE

YEAR

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