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REACHING ONE-DIGIT INFLATION: THE CHILEAN EXPERIENCE

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The main purpose of this paper is to analyze the process by which Chile was able to reduce inflation during the 1990s. During this period, inflation was gradually reduced from close to 30% per annum in 1990, to only 6% in 1997. The paper concludes that three factors were important in helping to accomplish this reduction. First, the independent Central Bank and its tough action early on -to convey the message that it was ready to stand behind its core objective (to reduce inflation)- helped to shape inflationary expectations and, in the event, led to lower wage inflation and ultimately a lower path for core inflation. Second, the Bank's restrictive monetary policy, and the foreign exchange intervention policies associated with it, resulted in a nominal exchange rate trajectory much below what would have been observed under a PPP rule adjusted for differences in productivity. This result was reinforced by the low credibility of the band, reflected in the effect on the observed rate of the location of the exchange rate within the band. Third, the higher rate of growth of labor productivity, given the wage equation, resulted in a lower rate of growth of the unit cost of labor than would have obtained otherwise. Of these three effects, the first, that is, the enhanced credibility of the new policy operating through the formation of inflation expectations, was found to be the most important factor in the successful reduction of the inflation rate.

I. Introduction

Following 40 years of high and variable inflation, Chile, during the 1990s, has made major progress in reducing inflation toward levels observed in industrial countries. Even more remarkable is that the inflation reduction

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was achieved without the short-term costs frequently incurred in terms of reduced output growth or a higher rate of unemployment. On the contrary, while inflation was being reduced, growth increased and the unemployment rate reached its lowest level in 30 years. Indeed, Chile's economic record over the past ten years has been outstanding. During the 1986-1997 period, the average GDP growth rate reached 7.6%, while the average inflation rate fell-to 17.8%. The unemployment rate also fell from close to 30% in late 1982, to only 5.3% during the last quarter of 1997. Furthermore, the inflation rate (Dec.- Dec.), which had reached 27,3% in 1990, decreased throughout the 1990s to reach 6.6% in 1996, and only 6.0% in 1997.

The foundations of Chile's anti-inflationary program were laid during the 1970s, when the public sector deficit was eradicated. However, it was only in the 1990s, with the creation of an independent Central Bank, when continuous progress was made on reducing inflation. This objective was pursued by a newly established independent Central Bank, founded with currency stability as one of its principal aims.

The historical record of high and variable inflation, with its negative effects on the efficiency of resource allocation and economic growth, and the increasingly accepted view that macroeconomic stability was a precondition for sustained high growth, motivated the granting of institutional independence to the Central Bank. An indicator of how widely this view was held is the fact that, although the independence of the Central Bank had been approved under the military government, it has also been embraced by the center-left coalition of parties which have governed Chile during the 1990s. Chilean inflation was an historic fact and, during the past 40 years, the record had been clearly poor. In the 1960s, inflation averaged 21.1 percent per annum. In the early 1970s, under the populist policies of the Allende government, inflation accelerated, reaching an annual rate of approximately 463 percent in August 1973, the month before Allende's fall. Underlying the acceleration of inflation was a consolidated non-financial public sector deficit that, by 1973, was close to 25 percent of GDP, a deficit mainly financed by printing money.

The military government which took power in September 1973 had among its main objectives the elimination of the severe and pressing macroeconomic disequilibrium which it inherited; it also took rapid action to reduce microeconomic distortions in relative prices. To achieve this goal, it was necessary to revise public sector size and responsibilities; as a result of this process, public sector participation in economic activities was heavily curtailed.

The newly independent Central Bank, created in October 1989, began operating in December 1989, only three months before the Presidency was transferred from Pinochet to Aylwin, and undertook the second stage of inflation reduction. Although the Central Bank's main objectives were to achieve price stability and to ensure the proper functioning of the domestic and external payment system, the existence of a robust financial system and solid external accounts allowed the Central Bank to concentrate on reducing inflation.

The purpose of this paper is to study Chilean stabilization policies. In Section 2, we will review the experience of the 1990s, when inflation was reduced from 26% in 1990, to only 6% in 1997. In Section 3, we will analyze the different factors behind that inflation reduction and, in Section 4, we present our main conclusions.

II. Stabilization Policy in the 1990s[1]

During the 1990s, monetary policy has been geared towards reducing inflation with the ultimate objective of achieving price stability. The new Central Bank Charter of 1989, which made the Central Bank institutionally independent, created the setting for the design of monetary policy during the 90s. The charter stipulates that the main objectives of monetary policy should

[1] For an analysis of Chilean stabilization policies in the pre-1990 period see Corbo and Fischer (1994).

be "the stability of the currency and the normal development of the internal and external payment systems".

In terms of the current literature on Central Bank independence, the Central Bank of Chile is modeled on Rogoff's "Conservative Central Banker" (1985)[2]. Chilean law gives the Central Bank independence to set its own targets as well as to choose the instruments it deems appropriate for achieving those targets. Furthermore, in contrast to other independent Central Banks created recently, the Central Bank of Chile is also responsible for the exchange rate system and for exchange rate policy.

The Central Bank has set itself the objective of gradually reducing inflation toward levels observed for industrial countries, while maintaining current account deficits which will not jeopardize the stability of the external payment system. The Central Bank has set out an upper bound for the current account deficit of 4% of GDP, with absorption and national disposable income measured at "normal" terms of trade levels. The meaning of the word "normal" has not been clearly defined. But whenever the two objectives enter into conflict, as was the case in 1996 and is the case again today, the inflation target has been given priority.

The inflation objective for the coming year is chosen by the Central Bank and announced to the Congress and to the country during the first fifteen days of September of every year. At first, that objective was stated in terms of a range for the CPI inflation rate for the period Dec-Dec of the coming year. Then, starting in September 1994, the Central Bank moved toward setting a point estimate for the inflation objective. Thus, the Central Bank uses an inflation target framework to conduct its monetary and exchange rate policy. The inflation target is the ultimate objective of policy, while an

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[2] In this model, the Central Bank board behaves as minimizing a quadratic loss function in which the arguments of the function are the departure of the inflation rate from its target and the departure of the current account deficit from its target (or the unemployment rate from its target in Rogoff's model). But *de facto*, the Central Bank has been assigning greatest weight to the inflation term, resulting in conduct similar to that observed for the "Conservative Central Banker" of Rogoff.

inflation forecast, not made public, is the intermediate objective, and the interest rate is the main instrument for achieving those objectives.

Stating the objective of monetary policy in terms of an inflation target is increasingly becoming the policy in a number of industrial countries (New Zealand, Canada, U.K., Sweden, Finland, Australia and Spain). However, in a major departure from the practice followed in industrial countries, the Chilean authorities announce a point estimate, while the industrial countries announce a range[3]. This is not a trivial difference. As monetary policy works with a substantial lag, to pre-commit an unconditional inflation target - independently of changes in external factors which do affect the inflation rate-can be costly. Specifically, achieving that target could make it necessary to implement an over-restrictive monetary policy or allow a sharp appreciation of the currency, building distortions in relative prices or increasing output volatility in the process.

A current account deficit target, at normal terms of trade, has been set by the Central Bank at less than 4 percent of GDP. In practice, this target has been expressed as a loose commitment to a competitive real exchange rate. As the real exchange rate has appreciated during the 1990s, a conflict between the inflation and the real exchange rate objectives has surfaced repeatedly and, although the inflation objective has been given priority, the Central Bank has struggled to avoid excessive real appreciation. To this end, it has intervened in the exchange rate market, implementing an aggressive and costly policy of foreign reserve accumulation, accompanied by the sterilization of the monetary effects of exchange rate accumulation.

The problem inherent to the pursuit of inflation and exchange rate targets, simultaneously, is well known. Within the exchange rate system, as long as the observed value of the exchange rate is well within the band, the uncovered interest rate parity condition provides a link between the interest rate and the exchange rate. Specifically, as long as the exchange rate is within the

[3] For a review of the international experience with inflation targeting, see Leiderman and Svensson (1995).

band, any adjustment of the domestic interest rate results in a movement of the nominal exchange rate. Therefore, for all practical purposes, exchange rate policy has not been independent[4]. Moreover, conflicts with the Ministry of Finance have arisen when an increase in domestic interest rates have caused a sharp nominal and real exchange rate appreciation. In those cases, it is correctly argued that such an appreciation could lead to fewer exports and eventually damage the long-term sustainability of the current account and Chilean export-led growth model itself.

In practice, the Central Bank began by controlling monetary aggregates; it then shifted to the use of the interest rate as its main instrument for achieving the inflation target[5]. Through the use of monetary policy, the Central Bank controls the evolution of actual inflation. It occasionally appears that the inflation forecast -used as an intermediate target- is closely related to the gap between domestic expenditures and GDP, and it is by managing this gap that it tries to avoid the build up of inflationary pressures which could endanger the inflation target. The Minister of Finance can then use supply-side fiscal policy to increase capacity output and to reduce the rate of natural unemployment.

Acknowledging the slowness with which the rate of change of nominal wages and prices adjusts in a fully indexed economy, such as Chile's, the Central Bank defined a policy aimed at achieving a gradual reduction of

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[4] During the 1990s, the exchange rate system has been managed as a diagonal exchange rate band. The central parity of the band is adjusted passively, on a daily basis, by the difference between the domestic and international inflation of the previous month. The width of the band was increased to 10 percent on both sides of central parity in January 1992. Up to July 1992, central parity was established in terms of the value of the US dollar. However, since then, it has been set in terms of a basket of currencies. Moreover, starting in November 1995, a further 2 percent per annum has been subtracted from the central parity to accommodate an estimate for trend appreciation of the equilibrium real exchange rate.

[5] This shift is, indeed, consistent in a world of continuous financial innovation whereby the link between the growth in monetary aggregates and inflation or the growth in nominal income is too fragile to be the cornerstone of stabilization policy.

inflation. When the board of the newly independent Central Bank took office in December 1989, in the context of the expansionary macroeconomic policies of 1989, the 12-month inflation rate (November 1988 to November 1989) was 21.1% and accelerating. One of the first measures adopted by the board was to introduce a sharp increase in real —CPI indexed— interest rates on Central Bank bills. The real interest rate on the 10-year Central Bank bond was raised by 280 base points, from 6.9 to 9.7 percent per annum. Simultaneously, the rate on the 90-day —CPI indexed— Central Bank bond was raised from 6.8 to 8.7 percent per annum. However, in a world of increasingly integrated capital markets, the high real interest rate policy pulled in foreign capital, which, in turn, led to an appreciation of the real exchange rate[6]. Not surprisingly, in 1990, the value of the peso appreciated up to the lower limit of the exchange rate band. To defend the band, the Central Bank found it necessary to intervene in the foreign exchange market, in the process, accumulating US $ 2.43 billion of additional foreign reserves in that year alone, an 82.3% increase in the stock of foreign reserves. This massive exchange rate accumulation amounts to a significant exchange rate intervention. However, as Central Bank authorities wished to establish credibility for their anti-inflationary stance, they accompanied the exchange rate accumulation with an aggressive sterilization policy run simultaneously.

III. Accounting for the Reduction of Inflation in the 90s.

The newly established, independent Central Bank has achieved an impressive record in gradually but continuously reducing inflation and in achieving inflation levels close to the target rate. In the process, it has gained credibility for its stabilization policy. In turn, most likely through its impact

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[6] The exchange rate policy of the 1990s has been of the exchange rate band type, with central parity adjusted on a daily basis by the past difference between domestic and foreign inflation. For details of the exchange rate policy see table III:1 in Corbo and Desormeaux (1996).

on the wage setting process, the increased credibility of its policies has reduced the short-term costs of gradual inflation reduction. This could explain the apparent low cost of the inflation reduction policy. But the process has not been easy.

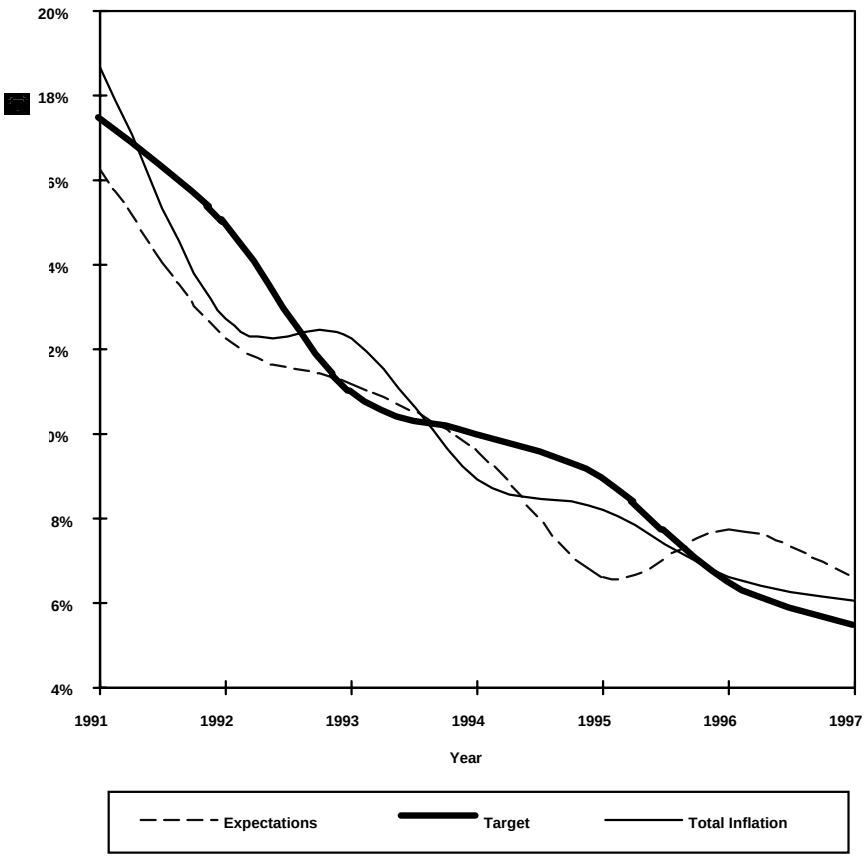
A comparison between actual inflation and the inflation target is presented in Table 1 and in Figure 1. In the same Figure, we also present an estimate of expected inflation obtained by comparing ex-ante values of the nominal and real interest rates of comparable liabilities for commercial banks.

Table 1. Actual and Target Inflation

Year	Actual	Target
1991	18.70%	17.50%
1992	12.70%	15.00%
1993	12.20%	11.00%
1994	8.90%	10.00%
1995	8.20%	9.00%
1996	6.60%	6.50%
1997	6.00%	5.50%

We will now analyze the process of inflation reduction. We will examine the hypothesis that the main channels through which the new strategy operated were: (1) changing the process of the formation of expectations regarding future inflation; (2) generating a trajectory of real exchange rate appreciation as a side effect of the combination of monetary and fiscal policies; and (3) slowing down the rate of growth of the unit cost of labor as a result of the effect of the economic reforms on average labor productivity. The first channel concerns the issue of whether the increasing credibility of the Central Bank inflation target modified the process of the formation of inflation expectations. If this is the case, those expectations affect the dynamics of wages directly, and the dynamics of the inflationary process indirectly. The

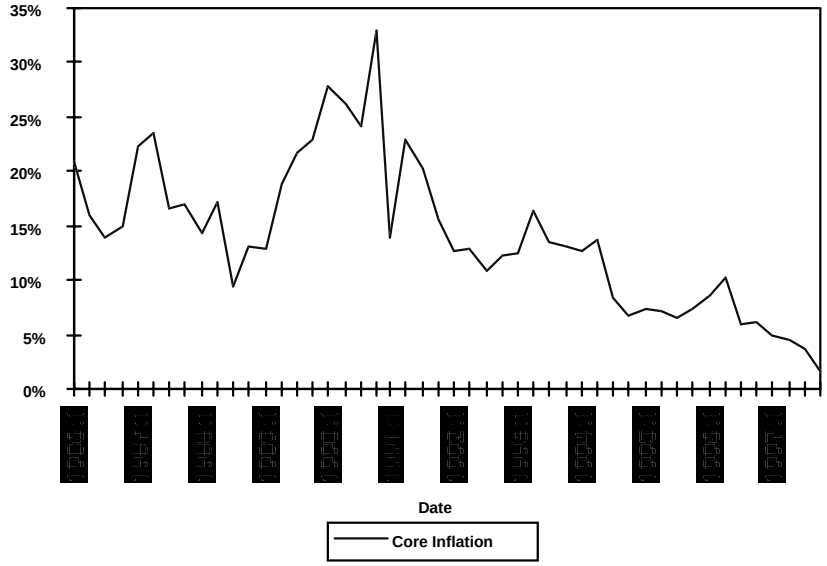
Figure 1. Actual, Expected and Target Inflation



second channel, the appreciation of the real exchange rate, works through the effects of the trajectory of the nominal exchange rate on the price dynamics of tradable goods and ultimately on inflation. Finally the third channel, the increase in average labor productivity, reduces the unit cost of labor and it produces its effects through the price of non-tradables.

Before proceeding to study the dynamics of Chilean inflation, we will examine its behavior during the last ten years. Figure 2 presents the evolution of the quarterly core inflation rate, expressed at an annual rate, from the first quarter of 1986, up to the last quarter of 1997.

Figure 2. Core Inflation: 1986.1 to 1997.4



This figure shows that annualized core inflation peaked in the last quarter of 1990, when it reached an annual rate of 32.9%. It has declined continuously since then, reaching an annual rate of only 1.7 % in the last quarter of 1997.

Inflation dynamics can be studied using a simple structure, as was done in Dornbusch and Fischer (1993) and Burton and Fischer (1997). They define the inflation rate as the weighted average of the rate of change in the prices of tradable and non-tradable goods and services. Then, to complete that simple structure, they assume that the rate of change in the price of non-tradable goods is given by the rate of change of wages. The rate of change in

the price of tradable goods is given by the sum of the rate of change of external prices and the rate of change in the exchange rate. In our case, we start with this simple model, but we define the price of non-tradable goods as the rate of change in the unit cost of labor.

That is, we start from the following model:[7]

$$\pi^S_t = \alpha\,(\omega_t - q_t) + (1-\alpha)\,(\pi^*_t + e_t)$$

where π^S is core inflation, ω is the rate of change of wages, q is the rate of change of average labor productivity, π^* is world inflation and e is the rate of depreciation of the local currency.

Adding and subtracting π^S_{t-1}, we obtain:

$$\pi^S_t = \pi^S_{t-1} + \alpha\,(\omega_t - q_t - \pi^S_{t-1}) + (1-\alpha)\,(\pi^*_t + e_t - \pi^S_{t-1});$$

From the above expression, it can be observed that inflation can be reduced when the rate of change of the unit cost of labor is below the inflation rate of the previous period and when the rate of change in the price of tradables $(\pi^*_t + e_t)$ is below inflation for the last period.

Downward pressure on the first term, $(\omega_t - q_t - \pi^S_{t-1})$, was exercised by the effect of the increasing credibility of stabilization policy on the trajectory of ω_t, by the effect of the gradual reduction of inflation on the behavior of nominal wages, and by the positive effect of structural reforms on average labor productivity.

Now we examine the second term, which can also be written as:

$$(\pi^*_t + e_t - \pi^S_t) + (\pi^S_t - \pi^S_{t-1})$$

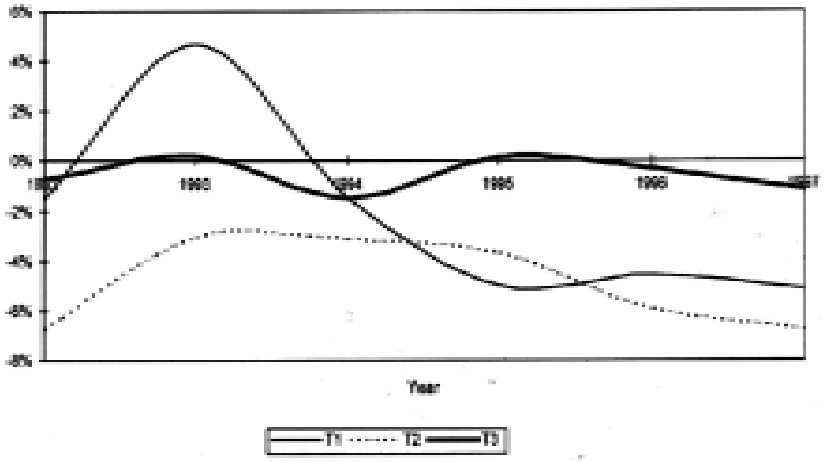
The first term is the rate of change of the real exchange rate and the

[7] The variables are expressed as quarterly rates of change.

second term is the first difference in the inflation rate. The first term is negative when the real exchange rate appreciates and the second term is negative when macroeconomic policies are oriented toward achieving a gradual reduction of inflation. It is clear that this term is negative as long as the real exchange rate appreciates or core inflation is being gradually reduced.

In Figure 3, we plot the three terms that appear on the right hand side of the inflation equation. We label the term T1= $(\omega_t - q_t - \pi^S_{t-1})$, T2 = $(\pi^*_t + e_t - \pi^S_t)$, and T3= $(\pi^S_t - \pi^S_{t-1})$. From observing the figure, it is clear that, since1994, both T1 and T2 made important contributions to the reduction of inflation.

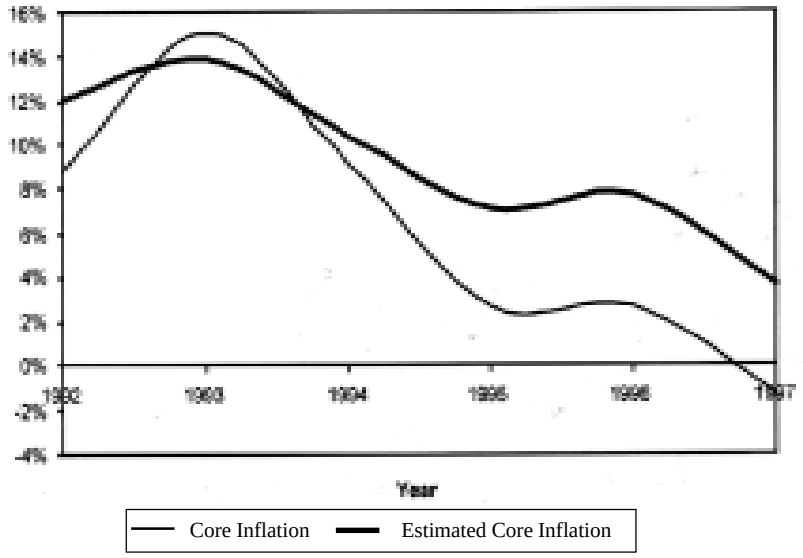
Figure 3. The Sources of Inflation



Using this model and a value of $\alpha = 0.59$, we obtain an inflation estimate[8]. In figure 4, we plot actual core inflation and the core inflation estimated through the simple model presented above.

[8] This estimate of α is obtained from a simple regression of the price equation, as given.

Figure 4. Actual Core Inflation and Estimated Core Inflation (Simple Model)



We will now estimate a model of inflation by extending the simple model presented above. The main extensions are the introduction of structural equations to describe the dynamic of core inflation, wages and the nominal exchange rate. The literature on the modeling of inflation in Chile is extensive[9]. We will concentrate on the open economy type models studied during the last fifteen years. Corbo (1985b) built a model of Chilean inflation to study inflation dynamics up to the early 1980s, using a reduced form of the Salter-Swan-Dornbusch dependent economy model. Corbo and Solimano (1991) investigated the dynamics of Chilean inflation up to the late 1980s, using a small structural model. Edwards (1993) examined the question of Chilean inflation dynamics and inertia in the context of the use of the exchange rate as a nominal anchor for the 1974 to 1982 period. He also

[9] For earlier models of the Chilean inflation, see Harberger (1963) and Corbo (1974). For a review of inflation models for countries with moderate inflation, see Dornbusch and Fischer (1993).

used a reduced form of the Salter-Swan-Dornbusch dependent economy model. In the reduced form of his model, inflation is a function of lagged inflation (which comes from the wage and exchange rate equations of his structural model), foreign inflation, and the rate of change in domestic credit. He also introduced a dummy variable, which takes the value of one during the fixed exchange rate period and zero otherwise. The dummy variable interacts with the coefficient of the lagged inflation variable to allow for inertia reduction following the fixing of the exchange rate. The results of his estimation led Edwards to conclude that the dynamic of inflation displayed considerable inertia during this period.

Corbo and Fischer (1994), using monthly data for the 1974.2 to 1982.1 period, estimated a small structural model similar to that used in Bruno (1978), Corbo (1985b), Bruno (1991) and Corbo and Nam (1992). In their solution from the structural model, they found that, during the 1980s, there was substantial inertia. Finally, Corbo and Piedrabuena (1995) estimated a structural version of the dependent economy model with quarterly data for the 1983.I to 1994.I period.

We are interested in accounting for the reduction of Chilean inflation in the 1990s. For this purpose, we need a model which will also be able to distinguish the contribution made by the three factors individualized above to the reduction of inflation. The model that we use is similar to the one used by Corbo and Fischer (1994), Edwards (1993) and Edwards (1996), in the following form:[10]

$$\pi^{S}_{t} = \alpha_0 + \alpha_1 \omega_t + \alpha_2 e_t + \alpha_3 \pi^{*}_{t} + \alpha_4 q_t + \alpha_5 GAP_{t-2} \quad (1)$$

$$\omega_t = \beta_0 + \beta_1 \pi^{E}_{t-1} + \beta_2 \pi_{t-2} + \beta_3 1/U_t + \beta_4 q_t \quad (2)$$

$$e_t = \gamma_0 + \gamma_1 \pi^{*}_{t-1} + \gamma_2 \pi_{t-1} + \gamma_3 \Delta RIN_t + \gamma_4 I_{t-1} + \gamma_5 PER_t + \gamma_6 PER_{t-1} \quad (3)$$

[10] The variables are measured as rate of change with respect to the previous quarter.

Where

π^S = Core Inflation. (Consumer price index, excluding perishables and oil products).
π = Actual Inflation (Overall consumer price index).
π^E = Expected Inflation.
ω = Rate of Change of the Average Wage Rate.
$\pi*$ = External Inflation in Dollars.
e = Rate of Change of the Exchange Rate, in Pesos per dollar.
q = Rate of Change of Average Labor Productivity.
GAP = Log of (GDP/Potential GDP).
ΔRIN = Change in Foreign Reserves, in US dollars.
I = Quarterly Change in GDP.
PER = Percentile within the band where the exchange rate in that quarter is located.

Equation (1) is the price equation for core inflation and is obtained as the weighted average of the price equations for tradable and non-tradable goods and services. Equation (2) is the wage equation where lag inflation enters through explicit indexation schemes in wage payments and expected inflation enters through the adjustment of wages in contracts that are forward-looking. Equation (3) describes the evolution of the nominal exchange rate within the band. Before estimating the equations, it was necessary to study the time series characteristics of the variables to avoid the possibility of estimating spurious relations. For this purpose, we study the order of integration of the variables that enter in the model[11]. The results of the test indicate that some variables are I(0) and others are I(1), and therefore we cannot estimate the regressions directly and need to determine first if the variables are cointegrated. We use the Johansen procedure to test for cointegration of the variables; the results are presented in the appendix. We proceed one equation at a time. From the

[11] The results of the test for the order of integration of the variables are presented in the appendix.

cointegration study, we conclude that the three structural equations cointegrate. As the structural equations have endogenous variables in the right hand side, we estimate those variables using the Stock and Watson (1993) methodology which corrects the estimates of standard errors of the coefficients to correct for the simultaneous equation problem.

We will now proceed to analyze the results for the estimations of the equations.

3.1 The Price Equation

The price equation is given by:

$$\pi^{S}_{t} = \alpha_0 + \alpha_1 \omega_t + \alpha_2 e_t + \alpha_3 \pi^{*}_{t} + \alpha_4 q_t + \alpha_5 GAP_{t-2} + \quad (1)$$
$$+ \alpha_6 D874881 + \alpha_7 D9123$$

Where D874881 and D9123 are dummies that take a value of one for periods in which there was a change in the tax law.

The results of the estimation are presented in the table below:

Coefficient	Value	Probability
α	0.0041	0.2922
α^{o}	0.5244	0.0004
α^{1}	0.3076	0.0034
α^{2}	0.1437	0.0001
α^{3}	-0.0737	0.0041
α^{4}	0.1294	0.0001
α^{5}	-0.0111	0.0003
α^{6}	0.0285	0.0000
α^{7}		
R^2	0.9553	
Adjusted R^2	0.8622	
DW	2.71	
Period of Estimation	1987:3 a 1996:4	

In the price equation, the external inflation rate and the rate of change of the exchange rate should have the same coefficient, as the relevant variable in the equation for the price of tradables is the external rate of inflation expressed in local currency. However, the effects of the rate of change of the exchange rate could also enter through expectations. Therefore, we do not impose the restriction $\alpha_3 = \alpha_4 + \alpha_5$ but rather test for it by using a Wald test. The result of the Wald test indicates that the null hypothesis is rejected with a probability of 0.0423 (the p-value associated to the χ^2).

We proceed further and test for homogeneity of degree one of the price equation in all the nominal variables. For this purpose, we test the null hypothesis that, in an equation where foreign inflation and the rate of change of the exchange rate enters with the same coefficient, the following restriction should be fulfilled: $\alpha_1 + \alpha_2 + \alpha_3 = 1$. The Wald test in this case has a p-probability of 0.6615 and therefore the null hypothesis cannot be rejected. The results for the restricted model were the following:

Final Price Equation:

Coefficient	**Value**	**Probability**
α_o	0.0030	0.2703
α_1	0.5484	n.a.
α_2	0.3049	0.0024
α_3	0.1467	0.0000
α_4	-0.0701	0.0022
α_5	0.1296	0.0001
α_6	-0.0112	0.0001
α_7	0.0281	0.0000
R^2	0.9552	
Adjusted R^2	0.9465	
DW	2.74	
Period	1987:3 a 1996:4	

This regression is the price equation that we use in the rest of the model for the simulation experiments.

3.2 The Wage Equation

In Chile, there is a long history of wage indexation, up to 1982 by law and since then as part of the normal process of collective bargaining in an economy with long experience of high and variable inflation. Therefore, we specify a wage equation in which wages respond to lag inflation, expected inflation, the rate of growth of average labor productivity and quarterly dummies. The initial wage equation is given by:

$$\omega_t = \beta_0 + \beta_1 \pi^E_{t-1} + \beta_2 \pi_{t-2} + \beta_3 1/U_t + \beta_4 q_t + \beta_5 D1 + \beta_6 D2 + \beta_7 D3 \qquad (2)$$

Where D1, D2 and D3 are dummies for first and second quarter.

Before estimating this equation, we must first discuss the measurement of inflation expectations. Fortunately, in Chile we have time deposits offered in nominal and real terms. Thus, we use a market reading of inflation expectations by comparing the interest rate of nominal and indexed 90 to 365 days deposits in the banking system, both expressed at an annual rate[12].

The results of the estimation for the equation are presented below:

Coefficient	Value	Probability
β_o	0.0091	0.4465
β_1	1.0142	0.0000
β_2	0.0074	0.1331
β_4	-0.0041	0.3905
β_5	-0.0014	0.8928

[12] It should be mentioned that we are not adjusting for inflation risk, as the difference between the nominal and the real return for a deposit of the same maturity also includes an inflation premium. Our procedure implicitly assumes that this inflation premium is a constant which enters through the constant term of the regression.

β_6	0.0646	0.2151
β_7	-6.77E-06	0.9116
R^2	0.8177	
Adjusted R^2	0.7604	
DW	1.42	
Period of Estimation	1986:2 a 1997:4	

In this equation, we observe that some of the coefficients are not statistically significant. We now proceed to test for homogeneity of degree one on the inflation variable which appears on the right hand side. The result of the Wald test for the null hypothesis that $\beta_1 = 1$ indicates that the null hypothesis cannot be rejected with a probability of 0.9122 (the p-value associated to the χ^2) leading us not to reject the restriction. The estimates for the restricted final model are presented below:

Restricted Wage Equation:

Coefficient	**Value**	**Probability**
β_o	0.0062	0.0000
β_1	1.0000	n/a
β_2	0.0159	0.0000
R^2	0.7958	
Adjusted R^2	0.7659	
DW	1.61	
Period	1986:1 a 1997:4	

3.3 Exchange Rate Equation

We will now analyze the trajectory of the rate of change in the nominal exchange rate. As discussed above, the exchange rate is restricted by a diagonal exchange rate band with a width of 5 percent in both directions of central parity up to January 1992, 10 percent up to January 1997, and 12.5

percent for the rest of the sample period. Also, as of July 1992, central parity was set in terms of a currency basket instead of the US dollar. Then, in November 1994, and again in January 1997, the currency composition of the basket was changed. All along, Central Bank authorities were struggling to leave room for the real appreciation required by their restrictive monetary policy.

The general equation from which we start is of a type similar to the one studied by Magendzo, Rojas y Vergara (1996). In this specification, the rate of nominal depreciation is given by the following equation:

$$e_t = \gamma_0 + \gamma_1 \pi^*_{t-1} + \gamma_2 \pi_{t-1} + \gamma_3 \Delta RIN_t + \gamma_4 I_{t-1} + \gamma_5 PER_t + \gamma_6 PER_{t-1}$$

Where PER is the percentile of the exchange rate band within which the exchange rate is located.

The results obtained from the equation estimation are presented below:

Coefficient	Value	Probability
γ_o	–0.0061	0.4730
γ_1	–0.2835	0.0480
γ_2	0.9513	0.0001
γ_3	–1.25E–05	0.0432
γ_4	–0.1605	0.0354
γ_5	0.0456	0.0408
γ_6	–0.0374	0.0354
R^2	0.6598[13]	
Adjusted R^2	0.5350	
DW	2.02	
Period	1987:2 a 1997:3	

[13] The low R^2 is an old fact in exchange rate equations. For Chile, see Cowan and De Gregorio (1996) where the estimated equations explain between 52 and 59 per cent, for monthly observations between 1990 and 1996.

We have completed the estimation of the structural model of inflation, but before carrying out the simulations of alternative policies, we need to endogenize the formation of expectations.

3.4 Completing the Model

To model inflation expectations, we allow for two different regimes. For the 1986.1 to 1991.4 period, we assume that inflation expectations are a function of a moving average of inflation during the four previous quarters. For the period after 1991, when the Central Bank pursued an inflation target policy, we make inflation expectations a function of the inflation target and the past difference between the inflation target and the actual inflation rate. The latter variable represents the effect of the degree of fulfillment of the target on expectations.

The estimation of the equations for expected inflation yields the following results:

Equation for the 1986.1 to 1991.4 period:

$$\pi^{e}_{\tau} = \varphi_0 + \varphi_1((\pi_{\tau} + \pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3})/4)$$

The results for the estimation of this equation are given below:

Coefficient	**Value**	**Probability**
φ_o	0.0029	0.7098
φ_1	0.9286	0.0000
R^2	0.7659	
Adjusted R^2	0.6255	
DW	2.28	
Period	1987:4 a 1991:4	

One would expect the coefficient of the moving average of inflation in

this equation to have a value of one. When we test this hypothesis using a Wald test, the p-value of the probability of a type-one error is 0,7296. Therefore, we cannot reject the null hypothesis. We impose this restriction and again estimate the above model, obtaining the following results:

Coefficient	Value	Probability
φ_o	–0.0004	0.7768
φ_1	1.0000	n.a.
R^2	0.7653	
Adjusted R^2	0.6586	
DW	2.30	
Period	1987:4 a 1991:4	

The model for the second period (when the Central Bank pursued an inflation target) is given by:

$$\pi^{\varepsilon}_{\tau} = \chi_0 + \chi \mathrm{TAR}_{\tau+4} + \chi_2(((\pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3} + \pi_{\tau-4})/4) - \pi^{\varepsilon}_{\tau-5})$$

Where TAR is the inflation target of the Central Bank converted from an annual to a quarterly base.

The estimated model yields the following results:

Coefficient	Value	Probability
χ_0	0.0033	0.7098
χ_1	1.0133	0.0002
χ_2	0.3443	0.0060
R^2	0.7621	
Adjusted R^2	0.4714	
DW	2.17	
Period	1992:1 a 1997:4	

We then test to determine if the coefficient of TAR_{t+4} is equal to one. The Wald test for this null hypothesis yields a p-value of 0.945, leading us to not reject the null hypothesis. This finding suggests that, during this period, the inflation target did play a key role as the anchor for the expected rate of inflation.

The final model, with the restriction imposed, is given by:

Coefficient	**Value**	**Probability**
χ_o	0.0035	0.0010
χ_1	1.0000	n.a.
χ_2	0.3463	0.0000
R^2	0.7621	
Adjusted R^2	0.5242	
DW	2.17	
Period	1992:1 a 1997:1	

3.5 Simulating the Effect of Policy on Inflation

Now we will carry out three experiments. First, we will simulate the effect of the inflation target announced by the independent Central Bank on inflation expectations and, then, the effects of this factor on the observed trajectory of inflation. (Simulation 1). Second, we will simulate the trajectory of the inflation rate as though the exchange rate policy had been a crawling peg which accommodated real appreciation of 2 percent per annum (Simulation 2). Third, we will simulate the rate of inflation for the case in which the average rate of productivity for the period 1991-1997 is set equal to its value for the 1970-1990 period. Finally, we simulate the cumulative effect of both changes taken together (Simulation 3).

To facilitate the discussion, we present, first, the full model used for the simulations.

$$\pi^{S}_{t} = \alpha_0 + \alpha_1 \omega_t + \alpha_2 e_t + \alpha_3 \pi^*_t + \alpha_4 q_t + \alpha_5 GAP_{t-2} + \\ + \alpha_6 D874881 + \alpha_7 D9123 \quad (1)$$

$$\omega_t = \beta_0 + \beta_1 \pi^{E}_{t-1} + \beta_2 D1 \quad (2)$$

$$e_\tau = \gamma_0 + \gamma_1 \pi^{\varepsilon}_{\tau-1} + \gamma_2 \pi_{\tau-1} + \gamma_3 \Delta RIN + \gamma_4 I_{\tau-1} + \gamma_5 \varpi_\tau + \gamma_6 \varpi_{\tau-1} \quad (3)$$

$$\pi^{\varepsilon}_{\tau} = \varphi_0 + \varphi_1((\pi_\tau + \pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3})/4) \quad (4)$$

for the period 1986.1 to 1991.4

$$\pi^{\varepsilon}_{\tau} = \chi_0 + \chi TAR_{\tau+4} + \chi_2(((\pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3} + \pi_{\tau-4})/4) - \pi^{\varepsilon}_{\tau-5}) \quad (5)$$

for the period 1992.1 to 1997.4

$$\pi^{s}_{t} = \pi_\tau \quad (6)$$

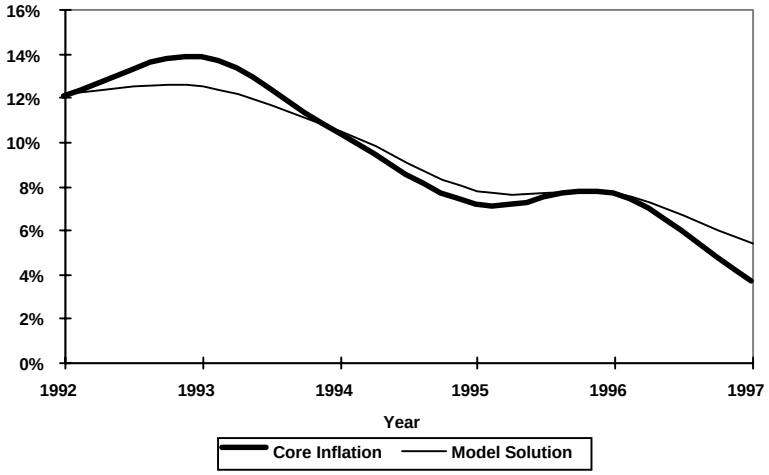
Before analyzing the simulations, we solve the complete model for the 1992.1 to 1997.4 period to obtain a benchmark. Those solved values from the model will be used to analyze the effects of the different simulations studied below.

As shown below, the comparison of the actual and simulated values for core inflation, on an annual basis, is very favorable to the model. The exception is 1997, when the inflation reduction was much greater than that estimated by the model.

[14] This equality is utilized in the simulations to take into account the effect of a change in the observed rate of inflation.

Year	Core Inflation	Model Solution
1992	12.10%	12.15%
1993	13.90%	12.51%
1994	10.39%	10.50%
1995	7.17%	7.80%
1996	7.72%	7.68%
1997	3.70%	5.39%

Inflation and Model Solution



Simulation 1: The Effect of the Inflation Target on Inflation Reduction

To carry out this simulation, we start by building a counter-factual where the expectations of inflation during the second period are driven by the same equation which accounts for them during the first period. That is, we assume that, during the second period, inflation expectations were explained by equation (4) above. As a summary, we compare the simulated trajectory of a

situation in which expectations had continued to be based on past inflation with the model solution which uses equation (5) for the 1992.1 to 1997.4 period.

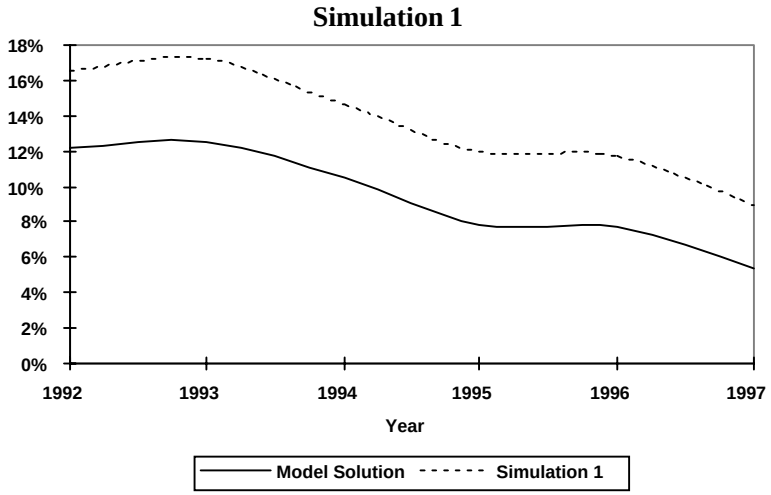
On an annual basis, the difference between the actual and the estimated core inflation yielded the following trajectory:

Simulation 1. The Effect of the Introduction of an Inflation Target on Inflation Expectations

Year	Simulation 1	Model Solution
1992	16.49%	12.15%
1993	17.21%	12.51%
1994	14.66%	10.50%
1995	11.95%	7.80%
1996	11.68%	7.68%
1997	8.91%	5.39%

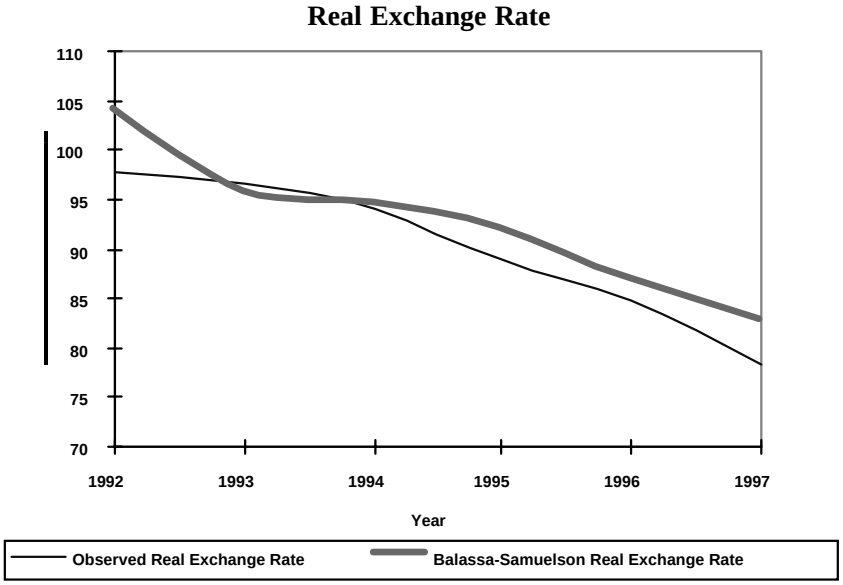
From the results presented in this table, we can observe that the change in the formation of expectations played a central role in the reduction of inflation throughout the period.

The difference in the trajectory of core inflation on a quarterly basis is presented in the following diagram:



Simulation 2: The effect of the Exchange Rate Trajectory.

In this simulation, with inflation expectations still modeled by equation 5, we change only equation (3) by a real exchange rate rule. For the exchange



rate rule, we assume that the real exchange rate appreciates 2% per annum to accommodate for the effect of the Samuelson-Balassa effect on the equilibrium real exchange rate. The comparison of the trajectory of the observed and simulated real exchange rate presented below indicates that the real exchange rate appreciated quite substantially in the latter part of the sample period.

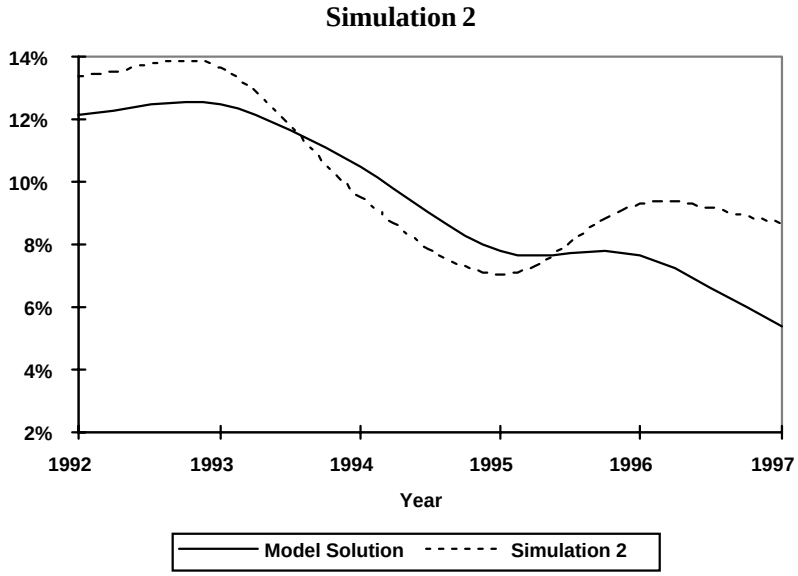
In our model, the appreciation above the two percent per annum rate helped to reduce inflation. Of course, it could be claimed that the equilibrium real exchange rate appreciated much more than what is assumed by our 2% per annum rule. The larger appreciation could be explained by other real factors. However, the sharp reduction in the growth of export volumes in recent years provides some evidence that the real appreciation was excessive.

On an annual basis, the difference between the base core inflation and the inflation rate simulated with the assumed real exchange rate rule is presented below:

Simulation 2. The Effect of Real Appreciation Greater than 2% per Annum

Year	Simulation 2	Model Solution
1992	13.38%	12.15%
1993	13.67%	12.51%
1994	9.49%	10.50%
1995	7.04%	7.80%
1996	9.30%	7.68%
1997	8.69%	5.39%

Thus, we observe that, if the real exchange rate had appreciated 2% per annum, then inflation would had been reduced much more slowly during the entire period. Furthermore, the difference between the model and simulated solutions is especially large in 1997, the year when real appreciation was



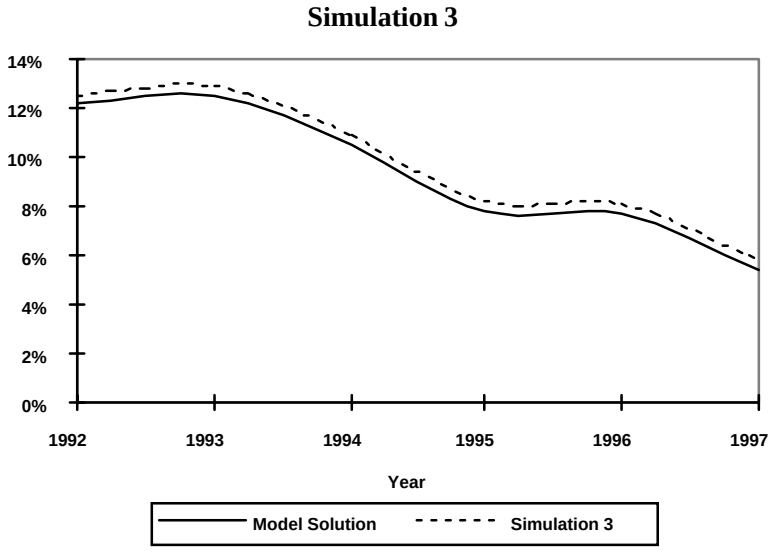
greatest. Thus, the sharp real appreciation of 1997 played a central role in the reduction of inflation that year.

As can be observed from the simulation results, the effect of the real exchange rate appreciation above 2 percent per annum has been an important contributor to the reduction of inflation during the last two years.

Simulation 3. The Effect of Increased Average Labor Productivity on the Reduction of Inflation

In this simulation, we assume that, during the 1992.1 to 1997.4 period, the rate of change of average labor productivity was, on average, equal to 1.96% per annum, a rate which is equal to the average rate of productivity growth during the 1960-1980 period. The results of the simulation are presented below. As can be observed, this effect explains a reduction of close to half a percentage point of the annual rate of inflation.

Year	Simulation 3	Model Solution
1992	12.49%	12.15%
1993	12.92%	12.51%
1994	10.91%	10.50%
1995	8.19%	7.80%
1996	8.07%	7.68%
1997	5.77%	5.39%



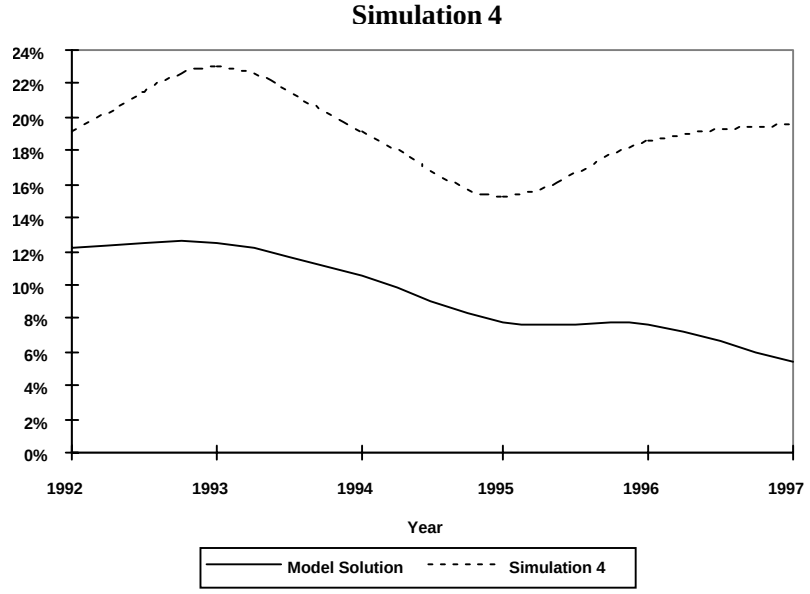
Simulation 4. The Effect of the Credibility of the Inflation Target, of the Appreciation of the Real Exchange Rate, and of Increased Productivity on the Reduction of Inflation.

In this simulation, we combine the effects of the three simulations. The difference in trajectory is as follows:

Year	Simulation 4	Model Solution
1992	19.14%	12.15%
1993	22.97%	12.51%
1994	19.11%	10.50%
1995	15.26%	7.80%
1996	18.53%	7.68%
1997	19.61%	5.39%

The analysis of the cumulative effect of the three simulations shows that, if it were not for the change in the formation of inflation expectations, for the appreciation of the real exchange rate above two percent per annum, and for increased labor productivity over its average value for the 1960-1980 period, the core inflation rate in 1998 would have been close to four times its observed value.

Finally, the difference in trajectory, for quarterly inflation, is presented below:



Summary of Results

Year	Core Inflation	Model Solution	Simulation 1	Simulation 2	Simulation 3	Simulation 4
1992	12.10%	12.15%	16.49%	13.38%	12.49%	19.14%
1993	13.90%	12.51%	17.21%	13.67%	12.92%	22.97%
1994	10.39%	10.50%	14.66%	9.49%	10.91%	19.11%
1995	7.17%	7.80%	11.95%	7.04%	8.19%	15.26%
1996	7.72%	7.68%	11.68%	9.30%	8.07%	18.53%
1997	3.70%	5.39%	8.91%	8.69%	5.77%	19.61%

IV. Conclusions

After 40 years of high and variable inflation, Chile has made major progress during this decade in reducing inflation toward levels observed in industrial countries. What is even more remarkable is that the reduction of inflation was achieved without incurring short-term costs. While inflation was reduced, growth increased and the unemployment rate reached its lowest level in 30 years. Thus, Chile's economic record over the past ten years has been remarkable. During the 1986-1997 period, the average GDP growth rate reached 7.6%, while average inflation ran at a rate of 17.8%. The unemployment rate, which rose to close to 30% in late 1982, was only 5.3% during the last quarter of 1997. Furthermore, the inflation rate (Dec.- Dec.), which had risen to 27,3% in 1990, decreased throughout the 1990s, reaching 6.6% in 1996, and 6.0% in 1997.

It appears that three factors were important in helping to accomplish this performance. First, the independent Central Bank and its tough action early on to convey the message that it was ready to stand behind its core objective (to reduce inflation) helped to shape inflationary expectations and, in the process, led to lower wage inflation and, ultimately, a lower path for core inflation. Second, restrictive monetary policy and the foreign exchange intervention policies associated with it resulted in a nominal exchange rate

trajectory much below what would have been observed under a PPP rule adjusted for differences in productivity. This result was reinforced by the low credibility of the band, reflected in the effect on the observed exchange rate of the location of the exchange rate within the band. Third, the higher rate of growth of labor productivity, given the wage equation, resulted in a lower rate of growth of the unit cost of labor than would have been observed otherwise. Of these three effects, the first, that is, the enhanced credibility of the new policy influencing the formation of inflation expectations, was the most important contributing factor to the successful reduction of the rate of inflation.

The question remains of how to continue reducing inflation, now that the rate of growth of average labor productivity has stabilized and real exchange rate appreciation has started to be reversed. The appropriate policy course here is to try to consolidate the gains made until now and to wait for a more favorable environment to continue making further progress to bring inflation close to industrial country levels.

Appendix. Testing for the Order of Integration of the Variables

In this appendix, we apply, first, a standard test to evaluate the order of integration of the different variables into the model used in the paper. Second, we apply Johansen's methodology to evaluate the cointegration of the different equations into the model.

Table A.1
Unit Root Tests for Inflation Variables
(1986: 1-1997:4)

Variable	ADF Test	5% Critical Value	D. of Integration
Core Inflation (π^S)			
No Intercept or Trend	-0.98	-1.95	I(1)
External Inflation (π^*)			
No Intercept or Trend	-2.26	-1.95	I(0)
Wages (ω)			
No Intercept or Trend	-1.01	-1.95	I(1)
Exchange Rate (e)			
No Intercept or Trend	-1.79	-1.95	I(1)
Average Productivity (q)			
No Intercept or Trend	-1.14	-1.95	I(1)
Gap			
Intercept and Trend	-4.61	-3.51	I (0)

Unit Root Tests for Inflation Variables
(1986: 1-1997:4)

Variable	ADF Test	5% Critical Value	D. of Integration
Expected Inflation (π^e)			
Intercept and Trend[15]	-2.94	-1.95	I(0)
Change in International Reserves (ΔR)			
Intercept and Trend	-4.44	-3.51	I(0)
Actual Inflation (π)			
No Intercept or Trend	-1.31	-1.95	I(1)
Exchange Rate Percentile (PER)			
No Intercept or Trend	-1.51	-1.95	I(1)
GDP Growth (I)			
No Intercept or Trend	-0.67	-1.95	I(1)
Target Inflation (TAR)			
Intercept and Trend	-5.04	-1.96	I(0)

[15] In this case, the critical value is equal to the normal distribution, in accordance with the methodology of Enders (1995). (See page 257).

Table A.2
Johansen (1991) Cointegration Test for Equations [16]

A. Price Equation:

Sample: 1985:1 1997:4
Included observations: 43
Test assumption: Linear deterministic trend in the data
Series: π^{S}_t ω_t e_t π^{*}_t q_t GAP_{t-2}
Lags interval: 1 to 3

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.821099	160.3392	94.15	103.18	None **
0.558409	86.33961	68.52	76.07	At most 1 **
0.513258	51.19262	47.21	54.46	At most 2 *
0.266204	20.23169	29.68	35.65	At most 3
0.136295	6.922142	15.41	20.04	At most 4
0.014352	0.621612	3.76	6.65	At most 5

*(**) denotes rejection of the hypothesis at 5% (1%) significance level
L.R. test indicates 3 cointegrating equation(s) at 5% significance level

B. Wage Equation:

Sample: 1985:1 1997:4
Included observations: 48
Test assumption: Linear deterministic trend in the data
Series: ω_t π^{E}_t
Lags interval: 1 to 2

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.368648	23.38017	15.41	20.04	None **
0.026829	1.305373	3.76	6.65	At most 1

*(**) denotes rejection of the hypothesis at 5% (1%) significance level
L.R. test indicates 1 cointegrating equation(s) at 5% significance level.

[16] To determine the length of lags that enter in the cointegration test, we use the Akaike information criterion (AIC).

C. Exchange Rate Equation:

Sample: 1985:1 1997:4
Included observations: 42
Test assumption: Linear deterministic trend in the data
Series: e_t π^*_t π_t ΔRIN_t I_{t-1} PER_t
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.888234	186.8818	94.15	103.18	None **
0.675063	94.84515	68.52	76.07	At most 1 **
0.459506	47.63198	47.21	54.46	At most 2 *
0.260943	21.79056	29.68	35.65	At most 3
0.131384	9.090607	15.41	20.04	At most 4
0.072803	3.174738	3.76	6.65	At most 5

*(**) denotes rejection of the hypothesis at 5% (1%) significance level
L.R. test indicates 3 cointegrating equation(s) at 5% significance level

D. Expectations Equations (1986 to 1991)

Sample: 1985:1 1991:4
Included observations: 17
Test assumption: Linear deterministic trend in the data
Series: π^{ε}_{τ} $((\pi_{\tau} + \pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3})/4)$
Lags interval: 1 to 2

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.870730	40.22884	15.41	20.04	None **
0.274249	5.449316	3.76	6.65	At most 1 *

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 2 cointegrating equation(s) at 5% significance level

D. Expectations Equations (1992 to 1997)

Sample: 1992:1 1997:4
Included observations: 24
Test assumption: Linear deterministic trend in the data
Series: π^{ε}_{τ} TAR_{τ} $((\pi_{\tau-1} + \pi_{\tau-2} + \pi_{\tau-3} + \pi_{\tau-4})/4)$
Lags interval: 1 to 4

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.678775	49.17217	29.68	35.65	None **
0.483190	21.91743	15.41	20.04	At most 1 **
0.223646	6.075526	3.76	6.65	At most 2 *

*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 3 cointegrating equation(s) at 5% significance level

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