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# DO FOREIGN CURRENCY DEPOSITS DID THEY IMPROVE WELFARE? THE PERUVIAN CASE 1970-1985

Carlos A. Janada

#### ABSTRACT

The Authorization of foreign currency deposits is interpreted here as a technological innovation reducing the demand for domestic money and improving welfare. The reduction of the inflation tax base leads to an increase of the inflation rate and of the associated excessburden. The final impact on Welfare is therefore ambiguous. An empirical estimation of the model for the Peruvian experience between 1970 and 1985 indicates that welfare actually improved when the government authorized foreign currency accounts.

## **1. INTRODUCTION**

Latin America has undertaken market-oriented reforms in the last few years. While some reforms - such as trade liberalization, privatization, and deregulation - have been unanimously implemented in the region, others such as financial liberal liberalization have been controversial. In particular, while some governments have allowed foreign currency deposits (e. G. Argentina, Ecuador, Peru, and Uruguay), some others have been reluctant to approve such a policy (e. G., Colombia, Chile, Mexico, and Venezuela). This paper attempts to assess the welfare impact of a foreign currency deposit policy based on the Peruvian experience between 1970 e 1985.

The authorization of foreign currency deposits (FCDs henceforth) has two opposite effects on welfare. First, consent of these deposits implicitly legalizes the use of a foreign currency in daily transactions. Agents no longer have to resort to the black market to get foreign currency and pay high transaction costs. It is now available at any commercial bank or exchange house. Thus, ability to hold legally an extra currency has a positive impact on individuals' welfare. Second, often in these economies, fiscal revenues depend on government's ability to print money (seigniorage). The more the government uses seigniorage, the higher the inflation rate is. In this sense, the inflation rate acts as tax rate, while individuals' domestic money holdings function as the

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base. The authorization of FCDs reduces the demand for domestic money. A decline of the tax base forces the government to increase the tax rate to keep constant its seigniorage revenues. As inflation rises, welfare decreases.

In summary, on the one hand, the authorization of FCDs has a positive impact on individuals' welfare per se. On the other hand, the rise in the inflation rate has a negative impact. Thus, the welfare impact of an FCD policy is ambiguous on theoretical grounds. An empirical investigation becomes necessary to evaluate the final outcome.

We use a theoretical framework developed by De Gregorio (1991) which show innovations in transaction technology affect welfare when government revenues depend on seigniorage. His paper concludes that if the inflation rate is close to zero, a technological innovation reducing transaction costs has a positive impact on welfare. However, if the inflation rate is close to the seigniorage maximizing rate, a technological innovation has a negative impact on individuals' welfare.<sup>1</sup> If the inflation rate is in between, the theoretical impact is ambiguous and an empirical estimation of the model becomes necessary.

We expand De Gregorio's model by using a more general specification of transaction cost technology. In particular, the transaction cost function used here depends not only on money but also on consumption. The authorization of FCDs is interpreted in this paper as an exogenous reduction in transaction costs (i.e., a technological improvement). The introduction of consumption and the adoption of a specific transaction technology make the model suitable for estimation purposes.

The structure of this paper is as follows. Section 2 contains the theoretical model. Section 3 presents the results of the empirical estimation of the model for the case of the Peru. The reduced form outlined in Section 2 is estimated using ordinary least squares and instrumental variables. The FCDs' welfare impact is assessed at the end of this section. Lastly, Section 4 offers some closing remarks.

#### 2. THE MODEL

The model assumes that the economy consists of a representative infinitely lived agent who maximizes the following intertemporal utility function:

$$W = \sum_{t=1}^{\infty} \beta^{t-1} v(m_t, x_t)$$

· (1)

<sup>&</sup>lt;sup>1</sup> It will be helpful to recall that seigniorage has a positive relationship with the inflation rate up to some point, right after which it becomes a negative one. This inverted V relationship is know in the literature as the Laffer's curve. This paper assumes that the government sets the inflation rate between zero and that maximizes seigniorage collection (seigniorage maximizing rate).

with:<sup>2</sup>

$$v_x > 0$$
  $v_{xx} \le 0$   
 $v_m \ge 0$   $v_{mm} \le 0$   $v_{xm} \ge 0$  (1.a)

where *m* represents the individual's money holdings and x denotes his consumption. The parameter  $\beta$  is a subjective discount factor. As show by Feenstra (1986), it is possible to rewrite the utility function as:

$$u(c) = v(x,m) \tag{2}$$

with:

$$u_c > 0$$
  $u_{cc} \le 0$  (2.a)

Where consumption (x) should be interpreted as the summation of *net* consumption (c) and transaction costs ( $\emptyset$ ). The following restrictions must also hold:

$$\phi(c,m) \ge 0 \tag{3}$$

h > 0

with:

$$\phi_m \le 0 \qquad \qquad \phi_{mm} \ge 0 \qquad \qquad \phi_{cm} \le 0 \qquad (3.a)$$

> n

The first partial derivatives indicate that transaction costs increase or remain constant with higher consumption and decrease or remain constant with higher money holdings. The second partial derivatives indicate a rising or constant marginal cost of consumption and a decreasing or constant marginal benefit of money. The cross derivative points out that higher money holdings bring about an unchanged or decreasing consumption marginal cost.

Since we will allow for a technological change, it is convenient to reexpress (3) as:

$$\phi(c,m,\gamma) \ge 0 \tag{4}$$

with:

where we have made *explicit* that the transaction cost function depends also on a technology parameter,  $\gamma$ , such that, a technological progress (measured as a reduction in  $\gamma$ ) lowers, ceteris paribus, transaction costs.

The representative agent maximizes (1) subject to the following budget constraint (capital letters stand for nominal variables):

$$i_{t-1} D_{t-1} + P_t W_t = P_t X_t + M_t - M_{t-1} + D_t - D_{t-1} \qquad \forall t = 1, 2, \dots, \infty$$
(5)

 $<sup>^2</sup>$  To simplify notation we omit the time subscript "t" whenever possible. A subscript different from "t" indicates a partial derivate.

where *i* is the nominal interest rate, *P* is the domestic price level, *D* is a nonmonetary assets, and *w* is the real wage. Assume for convenience, that D<sub>0</sub> and M<sub>0</sub> are both equal to zero, and denote the price increase by  $\pi(P_t/P_{t-1} - 1)$  and the real interest rate by *r*. If both *r* and  $\pi$  are constant, it is possible to reexpress the budget constraint (5) as:

$$\sum_{t=1}^{\infty} \frac{c_t + \phi_t}{(1+r)^{t-1}} + \sum_{t=1}^{\infty} \frac{m_t \cdot (r+\hat{\pi})}{(1+r)^t} = H$$
(6)

with:

$$\hat{\pi} = \frac{\pi}{1+r} \qquad \qquad H = \sum_{t=1}^{\infty} \frac{w_t}{(1+r)^{t-1}}$$

We will refer to the term  $\hat{\pi}$  as the inflation rate. Substituting (2) into (1) and maximizing this result subject to (6) gives the following first order conditions:

$$u_c = \lambda_c \left(1 + \phi_c\right) \tag{7}$$

$$\phi_m = -\frac{r + \hat{\pi}}{1 + r} \tag{8}$$

with:

$$\lambda = \frac{\lambda}{\beta^{t-1} \cdot (1+r)^{t-1}}$$
(9)

where  $\lambda$  is the Lagrange multiplier. Equation (7) indicates that the marginal utility of consumption equals the marginal utility of income ( $\lambda$ ) multiplied by its price. The price of consumption equals its output cost plus the consumption marginal cost of the transaction technology. Equation (8) points out that in steady state the transaction technology money marginal cost must equal in absolute value the opportunity cost of holding money (i.e., the nominal interest rate). In other words, equation (8) is an demand implicit for money function. Since in steady state it is reasonable to assume that  $\lambda = \lambda^*$ , then, from equation (6) and for a constant wage rate, we will have that for each period:

$$c + \phi + m \cdot \frac{r + \hat{\pi}}{1 + r} = w \tag{10}$$

Equation (10) says that, in steady state, the individual distributes its income among net consumption, transaction costs, interest forgone for holding money, and seigniorage paid to the government. We now proceed to analyze the net impact on welfare of an improvement in the technology transaction, in a situation where the government is required to collect a constant seigniorage. In steady state, real seigniorage for any period(s) is given by  $s = \hat{\pi} \cdot m$ 

Since we are imposing the condition that real seigniorage remains constant after the technological change, then

(11)

$$\frac{d\hat{\pi}}{d\gamma} = -\frac{\hat{\pi}}{m} \quad \frac{dm}{d\gamma} \tag{12}$$

Differentiating (8) and (10), and considering that in this case, the inflation rate changes to keep seigniorage constant, the solution to the resulting system in terms of  $dc/d\gamma$  and  $dm/d\gamma$  is given by

$$\frac{dc}{d\gamma}\Big|_{\overline{s}} = \frac{1}{\tau} \cdot \left[\phi_{\gamma} \cdot \phi_{mm} + \frac{\hat{\pi}}{1+r} \cdot \left(\phi_{m\gamma} - \frac{1}{m} \cdot \phi_{\gamma}\right)\right]$$
(13)

$$\frac{dm}{d\gamma}\Big|_{\overline{s}} = \frac{1}{\tau} \cdot \left[\phi_{m\gamma} \cdot (1 + \phi_c) - \phi_{\gamma} \cdot \phi_{mc}\right]$$
(14)

with:

$$\tau = \frac{\hat{\pi}}{1+r} \cdot \left[\frac{1}{m} \cdot (1+\phi_c) - \phi_{mc}\right] - (1+\phi_c) \cdot \phi_{mm}$$
(15)

In order to analyze the signs of expression (13) and (14), it will be useful to show how money demand changes when a technological innovation takes place, i.e.,

$$\frac{dm}{d\gamma}\Big|_{\hat{\pi}} = -\frac{\phi_{m\gamma}}{\phi_{mm}} + \frac{\phi_{mc}}{\phi_{mm}} \cdot \frac{\phi_{\gamma}}{1 + \phi_c}$$
(16)

Expression (16) indicates that there are two effects on money demand that run in opposite directions when a technological progress (measured by the first term on the right hand side of expression (16)). The second effect is the positive income effect on net consumption; since money demand depends positively on consumption (see expression (8)), money holdings rise due to this effect. Hence depending upon the relative strength of these effects, demand for money may go up or down as a result of a technological innovation. We will assume that the final outcome of a technological improvement will be a reduction in money demand, i.e.,

$$\phi_{mc} \cdot \phi_{\gamma} - (1 + \phi_c) \cdot \phi_{m\gamma} > 0 \tag{17}$$

Furthermore, since we have assumed that the economy is always located on the upward sloping region of the Laffer's curve - i.e., seigniorage increases along with the inflation rate - it is possible to show that expression (15) is always negative except at the seigniorage maximizing inflation rate, when it becomes zero. Suppose that the inflation rate is zero. Then, using (15) and (17) in expressions (13) and (14), it can be shown that

$$\frac{dc}{d\gamma}\Big|_{\vec{s}=s(\hat{\pi}=0)=0} < 0 \qquad \qquad \frac{dm}{d\gamma}\Big|_{\vec{s}=s(\hat{\pi}=0)=0} > 0 \qquad (18)$$

On the other hand, it is feasible to show after some algebraical manipulation that the seigniorage maximizing inflation rate is given by

$$\hat{\pi}^{*} = \frac{1 + \phi_{c}}{(1 + \phi_{c}) - m \cdot \phi_{mc}} - m \cdot (1 + r) \cdot \phi_{mm}$$
(19)

Replacing (19) in (13) and (14), it is possible to show that

$$\frac{dc}{d\gamma}\Big|_{\overline{s}=s\left(\hat{\pi}=\hat{\pi}^{*}\right)=s} > 0 \qquad \qquad \frac{dm}{d\gamma}\Big|_{\overline{s}=s\left(\hat{\pi}=\hat{\pi}^{*}\right)=s} > 0 \qquad (20)$$

Expression (18) indicates that a technological improvement will be welfare improving when the inflation rate is equal to zero. Intuitively. When the inflation rate is zero, the government does not collect any seigniorage at all. Thus, in spite of a reduction in money demand arising from the technological improvement, the inflation rate remains at zero. Thus, welfare necessarily improves.

Expression (20) points out that the welfare impact will be negative when the inflation rate equals the seigniorage maximizing rate. In this case we have that previous to the technological innovation the government was maximizing seigniorage. The technological improvement reduces the demand for money, thus the government rises the inflation rate to keep seigniorage collection constant. However, as the government increases the inflation rate, demand for money falls even more. In this particular point, the government keeps rising the inflation rate in an attempt to keep its seigniorage collection constant. The welfare loss of an increasing inflation rate becomes higher (in absolute terms) than the positive welfare gain produced by the technological improvement.

For any inflation rate between zero and the maximizing rate, the impact on welfare will be - in principle - ambiguous. However, since the utility function and the transaction technology are monotonic functions arguments, it is intuitively clear that the closer the inflation rate is to zero, the more likely that the impact on welfare is positive. On the other hand, the closer the inflation rate is to the seigniorage maximizing rate, the more likely that the impact is negative.

In order to proceed with the empirical estimation of the model and clarify our theoretical findings, we adopt a particular transaction technology from which a Goldfeld-form demand for money can be devised. This specific technology is given by

$$\phi(c,m,\gamma) = \frac{\delta}{1-\delta} \cdot e^{\gamma/\delta} \cdot \frac{c^{\beta/\delta}}{m^{1-\delta/\delta}} + m + c - \gamma^2 - \frac{1}{\gamma} \cdot c$$
(21)

Taking into account (8), the state money demand function arising from expression (21) is

$$\ln m = \gamma + \beta \cdot \ln c - \delta \cdot \ln \left[ 1 + \frac{r + \hat{\pi}}{1 + r} \right]$$
(22)

Note that in this case the relevant scale variable of money demand is net consumption instead of income. Without further knowledge of the specific parameter values it is not possible to determine the sign of expression (13). A way of obtaining plausible values for the parameters involved in this expression is through the estimation of the money demand function with data form a given country. An alternative is to calibrate equations (13) and (14) for a given set of parameter values and different values of the inflation rate. This done in Figures 1 and 2 for the following parameter set:  $\beta$ =1.80,  $\gamma$ = -3.30,  $\delta$ =3.40, and r=0.0075. These parameters are based on empirical estimates presented in the next section.

Figure 1 shows that for low values of the in inflation rate, the final impact on welfare is positive. For rates close to the seigniorage maximizing inflation rate, the final outcome on welfare is negative, as was pointed out before. The seigniorage maximizing inflation rate is 38% and the inflation rate at which expression (13) changes its sign is 12%. Figure indicates that for any value of the inflation rate, this particular parameter set always exerts a negative effect on money demand.

Figure 3 display the impact on welfare using the original and two alternative parameter sets in which we have only modified the value of the inflation elasticity of money demand ( $\delta$ ). The figure shows the well known (inverse) relationship between the inflation elasticity of demand for money and the seigniorage maximizing inflation rate.

Interestingly, it also shows that the higher the inflation elasticity, the more likely the impact on welfare arising from a technological change. In other words, a low seigniorage collection is in this context equivalent to a low inflation rate.

Finally, this exercise suggests that empirical estimation of the model depicted above becomes crucial to evaluate the impact on welfare since the final outcome is highly sensitive to the value of the parameters.

## **3. EMPIRICAL ESTIMATION**

Technological innovation resulting in the decrease of transaction costs may take different forms, including the introduction of automatic teller machines or the introduction of credit cards. Indeed, these innovations tend not only to reduce transaction costs, but also to prompt individuals to keep less money in their pockets and checking accounts. The technological innovation that took place in Peru was the authorization of FCDs.

In particular, the government allowed commercial banks to offer foreign currency checking accounts.<sup>3</sup> The government also permitted commercial banks to issue certificate of deposits denominated in foreign currency. These certificates were freely negotiable and highly liquid to make transactions. In addition, the government eliminates some exchange controls, authorized the establishment of exchange houses, and allowed citizens to satisfy contracts with foreign exchange. This liberalization may have reduced the demand for domestic money, affecting the ability of the authorities to collect seigniorage.

We have already established that the welfare impact of reduced transaction costs is unambiguous when the inflation rate is zero (positive impact) or when it maximizes seigniorage collection (negative impact). However, the seigniorage maximizing inflation rate is hardly known without an empirical estimate of demand for money. During the period analyzed, inflation in Peru was not close to zero and the seigniorage collected by the government increased *pari passu* the inflation rates. This suggests that the inflation rate was between the two extremes and, therefore, we need an empirical approach to evaluate the welfare impact of FCDs authorization.

Note that the money function is estimated using ordinary least squares (OLS) and instrumental variables (IV). The estimation period extends from the third quarter of 1970 to second quarter of 1985 (60 quarterly observations). We measure the impact of the authorization of FCDs (made in December 1977) on the demand for money through a dummy variable. The dummy viable shifts the value of the constant term between the two periods (1970-Q3/1977-Q4 and 1978-Q1/1985-Q2).

A conventional assumption of econometric estimations is that the time series employed are stationary. However, recent developments in applied research have shown that several economic time series traditionally used in econometric estimations might have unit roots. Given that the existence of unit roots has serious implications for the validity of regression analysis results (the spurious regression problem), this assumption must not be taken for granted

<sup>&</sup>lt;sup>3</sup> Even though the government authorized commercial banks to deal with several foreign currencies, banks chose the American dollar as the leading foreign currency in their operations.

and more attention should be paid to the appropriate econometric technique in the presence of non-stationary time series. In particular, time series with unit roots that are postulated to be linearly related can be estimated through the cointegration technique. We carry out the estimation of expression (22), i.e., demand for money, using OLS and IV and then test for cointegration.

The first step in the co-integration methodology is to determine whether the time series that are postulated to be linearly related are integrated of order one. The second step is to run a regression using the integrated series. This linear combination is generally a *long run relationship* that in principle should come from economic theory. Finally, one should test for co-integration in the residual vector of the last regression.

## 3.1 Testing for unit roots

There are different techniques to test whether a time series is stationary. We have adopted one of the most commonly used in the literature. Dickey-Fuller test. This test was applied to the following series: the logarithm of per capita money holdings (log m), the logarithm of per capita consumption (log c), and the inflation rate  $(\pi)$ .<sup>4</sup> See the appendix for data sources and definitions.

The methodology used to evaluate the unit root tests is the one outlined in Perron (1988). Table I displays our empirical findings. If K (the truncation lag parameter) equals zero, we have the simple Dickey-Fuller test. This test assumes that the residual term in the regression is i.i.d., if k is positive, we have the augmented Dickey-Fuller test. This test is a parametric way to deal with the likely autocorrelation of the error term.

We use the statistics  $n(\hat{p} - 1)$ ,  $\hat{\tau}$ , and  $\phi_3$  to evaluate whether there is evidence for rejecting the null hypothesis H<sub>0</sub> of a unit root. <sup>5</sup> The results show that only case where H<sub>0</sub> is rejected is in the inflation case at 5% of significance. However, rejection of H<sub>0</sub> might be due to the poor power properties of this test. A more powerful test might be carried out by ignoring the trend variable, but we first have to verify whether the drift is zero. The H<sub>0</sub> for the statistic  $\phi_2$  is that the time series has a unit root and is driftless; the H<sub>0</sub> is accepted for the series of money, consumption, and the inflation rate (when k= 1 and 3).

<sup>&</sup>lt;sup>4</sup> The inflation rate for the unit root test was defined as  $\pi = p_t/p_{t-1} - 1$ . However, we refer to  $\hat{\pi} = \left[ \frac{\pi}{(1 + \pi)} \right]$  as the inflation rate elsewhere in this paper.

<sup>&</sup>lt;sup>5</sup> Dickey and Fuller have shown that under H<sub>0</sub>,  $\tau$  distribution is strongly skewed to the left. Thus, the t distribution is a bad approximation in this case. However, the estimation of  $\rho$  is still feasible by simply applying OLS, the critical values for these statistics have been tabulated by Dickey and Fuller.

Table II shows the results when we ignore the trend variable. the H<sub>0</sub> for  $\phi_1$  is that there is a unit root. Note that in the case of money, H<sub>0</sub> is rejected for k=0. This was precisely the case for which H<sub>0</sub> for the statistic  $\phi_2$  was rejected. However, when we consider that the error term is likely to be auto-correlated, the results in Table II suggest that per capita money holdings, per capita consumption, and the inflation rate follow a random walk without drift.

In brief, the Dickey-Fuller tests suggest that the unit root hypothesis can not be discarded in the money and consumption series. However, the evidence is not conclusive for the inflation rate is our sample period.<sup>6</sup>

#### 3.2 Specification, estimation and co-integration

The long run relantionship to be estimated is the demand for money specified in (22). For estimation purposes, this equation may be rewritten as

 $\ln m_t = \gamma_0 + \gamma_1 \cdot dl_t + \gamma_2 \cdot d2_t + \beta \cdot \ln c_t - \delta \cdot \ln \left[1 + \frac{r + \hat{\pi}_{t+1}}{1 + r}\right] + u_t$ (22.a)

with:

$$\hat{\pi}_t = \frac{\pi_t}{1 + \pi_t} \qquad \qquad \pi_t = \frac{P_t}{P_{t-1}} - 1$$

where  $u_t$  is the residual term and  $d1_t$  an  $d2_t$  are two dummy variables. The first one accounts for the technological change (it takes the value of since 1978; zero elsewhere). The second one, for the unexpected increase in the money supply due to foreign factors.<sup>7</sup> Since the interest rates on deposits were under government control and Peru's stock market was underdevelopment, it as difficult to obtain information on the return on capital (r). We assumed a fix real return of 3% per annum to perform the estimation (22.a). The co-integration methodology requires that all series entering the regression be integrated of order one, I (1). Since the only series for which the unit root tests are not conclusive with respect to its non-stationary is the inflation rate, it will be assumed that the inflation rate is I(1).<sup>8</sup>

<sup>&</sup>lt;sup>6</sup> We found similar results using the Philips-Perron non-parametric test. We also carried showed the results showed no evidence of unit roots.

<sup>&</sup>lt;sup>7</sup> It takes the value if one for 1979 and 1980, zero elsewhere. The country's terms of trade increased substantially during these years. Since Peruvian exports depend heavily on raw materials, the improvement in the country's terms of trade resulted in a quick monetization of inflows.

<sup>&</sup>lt;sup>8</sup> Zambrano-Berendsohn (1992) found in his study on Peruvian demand for money that the inflation rate did have a unit root. His sample covered the period 1979-1988.

The estimated parameters are displayed in Table III for both OLS and IV.<sup>9</sup> Most of the parameters are significant at the usual 95% degree of confidence. The sign of  $\hat{\gamma}_1$  is negative in both cases as expected on theoretical grounds; these results indicate an exogenous reduction in demand for money between 15,3% and 19,5% when FCDs were introduced in 1978. The sudden impact on money supply due to foreign factors increased demand for money temporarily by 19%, approximately. The adjusted R<sup>2</sup> and the standard error of the regression,  $\hat{\sigma}$ , indicate a relatively good adjustment in both cases. The low D-W statistic might indicate either that the error term is auto correlated, the functional form of (22) is incorrect, or there are missing variables. We will use this to test for co-integration.<sup>10</sup>

With the estimated residual term ( $\hat{u}_t$ ) of cach regression, we proceed to test for co-integration. The null hypothesis H<sub>0</sub> is that the residual term is nonstationary. Rejection of H<sub>0</sub> means that the long run relationship is stable over time. Failure to reject H<sub>0</sub> indicates that the relationship might be meaningless. Egle and Granger (1987) suggest several methods to test for co-integration. A quick check, though, not recommended by these authors, is to examine the D-W statistic. They show that if the residual term from the regression is nonstationary, then D-W statistic converges to zero.<sup>11</sup> The critical value for the cointegrating D-W statistic is 0.367 at the 5% level of significance see Granger and Newbold (1986, p.264). According to this test, we reject H<sub>0</sub> in all cases. Thus, the co-integrating D-W statistic suggests that the estimated relationships are stable over time.

A more elaborated test is the augmented Dickey-Fuller. The relevant regressions to carry out this test are shown in Table IV. The critical value for the t test on the level of the lag variable is 3.13 (see Granger and Newbold (1986, p.264)). hence, at the 5% level of significance, we reject the null hypothesis for the co-integrating regression (22.a), i. E., the augmented Dickey-Fuller strongly indicates that the relationship (22.a) is co-integrated.

<sup>&</sup>lt;sup>9</sup> The instuments used were past values of per capita GDP, real money stock, inflation rate, and devaluation rate.

<sup>&</sup>lt;sup>10</sup> We have also examined with the estimated parameters that conditions (3.a) and (4.a) hold. We used average values of consumption and money holdings for the following periods: 1970-Q3/1977-Q4, 1978-Q1/1978-Q4, 1979-Q1/1980-Q4, and 1981-Q1/1985-Q1.

<sup>&</sup>lt;sup>11</sup> They have tabulated the critical values for the co-integrating D-W when the number of series in the regression is two and they are all random walks or ARIMA (4, 1, 0). Granger and Newbold (1986) have extend the number of series in the regression to three and for the case of random walks only.

## 3.3 Welfare evaluation

Since the Peruvian government authorized FCDs in December 1977, welfare evaluation was carried out with averages values of consumption, money holdings, and inflation rates for the period 1970-Q3/1977-Q4. The evaluation of expression (13) and (14) using the parameter set estimated for (22.a) is reported in Table V. The results indicate that although the introduction of FCDs had a negative impact on demand for money, it actually improved individual's welfare. This table also reports the seigniorage maximizing inflation rate ( $\hat{\pi}^*$ ).<sup>12</sup> Table VI reports the estimated values for expressions (13) and (14) using the parameters estimated with OLS for different levels of the inflation rate. The average inflation rate for the period 1970-Q3/1977-Q4 was only 4.57%. Thus, the economy was relatively far from the seigniorage maximizing rate when FCDs were introduced.

After the introduction of FCDs, the rate should have increased to 5.80% (5.53% using IV estimators) to keep seigniorage revenues constant. However, the average inflation rate for the second period (once FCDs were introduced) rose to 14.91%, i. e., the Peruvian government used more intensively inflationary finance. The modification of the exchange rate regime played a key role in this outcome. The government switched from a fixed exchange rate to a crawling peg almost simultaneously to the introduction of FCDs. This change allowed government to set up a higher rate than the international one. Even though the average inflation rate for the second period was still far from the seigniorage maximizing rate, i. e., below 30%, it should be pointed out that the inflation rate for the first two quarters of 1985 were 25.0% and 26.3%, respectively.

The model developed above indicates the direction of change in individual's welfare arising from a technological innovation and a simultaneous increase of the inflation rate in the steady state. However, two particular issues no treated do far arise when this model is applied to the Peruvian experience with FCDs. First, the FCDs policy was carried out for a limited period of time (92 months). Second, the government imposed a special one time capital levy on these deposits in 1985. A more accurate measurement of the welfare impact due to the FCDs policy must take into consideration these issues.

The first issue would have been irrelevant if the second one had not occurred. It is possible to find from equation (13) the change in individual's consumption *per period* arising from the introduction of FCDs and the simultaneous increase of the inflation rate. The present value of this additional

<sup>&</sup>lt;sup>12</sup> Note that the estimation of the seigniorage maximizing implicitly assumes constancy of the elasticities in demand for money.

consumption stream represents individual's long term welfare gain. Since the change in consumption is the same for any period and in the absence of any taxation, individual's long term welfare gain will be positive if and only if his change of consumption per period is also positive. This assertion is independent of the number of periods. However, the magnitude of the long term welfare gain will vary according to the number of periods.

The second issue is more subtle. The freezing of the FCDs in 1985 marked the end of the FCDs policy. Furthermore, depositors paid a special one time capital levy. The government froze the FCDs in July 1985. The freezing was done in terms of dollars. Residents could withdraw their FCDs at an exchange rate of I/. 13.94 per U.S. Dollar plus a premium of 3%, i. e., an effective exchange rate of I/. 14.36 (lower than the market exchange rate of I/. 17.38). Assuming that residents withdrew the equivalent of their FCDs in domestic currency right after freezing, the implicit tax rate they paid amounted to 17.4% [(17.38 - 13.94 \* 1.03)/17.38]. Since we have empirically estimated the change in the technological parameters,  $\gamma$ , it is possible to estimate from equation (13) the change in individual's consumption per period. Numerical evaluation of the integral of equation (13) using the OLS estimators found for the Goldfeld-type technology yields: dc = 0.1370. This value represents 0.42% of individual's consumption on an annual basis, approximately.<sup>13</sup> Therefore, the introduction of FCDs had a positive effect on individual's welfare equivalent to an increase of this consumption in 0.42%. It should be emphasized that this is a flow result. If FCDs had not been banned from the economy and there had not been a capital levy on these accounts, the individual's long term welfare gain would have been 14.24% (percentage of individual's consumption).14

However, FCDs in Peru lasted a limited period of time and they were subject to a special taxation. Thus, individual's long term welfare gain was obviously lower than the 14.24% estimated above. An attempt to evaluate individual's long term welfare gain once we consider the issues mentioned above is presented in Table VII. The second column of this table reports the cumulated welfare gain when taxation of FCDs is initially omitted. This indicator was only one fifth of its long term value by July 1985. The imposition of the tax reduced the cumulated welfare gain to the level it had in early 1980.<sup>15</sup> All in all,

<sup>&</sup>lt;sup>13</sup> The quarterly average real per capita consumption between 1970-Q3 and 1977-Q4 was I/.32.42 (intis of 1979). This amount represented annual real per capita consumption of I/. 129.68. The latter amount is used as a benchmark in the results presented in Table VII. The numerical evaluation of the integral equation (13) using the IV estimators yields a slightly higher result.

<sup>&</sup>lt;sup>14</sup> This was estimated as (4 \* 0.1370 / 129.68 = 0.42%) / 0.03.

<sup>&</sup>lt;sup>15</sup> The welfare gain considering taxation was estimated as follows. The implicit tax rate, 17.4%, was applied on real per capita FCDs at the end of July 1985, *I*/. 17.29 (intis of 1979). This result was then taken to present value in 1977 using the 3% real interest rate as a discount factor. We finally

the average Peruvian depositor was better off with the authorization of FCDs in spite of their subsequent taxation.

## 4. FINAL REMARKS

This paper has analyzed the welfare implications of authorizing FCDs in the domestic financial system, assuming that they represent a change in the steady state transaction technology. The estimation of the model for the Peruvian experience indicates that the average individual's welfare improved when the government introduced foreign currency accounts in December 1977. Note that this result holds in spite of the subsequent taxation imposed on these accounts in July 1985.

Our results suggest the financial innovations, at least in the Peruvian case, may have sizable effects on individuals' welfare in the long run. Indeed, our findings indicate that per capita consumption would have increased 14.2% in the long term if FCDs had not been banned from the economy.

Finally, our results also indicate that the seigniorage maximizing inflation rate was between 30% and 33% per quarter. This result proved to be robust. Seigniorage revenue increased until mid-1988, when the domestic inflation rate surpassed the 33% boundary. Thereafter, seigniorage collection decreased substantially as inflation kept increasing.

## APPENDIX A: DATA, SOURCES AND DEFINITIONS

All data were obtained from the Banco Central de Reserva del Peru and the Instituto Nacional de Estadistica e Informatica. None of these series was corrected for seasonality. A brief description of each series is as follows.

- m (per capita money holdings): Money is the summation of currency and demand deposits from the Peruvian banking system. We obtained first a quarterly average of (nominal) monthly observations. Then, we deflated the series by the quarterly average consumer price index. Finally, the deflated series was divided by the population to express it in per capita terms.

- c (per capita consumption): The Central Bank has a quarterly series of real private consumption since 1979. This series is available on a yearly basis prior to this date. We applied a procedure developed by Fair (1984, p. 453) to create

subtracted this result from the welfare gain without taxation (estimated until July 1986)and expressed it in percentage of per capita consumption. Note that our estimations implicitly assume that Peruvian depositors did not anticipate the imposition of the tax levy on FCDs. If the had done so, FCDs would have declined substantially days before the imposition of the tax. FCDs reached an all time historical record in January 1985 (\$1.73 billion). They decreased steadily after ward and were \$1.37 billion in July 1985.

quarterly data from annual observations for the period 1970-1978. Finally, we divided the quarterly series by the population.

-  $\pi$  (inflation rate): We estimated it using the relative change of the quarterly average of Lima's consumer price index (1979=100).

- Population: The Instituto Nacional de Estadistica has published projections of Peru's annual population in the 1970's and 1980's. We used an interpolation method to transform this series from a yearly to a guarterly frequency.

#### **APPENDIX B - TABLES AND FIGURES**

	$Y_t = \alpha + \beta$ .	$\left(t-1-\frac{n}{2}\right)+\rho$	$\mathbf{y}_{t-1} + \sum_{i=1}^{k} \delta_i (\mathbf{Y}_t)$	$-i - Y_{t-i-1} + e_t$	
	k=0	k=1	k=2	k=3	k=4
Real per capita money (log m)					
- $\hat{ ho}$	0.9472	0.9358	0.9347	0.9267	0.8953
$-n(\hat{\rho}-1)$	-03.11	-03.73	-03.72	-04.10	-05.76
- r	-01.37	-01.68	-01.65	-01.73	-02.40
$-\Phi_2$	06.68*	03.52	04.18	03.73	03.54
$-\Phi_{\mathcal{J}}$	04.76	03.15	03.72	03.53	04.16
	Real per capita consumption (log c)				
- $\hat{ ho}$	0.9072	0.8961	0.8848	0.8733	0.8526
$-n(\hat{\rho}-1)$	-05.48	-06.02	-06.56	-07.10	-08.11
	-01.91	-02.05	-02.16	-02.25	-02.47
$-\Phi_2$	01.68	01.81	02.01	02.13	02.39
$-\Phi_3$	02.51	02.71	03.02	03.20	03.59
			Inflation rate $(\pi)$		
- ô	0.3022	0.2955	0.0309	0.2163	-0.1226
$-n(\hat{\rho}-1)$	-41.17*	-40.68*	-55.24*	-43.89*	-61.74*
– î	-04.91*	-03.40	-03.98*	-02.66	-03.47
$-\Phi_2$	08.77*	05.12	06.65*	04.27	05.71*
-Ф <sub>3</sub>	12.48*	06.52	08.71*	04.33	06.82*

Table 1. Dickey- Fuller unit root test

. ( n)

Note: Reject H<sub>0</sub> at the 5% level of significance.

Critical Values:

	 1%	5%	10%
$-n(\hat{\rho}-1)$	 -25.70	-19.80	-16.80
– ŕ	-04.15	-03.50	-03.18
$-\Phi_2$	07.02	05.13	04.31
$-\Phi_3$	 09.31	06.73	05.61

Sources: Fuller (1976) and Dickey and Fuller (1981)

## Table 2: Dickey- Fuller unit root test

$Y_t = \alpha + \rho \cdot y_{t-1} + \sum_{i=1}^{\infty} \delta_i (Y_{t-i} - Y_{t-i-1}) + \Theta_t$					
·	k=0	k=1	k=2	k=3	k=4
		Real p	er capita money	(log m)	
- <i>p</i>	1.0314	1.0158	1.0214	1.0195	1.0080
$-n(\hat{\rho}-1)$	01.85	00.92	01.22	01.09	00.44
- î	01.86	00.93	01.22	01.05	00.40
1	06.58*	02.41	03.08	02.42	01.08
		Real per	capita consumpti	on (log c)	
$-\hat{\rho}$	0.9381	0.9313	0.9275	0.9234	0.9092
$-n(\hat{\rho}-1)$	-03,65	-03.98	-04.13	-04.29	-05,00
– r̂	-01.34	-01.44	-01.46	-01.47	-01.66
<u>-Φ1</u>	00.90	01.04	01.06	01.08	01.38
Inflation rate $(\pi)$					
$-\hat{ ho}$	0.9001	0.9917	0.9949	1.0388	1.0299
$-n(\hat{\rho}-1)$	-05,89*	-00,48	-00.29	02.18	01.64
– î	-01.28*	-00.10	-0.06	00.45	00.33
$-\Phi_1$	01.30	00.98	00.96	01.91	01.45

# k - (... V )

Note: Reject H<sub>0</sub> at the 5% level of significance.

Critical Values:

	1%	5%	10%
$-n(\hat{\rho}-1)$	-18.90	-13,30	-10.70
- î	-03.58	-02.98	-02.60
-Ф <sub>1</sub>	07.60	04.86	03.94

Sources' Fuller (1976) and Dickey and Fuller (1981)

## Table 3: Demand for money estimations 1970-Q3/1985-Q1 (50 observations)

	Equation	on (22.a)
Parameters <sup>a</sup>	OLS	IV IV
Ŷ	-2.9565	-3.1916
10	(0.9834)	(1.0126)
ŵ.	-0.1951	-0.1531
11	(0.0733)	(0.0761)
Ŷ	0.1994	0.1878
12	(0.0559)	(0.0564)
â	1.7757	1.8486
p	(0.2849)	(0.2934)
ŝ	3,7735	4.1370
0	(0.5294)	(0.5616)
$R^2$	0.8882	0.8872
$\hat{\sigma}$	0.1279	0.1284
D-W	1.3023	1.4483

Note: \* Standard errors of the estimated parameters are show in parenthesis.

· · · · · · · · · · · · · · · · · · ·	$\Delta \hat{u}_t = \alpha_{\cdot} \hat{u}_{t-1} + \beta_{j \cdot} \Delta \hat{u}_{t-1} + \varepsilon_t$		
	Equatio	on (22.a)	
Estimated residuals from parameters <sup>a</sup>	OLS	IV	
â	-0.6313 (0.1235)	-0.6863 (0.1263)	
$\hat{\boldsymbol{\beta}}_{4}$	0.2941 (0.1109)	0.3006 (0.1079)	
$R^2$	0.4010 0.1138	0.4413 0.1164	
D-W	1.8261	1.8401	

# Table 4: Co-Integration estimations 1971-Q4/1985-Q1 (54 observations)

Note: a Standard errors of the estimated parameters are show in parenthesis.

Table 5: Welfare evaluation

	OLS	IV
$\frac{dc}{d\gamma}\Big _{\overline{s}}$	-0.35	-0.80
$\frac{dm}{d\gamma}\Big _{\overline{s}}$	24.20	24.05
Revenue maximizing rate $\left( \hat{\pi}^{\star}  ight)$	33.13%	29.50%

# Table 6: Changes in consumption and demand for money

π%	$\frac{dc}{d\gamma}\Big _{\overline{s}}$	$\frac{dm}{d\gamma}\Big _{\overline{s}}$
01	-0.41	23.82
02	-0.41	23.87
03	-0.39	23.95
04	-0.38	24.07
05	-0.35	24.22
06	-0.32	24.41
07	-0.29	24.65
08	-0.24	24.93
09	-0.19	25.26
10	-0.13	25.65
11	-0.06	26.10
12	0.02	26.62
13	0.11	27.22
14	0.22	27.91
15	0.34	28.70
20	1.32	34.98
30	13.97	116.41
33	417.28	2712.81

	Without taxation	With taxation
1977-1980	1,21	
1977-1981	1.59	
1977-1982	1.96	
1977-1983	2.31	
1977-1984	2.66	
1977-1985 (March)	2.75	
1977-1985 (June)	2.83	
1977-1985 (July)	2.86	1.01
1977- ∞	14.24	1.01

## Table 7: Long term welfare gain (%<sup>a</sup>)

Note: a Percentages of per capita-average-yearly consumption for the period 1970-1977.





Figure 2: The final effect on demand for money



#### Figure 3: Alternative parameter sets



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#### SINOPSE

#### OS DEPÓSITOS EM MOEDA ESTRANGEIRA AUMENTAM O BEM-ESTAR? O CASO PERUANO, 1970-1985

A autorização para depósitos em moeda estrangeira é interpretada aqui como uma inovação tecnológica, reduzindo a demanda por moeda doméstica e aumentando o bem-estar. A redução da base do imposto inflacionário leva a um aumento da taxa de inflação e do superávit orçamentário associado. O impacto final sobre o bem-estar é portanto ambíguo. Uma estimação empírica do modelo para a experiência peruana, entre 1970 e 1985, indica que o bem-estar realmente aumentou quando o governo autorizou a abertura de contas em moeda estrangeira.