What is the Information content of Mexico's Term Structure of Interest Rates?*

Sara Castellanos	Eduardo Camero G.
Banco de México	Banco de México
(52)5237-2643	(52)5237-2574
(52)52237-2687	(52)5237-2687
sgcastel@banxico.org.mx	ecamero@banxico.org.mx

This version, June 2000

Abstract

We use some conventional models to measure the information content of Mexico's term structure of interest rates, from 1985 to 1999, about inflation and economic activity expectations and about future spot interest rates. We find that the treasury bill's nominal interest rate differentials between 1 and 12 months contain information about inflation and economic activity expectations that marginally improve the predictive power on theses variables of simple ARMA and VAR models, especially in out of sample forecasting. Information content about economic activity is higher than about inflation. In the former case, through VAR analysis we detect that up to 18 months ahead the

*We thanks the comments received from the participants of the Economics workshop of banco de México. Alejnadro Werner has made valuable suggestions and lorenza Martinez and Guillermo Babatz provided useful information about financial market regulation. All remaining errors are responsibility of the authors. The views expressed in this document do not necessarily reflect those of Banco de México.

longer term differentials have more information that the shorter term differentials, a pattern that is observed in other countries. On the other hand, changes in nominal interest rate seem to reflect changes in real interest rate differentials as well. We also detect that, for inflation, the models seem to perform better with the 1996-1999 subsample. This is interesting because previously both the exchange rate is fixed and the interest rates are less flexible, which would make interest rate differentials less informative. Regarding future spot interest rates we find that the relationship between these and the term structure, as predicted by the expectations hypothesis, is not confirmed by the data. Consistent with a changing risk premium, GARCH and GARCH-M estimations show significant conditional heteroskedasticity effects.

JEL Classification: E43, E47

1 Introduction

The relationship between interest rate differentials of various terms and economic variables such as inflation, GDP, real interest rates and future spot interest rates has been a traditional topic of the economic literature and of great interest for economic policy makers. This is due to the fact that results of numerous studies, pertaining data of the US and European countries mostly, show that the term structure of interest rates (TSIR) contains information of the aforementioned variables. Thus, it can be used as a simple and easily observable indicator of economic trends in the near future. These considerations and the fact that such systematic study is lacking for Mexico are the motivation for this paper. Our purpose is to measure the information content of the TSIR and compare its predictive value to that of other economic indicators for Mexico's case.

We believe that this is a timely moment for this kind of study. At present there exist some debate about how much importance should monetary authorities attribute to financial asset prices in their decision-making, especially in low inflation countries.[1] Taking a position on this issue first requires obtaining some quantitative measures of the information that these prices may be revealing. The TSIR is one of many variables that a monetary authority can follow both easily and systematically.

To the extent that interest rates are freely determined in the financial markets, asset returns will be determined by the economic agents' expectations about inflation, economic activity, currency depreciation, and risk, among other factors. In general, expectations will not be constant through time. Hence, we can expect that the difference between interest rates of different terms reflect, to some degree, changes in the economic agents' expectations. This implies that the TSIR may be a good indicator of the economy's future general conditions. In turn, this may be important for a monetary authority because of the influence it may have on the TSIR through monetary policy, which itself may be reflecting on the TSIR.

For example, if a central bank launches a credible anti inflation plan, restrictive monetary policy would make short term interest rates higher. But, as long as the public perceives the plan as successful to reduce inflation, longer term interest rates will contain lower inflation expectations and be lower as a result. So a successful plan to reduce inflation would make the slope of the TSIR less steep.

The TSIR may reflect supply and demand equilibrium of the credit market as well. Longer term interest rates would be more affected by changes in credit demand and supply. Increased credit demand would press longer term interest rates upwards, which would result on a steeper TSIR. Since this increased credit demand is related to the agents' better economic expectations, the slope of the TSIR may contain information about future economic growth.

But there are three reasons of why the predictive power of the TSIR on

[1] More details about this debate are available on "Safeguarding macroeconomic stability at low inflation," IMF World Economic Outlook, Chapter 4, October 1999 and on "Time to break the rules" and "Central Banks: all a-quiver, The Economist," May 13-19, 1999.

future expectations may be reduced. First, long term interest rates generally carry a risk premium over short term interest rates. Changes of the risk premium, not uncommon in emerging economies like Mexico, may change the TSIR slope and in the short term have no relationship with agents' inflation and economic activity expectations. This makes TSIR predictions noisy.

Second, even if the price system, when properly operated, produces signals about resources' best use that inform the economic agents, Grossman and Stiglitz ([19]) shows that if information acquisition is costly for the economic agents the prices cannot reflect all available information. This finding is reasonable because if prices reflected all available information there would not be incentives to collect it. This paradox portrays the limits up to which the argument that prices reflect all the data that an agent needs about the future in his decision making can be pushed. Beyond the ideal case, market frictions may weaken the prices signaling function.[2]

Third, Lucas' critique applies when interpreting the results: finding a relationship between an objective variable and an instrument variable does not imply that such relationship will remain constant because economic agents may further change their expectations if they know that the monetary authority is exploiting it.

Our results suggest that the *TSIR* contains some information about inflation and economic activity expectations. Inclusion of some interest rate differentials improves the out of sample predictive power of the variables of commonly used ARMA models in spite of the latter's better inside the sample adjustment. For inflation, we detect that the period in which the *TSIR* performs better is between 1996 and 1999. This period coincides with a less rigid financial regulation and with a flexible exchange rate regime. But a pattern of longer term differentials predicting more than shorter term differentials, common in other studies, is not detected in Mexico's case. For economic activity expectations such pattern is observed when comparing the

[2]Besides Adam Smith's and Frederick Hayek's classical discussions about this issues, Smith ([33]) provides a good summary of the main arguments.

out of sample predictive power of ARMA and VAR models. Some differentials contain information of economic activity up to 18 months ahead. On the other hand, probit models on the probability of future recessions show that a less steep *TSIR* is associated with a 2% to 26% decrease on such probability depending on which definition is used. Finally, we extend the analysis of Sod([34]) about the *TSIR*'s ability to predict future spot interest rates according to the rational expectations hypothesis. Our results for a 1985-1999 sample of CETEs with maturities of 28, 91, 182, and 365 days confirm that the rational expectations hypothesis is rejected and that this may be due to a fluctuating risk premium.

The rest of the article consists of four sections. Sections 2, 3, and 4, respectively, analyze inflation, economic activity, and future spot interest rates. Each briefly discusses previous studies, sets a basic model and presents estimation results with the Mexican data. Section 5 concludes.

2 Inflation

2.1 Previous studies

Fisher (13) is the first to write about the relationship between inflation and interest rates. Fisher's theory basically states that, whatever factors are involved on the determination of the real sector growth, rational investors do not suffer money illusion. Absence of money illusion implies that if an asset pays back a certain amount of money in the future, an investor that expects that money will have a lower purchasing power in terms of goods and services in the future will demand a higher return on such asset. His analysis of interest rates is contained in the now famous Fisher equation, which relates the nominal interest rate to the real interest rate and inflation expectations in a specific manner.

Using US data of the period between the 1950s and the 1970s, Fama (9) finds that the interest rates of the Treasury Bonds with maturity dates to 1 month and to 6 month provide statistically reliable forecasts of inflation

1 month ahead. Using the Fisher equation as a starting point, Mishkin (22) uses interest rates shorter than 1 year and inflation data of the US to estimate the power of changes on the interest rates from m to n periods to predict changes on the inflation rate from the same m to n periods; that is, estimate the relationship between the slope of the TSIR and the slope of "a term structure of inflation rates". Mishkin's results suggest that information content is greater on the longer term interest rates and support the theory that a less steep TSIR is associated to a lower increase in future inflation. Concretely, while the TSIR of maturities up to 6 months contain almost no information about future inflation, that of maturities up to 9 months and to 12 months do contain information. Coefficients are significant and close to 1 and R^2 statistics are close to 0.1.

Mishkin (23) repeats the exercise with interest rates of maturity dates from 1 to 5 years and finds that the predictive power of the longer term interest rate differentials is substantially higher: with a full sample from 1950 to 1987, all the coefficients associated to TSIR terms are larger than 1 and the R^2 are greater than 0.2 in all cases.

Among studies using data of countries other than the US, Estrella and Mishkin (8) analyzes interest rate differences with 3 months and 10 years maturity dates to predict changes in the inflation rate up to k periods ahead, with data of Germany, US, France, UK, and Italy. Results are consistent with previous findings for the US, but the information content about inflation does vary substantially among countries. For example, while significant results up to a 5 year horizon are found for Germany and the US, significant results for Italy and UK are up to 12 or 13 quarters and, lastly, for France results are not statistically significant at all. Robertson (24), with data of UK's 1 and 5 year bonds, finds results consistent with those of Mishkin (22), (23) and Estrella and Mishkin (8).

2.2 Estimations with Mexico's data

2.2.1 Model

Following Mishkin (22)'s setting of Fisher's theory, we can derive a relationship between the TSIR and future inflation with Fisher's equation as a starting point:

$$i_{t,t+m} = r_{t,t+m} + E_t \pi_{t,t+m}, \tag{1}$$

where $x_{t,t+m}$ is the value of variable x at time t for m periods ahead; E_t is the conditional expectation using the information set available at time t; and π, i and r are the inflation rate, the nominal interest rate and the real interest rate, respectively. Assuming rational expectations on the agents' forecasts about inflation, we have that observed inflation at time t for n periods ahead will be equal to the expected value of inflation plus an error term with zero mean and constant variance.

$$\pi_{t,t+m} = E_t \pi_{t,t+m} + \epsilon_t. \tag{2}$$

Substituting equation (1) into equation (2) and solving for $\pi_{t,t+m}$we get:

$$\pi_{t,t+m} = i_{t,t+m} - r_{t,t+m} - \epsilon_t. \tag{3}$$

Equation(3) is satisfied for all t and for all m. Hence, using the previous expression for n we find a relationship between the TSIR and the changes on inflation at time t for m and n periods ahead:

$$\pi_{t,t+m} - \pi_{t,t+n} = i_{t,t+m} - i_{t,t+n} - r_{t,t+m} + r_{t,t+n} + \epsilon_{t,n} - \epsilon_{t,m}. \tag{4}$$

Equation (4) can be estimated with econometric methods as follows:

$$\pi_{t,t+m} - \pi_{t,t+n} = \alpha_{m,n} + \beta_{m,n}(i_{t,t+m} - i_{t,t+n}) + \eta_{m,n}, \tag{5}$$

where:

$\alpha_{m,n} = \overline{r}_{t,t+n} - \overline{r}_{t,t+m}$, $\beta_{m,n} = 1$,

$\eta_{m,n} = \epsilon_{t,m} - \epsilon_{t,n} - (u_{t,t+m} - u_{t,t+n})$,

$u_{t,t+m} = r_{t,t+m} - \overline{r}_{t,t+m}$,

$u_{t,t+n} = r_{t,t+n} - \overline{r}_{t,t+n}$,

$\overline{r}_i$ is the equilibrium real interest rate in t for i periods, which we assume constant.

This specification, assuming rational expectations and a constant term structure of real interest rates (TSRR), when estimated through ordinary least squares (OLS) produces consistent estimates of $\beta_{m,n}$. If the slope of the TSRR is not constant, the TSIR may contain information about changes in future inflation, but OLS does not yield an optimal estimator because the term $(u_{t,t+m} - u_{t,t+n})$ is not, in general equal to zero. Besides, correlation between the TSIR and the TSRR may cause problems with the OLS estimators.[3]

Equation (5) and the assumptions behind it suggest two hypotheses about the $\beta_{m,n}$ coefficients. First, if the $\beta_{m,n} = 0$ hypothesis is statistically rejected, the TSIR contains information about changes in future inflation and the slopes of the TSIR and the TSRR do not move one to one. Second, if the $\beta_{m,n} = 0$ hypothesis is statistically rejected, the slope of the TSRR is not constant through time and the TSIR provides information about the TSRR.

2.2.2 Data

For the interest rates data, we use data from the weekly primary auction of Certificados de Tesorera (CETEs) from September of 1985 to June of 1999. CETEs are bonds with zero coupon issued by Mexico's Federal Government[4] with 28, 91, 182, 364 and 728 days maturity dates, respectively. We use all but the 728 days CETEs because of the small number of observations available in this case. We use the first observation of the week in a month to reflect the interest rate prevailing for the whole month.

[3]For a more detailed exposition of these issues, see Mishkin [28], pp:80,81.

[4]This implies that there is only sovereign risk.

For the inflation data, we use the monthly National Consumer Price Index (INPC, by its Spanish initials) constructed by Banco de Mexico. With the INPC we construct the yearly inflation rates at 1, 3, 6 and 12 months. With this data we construct the variables $i_{t,t+m} - i_{t,t+n}$ and $\pi_{t,t+m} - \pi_{t,t+n}$ of equation (5) for $m = 3, 6, 12$ and $n = 1, 3, 6$.

The time series data considered must be stationary in order to apply the usual regression techniques. The Augmented Dickey-Fuller unit root test is rejected in all cases but $i_{6,1}$ and $i_{12,1}$ and the Phillips-Perron unit root test is rejected in all cases. Hence we use the variables as defined above. Preliminary analysis of the data using Granger causality tests between the inflation and the interest rate differentials suggests causality from inflation differentials to interest rate differentials in all cases. But, despite of the basic model's prediction, causality from interest rate differentials to inflation differentials is rejected in most cases. The noticeable exception are the $i_{3,1}$, $i_{6,1}$ and $i_{6,3}$ differentials.[5]

2.2.3 Results

There is a problem with the estimation of (5). The use of data of a higher frequency than the prediction period (e.g., the use of monthly data to construct one quarter ahead interest rate differentials) produces serial correlation in the error terms η_t. This does not affect consistency of $\beta_{m,n}$, but the standard error are not correct and, thus, inferences using such standard errors are not correct either. One way to *avoid* this problem is to use data of the same frequency as the prediction period, but this eliminates the problem at the cost of losing observations. One way to *correct* this problem is to estimate the correct variance/covariance matrix of the regression. In order to not lose observations, we choose the second option and use the Newey-West method to estimate the variance/covariance matrix. Hence, valid inferences about the estimated OLS coefficients can be obtained. Unless stated otherwise, we use this methodology throughout the analysis.

[5] The tables with these results are in the appendix.

Table 1 presents the estimation results of equation (5). According to panel A, in the whole sample of 1985 to 1999 interest rate differentials are not significantly different from zero. Given that due to moves towards a more flexible financial regulation since 1987 and the adoption of a flexible exchange rate regime in 1994 performance of the interest rate differentials may vary through the period, we also estimated the model for the 1985-1987, 1988-1994 and 1996-1999 subsamples.[6][7] Panels B and C show no significant coefficients in the first two subsamples. By contrast, panel D shows significant coefficients associated to the $i_{3,1}$, $i_{6,1}$ and $i_{12,3}$ differentials during the 1996-1999 subsample. Thus, higher significance is associated with a more flexible regulation and a more flexible exchange rate regime.[8] These coefficients' sign is positive as the examined theory predicts. Nonetheless their magnitude seems very high, especially the latter two cases, when compared with the estimations of Estrella and Mishkin (8).

Although the model we examine refers only the relationship between inflation and interest rate differentials of the same period, it is valid to ask whether the interest rate differential is related to inflation differentials of other horizons. Following Estrella and Mishkin (8) we construct inflation differentials up to 3, 6, 9, 12, 15 and 18 months ahead to use them as dependent variables in estimations of equation (5) for the six interest rate differentials we have available. The results of this exercise are on Table 2.

According to Table 2, once more the coefficients associated to the interest rate differentials $i_{3,1}$ and $i_{6,1}$ are significant. In both cases, interest rate

[6] The 1985-1994 and 1988-1999 sample divisions were also analyzed without showing relevant results.

[7] Landmarks of the financial deregulation process that started in 1988 are: the liberalization of interest rates, the abolishment of required reserves on bank's liabilities, the abolishment of selective credit controls, the liberalization of the investment regime of mutual funds and the privatization of banks. Babatz and Conesa ([2]) contains a more detailed summary of the financial liberalization process.

[8] Fama (8) and Estrella and Hardouvelis (6) contain evidence that the *TSIR*'s predictive performance may vary among different monetary policy regimes and among different levels of financial regulation.

Table 1: *OLS* estimations of the inflation change equation. The dependent variable is $\pi_{m,n}$

(m, n)	$\alpha_{m,n}$		$\beta_{m,n}$		R^2	Obs
Panel A: January 1985- December 1999						
3,1	-1.2737		-0.3445		0.0154	161
6,1	3.3666		0.1801		0.0139	112
6,3	1.1596		0.7224		0.0121	112
12,1	1.2824		-0.0133		-0.0161	86
12,3	1.0948		0.4005		0.0036	86
12,6	0.3469		-0.1215		-0.0112	86
Panel B: January 1987- December 1987						
3,1	35.4400		-7.7086		0.1057	31
6,1	8.5135		1.2045		-0.0151	13
6,3	8.9008		0.0386		-0.0908	13
12,1	4.1345		0.0331		-0.0181	52
12,3	3.1777		0.7364		0.0163	54
12,6	0.8490		-0.2887		-0.0180	54
Panel C: January 1988- December 1994						
3,1	-1.7021		-0.2682		0.1310	82
6,1	2.5455		0.0223		-0.0162	60
6,3	1.7499		0.2095		-0.0112	60
12,1	4.1345		0.0331		-0.0181	52
12,3	3.5240		0.0909		-0.0193	52
12,6	-0.8847		0.1798		-0.0222	32
Panel D: January 1996- December 1999						
3,1	-2.9075	**	1.7756	*	0.1146	42
6,1	-6.2139	*	2.5896	*	0.3008	37
6,3	-2.8048	*	3.7952		0.5007	34
12,1	-3.4014		0.6368		0.0381	31
12,3	-1.9588		0.6806	***	0.0831	31
12,6	-0.8722		0.1859		-0.0228	31

*, ** **: Significant at the 1, 5 y 10% level

differentials seem to contain information about future inflation changes up to 18 months ahead.

As mentioned in section 2.2.1, the results we have can be used to examine real interest rates. Following Mishkin (22) again, from equation (5) we can obtain the next equation:

$$epr_{t,t+m} - epr_{t,t+n} = -\alpha_{m,n} + [1 - \beta_{m,n}](i_{t,t+m} - i_{t,t+n}) - \eta_{m,n}, \qquad (6)$$

where $epr_{t,t+m}$ is the ex post observed real interest rate of an n period bond. From equation (6) we observe that $\beta_{m,n} = 1$ implies that the term $1 - \beta_{m,n}$ is zero. Since the ex ante real interest rate is simply the expectation at time t of the ex post real interest rate, rejection of the hypothesis of $\beta_{m,n} = 1$ (or, of $1 - \beta_{m,n} = 0$) in practically all cases that we present on tables 1 and 2, (but the aforementioned exceptions) indicate that the TSIR contains

Table 2: *OLS* Estimations with different inflation horizons, 1996-1999

	$\alpha_{m,n}$		$\beta_{m,n}$		R^2	Obs	$\alpha_{m,n}$	$\beta_{m,n}$		R^2	Obs
			$i_{3,1}$					$i_{12,1}$			
3,1	-2.9075	**	1.7756	**	0.1146	42	-0.3138	0.0011		-0.0285	37
6,1	-5.1872	***	3.0384	**	0.1649	39	-2.4408	0.6126		0.0322	34
9,1	-6.1041	***	3.1817	**	0.1551	36	-3.5323	0.8237		0.0725	31
12,1	-6.8543		3.1887		0.1496	33	-3.4014	0.6368		0.0381	31
15,1	-8.2718	**	3.3480	**	0.2065	32	-4.4217	0.4164		-0.0024	31
18,1	-8.5798	***	3.5588	***	0.2144	30	-4.5915	0.4654		0.0013	30
			$i_{6,1}$					$i_{12,3}$			
3,1	-2.7621	***	1.0721	**	0.0895	37	0.03280	-0.3312		-0.0016	37
6,1	-6.2139	*	2.5896	*	0.3008	34	-0.8959	0.2733		-0.0222	34
9,1	-7.1699	**	2.7761	*	0.3084	31	-1.7541	0.5610		0.0011	31
12,1	-6.9938	***	2.4817	*	0.2768	31	-1.8261	0.3260		-0.0208	31
15,1	-8.2150	**	2.2440	**	0.2280	31	-3.0764	0.0421		-0.0342	31
18,1	-8.5427	**	2.3891	**	0.2401	30	-3.1486	0.0765		-0.0349	30
			$i_{6,3}$					$i_{12,6}$			
3,1	-1.1865		1.0723		0.0019	37	0.4482	-0.6842	**	0.0465	37
6,1	-4.0335		4.8707		0.2489	34	-0.0553	-0.3070		-0.0237	34
9,1	-4.6645		5.2580		0.2656	31	-0.8102	0.0854		-0.0339	31
12,1	-4.4679		4.3184		0.1955	31	-1.0782	-0.1336		-0.0329	31
15,1	-5.6349		3.5884		0.1297	31	-2.4989	-0.4570		-0.0161	31
18,1	-5.8836		3.8291		0.1372	30	-2.5295	-0.4400		-0.0199	30

*, ** **: Significant at the 1, 5 y 10% level

information of the TSRR. Similarly, rejection of the hypothesis of $\beta_{m,n} = 0$ (equivalently, $1 - \beta_{m,n} = 1$) means we reject the hypothesis that changes in the TSIR produce equal magnitude changes in the TSRR; that is, that they move together. As a result, our estimations do not support constant real interest rates during the analyzed period.

To grasp a better idea of the predictive value of the cases in which we detect a significant coefficient associated to the TSIR, comparison with other simple models is useful. To this end, we model $\pi_{m,n}$ as an ARMA(2,1) process, after examining several combinations of (p,q) with the Akaike information criteria, and compare the results of such exercise with those of the basic TSIR model. Comparing Table 2 and Table 3 reveals that both the R^2 and F tests for the ARMA(2,1) model are higher than for the basic TSIR model. This suggests that the former has a higher predictive power inside the sample than the latter.

Another way to evaluate the TSIR's information content is to add this variable to the ARMA model and observe wheter it conserves a significant coefficient (if it had it before). Table 4 presents the corresponding results

Table 3: Estimation of the ARMA (2,1) model

k	C	$\text{INF}_{k\ (t-1)}$	$\text{INF}_{k\ (t-2)}$	R^2	F
3,1	-1.7123	0.4572*	-0.4191**	0.2252	0.0000
6,1	-1.3382	0.8212*	-0.3650**	0.4403	0.0000
9,1	-2.7569	0.8665*	-0.2660*	0.4991	0.0000
12,1	-1.6865	0.8728*	-0.2464*	0.5152	0.0000
18,1	-0.0763	0.9107*	-0.1933**	0.5973	0.0000
24,1	-2.5743	0.9121*	-0.1871**	0.6005	0.0000

*, ** **: Significant at the 1, 5 y 10% level

of the "augmented" ARMA model. The interest rate differentials are significant only in two regresions, one associated to the 3 month inflation and one associated to the 24 month inflation. These significant values correspond to the variables $_i3,1$ and $_i6,1$. Notice also that most signs of the TSIR are negative in this table.

We also estimated vector autorregresive (VAR) models with these variables, using 12 lags of each, for inflation horizons up to 1, 3, 6, 9, 12, 18, and 24 months ahead.[9] We only found significant coefficients associated to the interest rate differential terms on the VARS of the 1, 12, 18 and 24 months. So these results also suggest that the TSIR's predictive power inside the sample is limited. Fernndez (12) finds similar results for Chilean interest rate differentials with 1 month and 12 month maturity in the 1993 to 1997 period.

Now we proceed to examine the TSIR's predictive power outside the sample by comparing the root mean square error (RMSE) across the models. The root mean square error is defined as:

$$\sqrt{\frac{1}{h+1}\sum_{t=s}^{S+h}(\widehat{y}_t - y_t)^2}, \qquad (7)$$

where y_t is the observed value of inflation, $\widehat{y}_t$ is the predicted value of inflation and h is the number of forecasted observations. To have comparable measures, first we estimate each model with a sample from February 1985 to August 1996 and then produce forecasted observations for the period from September 1996 to September 1998. Thus, h=25.[10] The lower is the RMSE

[9] All VAR estimations are available from the authors upon request.

[10] Data availability constrains us to use the mentioned periods to calculate the RMSE

Table 4: Estimation of the ARMA model with the *TSIR*

		C		ETTI		$INF_k\ (t-1)$		$INF_k\ (t-2)$		R^2	F
3,1	3,1	-1.0143		0.0075		0.4602	*	-0.4346	**	0.6256	0.0000
	6,1	0.4794		-1.0166	*	0.5709		-0.3479		0.7353	0.0000
	6,3	0.3448		-1.1100	*	0.4701		-0.4648	*	0.7719	0.0000
	12,1	-0.0329		-0.0701		0.6374	*	-0.3559	*	0.2619	0.0000
	12,3	-0.0264		-0.1189		0.6478	*	-0.3651	*	0.2665	0.0000
	12,6	-0.0255		-0.1040		0.6473	*	-0.3655	*	0.2645	0.0000
6,1	3,1	-0.9061		-0.0942		0.8205	*	-0.3548	**	0.4422	0.000
	6,1	1.4067		-0.1288		0.8920	*	-0.2186		0.5423	0.000
	6,3	1.4434		-0.1058		0.8888	*	-0.2110	*	0.5400	0.0000
	12,1	0.8423		-0.0441		1.1391	*	-0.3113	*	0.6855	0.0000
	12,3	0.8405		-0.1359		1.1431	*	-0.3181	*	0.6879	0.0000
	12,6	0.8460		-0.1562		1.1461	*	-0.3191	*	0.6885	0.000
9,1	3,1	-2.2156		-0.1934		0.8538	*	-0.2932	*	0.5068	0.0000
	6,1	0.3372		0.0766		0.7559	*	0.0778	*	0.5191	0.0000
	6,3	0.4165		0.1200		0.7314	**	0.0299	*	0.5227	0.0000
	12,1	0.9116		-0.0576		1.0419	**	-0.2076	**	0.7536	0.0000
	12,3	0.9092		-0.1292		1.0471	**	0.2070	***	0.7550	0.0000
	12,1	0.9140		0.1460		1.0448	*	-0.2085	**	0.7553	0.0000
12,1	3,1	-1.2116		-0.1870		0.8615	*	-0.2204	*	0.5240	0.0000
	6,1	0.0678		0.0819		0.7335	*	0.0363		0.5564	0.0000
	6,3	0.1308		0.1249		0.7063	*	0.0576		0.5602	0.0000
	12,1	1.1137		-0.0704		1.0107	*	-0.1579		0.7570	0.0000
	12,3	1.1147		-0.1336		1.0172	*	-0.1656		0.7586	0.0000
	12,6	1.1197		-0.1511		1.0196	*	-0.1677		0.7590	0.0000
18,1	3,1	0.4301		-0.3161		0.8792	*	-0.1440	***	0.6058	0.0000
	6,1	0.1709		-0.0592		0.8895		0.1161		0.7695	0.0000
	6,3	0.2641	**	-0.0054		0.8669	*	0.1303		0.7688	0.0000
	12,1	1.6281	**	-0.0794		1.0229	***	-0.1334		0.8204	0.0000
	12,3	1.6337	**	-0.1325		1.0287	*	-0.1405		0.8213	0.0000
	12,6	1.6370	**	-0.1477		1.0310		-0.1423		0.8216	0.0000
24,1	3,1	-1.9533		-0.2826		0.8847	*	-0.1466		0.6119	0.0000
	6,1	0.5962		-0.0762		0.8312	*	0.2095	*	0.8518	0.0000
	6,3	0.6685		-0.0205		0.8088	*	0.2245	*	0.8510	0.0000
	12,1	1.4990	**	-0.0606		0.9615	*	-0.0937	*	0.8107	0.0000
	12,3	1.4985	**	-0.1185		0.9677	*	-0.1043	*	0.8173	0.0000
	12,6	1.5015	**	-0.1432		0.9707	*	-0.1066	*	0.8122	0.0000

*, ** **: Significant at the 1, 5 y 10% level

of a model, the higher is its predictive power out of the sample.

In Table 5 we can see that the ARMA(2,1) model has a lower RMSE than the basic model with the available interest rate differentials except the $i_{12,1}$, $i_{12,3}$, $i_{12,6}$ differentials in the 1 month ahead inflation equation. In table 6, by contrast, for inflation 1 month ahead the augmented ARMA(2,1) model with any of the available interest rate differentials has a lower RMSE than the ARMA(2,1) model. For the 3 month horizon inflation we also observe lower RMSE when interest rate differentials with maturity of 3 or 6 months are

statistic properly. However, notice that the results on table 1 suggest that such proceeding affects adversly the estimation of the *TSIR* model.

Table 5: Comparison between the RMSE of the ARMA model and the basic inflation change equation

	ARMA	ETTI					
		3,1	6,1	6,3	12,1	12,3	12,6
inf1	10.0114	35.6158	17.9074	16.6746	7.6934*	9.3557*	9.1554*
inf3,1	5.1159	6.2706	5.7596	5.8055	5.9301	6.0562	6.1650
inf6,1	6.3510	9.7244	9.3141	9.1708	7.8859	8.6291	8.6324
inf9,1	7.4597	12.9744	9.9618	9.7842	8.6303	10.4061	10.3461
inf12,1	6.6545	10.5526	8.7834	8.5922	7.9661	9.4082	9.3536
inf18,1	7.0144	10.2237	8.8677	8.8626	8.5642	10.9603	11.0210
inf24,1	8.0272	14.1119	9.1643	9.0545	8.3619	10.4862	10.504

*: Smaller than those for the ARMA model

included. We also observe that the inclusion of the interest rate differential with maturity of 3 months reduces the RMSE of the simple ARMA for all the horizons considered up to the 12 months. These evidence suggests that in the margin, inclusion of interest rate differential improves predictive power.

Table 6: Comparison between the RMSE of the ARMA model and the ARMA model that includes the ETTI

	ARMA	$ETTI+$ $ARMA$					
		3,1	6,1	6,3	12,1	12,3	12,6
inf1	10.0114	9.5400*	7.9263*	7.9577*	7.6934*	7.6594*	7.6600*
inf3,1	5.1159	5.0809*	4.7965*	4.0332*	5.9301	5.8598	5.8789
inf6,1	6.3510	6.2361*	6.6148	6.6494	7.8859	7.8510	7.8456
inf9,1	7.4597	7.2768*	7.6460	7.7003	8.6303	8.5988	5.5936
inf12,1	6.6545	6.5528*	9.9641	6.9910	7.9661	7.9411	7.9370
inf18,1	7.0144	7.0448	8.1068	8.1025	8.5642	8.5418	8.5380
inf24,1	8.0272	7.9280	8.8881	8.8820	8.3619	8.3434	8.3320

*: Smaller than those for the ARMA model

In Table 7, evidence for the 1 month ahead inflation change is similar. The VAR models including variables $i_{12,1}$, $i_{12,3}$, $i_{12,6}$, $i_{3,1}$, and $i_{6,1}$ (with the corresponding lags) have a lower RMSE than the ARMA(12,1) model. Interestingly, the VARs with the $i_{3,1}$, $i_{12,1}$, $i_{12,3}$ and $_i 12,6$ have a lower RMSE on the inflation forecasts 24 month ahead.

In conclusion, nominal interest rate differentials have some power for predicting inflation, but limited and only during the 1996-1999 period, when both financial regulation and the exchange rate are more flexible. The basic model has lower inside the sample predictive power than simples ARMA(2,1)

Table 7: Comparison between the RMSEs of the ARMA(12,1) and VAR models

	ARIMA(12)	i31	i61	i63	i121	i123	i126
inf1	6.9812	6.2612*	6.5929*	8.8296	4.3410*	4.8284*	4.4915*
inf31	4.5189	5.9244	8.4027	6.5890	9.2633	9.0959	8.9923
inf61	5.8059	7.7199	10.7880	10.2890	11.7154	10.7285	9.1440
inf91	-6.9083	7.7112	10.4789	8.1632	7.5995	9.6252	8.9212
inf121	6.3075	6.6279	7.8012	6.0477*	7.4531	8.7387	7.8407
inf181	6.6271	7.1501	13.2370	9.6306	7.1929	8.1375	7.6792
inf241	7.2895	6.6660	11.8238	14.2897	7.0810	7.0761	6.3869

*: Smaller than those for the ARMA model

model. But there are some cases where including the differentials improves out of the sample predictive power of this kind of models, noteworthingly in predictions of the change in inflation 1 month ahead. In the period of analysis we do not detect the pattern of longer term interest rate differentials predicting more than the shorter term interest rate differentials that other authors have detected in other countries' data. But in Mexico's case this may be due to the fact that there are less observations available to construct the longer term differentials. On the other hand, the TSIR seems to contain information about the TSRR suggesting that the latter has not been constant throughout the period of analysis.

3 Economic Activity

3.1 Previous studies

Some studies about the relationship between financial assets' prices and consumption or production refer to the permanent income hypothesis of Hall (15). This hypothesis postulates that consumption is a function of permanent income and, thus, should not depend on transitory income measures. Hall (15) finds that the present level of equity real prices are useful to predict future income. However, the notion that changes on asset prices provoke changes on permanent income and, as a result, on future consumption or economic activity is not universally supported by data. Other authors, like

Mankiw (20), argue that interest rates or interest rates differentials predict better these variables than asset prices do.

Estrella and Hardouvelis (6) estimates the TSIR power to predict US economic activity using the interest rates differential between the 3 month and 10 year US Treasury bond and the quarterly GNP data from 1955 to 1988. They find a positive relationship between these variables and predictive power is the highest for 6 and 9 month horizon predictions. Decomposition of GNP into its components shows that the TSIR contains information on future consumption, investment, and consumption of durable goods as well but, unsurprisingly, not on future government expenditure. Estrella and Hardouvelis (6) carries out two additional complementary exercises. In the first one, it estimates the probability of economic recession with the TSIR data. The results suggest that the TSIR predicts relatively well US recessions 4 quarters ahead. In particular, it predicts substantially well 3 out of the 6 recessions documented by the NBER between 1955 and 1988. In the second exercise, it compares predictions of the TSIR with predictions of other variables. The comparison is favorable for the TSIR because, in general, it explains future economic activity better than a whole group of alternative indicators traditionally used for this purpose.

Estrella and Mishkin (8) finds very similar results with data of Germany, US, France, UK, and Italy. Bernard and Gerlach (2) carries out the first exercise with data of 8 European countries and finds that the slope of the domestic TSIR contains information about the probability of future recessions. Nonetheless, results are more robust for some countries than for others.

3.2 Estimations with Mexico's data

3.2.1 Model

The basic equation to be estimated is:

$$Y_{t,t+k} = \alpha_k + \beta_k[i_{t,t+m} - i_{t,t+n}] + \epsilon_{t,t+k}, \tag{8}$$

where $Y_{t,t+k}$ represents the yearly growth rate of economic activity k months ahead at date t, $i_{t,t+m} - i_{t,t+n}$ is the interest rate differential between periods m and n at date t, $\alpha_{t,t+k}$ and $\beta_{t,t+k}$ are the parameters to be estimated and $\epsilon_{t,t+k}$ is the estimation error. To evaluate the TSIR's predictive power only, we do not include additional variables in this basic model.

A similar question is whether the TSIR can predict changes on the economic growth rate, in effect, recession periods. Following Estrella and Hardouvelis (6) we estimate probit models of this relationship. To define "recession" we use 6 dicothomic variables:

$$\begin{array}{ll}
r_3 = 1 & \text{if } IAI_t < 0,\ IAI_{t-1} < 0 \text{ and } IAI_{t-2} < 0 \\
r_3 = 0 & \text{in any other case} \\
r_6 = 1 & \text{if } IAI_t < 0,\ IAI_{t-1} < 0, \ldots \text{ and } IAI_{t-5} < 0 \\
r_3 = 0 & \text{in any other case} \\
r_9 = 1 & \text{if } IAI_t < 0,\ IAI_{t-1} < 0, \ldots \text{ y } IAI_{t-8} < 0 \\
r_3 = 0 & \text{in any other case} \\
a_3 = 1 & \text{if } IAI_t < 0,\ IAI_{t+1} < 0 \text{ and } IAI_{t+2} < 0 \\
a_3 = 0 & \text{in any other case} \\
a_6 = 1 & \text{if } IAI_t < 0,\ IAI_{t+1} < 0, \ldots \text{ and } IAI_{t+5} < 0 \\
a_6 = 0 & \text{in any other case} \\
a_9 = 1 & \text{if } IAI_t < 0,\ IAI_{t+1} < 0, \ldots \text{ and } IAI_{t+8} < 0 \\
a_9 = 0 & \text{in any other case}
\end{array}$$

3.2.2 Data

There are two problems associated to using Mexico's GNP time series to construct economic activity growth indexes. First, since GNP is reported quarterly, using this variable implies losing 2/3 of the monthly interest rate observations that we have. This problem is worsen by the fact that, as a start, we have less observations for the 12 month interest rates than for the other rates. Second, calculating the observed product growth rates at the end of the sample reduces the number of observations as well. Hence, we would have less than 30 observations in some cases.

However, we can think of variables that are strongly related with the GNP and reflect economic activity. One of such variables is the Index of Industrial Activity (IAI, by its Spanish initials) produced by the INEGI. Correlation between IAI's quarterly average and GNP during the analyzed period is 96%, which strengthens our confidence on the former's suitability for our purposes.

The unit root tests for the rates of growth of economic activity, calculated with the IAI, for several dates show that these variables are stationary as defined. On the other hand, Granger causality tests between the interest rate differentials and the IAI growth rates do not reject the hypothesis that the interest rate differential does not (Granger) cause the IAI growth except in 5 cases. The complementary null hypothesis that the IAI growth rate does not (Granger) cause the interest rate differential is rejected at the conventional significance levels. Thus, once more preliminary evidence is not favorable for the model.

3.2.3 Results

Table 8 presents the OLS coefficients estimated from equation (9). Practically all $\alpha_{t,t+k}$ constants are positive and significant. With respect to the $\beta_{t,t+k}$ coefficients, which measure the TSIR's predictive power of economic activity k months ahead, we observe 9 cases where these coefficients are significant and only one of them has a negative sign. Magnitudes vary between 0.25 and 0.52 for the 3 months horizon and between 0.08 and 0.21 for the 18 months horizon. Hence, a less steep TSIR seems to be associated with lower future economic growth. It is worth noting that for this exercise dividing the sample on the 1985-94 and the 1996-99 periods does not produce noticeable changes, as we detect for the inflation regressions.

Table 8: Estimation of:

$$Y_{t,t+k} = \alpha_k + \beta_k(i_{t,t+m} - i_{t,t+n}) + \epsilon_{t,t+k}, \text{ 1985-1999}$$

k	(m,n)	α_k		β_k		R^2	F
1	3,1	0.4467	*	-0.0030		-0.0006	0.9467
	6,1	0.4417	**	0.0503		0.0008	0.7673
	6,3	0.4347		0.3213		0.0035	0.2450
	12,1	0.5369	***	-0.2096		0.0023	0.2779
	12,3	0.5399	***	-0.1573		0.0084	0.4106
	12,6	0.5424	***	-0.1618		0.0065	0.4681
3	3,1	1.0146	**	0.0197		-0.0055	0.6824
	6,1	0.8835	**	0.3218	*	0.0248	0.0595
	6,3	0.8559	**	0.5173	*	0.0240	0.0629
	12,1	1.1242	**	0.2481	***	0.0047	0.2427
	12,3	1.1267	**	0.0921		0.0024	0.6618
	12,6	1.1320	**	0.0093		-0.0124	0.9696
6	3,1	1.5922	*	0.0346	***	-0.0067	0.5729
	6,1	1.3432	***	0.1600		-0.0048	0.4747
	6,3	1.3267	***	0.5427	*	0.0123	0.1352
	12,1	1.2597		-0.0420		-0.0125	0.8760
	12,3	1.5335	***	-0.0854		-0.0114	0.7472
	12,6	1.5359	***	-0.0937		-0.0116	0.7613
9	3,1	1.9948	**	0.0630		-0.0011	0.3648
	6,1	2.0620	**	-0.0060		-0.0035	0.5245
	6,3	2.0486	**	0.2551		-0.0063	0.5416
	12,1	2.4421	**	0.0981		-0.0122	0.8936
	12,3	2.4139	**	-0.0118		-0.0131	0.9699
	12,6	2.4041	**	0.1048		-0.0100	0.7744
12	3,1	2.7410	**	-0.0548		-0.002	0.9526
	6,1	2.4480	**	-0.5632		0.0607	0.7071
	6,3	2.7198	**	0.5191	**	0.0071	0.1940
	12,1	3.0791	**	-0.7977		0.0501	0.3474
	12,3	2.9683		-0.0405		-0.0147	0.6804
	12,6	2.4513		0.0242		-0.0089	0.7997
18	3,1	4.6919	*	0.0756	***	-0.0012	0.3669
	6,1	3.3870	*	-0.8321		0.0729	0.6895
	6,3	3.3572	*	0.2128	***	0.0099	0.3533
	12,1	4.5885	*	0.0697		-0.0130	0.8487
	12,3	4.5967	*	-0.1151		-0.0121	0.7491
	12,6	3.8317	**	0.0210		-0.0135	0.8119
24	3,1	6.4612	*	-0.0431		-0.0050	0.5536
	6,1	5.7156	*	-0.3525	*	0.0053	0.2311
	6,3	5.7653	*	0.0343		-0.0118	0.9436
	12,1	5.8574	*	-0.1837		-0.0123	0.6311
	12,3	5.8601	*	0.0268		-0.0160	0.9451
	12,6	5.8365		0.2309		-0.0117	0.6045

*, ** **: Significativos al 1, 5 y 10%, respectivamente

The R^2 and F tests of the basic model are rather low, as in section 2. When these are compared with those of ARMA(2,1) model, according to Table 9, we also observe that the latter has better predictive power inside the sample. By contrast, the results of Table 10 show that including the TSIR improves the ARMA's predictive power of future IAI growth 1, 6, 12 and 18 months ahead. Observe also that there is no pattern of longer term

Table 9: Estimation of the ARMA(1,2) model

k	C	$\mathrm{Y}_k\ (t-1)$	$\mathrm{Y}_k\ (t-2)$		R^2	F
1	0.5771**	-0.6123*	-0.1482*	*	0.2931	0.0000
3	0.5177*	0.1251*	0.2108*	*	0.0574	0.0023
6	0.6130	0.1547*	0.4537*	*	0.2621	0.0000
9	0.8924***	0.3617*	0.3384*	*	0.3739	0.0000
12	0.6260***	0.3380*	0.4990	*	0.6120	0.0000
18	1.3628*	0.2575*	0.5107	*	0.4924	0.0000
24	1.1596*	0.3825*	0.4762	*	0.6766	0.0000

interest rate differentials predicting better than the shorter term interest rate differentials. However, it is worth mentioning that our VAR results for economic activity are better than for inflation. We detect many cases in which the lags of the interest rate differentials are significant and positive, up to 18 months ahead.

Table 10: Estimation of the ARMA(1,2) model with the *TSIR*

		C	ETTI	$Y_k\ (t-1)$	$Y_k\ (t-2)$	R^2	F
1	3,1	0.8622 *	-0.0054	-0.6132 *	-0.2037 *	0.2830	0.0000
	6,1	1.0942 *	0.2116 ***	-0.6443 *	-0.2548 *	0.3064	0.0000
	6,3	0.9134 *	0.0597	-0.6122 *	-0.2499 *	0.3060	0.0000
	12,1	0.8581 **	-0.2993 ***	-0.6177 *	-0.2512 *	0.3039	0.0000
	12,3	0.8749 **	-0.3047 **	-0.6299 *	-0.2579	0.3054	0.0000
	12,6	0.8788 **	-0.3107 ***	-0.6233 *	-0.2583 *	0.2978	0.0000
3	3,1	0.7421 **	0.0137	0.0994	0.1335	0.0162	0.1453
	6,1	0.7738 ***	-0.0307	0.0811	0.0296	0.0102	0.26194
	6,3	0.8642 ***	-0.0298	0.1052	0.0024	0.0120	0.2432
	12,1	1.0514 **	-0.1736	0.1148	-0.0613	-0.0089	0.5194
	12,3	0.7601	-0.1366	0.2225 ***	-0.0449	-0.0224	0.7749
	12,6	0.7418	-0.0118	0.2072	-0.0275	-0.0242	0.7818
6	3,1	0.4142	0.0203	0.2289 **	0.3688 *	0.2430	0.0000
	6,1	0.2233	-0.2117	0.1748 ***	0.4116 *	0.1856	0.0000
	6,3	0.2425	0.0624	0.1985 *	0.4347 *	0.1936	0.0000
	12,1	0.1468	-0.5061 ***	0.2048 *	0.4532 *	0.2229	0.0000
	12,3	-0.1331	-0.1452	0.2573 **	0.4805 *	0.2243	0.0000
	12,6	0.0664	-0.0367	0.2184 ***	0.5101 *	0.2242	0.0000
9	3,1	0.4498	0.0568	0.3966 *	0.3354 *	0.4046	0.0000
	6,1	0.5536	0.0814	0.4045 *	0.3259 *	0.3719	0.0000
	6,3	0.6371	0.1280	0.4010 *	0.3198 *	0.3696	0.0000
	12,1	0.7028	0.1764	0.3779 *	0.3726 *	0.3845	0.0000
	12,3	0.5018	0.0759	0.3428 *	0.4218 *	0.8410	0.0000
	12,6	0.2204	0.0250	0.5069 *	0.2969 **	0.3839	0.0000
12	3,1	0.2694	-0.0285	0.3629 *	0.4681 *	0.6231	0.000
	6,1	0.0316	-0.1268	0.4118 *	0.4283 *	0.6292	0.000
	6,3	0.0267	0.1129	0.5449 *	0.3501 *	0.6488	0.000
	12,1	0.0465	-0.4389	0.4509 *	0.3917 *	0.6569	0.000
	12,3	0.2103	-0.1149	0.5457 *	0.3494 *	0.6555	0.000
	12,6	0.0758	0.0164	0.5057 *	0.3930 *	0.6556	0.000
18	3,1	1.1252 **	0.0738	0.2757 *	0.5067 *	0.5058	0.000
	6,1	0.6443	-0.0720	0.2551 *	0.5372 *	0.5023	0.000
	6,3	0.4801	0.1383	0.2890 *	0.5342 *	0.4799	0.000
	12,1	0.9387	-0.3107	0.2589 *	0.4951 *	0.4741	0.000
	12,3	0.4108	-0.2456 ***	0.2448 *	0.5882 *	0.4750	0.000
	12,6	0.7916	0.0095	0.2717 **	0.5241 *	0.4739	0.000
24	3,1	0.9956 **	-0.0439	0.3786 *	0.4557 *	0.6920	0.000
	6,1	0.6515	-0.0497	0.3879 *	0.4591 *	0.7104	0.000
	6,3	0.5843	0.0935	0.4475 *	0.4204 *	0.7077	0.000
	12,1	0.6351	-0.0054	0.4247 *	0.4312 *	0.6833	0.000
	12,3	0.3980	-0.0883	0.4709 *	0.3909 *	0.6828	0.000
	12,6	0.2789	0.0028	0.5366 *	0.3105 *	0.6850	0.000

*, ** **: Significativos al 1, 5 y 10%, respectivamente

On the other hand, on Tables 11, 12 and 13 we can compare the different models with respect to out of the sample predictive power. The tables show that the models adding the interest rate differentials are marginally better than does than do not add these variables in the case of economic activity 3 months and 24 months ahead. Moreover, the pattern of longer term differentials predicting better than shorter term differentials does emerge in this analysis. Furthermore, there is some evidence of 12 month interest rate differentials predicting better than the 3 and 6 month differentials, especially in the case of the ARMA(12,1) model. Pratically in all cases, the VARs including the former variable have a lower RMSE than the corresponding simpler ARMA model.

Table 11: Comparison between the RMSE of the ARMA model and the basic prediction equation

	ARMA(2,1)	ETTI					
		3,1	6,1	6,3	12,1	12,3	12,6
y1	3.1251	3.28811	3.33596	3.2975	3.3007	3.2992	3.3184
y3	3.9492	3.83537*	3.82409*	3.8251*	3.7031*	3.7309*	3.8131*
y6	4.1815	4.63361	4.85433	4.7321	5.2484	5.4073	5.1995
y9	4.2662	4.56343	4.74889	4.5104	4.7581	5.2938	5.1378
y12	2.9183	3.37270	4.02062	3.7057	3.3091	3.6240	3.6772
y18	4.8711	5.42075	5.95429	5.8744	5.9727	6.2396	6.2031
Y24	3.4344	3.8428	3.8642	3.9406	3.7579	3.8774	3.9252

*: Smaller than those for the ARMA model

Table 12: Comparison between the RMSE of the ARMA model and the ARMA model that includes the ETTI

	ARMA(2,1)		ARMA +	ETTI			
		3,1	6,1	6,3	12,1	12,3	12,6
y1	3.1251	3.1554	3.1773	3.1641	3.1678	3.2277	3.2061
y3	3.9492	3.8600*	3.7834*	3.7724*	3.9298*	4.1612	4.1048
y6	4.1815	4.1986	4.2819	4.4104	4.2871	4.4783	4.3747
y9	4.2662	4.3373	4.3334	4.3111	4.6967*	4.5678	4.5479
y12	2.9183	2.9774	3.2050	3.2919	3.0237	3.0433	3.0710
y18	4.8711	4.8857	5.0177	5.0416	4.9564	5.0776	5.0558
y24	3.4344	3.3535*	3.3175*	3.4303*	3.3918*	3.4158*	3.3922*

*: Smaller than those for the ARMA model

Table 13: Comparison between the RMSEs of the ARMA(12,1) and VAR models

	ARIMA(12)	VARs					
		3,1	6,1	6,3	12,1	12,3	12,6
y_1	3.1253	4.1006	21.1703	7.6725	0.7277*	0.8724*	0.9647*
y_3	3.1862	4.0371	19.1337	4.1079	0.8897*	1.4037*	1.6650*
y_6	3.5888	4.0744	9.1911	4.6223	1.6438*	1.6910*	1.7026*
y_9	39252	3.9344	3.9334	7.2972	1.6602*	1.8615*	2.0417*
y_{12}	2.7259	3.8721	15.8424	26.8469	1.3283*	1.7026*	1.6233*
y_{18}	5.4906	5.5412	13.9561	8.3288	1.4677*	1.6262*	1.6266*
y_{24}	3.2872	3.9418	21.7335	20.9934	NA	NA	NA

*: Smaller than those for the ARMA model

Now we turn to the probit estimation results of Table 14. According to these results, not all definitions of recession produce a significant coefficient associated to the TSIR. When recession is defined as the variables r3, r6, r9 and a3, we find interest rates differentials that are significantly different from zero. In most of such cases, the sign of the coefficient is negative. This is consistent with the idea of a steeper TSIR being associated with a reduction of the probability of future recession. Coefficient's magnitudes vary between 2% and 25% depending on how recession is defined.

The corollary of this idea, a less steep TSIR being associated with an increase of the probability of future recession, if due to a higher short term interest rate may be more easily explained by the fact that in Mexico economic recessions have been followed by the authorities' inducing sharp increases of short term interest rates, which in turn would foster recession. Another common critique to this kind of studies on the relationship between interest rate differentials and economic activity is that both interest rate differentials and economic activity may be influenced by a common factor, like the monetary policy stance. One way to verify whether there is a common factor behind this relationship is by adding to the model a variable that reflects more accurately the actions of the monetary authorities. If the TSIR loses its significance as a result, it is considered that both variables are affected by monetary policy. We carry out this exercise using the 1 month and 3 month CETEs rates respectively to indicate the monetary policy stance.[11] We do not find any systematic connection among the introduction of such variables and the significance of the TSIR coefficients that allows us to unambiguously accept or reject the common factor hypothesis, so the exercise of proving for better indicators of monetary policy remains open.

With this caveat in mind we present a simple proof of the goodness of the probit models, namely a comparison with constant probability models, in the appendix. In general, the regressions in which the coefficients associated

[11] Plosser and Rouwenhort carry out this exercise with data fot the US, Germany, France, Canada and the UK.

Table 14: Probit Estimations

	α		β		Mc Fadden R^2	Obs
			$(m,n) = (12,1)$			
a3	-1.5221	*	0.0078		0.0043	95
a6	-1.6134	*	0.0066		0.0032	95
a9	-1.8524	*	0.0062		0.0029	95
r3	-1.7281	*	0.0076		0.0041	95
r6	-2.3065	*	0.0002		0.0000	95
r9	-2.4645	*	-0.0268	*	0.2403	95
			$(m,n) = (12,3)$			
a3	-1.5585	*	-0.0580		0.2446	95
a6	-1.6592	*	-0.0634		0.0362	95
a9	-1.8593	*	-0.0147		0.1767	95
r3	-1.7707	*	-0.0638		0.0397	95
r6	-3.0154	*	-0.1733	***	0.4035	95
r9	-1.8355	*	0.0256		0.0113	95
			$(m,n) = (12,6)$			
a3	-1.5197	*	-0.1586		0.0366	95
a6	-1.6139	*	-0.1581		0.0380	95
a9	-1.8457	*	-0.1087		0.0184	95
r3	-1.7219	*	-1.1496		0.0357	95
r6	-2.4402	*	-0.2466	***	0.1551	95
r9	-1.8476	*	0.0201		0.0052	95
			$(m,n) = (6,3)$			
a3	-1.6527	*	-0.0596		0.0248	95
a6	-1.7489	*	-0.0664		0.0320	95
a9	-1.9501	*	-0.0157		0.0017	95
r3	-1.8576	*	-0.0687		0.0364	95
r6	-3.0634	*	-0.2006	***	0.3692	118
r9	-1.9573	*	0.0054		0.0013	95
			$(m,n) = (6,1)$			
a3	-1.6357	*	0.0054		0.0022	95
a6	-1.7225	*	0.0046		0.0016	95
a9	-1.9513	*	0.0036		0.0011	95
r3	-1.8258	*	0.0056		0.0023	95
r6	-2.3867	*	0.0027		0.0007	118
r9	-2.3686	*	-0.0212	*	0.2158	120
			$(m,n) = (3,1)$			
a3	-1.4469	*	0.0317	**	0.0587	164
a6	-1.7248	*	0.0060		0.0024	95
a9	-2.0905	*	0.0010		0.0000	95
r3	-1.5881	*	0.0204	***	0.0324	164
r6	-2.5742	*	0.0194		0.0398	118
r9	-2.4957	*	-0.0208	*	0.2126	169

to the TSIR are significant show a gain on predictive power vis-a-vis the corresponding model that uses a constant 50% probability. This gain is almost 30% in the case of the 12 to 1 month and 3 to 1 month TSIR.

In conclusion, nominal interest rate differentials also contain some power to predict economic activity, up to 18 months ahead. The pattern of longer term differentials predicting more than shorter term differentials, observed for other countries' data, is also detected here. Interest rate differentials also seem to be associated with the probability of future recession: a 1 point decrease on the TSIR's slope is associated to a reduction on the probability of future recession of 1% to 25%, varying with respect to the definition in use.

4 Future spot rates and the rational expectations hypothesis of the TSIR

4.1 Previous studies

Theoretic and empirical literature about the relationship between spot and future markets and interest rates differentials is extensive. Most of the results obtained with data of industrialized countries reject the most basic theories and leave open the question of what can be behind such failures. But there are few results for developing countries. Only Sod ([34]) uses Mexican data to test implications of the rational expectations hypothesis of the TSIR (EH).

Using monthly data of 28 and 91 days CETEs interest rates of the 1982-1995 period, Sod (27) finds evidence to reject the EH that is consistent with the existence of a time varying risk premium. In the following sections we extend Sod's results in two directions: we consider a sample until 1999 and include data of the 182 and 365 CETEs interest rates.

4.2 Model

Literature about the TSIR has suggested that the spread between a short term and a long term interest rate reflects a prediction about the short rate's future behavior. In general, the simplest version of the EH proposes that:

$$R_t^k \approx \theta + \frac{1}{k} \sum_{i=0}^{k-1} E[r_{t+i}^j], , \tag{9}$$

where R_t^k is the k periods ahead (long term) interest rate, r_t^j is the j periods ahead (short term) interest rate, $j = 1$ in all cases and theta is the constant risk premium. This expression can also be expressed as:

$$\sum_{i=0}^{k-1} E[r^j_{t+i} - r_t] \approx -k\theta + k(R^k_t - r_t). \tag{10}$$

If forecast errors of interest rates at time t are given by:

$$Er_{t+i} = r_{t+i} + \upsilon_{t+i} \forall i, \tag{11}$$

equation 10 becomes:

$$\sum_{i=0}^{k-1} [r^j_{t+i} - r_t] = \alpha + \beta(R^k_t - r_t) + \epsilon_t, \tag{12}$$

where $\epsilon_t = \sum_{i=1}^{k-1} \upsilon_{t+i}$, $\alpha = -k\theta$ and $\beta = k$.

4.3 Results

We estimate equation 12 using the 28, 91, 182 and 365 CETEs data (that is, $k \in \{3, 6, 12\}$). Results on Table 15 show that the estimated coefficients differ significantly of those predicted by the EH according to equation 12 and, moreover, are not significantly different of zero at the conventional levels. Hence, the EH is rejected.

Table 15: Estimation of equation 12

	$E_{t,3}$	$E_{t,6}$	$E_{t,12}$
α	-0.1978	-0.8326	6.2659
β	0.0540	0.0437	0.1472
$R^2 Ajustada$	0.0128	0.0027	-0.0028
Obs	.718	.671	.524

*, ** **: Significant at the 1, 5 y 10%levels

A second test of the EH is to verify whether the risk premium can be predicted with a simple regression that includes current and lagged values of the interest rate differentials.[12] Equation 10 can be expressed as:

$$y_t \equiv (1 + R_t)^k - \sum_{i=0}^{k-1}[1 + r_{t+i}] \approx kR_t - \sum_{i=0}^{k-1}[r_{t+i}], \tag{13}$$

In this expression, the risk premium y_t equals the expected difference in returns between the long term and the short term bonds. EH assumes that the risk premium is constant through time. If expectations are rational, then the risk premium cannot be predicted with previously known variables. As a result in the regression:

$$y_t = \alpha + \beta x_t + \epsilon_t, \tag{14}$$

where x_t is a vector of variables known at t, ϵ_t is the forecast error with zero mean and constant variance, the null hypothesis is $\beta = 0$.

We estimate two versions of equation 14. One, presented on Table 16, includes as explanatory variables the interest rate differentials of periods t and $t-1$. The other one, presented on Table 17, includes lags of the risk premium. In both cases, results also reject the null hypothesis because some of the coefficients associated to the explanatory variables are significantly different from zero. We emphasize these last results because these are the only tests for which Sod (27) finds some evidence favoring the EH. Thus, all our tests reject the EH.

To test whether rejection of the EH is due to a fluctuating risk premium, following Sod (27) again we estimate a simple GARCH model:

$$y_t = c + \epsilon_t, \tag{15}$$

$$h_t = \alpha_0 + \alpha_+ \epsilon_{t-1}^2 + \beta_1 h_{t-1}, \tag{16}$$

in which the conditional mean of the risk premium y_t is equal to a constant c plus a forecast error ϵ_t, whose variance h_t follows a GARCH(1, 1) process.

[12]See Schiller and McCulloch ([?])for a more detailed explanation of the EH tests and the reasons for their equivalence.

Table 16: Estimation of equation 14

	$Y_{t,3}$	$Y_{t,6}$	$Y_{t,12}$
C	3.1900*	21.2072*	21.4791*
$I_{k,1}(t)$	-0.0189	8.8771*	10.2832*
$I_{k,1}(t-1)$	-0.0288	-0.3417*	-0.4468
$R^2 Ajustada$	0.0033	0.7990	0.1653
Obs	.621	.447	.294

*, ** **: Significant at the 1, 5 y 10% level

Table 17: Estimation of equation 14

	$Y_{t,3}$	$Y_{t,6}$	$Y_{t,12}$
C	0.5100***	0.2148	-1.0433
$Y_k(t-1)$	0.8111*	1.0733*	1.2410*
$Y_k(t-2)$	-0.0436	-0.0125	-0.0789
$Y_k(t-3)$	0.0636	-0.0763	-0.1565
$R^2 Ajustada$	0.6054	0.9602	0.9477
Obs	.596	.417	.273

*, ** **: Significant at the 1, 5 y 10% level

The results for the (3,1) interest rate differential are on Table 18. Evidence of conditional heteroskedasticity effects can be appreciated on the significant coefficients that we obtain.

Table 18: Estimation of the GARCH(1,1)

sqr(GARCH)	0.1671*	.
c	1.4140*	1.9785*
c	1.4316*	1.0574*
arch(1)	1.0263*	0.8282*
garch(1)	0.3561*	0.4546*
R^2	-0.0780	-0.0236

*, ** **: Significant at the 1, 5 y 10% level

5 Conclusions

Mexico's experience with relatively less rigid financial markets and a flexible exchange rate regime consists of a short time lapse. In the future it will be interesting to verify if some of the patterns regarding the TSIR that have been detected for other countries show up more clearly as more data becomes available. Our conjecture is that, as the corresponding financial markets for longer term government debt develop and become liquid, it will be the case that such interest rate differentials become significant indicators of future inflation and economic activity expectations.

Economic policy makers rely on other financial market prices like asset prices, indexed bonds, zero yield curves, or differences on return between government and commercial debt, in addition to nominal interest rate differential.[13]

[13] Smith([33] and IMF([24]) contain go od summaries of the main results in this area.) Hence, it is desirable to enlarge the comparison to include other financial market indicators in the future. It will also be useful to compare these with those that come from other sources, like the survey of financial specialists, and determine up to which degree they complement each other.

References

[1] Babatz, G, 1997, "The effect of financial liberalization on the capital structure and investment decisions of firms: Evidence from Mexican Panel Data", Harvard University PhD Dissertation.

[2] Babatz, G. and A. Conesa, 1994, "The term structure of interest rates: An aempirical analysis of Mexico", Harvard University, Mimeograph.

[3] Bernanke, B.S., 1990, "On the Predictive Power of Interest Rates and Interest Rate Spreads", *New England Economic Review* November/December, 51-68.

[4] Bernard, H. and S. Gerlach, 1996, "Does the term structure predict recessions? The International Evidence", *BIS Working Paper 37.*

[5] Campbell, J., R. Shiller and K. Schoenholtz, 1983, "Forward rates and future policy: interpreting the term structure of interest rates", *Brookings Papers on Economic Activity* 1, pp:173-217.

[6] Castellanos, Sara, 1999, "El efecto del 'corto' sobre la estructura de tasas de interés", mimeo, Banco de México.

[7] DiNardo, J. and J. Johnston, 1997, *Econometric Methods*, 4^a ed., Mc Graw-Hill.

[8] Estrella, A. and G. Hardouvelis, 1991, "The term structure as a predictor of real economic activity", *The Journal of Finance* 46, June, pp:555-76.

[9] Estrella, 1998, "Monetary Policy and the Predictive Power of the Term Structure of Interest Rates", mimeo, Federal Reserve Bank of New York, November.

[10] Estrella, A. and F. Mishkin, 1995,"The term structure of interest rates and its role in monetary policy for the european central bank" *NBER Working Paper 5279.*

[11] The Economist, "Time to Break the Rules", May 13-19 2000.

[12] The Economist, "Central Banks: all a-quiver," May 13-19 2000.

[13] Fama, E.F., 1975, "Short-term interest rates as predictors of inflation", *The American Economic Review* 65, June, pp:269-82.

[14] Fama, E.F., 1984, "The information in the term structure", *Journal of Financial Economics* 13, pp:509-28.

[15] Fama, E.F., 1990,"Term-structure forecasts of interest rates, inlfation and real returns", *Journal of Monetary Economics* 25, January, pp:59-76.

[16] Fernández, V., 1999, "Estructura de Tasas de Intersn en Chile Qu Tan Buen Predictor de Crecimiento e Inflacin?", *Mimeo*, Pontificia Universidad Catlica de Chile.

[17] Fisher, I., 1930, "The Theory of Interest", Macmillan, New York, N.Y.

[18] Green, E., 1990, "Econometric Analysis", McMillan, New York, N.Y.

[19] Grossman, S., y J.E. Stiglitz, 1980"On the imposibility of informationally efficient markets", American Economic Review 70, Junio, pp:393-408

[20] Hall, R.E., 1978, "Stochastic Implications of the Life Cycle/Permanent Income Hypothesis: Theory and Evidence", *Journal of Political Economy*,86, 971-87.

[21] Hamburger, M. and E. Platt, 1975, "The expectations hypothesis and the efficiency of the treasury bill market", *The Review of Economics and Statistics* 57, May: 190-99.

[22] Hansen, L.P. and R.J., Hodrick, 1980,"Forward exchange rates as optimal predictors of future spot rates: an econometric analysis" *The Journal of Political Economy*, 88, October, pp:829-53.

[23] Hardouvelis, G., 1988, "The predictive power of the term structure during recent monetary regimes", *The Journal of Finance* 43, June: 339-56.

[24] IMF, 1999, "Safeguarding Macroeconomic Stability at Low Inflation" *World Economic Outlook*, Octubre 1999, Cap. IV

[25] Mankiw, G., 1986(a), "The term structure of interest rates revisited", *Brookings Papers on Economic Activity* 1:61-110.

[26] Mankiw, N.G., 1981, "Hall's Consumption Hypothesis and Durable Goods", *Journal of Monetary Economics* 10, 417-25.

[27] Mankiw, G. and J. Miron, 1986(b) "The changing behavior of the term structure of interest rates", *The Quarterly Journal of Economics* 101, May:211-28.

[28] Mishkin, F., 1990[a], "What does the term structure tell us about future inflation", *Journal of Monetary Economics* 25, pp:77-95.

[29] Mishkin, F., 1990[b], "The information in the longer maturity term structure about future inflation", *Quarterly Journal of Economics* 105, Agosto, pp:815-28.

[30] Plosser, C.I. y K.G. Rouwenhorst, 1994, "International term structures and real economic growth", *Journal of Monetary Economics* 33, pp: 133-155.

[31] Robertson, D., 1992, "Term structure forecasts of inflation", *The Economic Journal* 102, September, pp: 1083-93.

[32] Shiller, R. y J.H. McCulloch, 1990, "The term structure of interest rates", in Friedman, B. and F. Hahn, *Hanbook of Monetary Economics vol. I*, pp:627-722.

[33] Smith, S., 1999, "What Do Asset Prices Tell Us about the Future?", *Federal Reserve Bank of Atlanta Economic Review*, Third Quarter.

[34] Sod, G., 1996, "The term structure of interest rates: rationality, volatility and the mexican experience (1982-1995)", mimeo.

6 Appendix

Table 19: Unit root tests

	Levels		1[st] Differences	
Variable	DFA	PP	DFA	PP
Panel A: Nominal interest rate differentials				
$i_{3,1}$	-4.6912*	-10.4544*	-4.3705*	-9.5591*
$i_{6,1}$	1.4280	-6.2434*	3.0014**	-11.4917*
$i_{6,3}$	2.1196*	-4.4998*	-1.1091	-18.9424*
$i_{12,1}$	-0.5757	-8.1900*	0.4936	-10.9422*
$i_{12,3}$	-0.9493*	-7.1228*	-4.2413*	-15.2291*
$i_{12,6}$	-3.7159*	-8.2281*	-8.3401*	-17.9129*
Panel B: Real interest rate differentials				
$re_{3,1}$	-4.6909*	-4.3705*	-10.4533*	-9.5590*
$re_{6,1}$	1.4813	3.0263**	-6.4010*	-11.7396*
$re_{6,3}$	-2.0088	-1.1108	-5.2714*	-19.1610*
$re_{12,1}$	-0.6418	0.4599	-8.4032*	-11.1729*
$re_{12,3}$	-1.0737	-4.3318*	-7.3046*	-15.5177*
$re_{12,6}$	-3.8449*	-8.4844*	-8.4864*	-18.3497*
Panel C: Inflation rates differentials				
$\pi_{3,1}$	-6.2987*	-8.7721*	-9.1768*	-16.6195*
$\pi_{6,1}$	-4.5693*	-4.9309*	-8.7622*	-10.8208*
$\pi_{12,1}$	-4.4073*	-4.2567*	-5.4301*	-9.3258*
$\pi_{6,3}$	-9.9732*	-2.9395**	-7.5223*	-1.9236*
$\pi_{12,3}$	-4.2436*	-3.7318*	-6.8155*	-4.4601*
$\pi_{12,6}$	-5.4605*	-3.4885*	-6.1885*	-4.2700*
Panel D: Growth rates of the IAI				
Y_1	-6.4560*	-11.1710*	-25.9054*	-69.2234*
Y_3	-4.5432*	-7.8064*	-11.2798*	-30.4886*
Y_6	-4.6038*	-4.6657*	-10.3900*	-28.8907*
Y_9	-3.4598**	-7.0522*	-7.1099*	-24.2922*
Y_12	-3.6672*	-5.4451*	-5.0926*	-23.2810*
Y_18	-3.5381*	-5.5365*	-6.7877*	-29.0653*

*, **: The unit root hypothesis is rejected at the 1% and 5% levels

Table 20: Granger causality tests for interest rate differentials and inflation rates

Hipótesis	Obs	Est F		Hipótesis	Obs	Est F	
$\pi_{12,1}$ does not cause $i_{3,1}$	77	3.466	*	$\pi_{6,3}$ no causa a $i_{3,1}$	86	11.757	*
$i_{3,1}$ does not cause $\pi_{12,1}$		4.268	*	$i_{3,1}$ does not cause $\pi_{6,3}$		5.349	*
$\pi_{12,1}$ does not cause $i_{6,1}$	77	4.224	*	$\pi_{6,3}$ does not cause $i_{6,1}$	86	15.277	*
$i_{6,1}$ does not cause $\pi_{12,1}$		4.282	*	$i_{6,1}$ does not cause $\pi_{6,3}$		3.872	*
$\pi_{12,1}$ does not cause $i_{6,3}$	77	15.823	*	$\pi_{6,3}$ does not cause $i_{6,3}$	86	12.654	*
$i_{6,3}$ does not cause $\pi_{12,1}$		1.563		$i_{6,3}$ does not cause $\pi_{6,3}$		0.396	
$\pi_{12,1}$ does not cause $i_{12,1}$	77	4.152	*	$\pi_{6,3}$ does not cause $i_{12,1}$	77	11.797	*
$i_{12,1}$ does not cause $\pi_{12,1}$		1.244		$i_{12,1}$ does not cause $\pi_{6,3}$		3.133	*
$\pi_{12,1}$ does not cause $i_{12,3}$	77	9.751	*	$\pi_{6,3}$ does not cause $i_{12,3}$	77	8.622	*
$i_{12,3}$ does not cause $\pi_{12,1}$		1.830		$i_{12,3}$ does not cause $\pi_{6,3}$		0.261	
$\pi_{12,1}$ does not cause $i_{12,6}$	77	14.602	*	$\pi_{6,3}$ does not cause $i_{12,6}$	77	7.437	*
$i_{12,6}$ does not cause $\pi_{12,1}$		0.819		$i_{12,6}$ does not cause $\pi_{6,3}$		0.322	
$\pi_{12,3}$ does not cause $i_{3,1}$	77	16.508	*	$\pi_{6,1}$ does not cause $i_{3,1}$	86	6.527	*
$i_{3,1}$ does not cause $\pi_{12,3}$		2.010	**	$i_{3,1}$ does not cause $\pi_{6,1}$		5.928	*
$\pi_{12,3}$ does not cause $i_{6,1}$	77	18.723	*	$\pi_{6,1}$ does not cause $i_{6,1}$	86	8.221	*
$i_{6,1}$ does not cause $\pi_{12,3}$		2.089	**	$i_{6,1}$ does not cause $\pi_{6,1}$		4.792	*
$\pi_{12,3}$ does not cause $i_{3,1}$	77	16.508	*	$\pi_{6,1}$ does not cause $i_{3,1}$	86	6.527	*
$i_{3,1}$ does not cause $\pi_{12,3}$		2.010	**	$i_{3,1}$ does not cause $\pi_{6,1}$		5.928	*
$\pi_{12,3}$ does not cause $i_{6,3}$	77	9.684	*	$\pi_{6,1}$ does not cause $i_{6,3}$	86	17.240	*
$i_{6,3}$ does not cause $\pi_{12,3}$		0.694		$i_{6,3}$ does not cause $\pi_{6,1}$		1.547	
$\pi_{12,3}$ does not cause $i_{12,1}$	77	14.053	*	$\pi_{6,1}$ does not cause $i_{12,1}$	77	11.797	*
$i_{12,1}$ does not cause $\pi_{12,3}$		1.161		$i_{12,1}$ does not cause $\pi_{6,1}$		3.133	*
$\pi_{12,3}$ does not cause $i_{12,3}$	77	7.062	*	$\pi_{6,1}$ does not cause $i_{12,3}$	77	8.622	*
$i_{12,3}$ does not cause $\pi_{12,3}$		0.556		$i_{12,3}$ does not cause $\pi_{6,1}$		0.261	
$\pi_{12,3}$ does not cause $i_{12,6}$	77	6.873	*	$\pi_{6,1}$ does not cause $i_{12,6}$	77	7.437	*
$i_{12,6}$ does not cause $\pi_{12,3}$		0.448		$i_{12,6}$ does not cause $\pi_{6,1}$		0.322	
$\pi_{12,6}$ does not cause $i_{3,1}$	77	18.819	*	$\pi_{3,1}$ does not cause $i_{3,1}$	157	2.228	*
$i_{3,1}$ does not cause $\pi_{12,6}$		1.296		$i_{3,1}$ does not cause $\pi_{3,1}$		1.104	
$\pi_{12,6}$ does not cause $i_{6,1}$	77	20.104	*	$\pi_{3,1}$ does not cause $i_{6,1}$	86	14.586	*
$i_{6,1}$ does not cause $\pi_{12,6}$		1.192		$i_{6,1}$ does not cause $\pi_{3,1}$		3.392	*
$\pi_{12,6}$ does not cause $i_{6,3}$	77	8.781	*	$\pi_{3,1}$ does not cause $i_{6,3}$	86	17.697	*
$i_{6,3}$ does not cause $\pi_{12,6}$		0.243		$i_{6,3}$ does not cause $\pi_{3,1}$		1.525	
$\pi_{12,6}$ does not cause $i_{12,1}$	77	16.462	*	$\pi_{3,1}$ does not cause $i_{12,1}$	77	13.808	*
$i_{12,1}$ does not cause $\pi_{12,6}$		0.599		$i_{12,1}$ does not cause $\pi_{3,1}$		1.380	
$\pi_{12,6}$ does not cause $i_{12,3}$	77	6.177	*	$\pi_{3,1}$ does not cause $i_{12,3}$	77	10.774	*
$i_{12,3}$ does not cause $\pi_{12,6}$		0.226		$i_{12,3}$ does not cause $\pi_{3,1}$		1.166	
$\pi_{12,6}$ does not cause $i_{12,6}$	77	4.054	*	$\pi_{3,1}$ does not cause $i_{12,6}$	77	15.389	*
$i_{12,6}$ does not cause $\pi_{12,6}$		0.250		$i_{12,6}$ does not cause $\pi_{3,1}$		0.481	

*, *****: Hypothesis is rejected at the 1%, 5% and 10% levels

Table 21: Granger causality tests for interest rate differentials and growth rates for the *IAI*

Hypothesis	Obs	F Est		Hypothesis	Obs	F Est	
y_{18} does not cause $i_{12,1}$	40	0.7266		y_6 does not cause $i_{12,1}$	42	0.8242	
$i_{12,1}$ does not cause $y_1 8$		1.8564		$i_{12,1}$ does not cause y_6		1.3799	
$y_1 8$ does not cause $i_{12,3}$	40	0.4585		y_6 does not cause $i_{12,3}$	42	0.7185	
$i_{12,3}$ does not cause $y_1 8$		1.1903		$i_{12,3}$ does not cause y_6		1.0931	
$y_1 8$ does not cause $i_{12,6}$	40	0.4223		y_6 does not cause $i_{12,6}$	42	0.6999	
$i_{12,6}$ does not cause $y_1 8$		1.1145		$i_{12,6}$ does not cause y_6		1.2204	
$y_1 8$ does not cause $i_{3,1}$	76	0.5609		y_6 does not cause $i_{3,1}$	79	0.8167	
$i_{3,1}$ does not cause $y_1 8$		1.0530		$i_{3,1}$ does not cause y_6		0.4238	
$y_1 8$ does not cause $i_{6,1}$	54	0.5734		y_6 does not cause $i_{6,1}$	56	0.4991	
$i_{6,1}$ does not cause $y_1 8$		0.9809		$i_{6,1}$ does not cause y_6		1.7685***	
$y_1 8$ does not cause $i_{6,3}$	54	0.9220		y_6 does not cause $i_{6,3}$	56	0.6722	
$i_{6,3}$ does not cause $y_1 8$		1.0330		$i_{6,3}$ does not cause y_6		0.8475	
$y_1 2$ does not cause $i_{12,1}$	42	0.4211		y_3 does not cause $i_{12,1}$	42	0.31074	
$i_{12,1}$ does not cause $y_1 2$		1.7656		$i_{12,1}$ does not cause y_3		4.1919	*
$y_1 2$ does not cause $i_{12,3}$	42	0.4278		y_3 does not cause $i_{12,3}$	42	0.6822	
$i_{12,3}$ does not cause $y_1 2$		0.8280		$i_{12,3}$ does not cause y_3		2.3932	**
$y_1 2$ does not cause $i_{12,6}$	42	0.5138		y_3 does not cause $i_{12,6}$	42	0.7986	
$i_{12,6}$ does not cause $y_1 2$		0.7827		$i_{12,6}$ does not cause y_3		2.0033	***
$y_1 2$ does not cause $i_{3,1}$	79	1.2949		y_3 does not cause $i_{3,1}$	79	0.6218	
$i_{3,1}$ does not cause y_{12}		1.6727	***	$i_{3,1}$ does not cause y_3		1.0123	
y_{12} does not cause $i_{6,1}$	56	1.1371		y_3 does not cause $i_{6,1}$	56	0.6345	
$i_{6,1}$ does not cause y_{12}		1.2838		$i_{6,1}$ does not cause y_3		1.5041	
y_{12} does not cause $i_{6,3}$	56	1.0295		y_3 does not cause $i_{6,3}$	56	0.6767	
$i_{6,3}$ does not cause $y_1 2$		0.6710		$i_{6,3}$ does not cause y_3		0.8670	

*, *****: Hypothesis is rejected at the 1%, 5% and 10% levels

Table 22: Comparison of the probit models with the constant probability model

	Estimated			$Prob = 0.5$		
	Dep=0	Dep=1	Total	Dep=0	Dep=1	Total
$(m, n) = 12, 3,\ R6$						
$P(dep = 1) < c$	94	1	95	94	1	95
$P(dep = 1) > c$	0	0	0	0	0	0
Total	94	1	95	94	1	95
Correct	94	0	94	94	0	94
%Correct	100	0	98.95	100	0	98.95
%Incorrect	0	100	1.05	0	100	1.05
Gain	0	0	0			
%Gain		0	0			
$(m, n) = 12, 6,\ R6$						
$P(dep = 1) < c$	94	1	95	94	1	95
$P(dep = 1) > c$	0	0	0	0	0	0
Total	94	1	95	94	1	95
Correct	94	0	94	94	0	94
%Correct	100	0	98.95	100	0	98.95
%Incorrect	0	100	1.05	0	100	1.05
Gain	0	0	0			
%Gain		0	0			
$(m, n) = 6, 3,\ R6$						
$P(dep = 1) < c$	117	1	118	117	1	118
$P(dep = 1) > c$	0	0	0	0	0	0
Total	117	1	118	117	1	118
Correct	117	0	117	117	0	117
%Correct	100	0	99.15	100	0	99.15
%Incorrect	0	100	0.85	0	100	0.85
Gain	0		0			
%Gain		0	0			
$(m, n) = 3, 1,\ A3$						
$P(dep = 1) < c$	149	3	162	150	14	164
$P(dep = 1) > c$	1	1	2	0	0	0
Total	150	14	164	150	14	164
Correct	149	1	150	150	0	150
%Correct	99.33	7.14	91.46	100	0	91.46
%Incorrect	0.67	92.86	8.54	0	100	8.54
Gain	-0.67	7.14	0			
%Gain		7.14	0			
$(m, n) = 3, 1,\ A3$						
$P(dep = 1) < c$	154	10	164	154	10	164
$P(dep = 1) > c$	0	0	0	0	0	0
Total	154	0	164	154	0	164
Correct	154	0	154	154	0	154
%Correct	100	0	93.90	100	0	93.90
%Incorrect	0	100	6.10	0	100	6.10
Gain	0	0	0			
%Gain		0	0			

Table 23: Estimation using the *TSRR*:

$$Y_{t,t+k} = \alpha_k + \beta_k(re_{t,t+m} - re_{t,t+n}) + \epsilon_{t,t+k}, \text{ 1985-1999}$$

k	m,n	α_k	β_k	R^2	F	k	m,n	α_k	β_k	R^2	F
1	12,1	1.8418***	0.0268	-0.0094	0.7072	9	12,1	2.2599*	-0.0445	-0.0004	0.3416
	12,3	1.7752***	0.2047	-0.0056	0.4880		12,3	2.3793*	0.0695	-0.0105	0.7366
	12,6	1.5452***	0.6077***	-0.001	0.3235		12,6	2.1195*	0.7464**	0.0290	0.0631
	6,3	1.6712**	-0.0131	-0.0087	0.9547		6,3	2.1578**	-0.2461	0.0136	0.1172
	6,1	1.6718**	0.0052	-0.0087	0.9307		6,1	1.9906**	-0.0736	0.0202	0.0748
	3,1	1.4265**	0.0091	-0.0061	0.8467		3,1	2.2419*	-0.0290	-0.0003	0.4953
3	12,1	1.6045*	0.0171	-0.0091	0.6677	12	12,1	3.2301*	-0.0476	0.0016	0.2885
	12,3	1.5659*	0.2359**	0.0125	0.1469		12,3	3.3595*	0.1011	-0.0082	0.5832
	12,6	1.2917**	0.7020**	0.0359	0.0396		12,6	3.0860*	0.7745***	0.0378	0.0401
	6,3	1.3561*	0.0397	-0.0081	0.7644		6,3	3.0038*	-0.1792	0.0037	0.2386
	6,1	1.3751*	0.0049	-0.0087	0.8876		6,1	2.8525*	-0.0776*	0.0260	0.0512
	3,1	1.5074*	0.0088	-0.0061	0.8241		3,1	2.9311*	-0.0519	0.0047	0.1911
6	12,1	1.7047***	-0.0118	-0.0107	0.7835	18	12,1	4.8474*	-0.0012	-0.0121	0.9813
	12,3	1.7381**	0.0639	-0.0101	0.7220		12,3	4.8976*	0.2547	0.0030	0.2653
	12,6	1.5560***	0.4927**	0.0091	0.1833		12,6	4.4424*	1.2744*	0.0781	0.0057
	6,3	1.6303**	-0.1415	-0.0007	0.3387		6,3	4.1737*	-0.1920	-0.0012	0.3544
	6,1	1.5437**	-0.0354	-0.0015	0.3689		6,1	4.0468*	-0.0543***	0.0001	0.3151
	3,1	1.9629**	-0.0241	-0.0041	0.5545		3,1	4.7931*	-0.0133	-0.0063	0.7918
						24	12,1	6.0494*	-0.1127*	0.0477	0.0362
							12,3	6.4278*	-0.0317	-0.0140	0.8917
							12,6	5.9318*	1.2843***	0.0817	0.0085
							6,3	6.1784*	-0.1555	-0.0033	0.4086
							6,1	5.9392*	-0.1141**	0.0471	0.0194
							3,1	6.5927*	-0.0879***	0.0211	0.0497

*, ** **: Significant at the 1, 5 y 10% level