PRODUCTIVITY, INFLATION, AND INVESTMENT: AN ANALYSIS OF CAUSALITY

José Luis de la Cruz
ITESM-CEM

José Antonio Nuñez
ITESM-CCM

Othon Moreno
ITESM-CEM

Abstract

This paper elaborates a Vector Error Correction (VEC) in order to determine the causality[1] between inflation and productivity, and between the productivity and investment in Mexico. A VEC allows a causality analysis among cointegrated variables with the same integration order [Hall and Milne, 1994]. This work incorporates the test of constancy in the cointegration rank developed by Quintos (1997). The results show a consistent and bidirectional causality between inflation and productivity. Furthermore, these results denote that some investment components (mainly machinery and equipment imports, and construction) have a strong link with productivity.

I. Introduction

During the last years, the Mexican Central Bank (Banxico) has implemented an exchange rate and monetary policy according to an inflationary target [Carsterns and Werner, 1999].[2] The price goal allows the economy to benefit form a macroeconomic environment with price stability such as: (1) the efficient behavior of the currency and price system; (2) transparency and credibility of the monetary policy; (3) the minimization the segnoriage; and (4) the contribution to the fiscal discipline. Also, the price stability favors the reduction of the interest rates, influencing the financial markets generating certainty and stability in their behavior; reduces the tax distortions [Saxton, 2002] allowing the development of efficient investment plans which increase the productivity [Clark, 1982 and Papapetrou, 2001]. Besides the rate fixed as an inflation target, it is important to study if the inflation rate has not only a correlation with the structural macroeconomic variables for the economic growth, but also to explore the causality and the direction of this causality in order to determine if the anti-inflationary policy of Banxico will have some influence in the productive capacity of the country.

This study searches a connection between the productivity, inflation and investment (the last one disaggregated in its components). The fundamental reason that justifies the research is the current international economic moment that creates the necessity to enforce the internal market in order to make it the main precursor of economic growth. Also, the enforcement of the internal market can improve the competitiveness of the external sector, mainly in the American market.

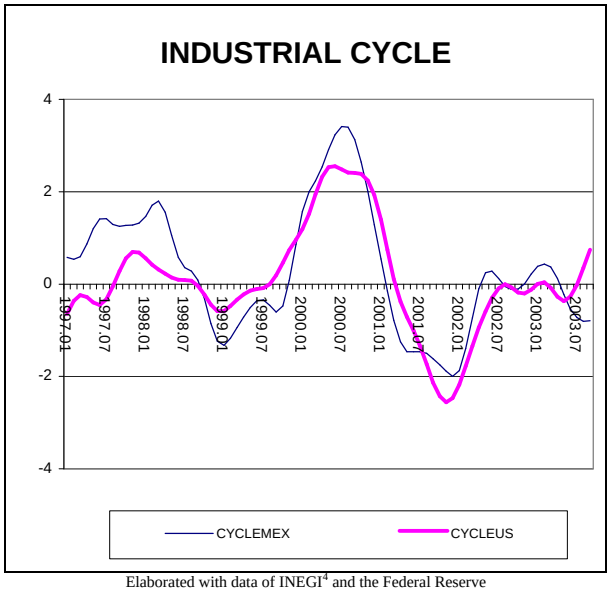
The paper is organized in the following order: section II presents the background; section III includes the methodology used to elaborate the VEC; section IV shows the data; section V states the empirical results; and finally, section VI presents the conclusion of the research.

[1] In the Granger sense
[2] The inflation target in 2003 is 3%.

II. Background

The recent results of the industrial production (IP) in Mexico demonstrate the negative situation that the industrial sector is facing.[3] The dependence that the country maintains with the American economic cycle gives no sign of consistent recovery in the short run.

Graph 1



Elaborated with data of INEGI[4] and the Federal Reserve

Given the behavior of the industrial cycles, the empirical evidence shown in the graph 1 (with data up to September 2003) establishes that the growth in the American sector is no longer an important source if recovery to Mexico in the short run. Contrasting with the previous years, now the relationship between the recovery in the United States and the negative situation of its Mexican counterpart is phasing out. In the other side, the Chinese entrance to the World Trade Organization (WTO) creates a more competent scenario in the American market. This is why it is important that the economic policy focus to favor investment, allowing the accumulation of capital stock, doting with the necessary factors to the productive agents in the long run to face the competence and helping the development of the human capital and reduce the labor costs.

In the economic growth theory, to study the level of production implies to analyze the production factors' situation that contribute in the production; the magnitude of the production will be obtained from the combination of these factors. Particularly, the economic growth theory states that by analyzing labor and capital it is possible to find a reasonable explanation of the economic dynamics of a country. Focusing the analysis on capital we will find that this factor has an association with technological innovation, which is the result of scientific advances, applied to the production processes. In the Mexican case, given that there is no economic series that describe the evolution of capital, it is necessary to refer the analysis to the investment, which

[3] During the period of January-September 2003 the industrial production shows an accumulated fall of 1.13 per cent in real terms compared with the same period of 2002.
[4] National Institute of Statistics, Geography and Informatics

represents the change of capital during a time period. With higher investment rates, it is expected an increase in the capital stock (without taking into account the depreciation). The available information provided by the INEGI in a monthly basis permits to study the evolution of the Gross Fixed Capital Formation (FBCF), disaggregated in its components: construction (FBCFC), and machinery and equipment (FBCFME) that can be divided in the national component (FBCFMEN) and the imports component (FBCFMEM). The FBCF data of the last 28 months are revealer: 20 out of 28 months show a negative annual variation, and from the first four months of 2003 just march has a positive value.[5] The average variation of the first four months between 2000 and 2003 is -4.7 per cent (refer to table 1).

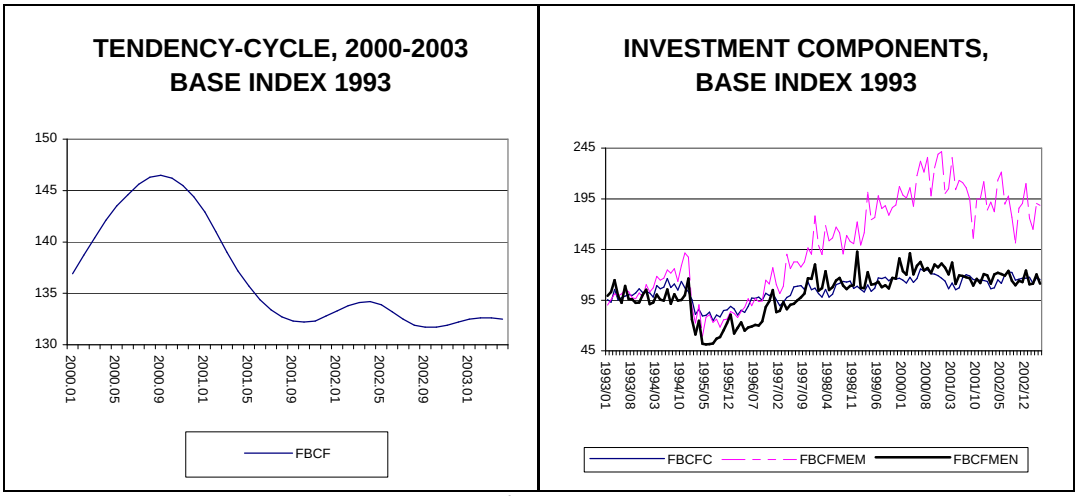
Table 1

Variable	2000-2003 (%)
Total Investment	-4.7
Investment in Construction	1.0
Investment in Machinery and Equipment	-9.3

Own elaboration with data from INEGI

In the other side, the trend of the investment series shows a fall in the late 2002. The preliminary data does not present any change in the slope that could indicate signs of recovery (refer to graph 2).

Graph 2



Elaborated with data of INEGI and the Federal Reserve

The implications that these variations have in an emerging economy (EM) as Mexico are relevant. The economic agents are not reestablishing the used capital during the production process. A decrease in the investment levels affects not only the current structure of the Mexican economy, but it could also implicate the lost in competitiveness of the national products in the internal and external markets in the medium and long run. China had proved that it is possible to increase the export value regardless the recessive economic moment, specifically in the United

[5] Using data up to July 15, 2003

States.[6] A collateral consequence for this scenario is the lack of job opportunities which is the main source of income in the Mexican society, and the effects that it could have in the internal market growth.

III. Methodology

The study tries to prove the existence of causality and the direction of this causality between inflation, measured by the consumer prices index (INPC), and productivity in the manufacturing sector (PROD). In order to achieve the objective an Error Correction Vector (VEC) was generated conformed by the components of the FBCF. The procedure used was the one originally proposed by Hall and Milne (1994) and applied by Liu and Romilly, Chandana and Paratab (2002), Liu, Burridge, and Sinclair (2002) who realized a causality analysis for integrated series of order one , I(1), with cointegration by generating a VEC. This mechanism permits to study the relationships in multivariate causality framework. In consequence, the series were subject to a unit root test to determine the existence and number (if necessary) of such roots using the Augmented Dickey-Fuller test (ADF). In order to obtain a strong multivariate causality result, before elaborating the VEC, the Johansen-Juselius cointegration test was applied to proof the existence of cointegration and the possible linear combinations between the series to obtain a result I(0).

The construction of the VEC to prove the existence of causality between INPC and PROD is based on the proposal of Jaret and Selody (1982), Selody (1990) and Papapetrou (2001). This methodology permits to avoid the inconsistencies of proving causality in a divariate environment such as: a) the resulting bias of omitting relevant variables, and b) the unreliable result as a consequence of estimating non-stationary variables in levels [Liu, Burridge y Sinclair, 2002]. The proposed VEC includes the industrial production in the United States (USIP) with one lag and the Monetary Base (BASE) in order to include the relationship with the American industrial cycle and the implementation of monetary policy of Banxico respectively.

Therefore, the proposed methodology can be resumed in the construction of a VAR of order *n* and *p* lags.

$$y_t^* = J(L)y_{t-1}^* + \varepsilon_t \qquad (1)$$

Where

$$J(L) = \sum_{i=1}^{p} JL^{i-1} \qquad (2)$$

and y_t^* is I (1).

So, the VEC is defined as

[6] Data from the American Department of Commerce shows that the Chinese exports grew 28 per cent during the period January-May 2003 respect to the same period of 2002. Meanwhile the Mexican exports grew only 3 per cent reducing the difference between the total exports of these two countries form 11,819 to 1,684 million dollars.

$$\Delta y_t^* = J_k^*(L)\Delta y_{t-1}^* + \Pi y_{t-1}^* + \varepsilon_t \qquad (3)$$

$$J_k^*(L) = \sum_{1}^{k-1} J_i^* L^{i-1} \qquad (4)$$

$$J_i^* = -\sum_{l=i+1}^{p} J_l \qquad (5)$$

$$\Pi = \alpha\beta' \qquad (6)$$

Where $\boldsymbol{\beta}$ and $\boldsymbol{\alpha}$ are matrixes that contain the parameters of long run and the adjustment coefficients respectively. The proposal studies the significance of the long run parameters $\boldsymbol{\beta_{ij}}$ and the adjustment coefficients $\boldsymbol{\alpha_{ij}}$. This can be proved applying zero restrictions on the $\boldsymbol{\alpha_{ij}}$. Then, the Wald test is run for the higher lags of the VEC in order to analyze if those lags are significant verifying the existence of bidirectional causality [Hall and Milne, 1994].

Finally, it is necessary to estimate if the cointegration relationships obtained in the VEC remain constant during a determined period of time. Hansen (1992), Tanaka and Quintos (1993 and 1997); developed tests that basically study the constancy in the cointegration rank, in other words, the constancy of the long run relationships established in a multivariate system. To achieve the objective they based the tests mainly on the Langrange Multipliers tests (LM) and the Likelihood Ratio (LR). In this paper the results presented by Quintos (1993, 1995 y 1997) are taken into account in order to compare the constancy in the cointegration rank of the VEC elaborated in the empirical tests.

The test of constancy in the rank assumes a VAR of *n* variables and *p* lags, constructed with equations (1) and (2).

The VEC is constructed with equations (3), (4), (5), (6), and with

$$\prod = (J(1) - I)$$

If there are *q* cointegration relationships, the matrix $\prod$ can be written as

$$\Pi = \alpha\beta'$$

Quintos applies a LR test to compare the possibility of existence of more cointegration relationships and a LM test for a fewer relationships. The statistic LR is based on

$$\sup_{k\in\varphi} Q_T^+(k) = \sup_{k\in\varphi}[kT]\sum_{i=q+1}^{n}\hat{\delta}_i^{([kT])}$$

Where $\hat{\delta}_i^{(.)}$ represent the roots of the matrix.

$$\hat{\Omega}_{0.\Delta Y}^{-1/2}(S_{\Delta Y^{+}Y}^{(.)}-\hat{\Delta}_{0\Delta Y}^{+})S_{YY}^{(.)-1}(S_{Y\Delta Y^{-}}^{(.)}-\hat{\Delta}_{0\Delta Y}^{+})\hat{\Omega}_{0\Delta Y}^{-1/2}$$

$$\Delta y^{+(.)}=\Delta Y^{(.)}-\Delta Y_{-1}^{(.)}\hat{\Omega}_{\Delta Y\Delta Y}^{-1}\hat{\Omega}_{\Delta Y0}$$

$$S_{YY}^{(T)}=T^{-1}Y_{-1}^{(.T)'}Y_{-1}^{(.T)}$$

$$S_{\Delta Y\Delta Y}^{(T)}=T^{-1}\Delta Y^{(.T)'}\Delta Y^{(.T)}$$

$$S_{\Delta YY}^{(T)}=T^{-1}\Delta Y^{(.T)'}Y_{-1}^{(.T)}$$

The matrix $\hat{\Omega}_{\Delta Y\Delta Y}$ represents the estimated kernel of the long-run variance for Δy_{t-1}, and $\hat{\Omega}_{\Delta Y0}$ represents the matrix of the estimated long-run variance of $u_t=\Delta y_t-\Pi y_{t-1}$ with Δy_{t-1}.

In the case of a fewer quantity of cointegration relationships, the LM test uses is:

$$\overline{Q_T}=T^{-2}tr\left\{\sum_{t=1}^{T}G_t\,G_{\ t}\right\}$$

The standardized residuals can be found in the following equations

$$G_t=\hat{\beta}^{(T)'}\hat{E}^{(t)'}$$

$$\hat{E}^{(t)'}=\hat{\Omega}_{00}^{-1/2}\hat{U}^{(t)'}$$

$$U^{(t)'}=\Delta Y^{(t)'}-\hat{\Pi}^{(t)}Y_{-1}^{(t)}$$

The long-run covariance matrix is determined by

$$\Omega=\begin{pmatrix}\Omega_{00} & .. & .. & \Omega_{0n}\\ & & & \\ & & & \\ \Omega_{n0} & .. & .. & \Omega_{nn}\end{pmatrix}$$

The results obtained must be compared with the tables that present the critical values developed by Quintos (1997) and Makinnon and Michelis (1999).

IV. Data

The INPC and the monetary base (BASE) are publicized by Banxico; and the FBFC, FBCFMEN, FBCFM, and the productivity index (PROD) by INEGI. The industrial production index in the United Sates (USIP), not seasonally adjusted, was obtained from the Federal Reserve. The study utilizes monthly data during the period between January 1993 and May 2003, because of the availability of the investment data.

V. Empirical Results

In the first place, an ADF test was implemented to the natural logarithm of the series. In every case a unit root can be observed which is possible to eliminate by applying the first difference to the series; the results are shown in the table 2.

Table 2
Augmented Dickey-Fuller Test

VARIABLE	ADF	SIGNIFICANCE %	VALUE
DLPRO[7]	-15.84	1	-4.03
DLFBCFC	-5.64	1	-4.04
DLFBCFMEN	-4.61	1	-4.03
DLFBCFMEM	-15.37	1	-4.03
DLINPC	-3.56	5	-3.45

The next step consists in the implementation of the Johansen cointegration test. The results suggest the construction of a VEC with four lags and four cointegration relationships (refer to table 3).

Table 3
Cointegration Rank

Series: LPRO, LFBCFMEN , LFBCFC, LFBCFMEM, LINPC
Interval: 1 – 4

Eigenvalue	Likelihood Ratio	5 Per cent	1 Per cent	Hypothesis EC(s)
0.531003	214.0806	87.31	96.58	None **
0.393484	123.9787	62.99	70.05	1 **
0.229777	64.47586	42.44	48.45	2 **
0.188973	33.40787	25.32	30.45	3 **
0.068804	8.482911	12.25	16.26	4

**Denotes the rejection of the null hypothesis at 1 per cent of significance.

The VEC is specified in growth rates because of the usage of the logarithm and the first difference applied to the variables. To proof weak exogeneity we selected the Wald test for the adjustment coefficients. The null hypothesis used was zero for all the values in the matrix $\boldsymbol{\beta}$. The p-values obtained for all the variables are less than 0.05 so it is possible to reject the null hypothesis in all cases (refer to table 4).

[7] The logarithm is represented by the letter L, and d represents the first difference of the variable.

Table 4
Weak exogeneity tests

Variable	P-value
LPROD	0.0005
LFBCFMEN	0.0000
LFBCFC	0.0000
LFBCFMEM	0.0000
LINPC	0.0001

The Wald test is now applied to all the lags with the higher order to establish the existence of bidirectional causality. The results of the analysis present the existence of causality between inflation and productivity. Therefore, the monetary policy conducted by Banxico, conducted by an inflation target, could have some influence in the real variables, particularly in the productivity (PROD). At the same time, the FBCFC presents a causal relationship with the productivity and the rest of the investment components. Therefore, the investment in the construction sector acts as one of the growth enhancement factors in the Mexican economy, and emphasize one of the aspects that the economic policy should prioritize: the construction sector shows a linkage with the rest of the investment components so it is necessary to establish adequate instruments to promote its development. The results also present a causal relationship between the FBCFMEM and productivity; implying the importance of the machinery imports in the national production, in other words, there are significant benefits in the acquisition of foreign technology and its implementation in the productive processes in the country (refer to table 5).

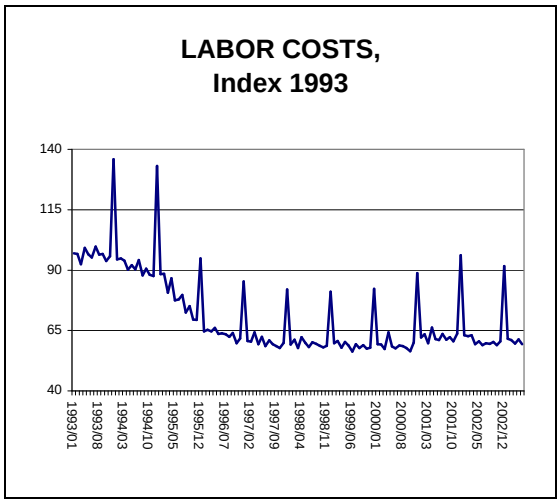
From the results obtained (bidirectional causality observed between Productivity and FBCFC, and FBCFMEM; including the unidirectional causality to FBFMEN) can be inferred the existence of a virtuous cycle including the productivity improvements and the investment. Taking into account the framework stated by the economic growth models, this virtuous cycle must be traduce in a positive impact to capital accumulation and the economic growth. If stability in the Labor Costs (CLU, Graph 3) is included in the analysis, it is possible to infer that the economic system must prioritize the capital accumulation in order to acquire the pertinent competitive advantages to face the new international environment.

Table 5
Wald Test

Dependent Variable	**P-value**					
	DLPRO	**DLFBCFMEN**	**DLFBCFC**	**DLFBCFMEM**	**DLINPC**	**Causality**
DLPRO	-	0.4218	***0.0112***	***0.0834***	*0.0633*	FBCFC-PROD FBCFMEM-PRO INPC-PRO
DLFBCFMEN	0.1616	-	***0.0411***	0.6004	0.3473	FBCFC-FBCFMEN
DLFBCFC	***0.0001***	***0.0739***	-	0.7894	0.5165	PRO-FBCFC FBCFMEN-FBCFC
DLFBCFMEM	***0.0017***	0.8060	***0.0091***	-	0.2831	PRO-FBCFMEM FBCFC-FBCFMEM
DLINPC	***0.0511***	0.8434	0.5485	0.3572	-	PRO-INPC

Concluding, the results present the investment and the capital stock accumulation as the main opportunity area to the Mexican economy since is hard to expect a substantial reduction of the CLU given their recent trajectory and the rigidity of the labor markets (refer to graph 3) [8]

Graph 3



Source: INEGI, constant Mexican pesos

Using international data from the Bureau of Labor Statistics, the Mexican index had diminished form 23 in 1975 to 12 in 2002, with a minimum of 9 in 1995 (using the compensation costs in the US as a reference) [9]. The tendency observed in Mexico is the opposite of other economies, especially those followed by the new industrialized countries in Asia (NICs) that clearly shows an increase in their indexes. Japan is the extreme case where the index increases from 47 to 111 during the same period, with a maximum value of 139 in 1995. In general, the compensation costs in the US had increased in the last five years respect to Canada and Europe, and diminished respect to Mexico, Korea and Japan (refer to table 6).

[8] In terms of constant Mexican pesos, the CLU remains in a similar level respect to the after 1995 crisis values, making impossible to infer that the CLU represent the main cause of the low competitiveness in the sector.

[9] Considering the Bureau of Labor Statistics definition for compensation, wages and salaries by hour, social security expenses, taxes, and other economic benefits.

Table 6

	Compensation Costs Index by hour in manufacturing								
	1975	**1980**	**1985**	**1990**	**1995**	**1997**	**1998**	**1999**	**2000**
United States	100	100	100	100	100	100	100	100	100
Canada	94	88	84	107	94	90	84	82	81
Mexico	23	22	12	11	9	10	10	11	12
Hong Kong	12	15	13	22	28	30	29	29	28
Japan	47	56	49	86	139	107	98	109	111
South Korea	5	10	10	25	42	43	31	37	41
Singapore	13	15	19	25	43	45	42	37	37
Taiwan	6	10	12	26	35	32	28	39	30
OECD	67	74	57	90	103	90	85	86	82
OECD[10]	76	84	65	104	119	103	98	99	93
Europe	80	100	61	116	128	112	111	107	93
ASIA(NICS)	8	12	13	25	37	37	32	33	34

Source: Bureau of Labor Statistics

Given those references, it is hard to expect that the competitiveness of the national producers could be achieved by a reduction in the CLU, and it is convenient to explore the improvement in productivity as an option.

Finally, a test for constancy in the cointegration rank was applied. Following Quintos' (1998) and Haug's (1999) observations about the problems in the likelihood ratio when there are no cointegration vectors in the system, a methodology proposed by Johansen was implemented to estimate the necessary eigenvalues to implement the test for constancy in the cointegration rank. The results concludes that there is not constancy in the rank after comparing the values of Q^+ and Q^- with the critical values provided by Mackinnon, Haug Michelis(1999) and Quintos(1997) is not possible to reject the null hypothesis with a 5 per cent of significance. [11]

VI. Conclusions

The obtained results state a quantitative evidence for the bidirectional causality between inflation and productivity. As a consequence, the current monetary policy, based on an inflation target, implemented by Banxico must have a positive impact in the levels of productivity. Therefore, the monetary policy and the exchange rate policy instrumented by the Mexican Central Bank have influence over the real sector variables, which are indicative to the decision making agents at the time that they implement the investment strategies. It is also relevant to notice that the unidirectional and bidirectional causality between some investment components and productivity proves that favoring investment would provide the productive economic agents with a comparative advantage. During the last years, the real investment levels had fallen giving as a result a negative tendency or non-decreasing, in the best scenario. This situation creates a potential structural problem that the Mexican economy could face if the lethargy in the variable does not revert.

[10] Excluding México and South Korea
[11] Q^+ and Q^- takes a value of 12.25 and 0.00 respectively.

The results suggest an economic policy oriented to favor the investment in the construction sector and the acquisition of technology to increase the total productivity. Given the recent behavior of the national labor costs and the international salary scheme, an increase in productivity will make the Mexican economy capable to develop competitive advantages to compete in the new worldwide economic and financial environment.

References

Carsterns, A; Werner, M. (1999), Mexico's monetary policy framework under a floating exchange rate regime, Banco de México, Documento de Investigación 9905

Chandana, C. and Paratab, B. (2002) Foreign direct investment and growth in India: A cointegration approach, *Applied Economics,* **34**, 1061-1073.

Clark, K. (1982) Inflation and the productivity decline, *American Economic Review*, Papers and Proceedings, 72, 149-54.

Dickey, D, Fuller, W. (1979) Distributions of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association*, 74, 427-31.

Dickey, D, Fuller, W. (1981) The likelihood ratio statistics for autoregressive time series with a unit root, *Econometrica*, 49, 1057-72.

Hall, S. and Milne, A. (1994) The relevance of p-star analysis to UK monetary policy, *The Economic Journal*,**104**, 597-604.

Jarret, J Selody, J, (1982) The productivity-inflation nexus in Canada, The review of Economics and Statistics, 64-3, 361-7

Johansen, S. (1998) Statistical analysis of cointegration vectors, *Journal of Economic Dynamics and Control,* **12**, 213-54.

Liu, X, Burridge, P. and Sinclair P.(2002) Relationship between economic growth, foreign direct investment and trade: evidence from China, *Applied Economics,* **34**, 1433-1440.

Liu, X. and Romilly, P. (1997) An empirical investigation of the causal relationship between openness and economic growth in China, *Applied economics,* **29**, 1679- 86.

Mehra, Y, (1993). Unit Labor Costs and the Price Level, Economic Quarterly-Federal Reserve Bank of Richmond, **79**, 35-51.

Papapetrou, E.(2001) Bivariate and multivariate tests of inflation-productivity Granger-temporal causal relationship: evidence from Greece, *Journal of economic Studies*, **28**, 213-226.

Quintos, C. y Phillips, P. (1993) Parameter Constancy in Cointegrating Regressions, *Empirical Economics,* **18**, 675-706.

Quintos, C. (1997) Stability tests in error correction models, *Journal of Econometrics*, **82**, 289-315.

Quintos, C. (1998) Fully Modified Vector Autoregressive Inference in Partially Nonstationary Models, *Journal of the American Statistical Association*, **93**, 783-795.

Mackinnon, J., Haug, A. and Michelis, L. (1999), Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration, *Journal of Applied Econometrics*, **14**, 563-577.

Saxton, J, (2002) Inflation Targeting goals for the Federal Reserve, Join Economic Committee United States Congress,1-12.

Selody, J(1990), Inflation and total factor productivity in Germany, Weltwirtschaftliches Archiv, 131-2, 403-05.