ERASMUS UNIVERSITEIT ROTTERDAM
ERASMUS SCHOOL OF ECONOMICS

Exchange Rate and Economic Growth: Evidence from a Structural Macroeconomic Model for Costa Rica

Master Thesis

Bernal Laverde-Molina
413061

MSc. International Economics
Erasmus University Rotterdam
Supervisor: Prof. Dr. Job Swank

ABSTRACT

The argument that a policy of currency depreciation would boost economic growth by increasing competitiveness is based on a short term partial equilibrium analysis and only considers one mechanism of transmission. A broader analysis of the economic dynamics suggest that, in the case of Costa Rica, such policy would have a marginal effect on the long term growth with a high cost in terms of inflation.

This research evaluates the impact on economic growth of the change in Costa Rica´s exchange rate regime in October 2006 from a twenty year old crawling peg with the US dollar to a scheme of floating within bands.

A structural macroeconomic model is estimated in order to measure the effect of nominal exchange rate movements and its volatility on economic growth from 1991 to 2014. The model is used to simulate the effects of keeping the crawling peg regime during the second part of the sample period.

Results show that the average GDP growth rate between 2007 and 2014 under the crawling peg regime would have been comparable to that under the floating within bands regime, whereas the rate of inflation would have been substantially higher.

Contents

1 Introduction

The debate about the optimal exchange rate regime has been present in both academic and political arenas since the fall of the Bretton Woods system in 1971. From fixed exchange rate to free floating rates or even abandoning a national currency, countries have adopted different regimes as policy tools to encourage economic stabilization and growth, or at least to avoid the exchange rate to be a distortion in the realization of these goals.

Episodes of major fluctuations on the value of currencies, like the Swiss Franc appreciation in January 2015 (14% in two days) and the Chinese Yuan depreciation in August 2015 (4% in two days) drive turmoil in international markets and bring concerns about the effects of such movements on competitiveness and growth.

Theoretically, the direction and magnitude of exchange rate movements affect economic growth through several channels. One is the change in relative prices of tradable and non-tradable goods that affects exports and imports. Another is the –temporary- deviation from interest rate parity that may influence variables like investment, production and consumption. Exchange rate volatility is also expected to have an impact on economic growth as it increases uncertainty about the future outcome of current economic decisions. These mechanisms are usually studied individually, even though they actually interact and their effects reinforce or neutralize each other.

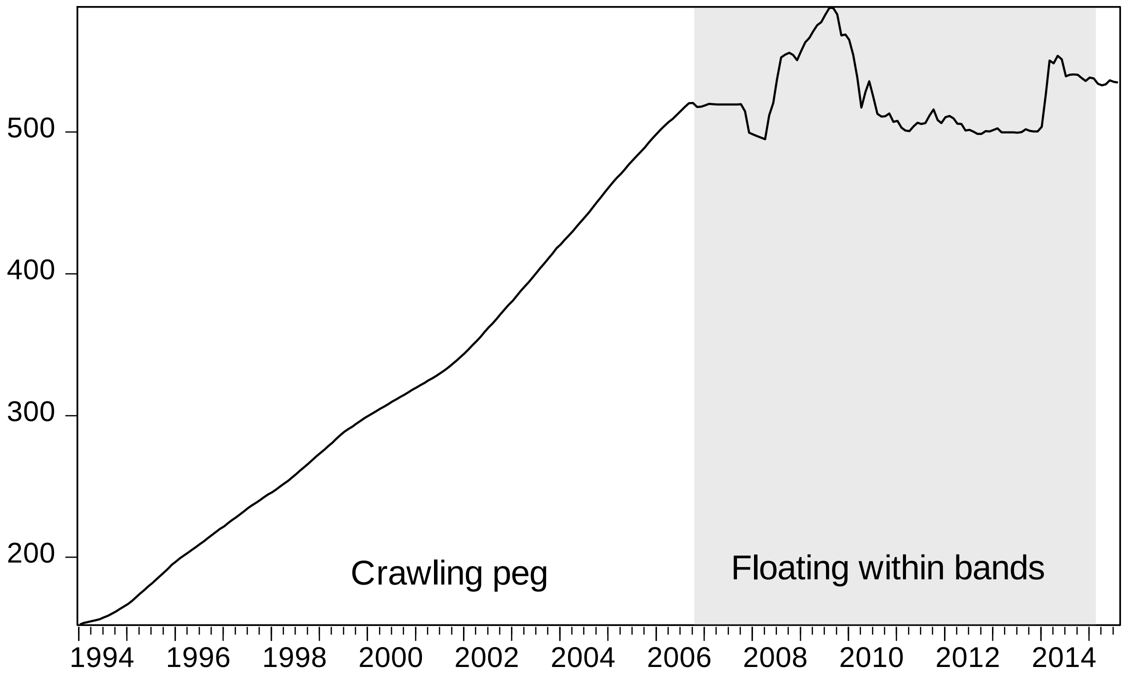
The potentially beneficial or harmful effects of exchange rate movements on the economy are the main argument of those in favour of government intervention on foreign exchange markets. On the other hand, supporters of free flotation see the exchange rate fluctuation as a necessary adjustment to exogenous shocks that otherwise would be reflected in other relative prices and productivity changes, with a higher impact on growth (Edwards & Levy Yeyati, 2003).

For a small, open economy like Costa Rica, with a lasting negative trade balance, mostly financed by Foreign Direct Investment and the absence of a forward foreign exchange market, the exchange rate policy is a key instrument for seeking stability and growth. Given the current conditions of a depressed global economy, low prices and depreciated emerging currencies, some sectors call for further intervention in order to depreciate the Costa Rican Colón as a measure to restore competitiveness and economic growth.

In 2006, the country changed its exchange rate regime from a twenty years old crawling peg with the US dollar to a scheme of floating within bands. This policy change substantially modified the behaviour of the exchange rate, increasing its volatility and generating episodes of nominal appreciation, never seen during the preceding regime (figure 1).

The purpose of this research is to find empirical evidence of the impact that these changes had on Costa Rica´s economic growth. This evidence will bring some quantitative information over the debate about a new depreciation oriented policy.

Figure 1. Costa Rica: Nominal Exchange Rate (CR Colón / US Dollar)



Source: Central Bank of Costa Rica

A structural macroeconomic model for Costa Rica from 1991 to 2014 is estimated to simultaneously consider the diverse mechanisms by which the exchange rate affects the components of the aggregate demand (private consumption, private investment, exports and imports) and then economic growth. The model is used to simulate the economic effects of keeping the crawling peg regime during the second part of the sample period (2007-2014) instead of the currency bands regime.

Section 2 of this paper presents the theoretical basis of this research and an overview of the recent related literature. Section 3 describes the model specification, data and estimation technique. The results of the baseline estimation and the different simulations are discussed in section 4. Section 5 summarizes the conclusions.

2 Theoretical Framework and Literature Review

2.1 Exchange rate levels and economic growth

A vast collection of theoretical and empirical literature supports the existence of a linkage between real exchange rate levels and economic growth. Gala (2008), cites a number of previous studies for developing countries that find negative (positive) effects of overvalued (undervalued) currencies on per capita growth rates. The author conducts his own empirical research using data of 58 developing countries from 1960 to 1990. He concludes that exchange rate policies and the resulting levels of real exchange rates played a key role in the contrasting economic performance of Southeast Asian countries on the one hand and African and Latin American countries on the other.

Determining the degree of overvaluation (undervaluation) of a currency is not trivial. Gala (2008) uses the approach of comparing Purchasing Power Parity (PPP) adjusted for Balassa-Samuelson effects that predict lower relative prices of non-tradables in developing Countries. Using GDP per capita as a control variable for this effect, a currency is assumed to be misaligned if prices deviate from those predicted by PPP.

An alternative approach compares the current real exchange rate with an estimated exchange rate equilibrium. Barquero and Muñoz (2015) quote Sebastian Edwards defining real exchange rate equilibrium as a level that is consistent with internal (no output gap and absence of inflationary pressures) and external (sustainable current account) equilibrium. This equilibrium level is not constant and depends on economic conditions known as "fundamentals". Barquero and Muñoz (2015) use fundamentals like terms of trade, productivity, government spending and domestic and international interest rate differential to estimate an equilibrium zone for Costa Rica's real exchange rate. They conclude that there have not been real exchange rate misalignments from 2000 to 2015.

There are several transmission mechanisms by which the real exchange rate affects economic growth. The most direct is its influence on international trade flows by changing relative prices. An appreciation of the domestic currency makes the locally produced tradable goods more expensive related to those produced abroad, decreasing exports and increasing imports. The theoretical effect of the real exchange rate on exports and imports was empirically verified by Mora and Torres (2008) for Costa Rica from 1991 to 2006.

As a consequence of a real appreciation, domestic firms of tradable goods face a lower demand, reducing production, investment and employment. On the other hand, lower import prices cause an increase in households' real income that initially stimulates consumption. Eventually, higher unemployment reduces wages, decreasing the real income of households and pulling down consumption (Krugman, Obstfeld, & Melitz, 2012).

On the other hand, a real appreciation also decreases the price of capital and intermediate import goods, reducing production costs. This is a particularly important effect in developing countries that do not have adequate domestic substitutes for these goods (Kandil, 2015). The positive import supply effect of a real appreciation may overcome the negative export demand effect, leading to a faster economic growth. Evidence from Kandil (2015) suggests that this may be the case in Latin America and the Caribbean between 1981 and 2007.

Gala (2008) points out another consequence of the shift in relative prices generated by exchange rate movements related to what he calls technological upgrading. A real appreciation incites the relocation of resources from the tradable sector, including manufacturing and non-traditional primary production characterized by increasing returns, to non-tradable activities and commodities that are generally produced with decreasing returns. The result is a decrease in the total productivity and the undesirable symptoms of the Dutch disease. A real depreciation, on the other hand would incite investment in more profitable tradable goods production, increasing the productivity of the whole economy.

Maintaining an undervalued currency to promote economic growth has been considered to have a "beggar thy neighbour effect" that may lead to competitive devaluations with a harmful result for the involved economies. This mechanism contributed to the spreading and deepening of the Great Depression of the 1930s (Eichengreen & Sachs, 1986). Concerns about China's currency undervaluation policy are also based on this argument (Mbaye, 2012).

Other mechanism by which the exchange rate may affect economic growth arises from its influence on the interest rate. The interest rate parity condition predicts that a movement in the exchange rate will be compensated by a change in the domestic interest rate in order to maintain the same expected return of similar assets denominated in different currencies. This change in the domestic interest rate alters the opportunity cost of investment projects and the inter-temporal consumption allocation, affecting aggregate demand, output and prices (Krugman, Obstfeld, & Melitz, 2012).

It is worthwhile to emphasize that the real exchange rate, not the nominal, is the one expected to have an impact on economic growth. Nevertheless, movements in the nominal exchange rate have an immediate and equal -transitory- effect on the real exchange rate, as it can be inferred from the following definition.[1]

$$rer = ner * \frac{P^*}{P}$$

Where:
rer = real exchange rate.
ner = nominal exchange rate (units of domestic currency by unit of foreign currency).
P^*= international prices level.
P= domestic prices level.

However, the effect of an increase in the nominal exchange rate on the real exchange rate tends to dissipate over time since it also increases the domestic prices level. This effect on prices, known as the exchange rate pass through, makes the policy of maintaining an artificial undervalued currency inefficient and costly in terms of inflation.

[1] According to this definition, an increment of the nominal (and real) exchange rate implies a devaluation of the domestic currency.

2.2 *Exchange rate volatility, uncertainty and risk*

More recently, attention has shifted to exchange rate volatility and its possible influence on economic growth. Several theoretical explanations for such influence have been proposed and empirical verification is increasingly documented.

According to the option value approach, volatility increases the uncertainty about future outcomes and raises the expected adjustment costs of reverting investment and hiring, making firms more cautioned about embarking new projects (Bloom, 2014). The same reasoning applies to consumers considering buying durable goods. As a result, uncertainty from a more volatile exchange rate may reduce the levels of investment, employment and consumption.

From a risk aversion perspective, exchange rate volatility increases interest rates through a higher risk premium and may limit firms' access to borrow. Increased cost and constraints of financial capital have a negative impact on the economy. In addition, higher risk increases precautionary savings and reduces consumption. These additional savings may not result in more investment due to capital outflows and price rigidities (Bloom, 2014).

Regarding the effect of exchange rate volatility on international trade, Bowen et al. (2012) theoretically show that if agents have access to a forward exchange market, the levels of exports and imports are not affected by the exchange rate volatility, but if absent, this volatility reduces the volume of international trade.

Evidence of the relationship between exchange rate fluctuations and economic growth presents mixed and non-conclusive results. Some research suggests that exchange rate fluctuations are good for economic growth. For example, Edwards & Levy Yeyati (2003), analysing data of 183 countries from 1974 to 2000, conclude that economies with flexible exchange rates grow faster than those with more rigid exchange rates, as they adapt better to negative shocks.

There is also evidence of exchange rate stability helping economic growth, as found by Schnabl (2007) for 41 countries around the European Monetary Union from 1994 to 2005, and particularly, for the Emerging European Countries that maintained a stable exchange rate to the euro.

For a sample of 32 developing countries in Latin America and the Caribbean from 1981 to 2007 (including Costa Rica), Kandil (2015) finds evidence that higher real exchange rate variability is related to a reduction in real growth and an increase in inflation.

More specific studies try to measure the effect of exchange rate volatility on particular components of the aggregate demand. For instance, Bahmani-Oskooee and Hajilee (2013) apply an error correction model to a sample of 36 countries over the period 1975-2008, looking for evidence of the relationship between exchange rate volatility and private investment. They found significant short term and long term relationships between these variables in 27 and 10 countries respectively. For Costa Rica they report only a short term (positive) relationship. Moreover, from the 10 countries that show a long term effect of exchange rate volatility on private investment, 5 have a positive effect and the other 5 have a negative one.

In a similar study for 10 emerging economies with quarterly data from 1995 to 2014, Bahmani-Oskooee, Kutan and Xi (2015) find short term and long term effects of exchange rate volatility on private consumption for 8 and 5 countries respectively, 4 from the 5 long term relationships were negative.

The effect of exchange rate volatility on international trade, particularly on exports is the most studied. To mention an example, Verheyen (2012) finds that the Euro-US dollar volatility has a negative effect on exports from the euro zone countries to the United States, particularly for manufactured goods and machinery and equipment. Using a similar methodology, Choudhry and Hassan (2015) identify a negative relationship between exchange rate volatility and UK imports from Brazil, China and South Africa.

3 Methodology

In this research, a structural small scale macroeconomic model for Costa Rica is estimated using quarterly data from 1991 to the first quarter of 2015. The model allows to simultaneously evaluate the different mechanisms by which the exchange rate level and volatility affect aggregate demand components and economic growth.

In this model exchange rate is an exogenous policy variable that receive diverse shocks to simulate different policy scenarios. The effects of these shocks on the model´s endogenous variables determine the overall impact of the simulated policy changes on GDP growth.

As opposite to individual regressions, macroeconomic models provide a general equilibrium framework to analyse the effects of the exchange rate on the economy. They usually incorporate the conventional channel of the exchange rate affecting international trade by modifying relative prices. Some examples are the Macroeconomic Policy Model of the Netherlands (De Nederlandsche Bank, 2011), the Area-Wide Model for the Euro Area (Fagan, Henry, & Mestre, 2001) and the Macroeconomic Model for the United States (Federal Reserve Board, 1996).

3.1 *The Model*

The model includes behavioural equations for private consumption, private investment, exports and imports, all expressed in real terms. The dynamics of these variables determine aggregate economic growth.[2] It also includes equations to estimate the behaviour of interest rate and inflation. Exchange rate levels and volatility are directly or indirectly included as determinants of these variables. Possible differences on the impact of the exchange rate along different regimes are identified by a dummy variable. Cointegrating relationships between non-stationary variables and error correction mechanisms are used in order to identify both short term dynamic and long term effects.

Estimated equations are included in the model specification, along with the relevant identities described in this section. A baseline scenario is estimated from the actual data to evaluate the model´s capacity to replicate the current behaviour of the variables. Then, an alternative scenario is constructed by modifying the exchange rate level and volatility from 2007 to 2014, simulating the behaviour under the previous exchange rate regime. The model baseline and the alternative scenario are dynamic and deterministically solved by an iteration algorithm using the software EViews 9.

3.1.1 Consumption

Real private consumption is specified as a long term function of real GDP, following Keynes' Absolute Income Hypothesis.[3] It is expected that GDP, as a measure of income, has a positive effect on consumption.

In the short term, in addition to real GDP, it is expected that the nominal interest rate has an effect on consumption that may be negative or positive depending on the interaction of the substitution effect (higher opportunity cost of present consumption when interest rate increases) and the income effect (higher income of net lenders and lower income of net borrowers when interest rate increases). Changes of the nominal exchange rate and its variability are also expected to have a short term negative impact on consumption through the effect on import prices and uncertainty. Lagged values of consumption and an error correction to its long term relationship are also included. Equation 1 shows this specification.

$$\Delta cp = \propto_{01} + \alpha(L)_{02}\Delta cp_{-1} + \alpha(L)_{03}\Delta y + \alpha(L)_{04} i + \alpha(L)_{05}\Delta rer + \propto_{06} V^{ner} + \propto_{07} ec_{cp} \quad (1)$$

$$ec_{cp} = \beta_{01} + \beta_{02} cp_{-1} + \beta_{03} y_{-1}$$

Where:

[2] Government expenditure is another determinant of economic growth. It is assumed as an exogenous policy variable.

[3] See Fernandez Corugedo (2004) for a consumption theory review.

cp = real private consumption in logarithm.
y = real domestic GDP in logarithm.
i = nominal domestic interest rate.
rer = real exchange rate (CRC/USD) in logarithm.
V^{ner} = nominal exchange rate volatility.
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

3.1.2 Investment

As in consumption, private investment is positive related to real GDP in the long term. The short term equation has as additional explanatory variables the nominal interest rate, the real exchange rate level and the volatility of nominal exchange rate. It is expected that the nominal interest rate has a negative effect on investment since it reflects the opportunity cost of increasing capital. A positive effect of the real exchange rate on investment can be explained by the improvement in the competitive position that encourages additional investment to meet a growing exports demand. Exchange rate volatility would have a negative impact on private investment since it increases the uncertainty about future outcomes. Lagged investment and the error correction term from the cointegrating relationship are added to the short term equation (equation 2).

$$\Delta ip = \propto_{11} + \alpha(L)_{12}\Delta ip_{-1} + \alpha(L)_{13}\Delta y + \alpha(L)_{14} i + \alpha(L)_{15}\Delta rer + \propto_{16} V^{ner} + \propto_{07} ec_{ip} \quad (2)$$

$$ec_{ip} = \beta_{11} + \beta_{12} ip_{-1} + \beta_{13} y_{-1}$$

Where:
ip = real private investment in logarithm.
y = real domestic GDP in logarithm.
i = nominal domestic interest rate.
rer = real exchange rate (CRC/USD) in logarithm.
V^{ner} = nominal exchange rate volatility.
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

3.1.3 Exports

Long term determinants of exports are consistent with an export demand with a positive income effect, measured as World GPD and a negative price effect with respect to a real exchange rate appreciation.[4] The short term equation additionally includes the domestic output gap as a measure of productive capacity that influences exports supply (Goldstein & Mohsin, 1985). As in previous equations, lagged values of the dependent variable, an error correction term and the exchange rate volatility have been incorporated in the specification (equation 3).

$$\Delta x = \propto_{21} + \alpha(L)_{22}\Delta x_{-1} + \alpha(L)_{23}\Delta y^{W} + \alpha(L)_{24}\Delta y^{GAP} + \alpha(L)_{25}\Delta rer + \propto_{26} V^{ner} + \propto_{27} ec_{x} \quad (3)$$

$$ec_{x} = \beta_{21} + \beta_{22}x_{-1} + \beta_{33}y^{W}_{-1} + \beta_{24}rer$$

Where:
x = real total exports in logarithm.
y^{W} = World GDP in logarithm.
y^{GAP} = Output GAP (difference between actual GDP and potential GDP in logarithm).
rer = real exchange rate (CRC/USD) in logarithm.
V^{ner} = nominal exchange rate volatility.
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

3.1.4 Imports

The specification of the imports long term and short term equations follows the same theoretical guidelines as the exports. A positive income effect of the domestic GDP and a positive price effect related to a real exchange rate appreciation are expected.

$$\Delta m = \propto_{31} + \alpha(L)_{32}\Delta m_{-1} + \alpha(L)_{33}\Delta y + \alpha(L)_{34}\Delta rer + \propto_{26} V^{ner} + \propto_{27} ec_{m} \quad (4)$$

$$ec_{m} = \beta_{31} + \beta_{32}m_{-1} + \beta_{33}y_{-1} + \beta_{34}rer$$

Where:
m = real total imports in logarithm.
y = real domestic GDP in logarithm.
rer = real exchange rate (CRC/USD) in logarithm.
V^{ner} = nominal exchange rate volatility.
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

[4] The theoretical background for exports and imports determinants comes from the Imperfect Substitutes Model, presented in Goldstein & Mohsin (1985).

3.1.5 Interest rate

The 6 months deposits interest rate is widely used in Costa Rica as a reference for savings and credit. Movements of this rate are modelled following the relative interest rate parity condition, as a function of the movements in the international interest rate (LIBOR 6 months, used as a reference for domestic deposits and loans denominated in US dollar), the expected variation of nominal exchange rate and the expected domestic and international inflation rates.[5] Additionally, lagged values of the interest rate variation, the variation of the government debt as a share of GDP and exchange rate volatility are included, as shown in equation 5.

$$\Delta i \ =\propto_{41} + \alpha(L)_{42}\Delta i_{-1} + \alpha(L)_{43}\Delta iw + \alpha(L)_{44}\Delta E(ner) + \alpha(L)_{45}\Delta E(inf) + \alpha(L)_{46}\Delta E(inf^{*}) + \ \alpha(L)_{47}\Delta dg \ + \alpha_{48}\, V^{ner} \qquad (5)$$

Where:
i = nominal domestic interest rate for 6 months deposits.
iw = LIBOR interest rate for 6 months.
ner = nominal exchange rate (CRC/USD) in logarithm.
inf = domestic annual inflation.
inf^{*} = United States annual inflation.
dg = first difference of government debt as a share of GDP.
V^{ner} = nominal exchange volatility.
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

3.1.6 Inflation

To estimate the inflation rate, a combination of theoretically and empirically supported variables is used. These variables have been used in previous studies to explain and forecast inflation in Costa Rica.[6] Then the variation in domestic prices is a function of the lagged variation of the same prices, the variation of the output GAP (with positive effect as predicted by the short term Phillips Curve), the variation of the nominal exchange rate (with a positive exchange rate pass through) the variation of oil energy imports price (positive effect) and the nominal exchange rate volatility (positive effect).

$$\Delta P \ =\propto_{51} + \alpha(L)_{52}\Delta P_{-t} + \alpha(L)_{53} y^{GAP} + \alpha(L)_{54}\,\Delta ner + \alpha(L)_{55}\Delta P^{oil} + + \propto_{56}\, V^{ner} \qquad (6)$$

[5] Current values are used as proxy variables of expected movements in exchange rate and inflation.
[6] See for example Rodríguez Vargas (2009), Álvarez Corrales and Torres Gutiérrez (2011) and Segura and Vásquez (2011).

Where:
P = domestic consumer price index in logarithm.
y^{GAP} = Output GAP (difference between actual GDP and potential GDP in logarithm).
ner = nominal exchange rate (CRC/USD) in logarithm.
P^{oil} = oil energy imports price in logarithm.
V^{ner} = nominal exchange volatility (from GARCH model).
Δ = first difference of the corresponding variable.
$\alpha(L)x$ = lag operator of the form $\alpha_0 x + \alpha_1 x_{-1} + \alpha_2 x_{-2} + \ldots + \alpha_p x_{-p}$

3.1.7 Model identities

In order to fully specify the model, it is necessary to add the following economic identities or definitions.

The national income identity from the view of expenditure:

$$y = cp + ip + cg + ig + x - m \quad (7)$$

The output gap definition:

$$y^{GAP} = \log(y) - \log(y^{POT}) \quad (8)$$

The real exchange rate definition:

$$rer = ner * \frac{P^{US}}{P} \quad (9)$$

3.1.8 Data and estimation method

The time series for this research were provided by the Central Bank of Costa Rica. These series are used for national accounts compilation, macroeconomic programming, modelling and forecasting. Appendix 1 summarizes the characteristics of the series while most of them are available on: http://www.bccr.fi.cr/bccr_home_page/economic_indicators.

Each equation is estimated following a standard procedure:

First, unit root tests are performed for all the variables (see Appendix 2 for the results). Since most of the macroeconomic aggregates are integrated of order one, it is necessary to find cointegration in order to establish long term relationships between them. To do so, unrestricted VARs are estimated and tested to obtain the optimal lag structure of these relationships. The optimal lag structure is later used as a guide in the short term equation.

With the appropriate lags, Johansen Cointegration tests are applied to verify cointegration (results in Appendix 2). Then Vector Error Correction (VEC) of the cointegrating variables are estimated to obtain the long term equation and the error correction term (Appendix 3).

Short term equations are estimated using first differences or levels of variables previously verified as integrated of order zero. The corresponding error correction term is also included in the equation. The estimation methodology for these equations is Ordinary Least Squares (see results in Appendix 3). Conventional tests are performed.

4 Results

4.1 Estimated equations

This section presents the main results of the estimated equations. For a complete review of the estimations see the tables in Appendix 3.

4.1.1 Consumption

A long term relationship between real private consumption and real GDP with expected sign and magnitude was confirmed. In the short term, the variation in real consumption is explained by its own lagged values, the contemporary variation in real GDP and the error correction term. There is no evidence of a direct significant influence of the nominal interest rate, the variation of the real exchange rate or exchange rate volatility (Table 1).

Table 1. Consumption Estimation

Long term: Log(CP)

Explanatory variable	Coefficient
C	1.7889**
Log(Y)	0.8495*

Short term: Dlog(CP)

Explanatory variable	Significant lags	Overall effect
Dlog(CP)	1 to 6*	0.8362
Dlog(Y)	0***	0.0242
EC_C	0*	-0.0074
I	none	0.0000
Dlog(RER)	none	0.0000
VNER	none	0.0000

Adj. R2: 0.9270 DW: 1.9360

Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

4.1.2 Investment

Real private investment is positively related to real GDP in the long term with an elasticity above one. In the short term, lagged variation of the real GDP has a large impact on changes in private investment. As expected, the interest rate has a significant negative effect

There is evidence of a positive effect of real exchange rate depreciations on investment. A plausible explanation is that domestic firms producing tradable goods decide to increase their productive capacity to take advantage of a higher exports demand.

The volatility of the nominal exchange rate has a negative significant effect on real private investment but only during the more flexible exchange rate regimes (starting in 2006Q4, the dummy variable DER is equal to 1). During the preceding crawling peg regime, the volatility of exchange rate variation was virtually zero.

The first two lags of the private investment variation and the error correction term have a significant explanatory power as well. (Table 2).

Table 2. Investment Estimation

Long term: Log(IP)

Explanatory variable	Coefficient
C	-5.3814**
Log(Y)	1.2848*

Short term: Dlog(IP)

Explanatory variable	Significant lags	Overall effect
C	0	0.0119
Dlog(IP)	1 to 2**	0.2431
Dlog(Y)	1 to 2*	2.2535
EC_IP	0*	-0.2056
I	0 to1*	-0.0597
Dlog(RER)	0*	0.3502
VNER*DER	0**	-18.5090
Adj. R2: 0.5659	DW: 1.6205	

Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

4.1.3 Exports

Exports in the long term are related to the demand from the rest of the world, approximated by World GDP. The elasticity is considerably higher than expected. On the other hand the

Table 4. Imports Estimation

Long term: Log(M)

Explanatory variable	Coefficient
C	1.8143**
LOG(Y)	1.0831*
Log(RER)	0.0000

Short term: Dlog(M)

Explanatory variable	Significant lags	Overall effect
C	0	-0.0103
Dlog(M)	1***	0.1464
Dlog(Y)	0 to 2***	2.5079
EC_M	0*	-0.2748
Dlog(RER)	2**	-0.3508
VNER	0*	-23.0338
Adj. R2: 0.5120	DW: 1.9820	

Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

estimated long term effect of the real exchange rate on exports is low and not significant; nevertheless it is kept in the equation due its theoretical relevance.

In the short term, only the error correction term, the variations of the World GDP and the output gap showed a significant influence on the exports variation, while real exchange rate changes and nominal exchange rate volatility do not seem to have any effect (Table 3).

4.1.4 Imports

Imports are related to real GDP in both the long and the short term. The long term relationship presents a unitary elasticity while in the short term, changes of the GDP impact real imports variation with an elasticity of 2.5. Contrary to expected, it was not possible to find a long term relationship between imports and the real exchange rate. On the other hand, a negative short term effect of a real exchange rate depreciation on the variations of imports rate was verified.

Other variables with a short term impact on real imports variations are the volatility of the nominal exchange rate with a negative effect, the lagged values of the same imports variations and the error correction term (Table 4).

Table 3. Exports Estimation

Long term: Log(X)

Explanatory variable	Coefficient
C	1.0488
Log(YW)	2.0153*
Log(RER)	0.1793

Short term: Dlog(X)

Explanatory variable	Significant lags	Overall effect
C	0*	0.0335
Dlog(X)	none	0.0000
Dlog(YW)	1*	1.6706
D(YGAP)	0*	1.1392
EC_X	0*	-0.2025
Dlog(RER)	none	0.0000
VNER	none	0.0000
Adj. R2: 0.4465	DW: 1.9564	

Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

4.1.5 Interest rate

Interest rate changes are explained by changes in the international interest rate and variations of the nominal exchange rate and domestic inflation. All these effects were verified by significant coefficients with the expected signs (Table 5).

Table 5. Interest Rate Estimation D(I)

Explanatory variable	Significant lags	Overall effect
C	0*	0,0773
I	2*	-0,3435
D(IW)	1*	0,8249
Dlog(NER)	0*	0,4143
D(INF)	1*	0,2888
D(INFUSA)	none	0,0000
D(DG)	1*	0,6309
VNER	none	0,0000
TREND	0*	-0,0006
Adj. R2: 0,5605	DW: 1,8727	

Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

Other variables that were found to have a significant effect are the change in the Government Debt to GDP ratio, the first two lags of the interest rate itself and a time trend. The significant negative coefficient of the time trend is consistent with an interest rate being a stationary variable around a negative trend (see Appendix 2 for the unit root test results). International inflations and the volatility of exchange rate variations did not have a significant impact.

4.1.6 Inflation

Domestic inflation is a stationary variable and its behaviour can be explained by its first lagged value, the output gap in the previous period, and the price of oil energy imports two periods before.

There is also evidence of a positive pass through from the nominal exchange rate to domestic prices. However, the magnitude of this effect decreased drastically after the adoption of more flexible exchange rate regimes.[7] This can be inferred from the significant and negative coefficient of the exchange rate variation multiplied by dummy variable indicating the exchange rate regime.

Exchange rate volatility does not have a significant impact on inflation (Table 6).

Table 6. Inflation Estimation Dlog(P)

Explanatory variable	Significant lags	Overall effect
C	0*	0.0099
Dlog(P)	1*	0.3523
YGAP	1**	0.1500
Dlog(NER)	1*	0.3792
Dlog(NER)*DER	1*	-0.3334
Dlog(POIL)	2**	0.0190
VNER	none	0.0000
Adj. R2: 0.4684	DW: 2.2840	

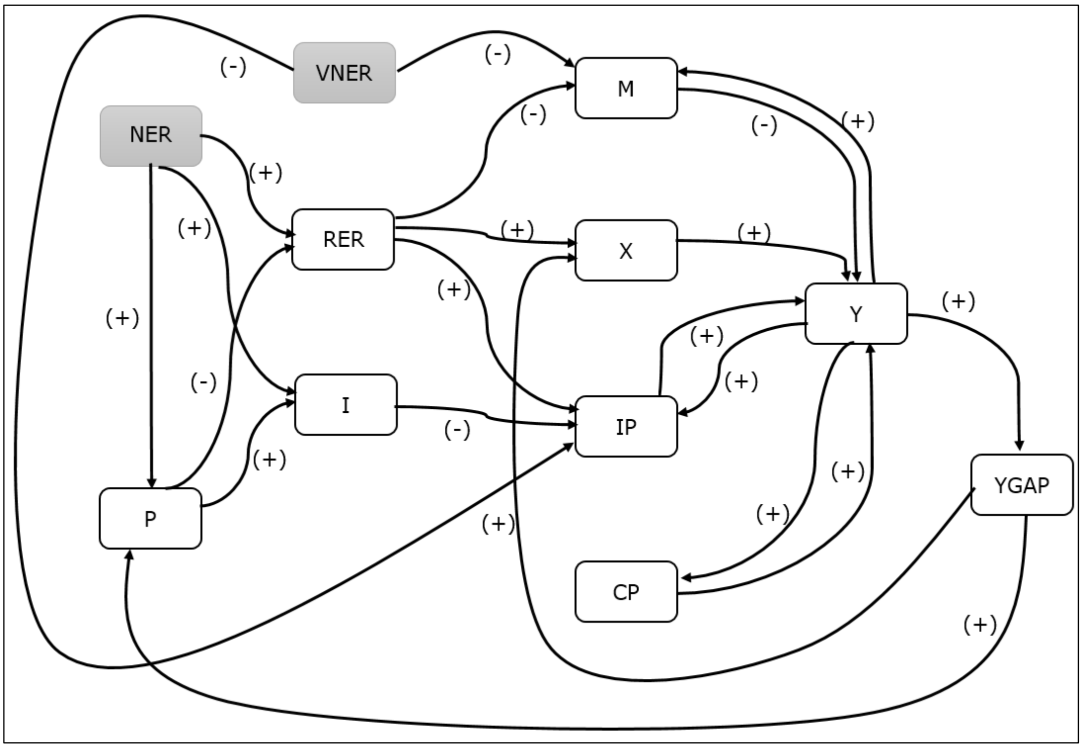
Significance *=99%, **=95%, ***=90%
Lag=0 is the current value of the variable.
Overall effect is the sum of coefficients of all significant lags which is also significant.

[7] This result is consistent with other empirical studies, like Rodíguez Vargas (2009).

4.2 Exchange rate transmission

Exchange rate level and volatility are direct or indirect determinants of all the estimated equations described in the previous section. Through the interaction of the equations and the identities in the model, it is possible to identify three transmission mechanisms from exchange rate to GDP in Costa Rica. They are illustrated in figure 2.

Figure 2. Transmission from exchange rate to GDP in the estimated model



First, an increase in the nominal exchange rate (NER) causes a real depreciation (RER increases) that has a positive effect on exports (X) and private investment (IP) and a negative effect on imports (M), boosting economic growth (Y increases). Second, the nominal depreciation (NER) increases the interest rate (I), negatively affecting private investment (IP) and production (Y). The third mechanism is related to an increase in the exchange rate volatility (VNER) that decreases private investment (IP) and imports (M), having opposite effects on production (Y).

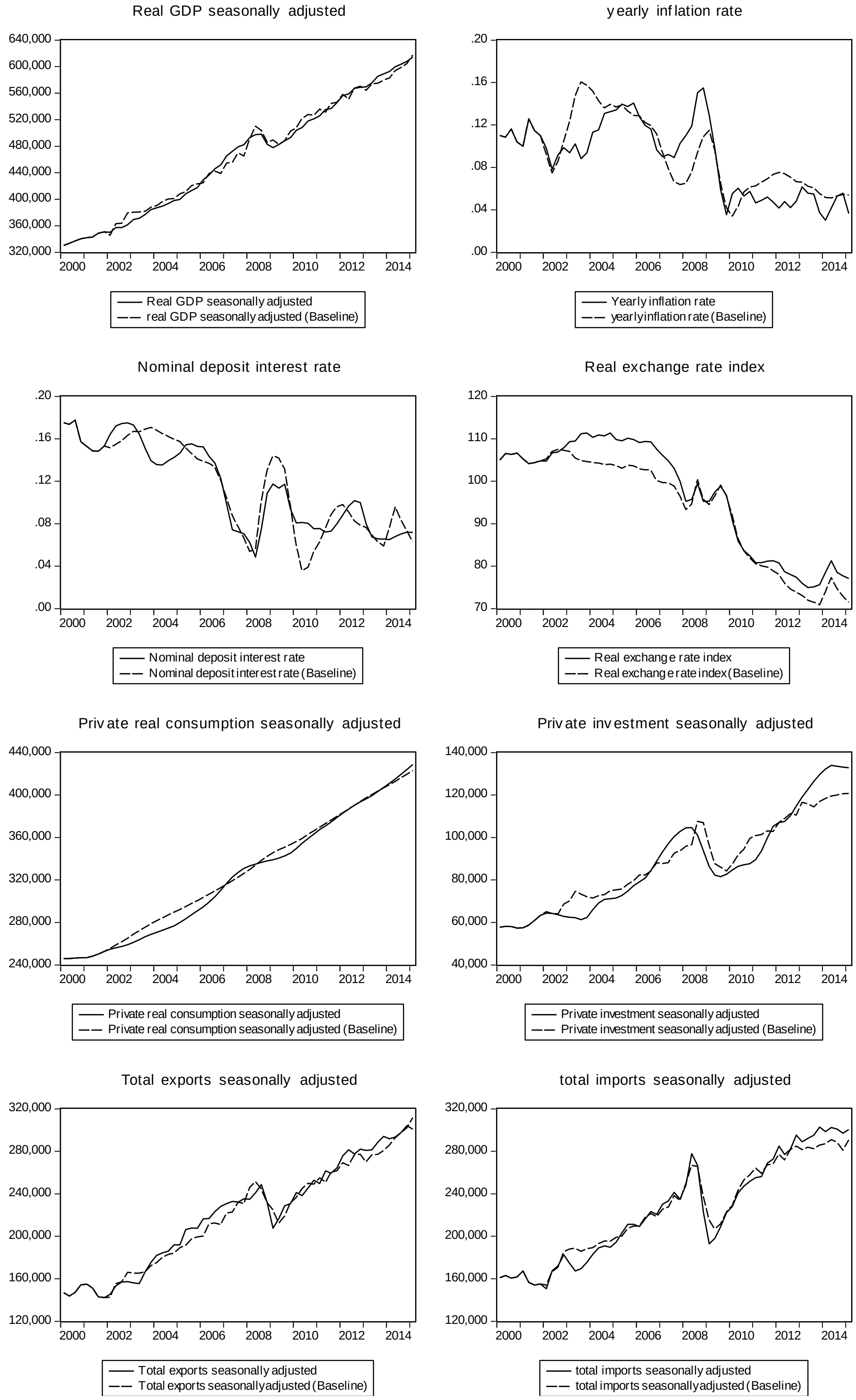
According to the dynamics of the model, an increase in production (Y) stimulates private consumption (CP) and private investment (IP), reinforcing economic growth. On the other hand, domestic prices (P) increase on further periods due the exchange rate pass through (NER) and a larger output gap (YGAP). Higher domestic prices partially reverts the initial real depreciation (RER decreases) and increases the interest rate (I). These effects cause a reduction in the (Y).

By putting together the equations and solving them as a model it is possible to simultaneously consider these transmission mechanisms, within a robust theoretical framework and with the dynamics and the parameters obtained from the data. The net effect of exchange rate movements and volatility in economic growth depend on the magnitude (value of the coefficients) and persistence (number of lags) on the equations.

4.3 Model baseline estimations

In addition to a solid theoretical framework, a desirable characteristic of a model is a good capability to replicate variables behavior in reality. Figure 3 presents the baseline estimations from the model (before any simulation is performed) compared to the current data.

Figure 3. Model baseline estimations



In general the model captures the trend and variations of the series. In some cases, however, it is not possible to adequately replicate the magnitude of the changes generated by the world crisis in 2008-2009. As a consequence of the relative larger estimation errors in this period, the model subsequently underestimates private investment and overestimates inflation. Those miscalculations are transmitted to other variables like the real exchange rate and imports.

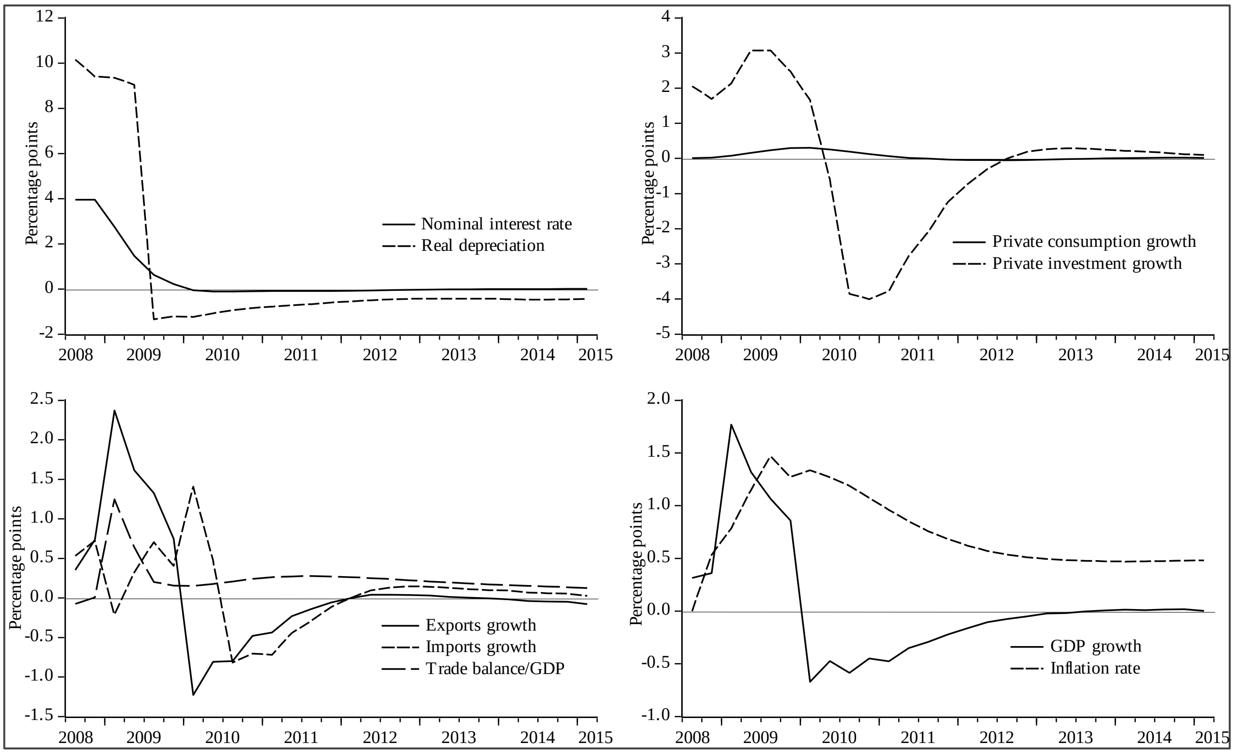
On the other hand, estimations of GDP, consumption and exports acceptably replicate the actual behavior during and after the crisis.

4.4 Impulse-response: 10% nominal depreciation

In 2008 the international crisis generated a sharp decline in Costa Rica´s exports and capital inflows. The foreign exchange market reacted with a depreciation of the domestic currency; however GDP stopped growing and even decreased the year after. It could be argued that a more aggressive depreciation would have mitigated the negative effects of the international crisis and accelerated the recovery.

In order to test the reaction of the variables in the model, an additional increase of 10% in the nominal exchange rate (a nominal depreciation) is incorporated in the third quarter of 2008. The main responses to this shock are presented in figure 4.

Figure 4. Responses to a nominal depreciation of 10 percentage points in one quarter



The temporary nominal depreciation generates a real depreciation that increases private investment and exports. The combination of these effects increases the GDP growth by 1.8 percentage points two quarters after the shock. On the other hand inflation rises 1.5 percentage points one year later due to the nominal depreciation and the higher output gap.

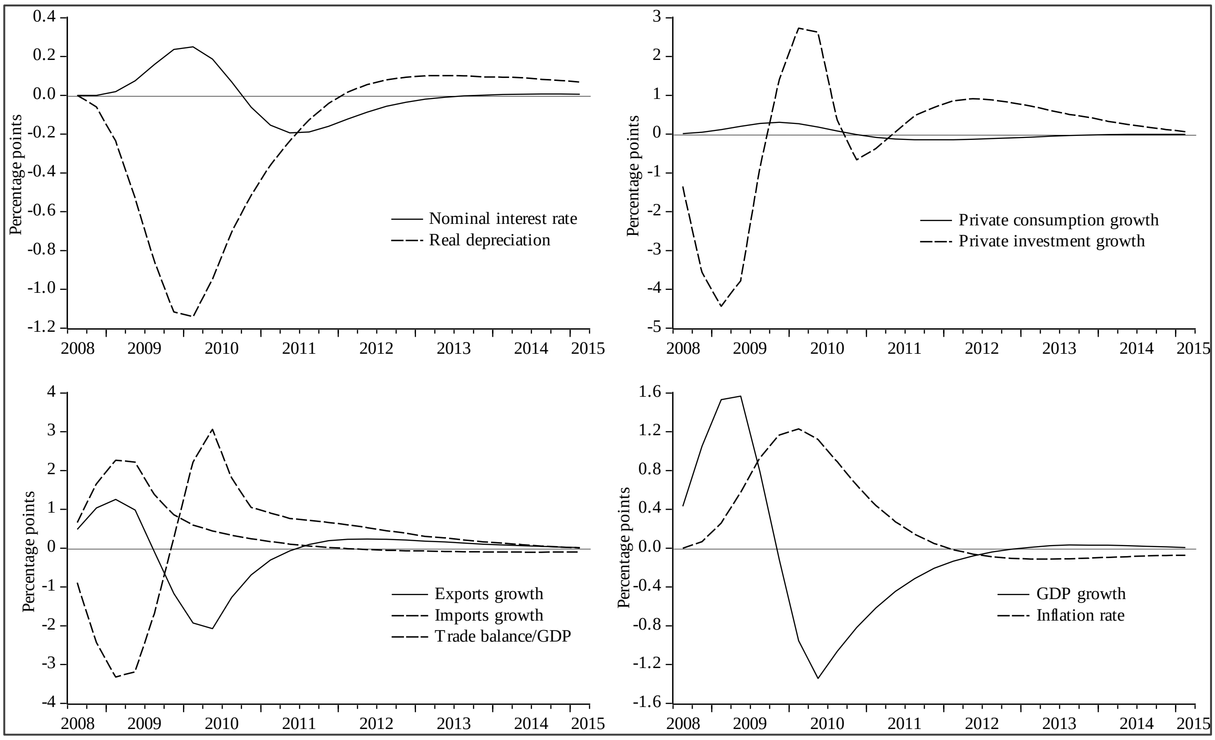
When the nominal depreciation returns to its original values, a persistent real appreciation occurs as the inflation rate remains higher. The result is a reduction in private investment and exports and an increment in imports that reduces GDP growth by 0.7 percentage points with respect to the baseline scenario, six quarters after the nominal depreciation. Five years later, any effect of the nominal depreciation on economic growth has disappeared but keeps increasing inflation by 0.5 percentage points.

These results verify the existence of a positive impact of a nominal depreciation on economic growth and inflation. However, economic growth increases during a small number of periods while the effect on inflation persists in the long term.

4.5 Impulse-response: 100% exchange rate volatility

Another relevant question is how the variables in the model react to an increase in nominal exchange rate volatility. The shock consists of doubling the level of volatility for one year (2008Q3-2009Q2). Responses are shown in figure 5.

Figure 5. Responses to a double exchange rate volatility for one year



Such as increase in exchange rate volatility has two immediate effects with opposite impact on GDP. One is a fall of 4.4 percentage points in the growth rate of private investment and the other a decrease of 3.3 percentage points in the growth rate of imports. Import goods are substituted by non-tradable goods as private consumption does not decrease. The net effect on GDP growth is an increase of 1.6 percentage points. A higher output gap increases the inflation rate up to 1.2 percentage points one year after the shock.

When the shock in the exchange rate volatility disappears, both private investment and imports recover and even grow at a higher rate with respect to the baseline scenario. This overshooting is explained by the higher GDP and, in the case of imports, also by the real appreciation caused by a higher inflation. The increased growth rates of imports and private investment have opposite effects on GDP growth, resulting in a net decrease of 1.3 percentage points.

Higher volatility of the exchange rate seems to be transmitted to the volatility of GDP and the aggregate demand components but it does not have any effect in the long term growth rate.

4.6 Policy simulation: Keeping the crawling peg

From 1983 to 2006 Costa Rica implemented a regime of a crawling peg to the US Dollar. The Central Bank intervened in the foreign exchange market in order to depreciate the domestic currency by a predetermined amount every day. This amount was established according to the differential between domestic and international inflation in order to maintain a stable real exchange rate (Banco Central de Costa Rica, 2015). At the end of this regime, the intervention rule implied a quarterly nominal depreciation of 1.75%, with virtually null volatility around the trend.

On the other hand, there are no specific exchange rate targets or predetermined intervention rules under the currency bands regime. Since its start in October 2006, the quarterly variation of the nominal exchange rate has fluctuated between -4.6% and 7.7%.

A comparison of Costa Rica's economic performance in the last 8 years of crawling peg (1999-2006) and the 8 years of flotation within bands (2007-2014), shows that the economic growth was similar, however there were substantial differences in the underlying structure (see table 7).

During the first of these periods, GDP growth was driven by a dynamic exporting sector while the growth rates of government expenditure and private consumption were relatively low. In contrast, the economic growth in the second period was boosted by investment and consumption of both government and private sector. Inflation was substantially lower during this second period.

These differences may be partially attributed to the shift in the exchange rate policy as well as other factors such as the fiscal stance and international conditions, including the crisis in 2008-2009.

Table 7. Average growth rates for selected variables before and after the change in the exchange rate regime (%)

	1999-2006	2007-2014
Domestic GDP	4.2	4.0
Private consumption	2.9	4.1
Private investment	4.3	6.7
Exports	6.6	3.9
Imports	3.5	4.8
Government (C + I)	1.3	5.9
Government debt / GDP	-0.8	4.2
Nominal exchange rate	9.0	0.8
Domestic prices	11.1	6.9
Oil import prices	24.2	9.9
USA prices	2.7	2.0
World GDP	3.1	2.5

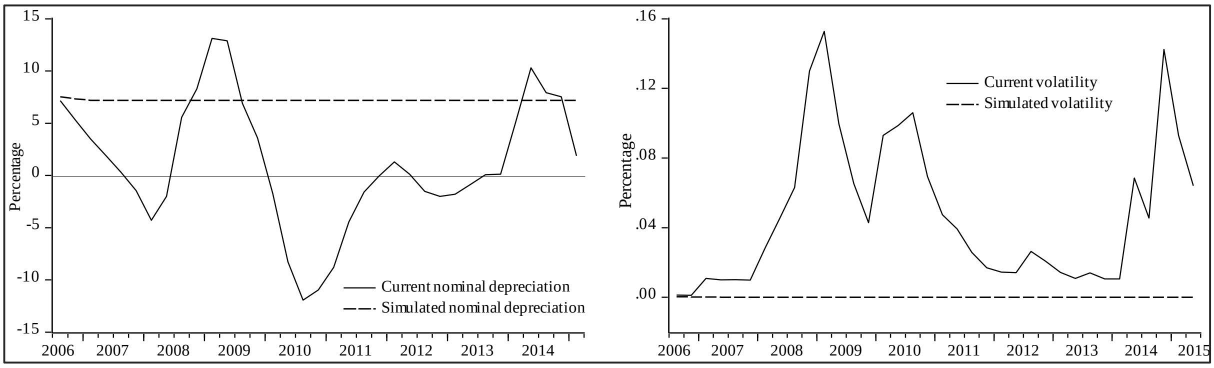
Source: Central Bank of Costa Rica.

In order to evaluate the effect of the exchange rate policy, a scenario is constructed to simulate that Costa Rica kept the crawling peg regime from 2007 to 2014. This scenario incorporates three simultaneous changes in the model.

1. A constant nominal depreciation of 1.75% each quarter (a yearly rate of 7.19%).
2. A null volatility around the trend of the nominal exchange rate.
3. An increase in the transmission of nominal depreciation to inflation from 0.05 to 0.38, according to the inflation equation.

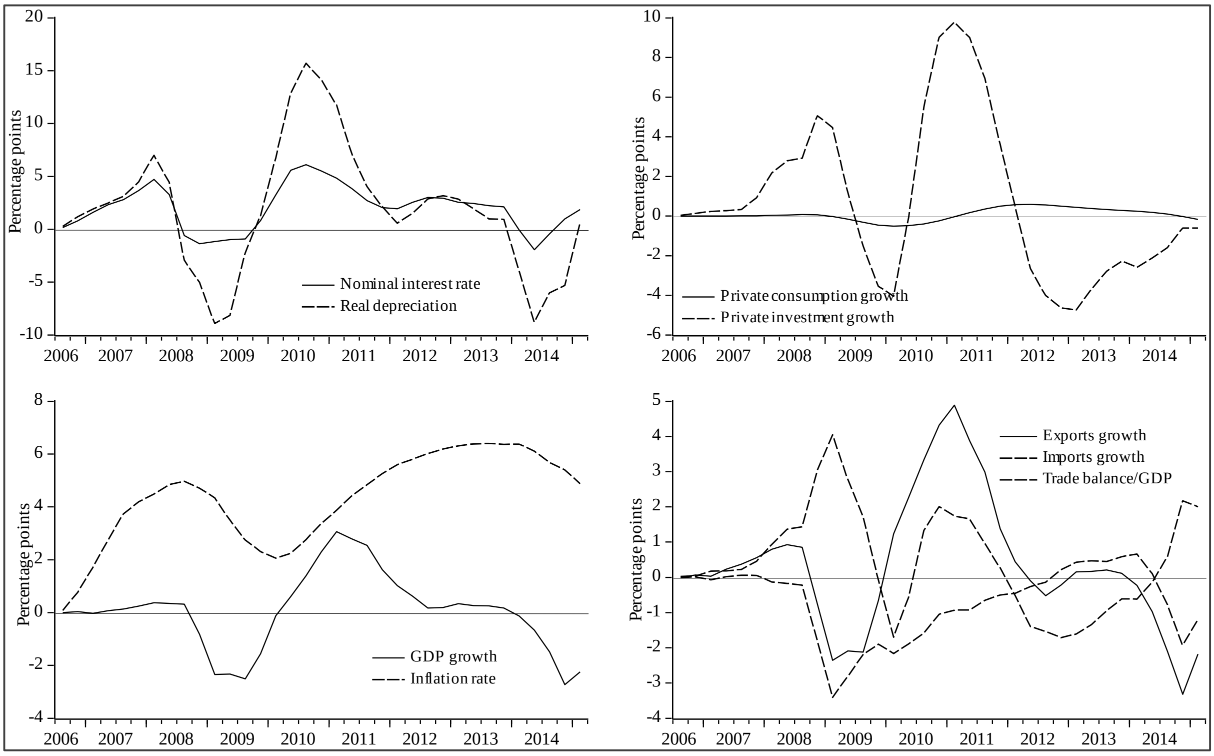
Figure 5 compares the simulated variation and volatility of the nominal exchange rate with the current values.

Figure 5. Changes in policy variables of the crawling peg scenario



The first 6 quarters of the floating regime presented a relatively stable exchange rate with a small appreciation at the end. During this period, GDP growth of the simulated crawling peg is very similar to the current rate under a more flexible regime (figure 6).

Figure 6. Differences between the crawling peg scenario and baseline estimations



During the second part of 2008 and the entire 2009, the average nominal depreciation under the current regime was higher than the supposed crawling peg target. This depreciation partially buffered the negative impact of the international crisis. As a result, the fall in GDP in 2009 and 2010 was less severe under the more flexible regime than it would have been under the fixed regime.

In the years following the crisis (2010-2013), a persistent nominal appreciation under the more flexible regime generated a 0.3 to 3 percentage point decrease in the economic growth as opposed to the crawling peg regime. Finally, in 2014 and the first quarter of 2015, a new nominal depreciation generated a higher GDP growth.

The simulated crawling peg regime shows an inflation rate between 1 and 6 percentage points higher than in the currency bands. The main reason of this difference is that the transmission (pass through) of a nominal depreciation to inflation substantially decreased during the more flexible regime.

As regards the components of aggregate demand, private investment, exports and imports would have grown at a higher rate as a result of the combination of a real depreciation and null exchange rate volatility around the trend. Private consumption would have grown at similar rates under both regimes as GDP growth rates are similar as well (table 8).

In summary, the average GDP growth rate between 2007 and 2014 under the crawling peg regime would have been comparable to that under the floating within bands regime, whereas the rate of inflation would have been substantially higher (table 8).

Table 8. Average growth rates from 2007 to 2014 for actual currency band and simulated crawling peg regimes (%)

	Actual Currency band	Simulated Crawling peg
Domestic GDP	4.0	4.1
Private consumption	4.1	4.2
Private investment	6.7	7.4
Exports	3.9	4.3
Imports	4.8	5.2
Nominal exchange rate	0.8	7.2
Domestic prices	6.9	11.5
Oil import prices	9.9	
USA prices	2.0	
World GDP	2.5	

Source: Central Bank of Costa Rica and own simulations.

5 Conclusions

Exchange rate policy plays a key role as an instrument to promote economic stabilization and growth. However, theoretical development and empirical evidence of the exchange rate´s impact on economic growth is not unambiguously conclusive.

This research estimates a structural macroeconomic model for Costa Rica from 1991 to 2014 in order to evaluate the impact of the change in the exchange rate regime in October 2006 from a twenty year old crawling peg with the US dollar to a scheme of floating within bands.

The model includes behavioral equations for private consumption, private investment, exports and imports, as well as for domestic interest and inflation rates. Estimation is performed using cointegration and error correction techniques. The explanatory variables are backed up by economic theory and the estimated parameters show the expected signs and adequate significance.

As a result of the model estimation, three mechanisms of transmission can be identified. First, exchange rate movements change the relative prices of tradable and non-tradable goods, affecting exports production and imports demand. Second, these movements have an impact on the domestic interest rate, a determinant of private investment. Finally, the volatility of exchange rate variations affects private investment and imports. These mechanisms interact with the economic dynamics represented in the model, affecting other macroeconomic variables and ultimately impacting economic growth.

According to these mechanisms, a nominal depreciation has a short term positive effect on GDP growth that disappears six quarters later. This shock also causes an increase in the inflation rate which remains in the long term. Moreover, an increase in the exchange rate volatility raises the variability of GDP, inflation and components of the aggregate demand.

A simulated crawling peg regime between 2007 and 2014 combines a constant nominal depreciation, a decreased volatility and a higher *pass-through-effect*. The result is an economy growing at almost the same rate as under the current more flexible exchange rate regime with a considerably higher inflation. Private investment and exports show higher growth rates under this crawling peg scenario.

These results refute the argument that a policy of currency depreciation would boost Costa Rican economic growth by increasing competitiveness. A broader analysis of the economic dynamics suggests that such policy would have a marginal effect on GDP growth in the long term with a high cost in terms of inflation.

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Appendix 1. Description of variables

	Endogenous Variables
CP	Private real consumption seasonally adjusted. Colones of 1991.
IP	Private real investment seasonally adjusted. Colones of 1991.
X	Total real exports seasonally adjusted. Colones of 1991.
M	Total real imports seasonally adjusted. Colones of 1991.
Y	Real GDP seasonally adjusted. Colones of 1991.
P	Consumer price index. Quarter average. July 2006 = 100
I	Nominal deposit interest rate. Reference average rate of 6 months deposits for the financial system. (Tasa Basica Pasiva)
RER	Bilateral real exchange rate index with the United States. July 1997 = 100
	Exogenous Variables
NER	Nominal exchange rate. Quarter average of the purchase and sale exchange rates from the authorized dealers (Tipo de cambio de referencia compra - venta)
VNER	Conditional variance of the first log-difference of the nominal exchange rate obtained from a GARCH model.
DER	Dummy variable of the exchange rate regimes (0 from 1991Q1 to 2006Q3 and 1 from 2006Q4 to 2015Q1)
IW	International interest rate. Libor interest rate 6 months
DG	Government debt as share of GDP
P_USA	Consumer price index United States
P_OIL	Oil energy imports price USD/barrel
IG	Government real investment. Colones of 1991
CG	Government real consumption. Colones of 1991
Y_POT	Real potential GDP. Average from production function and statistical filters estimations. Colones of 1991
Y_W	World GDP index seasonally adjusted. 1991 = 100

Appendix 2. Unit root and cointegration tests

Unit root tests

Variable	Level				First difference			
	Test	Const.	Trend	Result	Test	Const.	Trend	Result
LOG(CP)	ADF	Yes	Yes	**I(1)**	ADF	Yes	No	**I(0)**
LOG(IP)	ADF	Yes	No	**I(1)**	ADF	Yes	No	**I(0)**
LOG(X)	ADF	Yes	Yes	**I(1)**	ADF	Yes	No	**I(0)**
LOG(M)	ADF	Yes	No	**I(1)**	ADF	Yes	No	**I(0)**
LOG(Y)	ADF	Yes	No	**I(1)**	ADF	Yes	No	**I(0)**
LOG(P)	ADF	Yes	No	**I(0)**	ADF	Yes	Yes	**I(0)**
I	ADF	Yes	Yes	**I(0)**	ADF	Yes	No	**I(0)**
LOG(RER)	ADF	Yes	No	**I(1)**	ADF	Yes	No	**I(0)**
LOG(NER)	ADF	Yes	No	**I(1)**	ADF	Yes	Yes	**I(0)**
VNER	ADF	Yes	No	**I(0)**	ADF	No	No	**I(0)**
IW	KPSS	Yes	Yes	**I(0)**	ADF	Yes	No	**I(0)**
DG	ADF	Yes	No	**I(1)**	ADF	No	No	**I(0)**
INFUSA	ADF	Yes	No	**I(0)**	ADF	Yes	No	**I(0)**
LOG(POIL)	ADF	Yes	Yes	**I(1)**	ADF	Yes	No	**I(0)**
YGAP	ADF	No	No	**I(0)**	ADF	No	No	**I(0)**
LOG(YW)	ADF	Yes	Yes	**I(1)**	ADF	Yes	No	**I(0)**

Cointegration tests

Consumption

Sample (adjusted): 1992Q4 2015Q1
Included observations: 90 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: LOG(CP) LOG(Y)
Lags interval (in first differences): 1 to 6

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.200488	27.24113	20.26184	0.0046
At most 1	0.075891	7.103284	9.164546	0.1210

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.200488	20.13784	15.89210	0.0101
At most 1	0.075891	7.103284	9.164546	0.1210

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG(CP)	LOG(Y)	C
-15.46774	13.13990	27.66932
49.84470	-43.25104	-68.77229

Unrestricted Adjustment Coefficients (alpha):

D(LOG(CP))	0.000710	-0.000162
D(LOG(Y))	0.002949	0.002614

1 Cointegrating Equation(s): Log likelihood 733.4421

Normalized cointegrating coefficients (standard error in parentheses)

LOG(CP)	LOG(Y)	C
1.000000	-0.849503	-1.788840
	(0.05673)	(0.73825)

Adjustment coefficients (standard error in parentheses)

D(LOG(CP))	-0.010979
	(0.00271)
D(LOG(Y))	-0.045611
	(0.01969)

Investment

Sample (adjusted): 1992Q1 2015Q1
Included observations: 93 after adjustments
Trend assumption: Linear deterministic trend
Series: LOG(IP) LOG(Y)
Lags interval (in first differences): 1 to 3

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.151944	17.10436	15.49471	0.0284
At most 1	0.018927	1.777118	3.841466	0.1825

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.151944	15.32724	14.26460	0.0338
At most 1	0.018927	1.777118	3.841466	0.1825

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG(IP)	LOG(Y)
-16.72213	21.48506
2.161798	0.878156

Unrestricted Adjustment Coefficients (alpha):

D(LOG(IP))	0.010762	0.000374
D(LOG(Y))	0.001949	-0.001630

1 Cointegrating Equation(s): Log likelihood 486.3034

Normalized cointegrating coefficients (standard error in parentheses)

LOG(IP)	LOG(Y)
1.000000	-1.284829
	(0.05556)

Adjustment coefficients (standard error in parentheses)

D(LOG(IP))	-0.179966
	(0.04638)
D(LOG(Y))	-0.032593
	(0.02305)

Exports

Sample (adjusted): 1991Q3 2015Q2
Included observations: 96 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: LOG(X) LOG(YW) LOG(RER)
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.243582	44.22145	35.19275	0.0041
At most 1	0.149132	17.42198	20.26184	0.1175
At most 2	0.019783	1.918181	9.164546	0.7939

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.243582	26.79947	22.29962	0.0110
At most 1	0.149132	15.50380	15.89210	0.0574
At most 2	0.019783	1.918181	9.164546	0.7939

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG(X)	LOG(YW)	LOG(RER)	C
-13.73936	27.68854	2.464036	14.40987
19.65663	-38.26247	-2.619440	-34.89810
2.549515	-11.49387	-9.649624	70.66538

Unrestricted Adjustment Coefficients (alpha):

D(LOG(X))	0.007759	-0.010407	0.000185
D(LOG(YW))	-0.001430	-0.001194	-2.15E-06
D(LOG(RER))	-0.000879	-0.001037	0.002602

1 Cointegrating Equation(s): Log likelihood 849.3265

Normalized cointegrating coefficients (standard error in parentheses)

LOG(X)	LOG(YW)	LOG(RER)	C
1.000000	-2.015271	-0.179341	-1.048802
	(0.08931)	(0.15066)	(1.03915)

Adjustment coefficients (standard error in parentheses)

D(LOG(X))	-0.106606
	(0.04333)
D(LOG(YW))	0.019652
	(0.00571)
D(LOG(RER))	0.012074
	(0.02687)

Imports

Sample (adjusted): 1991Q4 2015Q2
Included observations: 95 after adjustments
Trend assumption: Linear deterministic trend
Series: LOG(M) LOG(Y)
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.178540	19.43209	15.49471	0.0121
At most 1	0.007846	0.748284	3.841466	0.3870

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.178540	18.68380	14.26460	0.0094
At most 1	0.007846	0.748284	3.841466	0.3870

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

LOG(M)	LOG(Y)
-15.99032	17.31973
-4.671633	8.722792

Unrestricted Adjustment Coefficients (alpha):

D(LOG(M))	0.017976	-0.000521
D(LOG(Y))	0.002830	-0.001043

1 Cointegrating Equation(s): Log likelihood 469.3790

Normalized cointegrating coefficients (standard error in parentheses)

LOG(M)	LOG(Y)
1.000000	-1.083138
	(0.04999)

Adjustment coefficients (standard error in parentheses)

D(LOG(M))	-0.287447
	(0.06611)
D(LOG(Y))	-0.045246
	(0.02246)

Appendix 3. VEC and OLS estimations

Consumption

Vector Error Correction Estimates
Sample (adjusted): 1992Q4 2015Q1
Included observations: 90 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LOG(CP(-1))	1.000000	
LOG(Y(-1))	-0.849503	
	(0.05673)	
	[-14.9752]	
C	-1.788840	
	(0.73825)	
	[-2.42307]	
Error Correction:	**D(LOG(CP))**	**D(LOG(Y))**
CointEq1	-0.010979	-0.045611
	(0.00271)	(0.01969)
	[-4.05839]	[-2.31676]
D(LOG(CP(-1)))	1.845963	1.964881
	(0.10187)	(0.74137)
	[18.1212]	[2.65035]
D(LOG(CP(-2)))	-1.674999	-2.598295
	(0.17370)	(1.26415)
	[-9.64301]	[-2.05537]
D(LOG(CP(-3)))	1.602587	2.440911
	(0.15916)	(1.15832)
	[10.0690]	[2.10728]
D(LOG(CP(-4)))	-1.640893	-1.023916
	(0.15835)	(1.15241)
	[-10.3626]	[-0.88850]
D(LOG(CP(-5)))	1.233357	1.305424
	(0.16675)	(1.21356)
	[7.39645]	[1.07570]
D(LOG(CP(-6)))	-0.444413	-1.200391
	(0.09457)	(0.68828)
	[-4.69910]	[-1.74403]
D(LOG(Y(-1)))	-0.041471	-0.545047
	(0.01587)	(0.11553)
	[-2.61249]	[-4.71786]
D(LOG(Y(-2)))	-0.034994	-0.013399
	(0.01705)	(0.12407)
	[-2.05261]	[-0.10799]
D(LOG(Y(-3)))	-0.012285	0.039471

	(0.01702)	(0.12388)
	[-0.72173]	[0.31863]
D(LOG(Y(-4)))	-0.020056	-0.140838
	(0.01689)	(0.12290)
	[-1.18767]	[-1.14595]
D(LOG(Y(-5)))	-0.018861	0.046917
	(0.01707)	(0.12421)
	[-1.10512]	[0.37773]
D(LOG(Y(-6)))	0.008227	-0.079316
	(0.01535)	(0.11168)
	[0.53612]	[-0.71020]
R-squared	0.937859	0.408142
Adj. R-squared	0.928175	0.315905
Sum sq. resids	0.000212	0.011227
S.E. equation	0.001659	0.012075
F-statistic	96.84345	4.424902
Log likelihood	455.4457	276.8120
Akaike AIC	-9.832128	-5.862489
Schwarz SC	-9.471044	-5.501406
Mean dependent	0.009970	0.010183
S.D. dependent	0.006191	0.014599
Determinant resid covariance (dof adj.)		3.91E-10
Determinant resid covariance		2.86E-10
Log likelihood		733.4421
Akaike information criterion		-15.65427
Schwarz criterion		-14.84877

Dependent Variable: DLOG(CP)
Method: Least Squares
Sample (adjusted): 1992Q4 2015Q1
Included observations: 90 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EC_C	-0.007420	0.002318	-3.200741	0.0020
DLOG(CP(-1))	1.782509	0.098419	18.11152	0.0000
DLOG(CP(-2))	-1.626536	0.171287	-9.495965	0.0000
DLOG(CP(-3))	1.546951	0.159023	9.727827	0.0000
DLOG(CP(-4))	-1.650474	0.155490	-10.61465	0.0000
DLOG(CP(-5))	1.158692	0.163814	7.073219	0.0000
DLOG(CP(-6))	-0.374901	0.090854	-4.126406	0.0001
DLOG(Y)	0.024213	0.012637	1.916060	0.0588

R-squared	0.932764	Mean dependent var	0.009970
Adjusted R-squared	0.927025	S.D. dependent var	0.006191
S.E. of regression	0.001672	Akaike info criterion	-9.864437
Sum squared resid	0.000229	Schwarz criterion	-9.642232
Log likelihood	451.8997	Hannan-Quinn criter.	-9.774831
Durbin-Watson stat	1.935967		

Investment

Vector Error Correction Estimates
Sample (adjusted): 1992Q1 2015Q1
Included observations: 93 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LOG(IP(-1))	1.000000	
LOG(Y(-1))	-1.284829	
	(0.05556)	
	[-23.1263]	
C	5.381351	
Error Correction:	**D(LOG(IP))**	**D(LOG(Y))**
CointEq1	-0.179966	-0.032593
	(0.04638)	(0.02305)
	[-3.88035]	[-1.41375]
D(LOG(IP(-1)))	0.316131	0.090298
	(0.09378)	(0.04661)
	[3.37115]	[1.93712]
D(LOG(IP(-2)))	0.063624	0.024414
	(0.07561)	(0.03758)
	[0.84151]	[0.64959]
D(LOG(IP(-3)))	0.074762	0.044485
	(0.07216)	(0.03587)
	[1.03605]	[1.24017]
D(LOG(Y(-1)))	0.522031	-0.453605
	(0.22653)	(0.11261)
	[2.30448]	[-4.02828]
D(LOG(Y(-2)))	1.358968	0.080392
	(0.25763)	(0.12807)
	[5.27481]	[0.62774]
D(LOG(Y(-3)))	-0.388039	0.104835
	(0.27322)	(0.13581)
	[-1.42026]	[0.77191]
C	-0.009037	0.011048
	(0.00576)	(0.00286)
	[-1.56996]	[3.86104]
R-squared	0.556999	0.257212
Adj. R-squared	0.520516	0.196041
Sum sq. resids	0.060807	0.015025
S.E. equation	0.026747	0.013295
F-statistic	15.26757	4.204815
Log likelihood	209.0068	274.0126
Akaike AIC	-4.322726	-5.720701
Schwarz SC	-4.104868	-5.502843
Mean dependent	0.014489	0.010679
S.D. dependent	0.038626	0.014828

Determinant resid covariance (dof adj.)	1.18E-07
Determinant resid covariance	9.84E-08
Log likelihood	486.3034
Akaike information criterion	-10.07104
Schwarz criterion	-9.580861

Dependent Variable: DLOG(IP)
Method: Least Squares
Sample (adjusted): 1991Q4 2015Q1
Included observations: 94 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EC_IP	-0.205633	0.043543	-4.722565	0.0000
DLOG(IP(-1))	0.133088	0.077353	1.720518	0.0890
DLOG(IP(-2))	0.109986	0.072755	1.511739	0.1343
DLOG(Y(-1))	0.585046	0.218870	2.673023	0.0090
DLOG(Y(-2))	1.668424	0.216462	7.707701	0.0000
I	-0.401180	0.164329	-2.441313	0.0167
I(-1)	0.341451	0.160078	2.133032	0.0358
DLOG(RER)	0.350173	0.165404	2.117075	0.0372
VNER*DER	-18.50897	8.056342	-2.297440	0.0241

R-squared	0.603210	Mean dependent var	0.015998
Adjusted R-squared	0.565865	S.D. dependent var	0.041107
S.E. of regression	0.027085	Akaike info criterion	-4.288824
Sum squared resid	0.062356	Schwarz criterion	-4.045317
Log likelihood	210.5747	Hannan-Quinn criter.	-4.190465
Durbin-Watson stat	1.620468		

Exports

Vector Error Correction Estimates
Sample (adjusted): 1991Q3 2015Q2
Included observations: 96 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1		
LOG(X(-1))	1.000000		
LOG(YW(-1))	-2.015271 (0.08931) [-22.5641]		
LOG(RER(-1))	-0.179341 (0.15066) [-1.19037]		
C	-1.048802 (1.03915) [-1.00929]		
Error Correction:	**D(LOG(X))**	**D(LOG(YW))**	**D(LOG(RER))**
CointEq1	-0.106606 (0.04333) [-2.46051]	0.019652 (0.00571) [3.43875]	0.012074 (0.02687) [0.44941]
D(LOG(X(-1)))	-0.271188 (0.09807) [-2.76529]	-0.010938 (0.01294) [-0.84558]	-0.052064 (0.06081) [-0.85619]
D(LOG(YW(-1)))	3.991324 (0.69548) [5.73895]	0.639996 (0.09174) [6.97649]	-0.516929 (0.43124) [-1.19869]
D(LOG(RER(-1)))	-0.125823 (0.16011) [-0.78588]	0.004445 (0.02112) [0.21048]	0.290008 (0.09928) [2.92123]
R-squared	0.195107	0.186733	0.105880
Adj. R-squared	0.168860	0.160213	0.076724
Sum sq. resids	0.087828	0.001528	0.033769
S.E. equation	0.030897	0.004075	0.019159
F-statistic	7.433617	7.041325	3.631497
Log likelihood	199.6245	394.0904	245.5054
Akaike AIC	-4.075510	-8.126882	-5.031362
Schwarz SC	-3.968662	-8.020034	-4.924514
Mean dependent	0.014727	0.007286	-0.003972
S.D. dependent	0.033891	0.004447	0.019939
Determinant resid covariance (dof adj.)		4.72E-12	
Determinant resid covariance		4.15E-12	
Log likelihood		849.3265	
Akaike information criterion		-17.36097	
Schwarz criterion		-16.93358	

Dependent Variable: DLOG(X)
Method: Least Squares
Sample (adjusted): 1991Q3 2015Q2
Included observations: 96 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.033531	0.008887	3.772816	0.0003
EC_X	-0.247126	0.062917	-3.927813	0.0002
DLOG(YW(-1))	1.670564	0.592634	2.818878	0.0059
D(YGAP)	1.139242	0.183215	6.218056	0.0000

R-squared	0.463980	Mean dependent var	0.014727
Adjusted R-squared	0.446501	S.D. dependent var	0.033891
S.E. of regression	0.025214	Akaike info criterion	-4.482049
Sum squared resid	0.058489	Schwarz criterion	-4.375201
Log likelihood	219.1384	Hannan-Quinn criter.	-4.438859
F-statistic	26.54516	Durbin-Watson stat	1.956352
Prob(F-statistic)	0.000000		

Imports

Vector Error Correction Estimates
Sample (adjusted): 1991Q4 2015Q2
Included observations: 95 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LOG(M(-1))	1.000000
LOG(Y(-1))	-1.083138
	(0.04999)
	[-21.6664]
C	1.814257

Error Correction:	D(LOG(M))	D(LOG(Y))
CointEq1	-0.287447	-0.045246
	(0.06611)	(0.02246)
	[-4.34786]	[-2.01434]
D(LOG(M(-1)))	0.267498	0.073903
	(0.11980)	(0.04070)
	[2.23283]	[1.81563]
D(LOG(M(-2)))	-0.036206	0.029768
	(0.11888)	(0.04039)
	[-0.30455]	[0.73700]
D(LOG(Y(-1)))	-0.133795	-0.445004
	(0.38312)	(0.13017)
	[-0.34922]	[-3.41871]
D(LOG(Y(-2)))	0.694983	0.071127
	(0.37744)	(0.12824)

	[1.84129]	[0.55465]
C	0.004369	0.013575
	(0.00715)	(0.00243)
	[0.61091]	[5.58693]
R-squared	0.243080	0.206864
Adj. R-squared	0.200557	0.162306
Sum sq. resids	0.144532	0.016684
S.E. equation	0.040298	0.013692
F-statistic	5.716369	4.642570
Log likelihood	173.3871	275.9423
Akaike AIC	-3.523939	-5.682996
Schwarz SC	-3.362641	-5.521699
Mean dependent	0.013770	0.010967
S.D. dependent	0.045071	0.014959
Determinant resid covariance (dof adj.)		2.00E-07
Determinant resid covariance		1.75E-07
Log likelihood		469.3790
Akaike information criterion		-9.586927
Schwarz criterion		-9.210566

Dependent Variable: DLOG(M)
Method: Least Squares
Date: 10/01/15 Time: 16:09
Included observations: 95 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.010305	0.006923	-1.488534	0.1402
EC_M	-0.274762	0.054280	-5.061982	0.0000
DLOG(M(-1))	0.146416	0.095547	1.532403	0.1291
DLOG(Y)	1.619321	0.244884	6.612594	0.0000
DLOG(Y(-1))	0.440961	0.319528	1.380038	0.1711
DLOG(Y(-2))	0.447581	0.241768	1.851282	0.0675
DLOG(RER(-2))	-0.350804	0.172183	-2.037388	0.0446
VNER	-23.03376	8.144084	-2.828281	0.0058

R-squared	0.548306	Mean dependent var	0.013770
Adjusted R-squared	0.511963	S.D. dependent var	0.045071
S.E. of regression	0.031486	Akaike info criterion	-3.998085
Sum squared resid	0.086250	Schwarz criterion	-3.783022
Log likelihood	197.9090	Hannan-Quinn criter.	-3.911183
F-statistic	15.08688	Durbin-Watson stat	1.982040
Prob(F-statistic)	0.000000		

Interest rate

Dependent Variable: D(I)
Method: Least Squares
Sample (adjusted): 1991Q3 2015Q2
Included observations: 96 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.077258	0.011248	6.868791	0.0000
I(-2)	-0.343484	0.039256	-8.749822	0.0000
D(IW(-1))	0.824869	0.299349	2.755548	0.0071
D(DG(-1))	0.630850	0.195884	3.220523	0.0018
DLOG(NER)	0.414289	0.074204	5.583088	0.0000
@TREND	-0.000621	0.000105	-5.910093	0.0000
D(INF(-1))	0.288838	0.077398	3.731845	0.0003

R-squared	0.588570	Mean dependent var	-0.002642
Adjusted R-squared	0.560833	S.D. dependent var	0.019278
S.E. of regression	0.012775	Akaike info criterion	-5.812456
Sum squared resid	0.014526	Schwarz criterion	-5.625472
Log likelihood	285.9979	Hannan-Quinn criter.	-5.736874
F-statistic	21.21976	Durbin-Watson stat	1.872733
Prob(F-statistic)	0.000000		

Inflation

Dependent Variable: DLOG(P)
Method: Least Squares
Sample (adjusted): 1991Q4 2015Q2
Included observations: 95 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009869	0.002225	4.434916	0.0000
DLOG(P(-1))	0.352316	0.086748	4.061354	0.0001
YGAP(-1)	0.150033	0.063789	2.352030	0.0209
DLOG(NER(-1))	0.379179	0.081940	4.627496	0.0000
DLOG(POIL(-2))	0.018981	0.007847	2.418900	0.0176
DER*DLOG(NER(-1))	-0.333400	0.107820	-3.092201	0.0027

R-squared	0.496663	Mean dependent var	0.024972
Adjusted R-squared	0.468386	S.D. dependent var	0.014661
S.E. of regression	0.010690	Akaike info criterion	-6.178010
Sum squared resid	0.010170	Schwarz criterion	-6.016713
Log likelihood	299.4555	Hannan-Quinn criter.	-6.112834
F-statistic	17.56401	Durbin-Watson stat	2.283978
Prob(F-statistic)	0.000000		