The differential impact of real interest rates and credit availability on private investment: evidence from Venezuela

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1. Introduction

Private spending on fixed capital goods has been an important topic of discussion among economists and policy makers. The influence of investment on growth and its volatility contributing to business cycles justify this focus. Recent empirical research has evaluated the effects of economic reforms, especially financial reforms, on capital formation and growth in developing countries. This issue sheds light on the link between financial and real variables. In traditional theory, this link is given by means of the real interest rate. However, credit may also have a direct effect on real variables by affecting consumption and investment when asymmetric information and/or excessive government intervention characterize the financial market.

In the 1970's, some economists, led by McKinnon (1973) and Shaw (1973), began to argue in favor of financial liberalization as a medium of promoting saving, investment, and growth. This was based on the argument that real interest rates are frequently negative in developing countries due to administrative controls on the nominal interest rates and heavy regulation in the financial market. This argument implies that real interest rates have a net positive effect on private investment, contradicting the traditional view of a negative relationship between private investment and real interest rates. Nevertheless, the financial liberalization literature argues in favor of higher interest rates due to what was observed in developing economies at the time, and the possibility of a negative relationship between investment and interest rates was not ruled out. McKinnon (1973) argued that in those countries where self-finance is very important and the interest rate is negative or very low, an upward increase in real deposit rates encourages saving (the substitution effect dominates the income effect) and the substitution from goods to bank deposits. Both have positive effects on private investment because self-financed investment rises and because there is a rise in the availability of funds to finance any profitable investment project. However, at higher rates, economic agents would prefer to hold deposits that yield a higher return than investment in physical capital. Therefore, at high rates, investment and real bank rates are expected to be negatively related. Hence, McKinnon's arguments imply a nonlinear relationship between real interest rates and private investment.

Furthermore, private investment can be nonlinear in credit availability (Günçavdı et al (1998)). That is, if we expect that credit constraints are present at all levels of interest rates, then when the effect of an increase in the real interest rates in the loan supply is higher than the costs brought about by higher rates due to asymmetric information problems, a decrease in the sensitivity of private investment on credit availability at higher rates should be expected as well.

Investigating the effects of financial factors on private investment, especially the role of interest rates, constitutes an important issue for developing countries where economic

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authorities in general believe that real interest rates play an important role in investment decisions and therefore on growth. In particular, the current Venezuelan government emphasizes the need to lower interest rates to encourage private investment. However, Venezuela is one of the countries that has maintained, on average, low real interest rates in recent years (see Mendoza Lugo (2001), Appendix A, Tables A.1 and A.2), with long periods of negative real rates and with periods of administrative control and decontrol on the nominal interest rates.

To investigate the nonlinear relationship and, therefore, the differential impact of real interest rates and credit availability on private investment, we use Venezuelan quarterly data for the period 1983:1–2000:4. The variables used in this study, besides private investment, are bank lending real interest rates, bank loans to the private sector as an indicator of credit availability, public investment and real gross domestic output generated by the private sector or private GDP. All these variables are, in principle, treated as endogenous, but the main focus is given to private investment spending. In addition to the mentioned variables, some dummy variables are taken into account to control for special events, structural economic reform and seasonality. Since we are interested in a model specification where the variable defining the states of the economy is known, the proposed econometric model is a logistic smooth transition vector error correction (LSTVEC) model, which is a generalization of the smooth transition regressive (STR) models proposed by Granger and Teräsvirta (1993).[2]

We estimate a LSTVEC model for private investment and its determinants with lagged values of DLCREDIT explaining the states of the economy in four of the five equations considered in this study.[3] To estimate the LSTVEC model, we use as a benchmark a linear specification, namely a subset or restricted in coefficients VEC model, and follow, with some modifications, the procedure recommended by Granger and Teräsvirta (1993) to estimate a STR model. From the LSTVEC model, generalized impulse response functions are constructed (Koop et al (1996), Weise (1999)) to explore, especially, the effects of positive and negative shocks to the real interest rate and credit availability on private investment when facing credit contractions or expansions. The impulse responses show evidence for asymmetric effects of shocks of the growth rate of these financial variables to the growth rate of private investment. However, these asymmetries are not totally in line with the predictions of the financial liberalization theory.

Section 2 summarizes some theoretical issues and empirical evidence reported in the literature with special focus on developing countries. However, it is not our purpose to present an exhaustive survey of the literature, but merely present a review of results of previous research that support and allow for comparison to the results of this research. Section 3 presents the data. Section 4 introduces a smooth transition specification for a VEC model with special emphasis on the modeling of a nonlinear private investment function. Section 5 is related to the estimation procedure and presents the results. Section 6 shows the impulse response functions on the growth rate of private investment (DLPRIVINV) to shocks on the five endogenous variables considered in the study. Finally, Section 7 presents the conclusions.

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[2] The STR models belong to the category of regime-switching models. Among the regime-switching models, two general categories can be distinguished. They are: (1) the smooth transition regressive (STR) models (the threshold models are a particular case of this category), which assume that the variable defining a regime or state of the world process is observable; and (2) the switching regression models, which assume that the regime is not known with certainty but some probabilities of its occurrence can be assigned. Franses and van Dijk (2000) discuss the properties and applications of these two categories in modeling financial variables.

[3] Even though the linearity test indicates that the equation for the growth rate of private GDP is nonlinear when the transition variable is the growth rate of public investment lagged four periods, a satisfactory nonlinear equation was not found. Therefore, the specification of this equation is assumed linear.

2. On the determinants of private investment in developing countries

Some economists argue that when studying investment in developing countries, special features not accounted for in traditional theories of investment should be considered. Agénor and Montiel (1999, pp 97–99) list six of those factors. First, financial variables may influence private investment because of underdeveloped financial systems and financial repression. Second, foreign exchange rationing and the exchange rate in the free market may influence investment decisions because of the importance of imported capital goods. Third, due to their importance in the production process in developing countries, imported intermediate goods should be taken into account in the specification of relative prices. Fourth, debt overhang inhibits investment because of the possibility of higher taxes to finance future debt service. Fifth, public investment has played an important role in the process of capital formation in developing countries. It may have a positive or negative effect on private investment depending on whether public investment is complementary to or a substitute for private investment. And sixth, macroeconomic instability and its resulting uncertainty, which have characterized developing countries, may have an important effect on private investment. Despite the understanding that all these elements may be important determinants of investment, the present study focuses on the first and fifth issues; that is, this research is basically limited to the role of financial factors, credit availability and interest rates as determinants of private investment. Public investment is considered in the analysis because it may affect private investment by means of its effects on financial variables as well as its direct effect by means of positive externalities enhancing the productivity of the private sector. In addition, gross domestic product and economic reform policies are taken into account because they have been found in previous research to be important determinants of private investment. Further, these two variables might play an important role in understanding private investment spending in the presence of asymmetric information and the transition from a heavily regulated economy to a more market-oriented economy.

2.1 Real interest rates as a determinant of private investment

The effect of real interest rates on private investment spending was first formalized in an investment equation by Jorgenson (1963), who derived the desired stock of capital as a function of real output and the opportunity cost of capital. In this approach, known as the neoclassical approach, a representative firm maximizes the present value of its future cash flows. The desired capital stock is directly related to output and inversely related to the cost of capital. A decrease in the real interest rate lowers the opportunity cost of capital and, therefore, raises the desired capital stock and investment spending.

Other literature, emphasizing the role of financial markets on capital formation (McKinnon (1973); Shaw (1973); Fry (1988)) includes suggestions that an increase in real interest rates has a positive effect on the volume and on the quality of investment in financially repressed economies.[4] The former effect is seen because self-finance is important and investment is lumpy. Then, the economic agents must accumulate resources before any investment project is executed. An increase in real interest rates thus stimulates both total and financial savings and, consequently, investment. The latter effect, improvement in the quality of investment, occurs because a higher interest rate will rule out investment projects with low productivity. At the same time, higher rates move resources from less efficient (eg goods facing some

[4] Financial repression is defined as high intervention by the government in the financial markets by setting ceilings on nominal interest rates, imposing high legal reserve ratios, and direct intervention on credit allocation.

depreciation) to more efficient forms of accumulation (eg bank deposits with a more favorable return).[5]

In particular, McKinnon (1973), when explaining the link between interest rates, money and investment, suggests a nonlinear relationship between the real interest rates on deposits and the rate of private investment. When the real return to money is lower than the average real return to physical capital, a further increase in money returns induces the accumulation of cash balances to finance a significant number of investment projects. But at higher interest rates, more economic agents may prefer to hold money rather than finance investment projects because money offers a higher return than their investment possibilities in physical capital. Therefore, one expects to find a positive (negative) relationship between these two variables at low (high) returns holding the average return to physical capital constant.

McKinnon's investment equation is given by

$$\frac{I}{Y} = F(r,d)$$

with, $\partial F/\partial r > 0$ and $\partial F/\partial d \underset{<}{\overset{>}{-}} 0$ if $d \underset{>}{\overset{<}{-}} r$. Where I denotes private investment, Y is output, r is the average return on physical capital, d is the real return on money, and the last derivative expresses the nonlinear relationship between real interest rates for money and the rate of investment.

Warman and Thirlwall (1994) study the effects of real interest rates on saving, investment and growth. They use data from Mexico for the period 1960–90 to quantify the level effects of low and high interest rates on private investment. They use the following investment equation.

$$I = a_1 + b_1 r + c_1[(r - r^e)D] + d_1 C + d_2 \Delta GDP_{-1}$$

where $b_1>0$, $c_1<0$, $d_1>0$, $d_2>0$.

They specify investment (I) as a function of the real interest rate (r), credit to the private sector (C), the first difference of GDP (ΔGDP), and a term, $(r–r^e)*D$, to capture the non-linearity between interest rates and private investment. r^e is the threshold rate or the border rate between two regimes in which the interest rate affects investment in different (positive and negative) ways. D is a dummy variable taking values of one when $r–r^e$ is positive and zero otherwise.

Under the above specification, Warman and Thirlwall find that the coefficients for interest rates and for the term measuring nonlinearity are very low and statistically insignificant. When a linear relationship is assumed, the real interest rate has an important negative and statistically significant effect on private investment. However, they may have failed to find a nonlinear relationship between the real interest rate and investment because of a misspecified nonlinear investment equation.

A further study of the nonlinearity of investment in financial factors is provided by Günçavdı et al (1998). They argue that after financial liberalization, the investment equation should become more sensitive to the cost of capital and less sensitive to the flow of credit to the private sector because of the relaxation of the credit constraints. Based on the fact that after financial liberalization the real interest rate became positive in Turkey, Günçavdı et al test for structural changes in the coefficients for cost of capital and credit availability in an estimated

[5] Empirical research in general finds a positive but statistically insignificant effect of real interest rates on savings. Bandeira et al (2000) verify that result from previous research in a country by country study for eight developing countries (Chile, Ghana, Indonesia, Korea, Malaysia, Mexico, Turkey, and Zimbabwe).

private investment equation for Turkey. They find that the sensitivity of private investment on credit availability decreases after financial liberalization but they do not find evidence for an increase in the sensitivity of investment on the cost of capital.[6]

Furthermore, some economists argue that when analyzing the effect of interest rate policies in developing countries, the assumption of perfect competition in the banking system is unrealistic because in these countries the banking sector is characterized by a small number of banks. In addition, credit markets face asymmetric information. For example, Demetriades and Luintel (2001) argue that under imperfect competition, mild repression[7] in the lending rates has a positive effect on bank loans. That is, under government intervention with an interest rate fixed below the monopoly equilibrium level, it is optimal for bankers to increase the amount of loans. However, repressing interest rate levels below those that would prevail under perfect competition will likely reduce the amount of loans and consequently have a negative effect in the economy.

Data on interest rates is only available since the eighties or early nineties for most of developing countries; therefore there is not an abundance of empirical work testing the effects of interest rates or the cost of capital on private investment for developing countries. Previous work for developing countries is not only sparse but also shows mixed results for the effect of interest rates on investment spending. For instance, Warman and Thirlwall (1994) show a negative and significant relationship using data for Mexico. De Melo and Tybout (1986) report a negative but statistically insignificant effect using data for Uruguay. Laumas (1990) and Athukorala (1998) find a positive relationship between real interest on deposits and private investment in India. With respect to the relationship between the cost of capital and investment, the relation is found to be negative in Athukorala (1998) but positive in Günçavdı et al (1998) for Turkey.

2.2 Bank lending as a determinant of private investment

When studying developing countries, bank lending to the private sector is an important determinant of private investment due to the banking system's importance as a source of external finance in those countries. That is, bank loans do not have close substitutes. Therefore, a contraction in the bank supply of credit may limit spending financed by credit. If the supply of bank credit is limited by the size of deposits, then a contraction of deposits will contract the supply of credit.

The financial repression literature, or the literature in favor of financial liberalization, takes the special role of the banking system as a source of finance in developing countries into account. When administrative controls are imposed on interest rates, credit is not allocated according to the expected return on the projects, but according to the quality of collateral, loan size, political pressure, and covert benefits to loan officers. With interest rate ceilings, financial institutions do not take risk because higher interest rates cannot be charged. Consequently, many high-yielding projects may face credit rationing (Fry (1988), page 18). An increase in real interest rates encourages deposits and, hence, increases the availability of funds to the private sector to finance investment projects while deterring low-yield projects.

In contrast, the theory emphasizing the role of asymmetric information in financial markets predicts that an increase in interest rates causes credit rationing because the lenders' expected profitability is not monotonically increasing in interest rates. At higher rates, lenders

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6 In contrast, Jaramillo et al (1996), using data from Ecuador at the firm level, do not find support for a relaxing of the credit constraints for small firms after financial reform.

7 Mild repression may be understood as interventions in the capital market leading to fixing the interest rate between the equilibrium level of monopoly and that which would exist under perfect competition.

may experience a decrease in profits due to adverse selection, moral hazard, and monitoring costs. Therefore, lenders are not willing to lend at a rate higher than that which maximizes their expected profits, even though there are agents willing to borrow at that higher rate (see, for instance, Walsh (1998), Chapter 7).[8]

The opposite predictions of these two literatures do not imply that they exclude each other. If we interpret the type of constraint predicted by the financial liberalization theory as more closely related to price rationing than a credit constraint, then both effects might be present in an economy. That is, higher interest rates may lead to higher credit availability but, for a given amount of credit, some firms may have access to bank loans and others may not. This would imply that credit constraints might be present not only at low interest rates, but also at high interest rates. If both causes of credit constraints exist, then it is expected that credit availability will have a direct effect on private investment at both high and low interest rates. At the empirical level, if the finding is that credit availability affects investment only when interest rates are low, this will be an indicator of financial restraints and shed light in favor of higher interest rates to encourage investment. If credit availability also enters into the investment equation at high interest rates, then the sensitivity of investment to credit availability would depend on the net effect of interest rates on credit. That is, lenders may be willing to lend more if the effect of an increase of interest rates on deposits is higher than the cost brought about by the asymmetric information problem. If this were the case, we would expect a decrease in the sensitivity of investment on credit availability at higher interest rates. This suggests a nonlinear relationship between credit allocated to the private sector and private investment.

Previous empirical studies have generally found a positive and statistically significant effect of credit availability (net flow of credit to the private sector) on private investment. Oshikoya (1994) finds that credit to the private sector has a significant positive effect on private investment in middle and low income African countries.[9] Shafik (1992) reports both short- and long-term positive and significant relationships between private investment and credit allocated to the private sector using data for Egypt. Leff and Sato (1988), using data for 21 Latin American countries, found, in general, a positive relationship between private investment and the change in total real credit. Ramirez (2000) also found a positive coefficient for the lagged ratio of credit to the private sector to gross domestic product (GDP) in an equation for the private investment-GDP ratio for eight Latin American countries.[10]

There is also evidence of financial development causing investment and growth. For instance, Bell and Rousseau (2001), using data for India, find that credit allocated to the private sector, and two other broader financial indicators,[11] Granger cause aggregate investment and output without evidence of feedback.

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8 A more recent development in this area emphasizes that credit rationing could be a consequence of the weakness of the legal system to enforce contracts (see for instance, La Porta et al (1998), and Levine et al, (2000)). Thus, credit market imperfections may have large impacts on financial markets in developing countries due to the weakness of their legal institutions enforcing contracts.

9 In this study, the middle income countries considered for the estimation of the private investment equation are Cameroon, Mauritius, Morocco, and Tunisia. The low income countries are Kenya, Malawi, and Tanzania.

10 See also, for instance, Warman and Thirlwall (1994), Günçavdı et al (1998), and Athukorala (1998).

11 These two indicators are domestic assets of deposit money banks and total domestic credit excluding credit to money banks.

2.3 Public investment as a determinant of private investment

In developing countries, the government has played an important role in capital formation. That is, public investment constitutes an important portion of total investment. Thus, evaluating the effect of this expenditure on private investment decisions may be worthwhile.

According to theory, the effect of public investment on private investment is indeterminate. Public investment can act as a substitute (negative effect on private investment) to or a complement (positive effect on) for private investment. The sign of the effect depends on the area in which the government executes the investment projects. Public investment may encourage private investment when such expenditure contributes to increasing private-owned firms' productivity. On the other hand, it may crowd out private investment when: (i) the government invests in inefficient state-owned firms; (ii) private investors expect higher taxes to finance such expenditures; and/or (iii) the public sector competes with the private sector for domestic loanable funds.[12]

Empirical studies on this issue report contrasting results for both developing and developed countries.[13] Oshikoya (1994) finds a positive and statistically significant relationship between private and public investment in middle income African countries. Paradoxically, this effect is weak or negative in low income countries. Recently, Apergis (2000) evaluated the effect of public spending (consumption and investment) on Greece for the period 1948–96. He found that for early years both variables are positively cointegrated. However, for a more recent sub-period, 1981–96, the cointegration relationship between those variables is negative. Ramirez (2000) finds a positive relationship between public and private investment in eight Latin American countries (Argentina, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and Uruguay) for the period 1980–95. Cardoso (1993) found a similar result with data for six Latin American countries (Argentina, Brazil, Colombia, Chile, Mexico, and Venezuela) using a panel comprising information for three sub-periods between 1970 and 1985.[14]

Separating public investment into infrastructure and non-infrastructure investment, some empirical studies have found evidence of a positive relationship between public investment in infrastructure and private investment. By contrast, the effect of government spending on non-infrastructure has a negative effect on private investment (see, for instance, Blejer and Mohsin (1984)). Pereira (2000) reports that five types of total public investment have a positive effect on private investment and output in the US for the period 1956–97 using a four variable VAR in first difference.[15] Due to the type of spending considered,[16] the result is consistent with the view that public investment in infrastructure tends to encourage private activity by means of a rise in private sector productivity.[17]

[12] See Apergis (2000) for references on each of these possibilities.

[13] For early references on this issue, see Agénor and Montiel (1999, page 101).

[14] Another study reporting complementarity between public investment and private investment is Athukorala (1998) for India.

[15] The VAR contains the first difference of the logarithm of private investment, private employment, private GDP, and one of six indicators of public investment.

[16] Infrastructure: classified in three groups, including buildings for the provision of quasi-public goods (health, education, etc) and conservation structures.

[17] See also Rioja (1999) and Feltenstein and Ha (1999). Both studies, using a general equilibrium framework, conclude that investment in infrastructure is not always welfare improving. Rioja argues that Latin American countries need an additional 4% of GDP to dedicate to investment in infrastructure to optimize their welfare gains from this type of investment. Feltenstein and Ha use data for 16 sectors of the Mexican economy and conclude that only small increases in public infrastructure have a positive impact in the real economy.

2.4 On the other determinants of private investment[18]

In addition to the determinants mentioned above, private investment spending depends on output, economic reform policy, and on its owned lagged values. Since the early study of Clark (1917), the change in output is considered as a determinant of investment spending. This effect is the well known “accelerator effect”. Output also plays an important role in the neoclassical approach of investment introduced by Jorgenson (1963), although the central feature of this theory is to evaluate the effects of relative prices on the demand for capital. Output affects investment decisions due to its effect on firms’ profitability and also by means of the output-saving-aggregate investment channel.[19] Empirical results usually confirm a strong and positive effect of changes in GDP on private investment or GDP growth on the investment-GDP ratio.

Moreover, recent empirical studies for developing countries have found evidence for important changes in the investment equation due to economic reform. For instance, Fielding (1997) evaluates the impacts of policy reform in six African countries (Kenya, Nigeria, Zimbabwe, Côte d’Ivoire, Cameroon, and Mauritius) and finds evidence for economic reform altering the investment equation. Also, Athukorala (1998) finds that market-oriented reforms positively affected the private investment function in India. Other empirical researchers have found evidence of the impact of financial reforms on private investment. In general, this line of research tests for structural changes in the parameters of the investment function. For example, Günçavdi et al (1998) and De Melo and Tybout (1986) test for structural breaks in the investment equation after financial liberalization policies were implemented in Turkey and Uruguay.

3. Data

The data cover the period 1983:1–1999:4. In Section 2, we discussed the determinants of private investment considered in this research. For empirical implementation, those variables, except for the real interest rate, are transformed into natural logarithms. These variables are denoted as follows:

v = LPRIVINV or the logarithm of real private investment spending;

w = DLCREDIT or first difference of logarithm of real stock of credit to the private sector;

x = RIQ or the real bank lending interest rate;

y = LPRIVGDP or logarithm of private GDP; and

z = LPUBINV or logarithm of public investment.

Data for GDP and investment have been provided by the econometrics department (Departamento de Apoyo Cuantitativo) of the Central Bank of Venezuela (BCV). Data on the nominal stock of credit to the private sector are obtained from the IMF, *International financial statistics*, CD-R April 2001. The real stock of credit is the nominal stock of credit deflated by the consumer price index (CPI). Investment (total, public, and private), GDP, and the real stock of credit are expressed in billions of bolivares and in 1984 prices. The natural logarithm transformation is applied to those variables as well.

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[18] Due to the large number of variables that economists consider when studying developing countries, the term “other determinants of private investment” should be understood as the other variables considered in this research.

[19] In the Q-theory of investment, future output stream affects the market value of the firm and consequently the firm’s investment decisions.

What matters for investment spending in period *t* is the amount of funds available in that period rather than the credit stock. Credit allocated to the private sector in real terms should be measured by means of the first difference of the nominal stock of credit deflated by the price index. This takes into account not only the change in the real stock of credit but also the replacement of the stock due to inflation. However, when the series are transformed into logarithms there is an important loss of information because the logarithm is not defined for negative numbers. Nevertheless, in this research, the indicator for credit availability is obtained as the first difference of the logarithm of real stock of credit.

Furthermore, the real interest rate in quarterly terms is constructed from monthly data on nominal lending interest rates from the six most important banks, and the CPI is provided by the BCV. See Mendoza Lugo (2001, Appendix A) for details on the procedure used in the calculation of the real interest rate series. In Venezuela, the public sector constitutes an important proportion of total GDP. It represents 37.5% of total GDP throughout the period under analysis. Therefore, it seems better to use GDP generated by the private sector rather than total GDP as a determinant of private investment. Private GDP for 1983:1–1990:3 is calculated by interpolation based on proportions of private GDP to total GDP using annual data obtained from Antivero (1992), Tables II-8 and II-9, and the quarterly total GDP for the same period obtained from the BCV. That is, the proportion of private GDP to total GDP is obtained from annual data and the four observations of quarterly total GDP for each year are multiplied by this proportion. The computed new series is used as the indicator of private GDP.

The series used in this research are intentionally left seasonally unadjusted. Even though much empirical work uses seasonally adjusted data, some time series analysts suggest working with seasonally unadjusted data because: (i) seasonally adjusted data may lead to misleading inferences about the relationship among the variables; and (ii) seasonal adjustments imply a loss of important information when seasonal fluctuations explain an important part of the behavior of the variables in analysis (see for instance, Lee (1992), Lee and Siklos (1997), and Bohl (2000)). Thus, the data is tested for unit roots at all frequencies (seasonal and long-run) using the HEGY (Hylleberg, Engle, Granger, and Yoo) test for unit roots, which allows discrimination of unit roots at long-run, semiannual, and annual frequencies. Also, the augmented Dickey-Fuller (ADF) test and the Phillips and Perron (PP) test are performed for comparison purposes. The PP test is applied in this research only when the residuals from the ADF regression are hereroskedastic as reported by the Q statistic on the square of the residuals. The HEGY test indicates that the Venezuelan data in this research does not have seasonal unit roots. While at the long-run frequency, unit roots are found for LPRIVGDP, LPRIVINV, and LPUBINV. Results and discussion about unit root tests are reported in Mendoza Lugo ((2001), Appendix B).

4. Modeling a nonlinear private investment function

The literature offers a wide variety of nonlinear models. Among the nonlinear parametric specifications, the smooth transition regression (STR) models and the threshold regression (TR) models have recently been increasingly used in modeling economic relationships. However, since the TR models are a particular case of the STR models, it is convenient to start investigating a nonlinear relationship with the STR models to avoid specification problems.

The smooth transition models belong to the category of regime switching models and are introduced in the literature in their autoregressive (STAR) version by Chan and Tong (1986); Luukkonen, Saikkonen, and Teräsvirta (1988); Teräsvirta and Anderson (1992); and

Teräsvirta (1994). Granger and Teräsvirta (1993) extend the STAR models to a multivariate context resulting in the STR models.[20]

4.1 A smooth transition specification for private investment within a VEC model

We model a nonlinear specification for private investment within a smooth transition vector error correction (STVEC) model in which private investment depends on its own lagged values and on the lags of other variables determining investment. In other words, it is claimed that if a linear specification for private investment is rejected, then there exists a nonlinear dynamic that is appropriately described by an STR model. The STR models, in addition to offering a less restrictive framework, are recommended when analyzing aggregates as in the case of private investment spending (Granger and Teräsvirta (1993, page 40)). That is, at the micro level the decisions to invest may be constrained to "invest given a state of the economy, say state or regime 1" or "do not invest given state or regime 2". However, at the macro level the lack of coordination among individual decisions may lead to a smooth transition from one regime to the other.

A general STVEC model can be expressed as follows:

$$\Delta X_t = \Pi_{0,1} D_t + \Pi_1 X_{t-1} + \sum_{m=1}^{p-1} \theta_{m,1} \Delta X_{t-m} + [\Pi_{0,2} D_t + \Pi_2 X_{t-1} + \sum_{m=1}^{p-1} \theta_{m,1} \Delta X_{t-m}] F(TV_{t-d}) + \varepsilon_t \qquad (4.1)$$

where,

D is a (n_0 x 1) matrix of deterministic terms, X is a (n x 1) vector, n is the number of endogenous variables; $\pi_{0,i}$ i = 1,2, is a (n x n_o) vector of coefficients for the ith regime, and π_i and $\theta_{m,i}$ are (nxn) matrices of coefficients. The rank of $\pi_{0,i}$, r, is the number of cointegrating vectors. The matrix $\pi_{0,i}$ can be expressed as $\pi_{0,i} = \gamma_i \alpha_i ; \gamma_i$ and α_i are (n x r) matrices with rank r. The former is the matrix containing the adjustment coefficients and the latter is the matrix of cointegrating vectors. In the estimation procedure, we assume $\alpha_1 = \alpha_2 = \alpha$; αX_t is the cointegrating vector (CIV_t) for both regimes. $\pi_{0,2}$ is a matrix of zeros the coefficient denoting the constant term. That is, the model is lineal in determinist variables the constant term. In addition, ΔX_t = [dv_t, dw_t, dx_t, dy_t, dz_t] and $F(TV_{t-d})$ is the indicator or transition function taking values between zero and one, both extremes, inclusive. When taking intermediate values, it allows a smooth transition between regimes. In general, $F(TV_{t-d})$ is specified by one of the following two forms:

$$F(TV_{t-d}) = \{1 + Exp[-\gamma(TV_{t-d} - c)]\}^{-1}, \ \gamma > 0 \qquad (4.2)$$

or

$$F(TV_{t-d}) = 1 - Exp\{-[\gamma(TV_{t-d} - c)]^2\}, \ \gamma > 0 \qquad (4.3)$$

[20] The smooth transition models have been applied to explain the dynamic behavior of some macroeconomic variables. For instance, Weise (1999) tests for asymmetric effects of monetary policy in the United States using a logistic smooth transition vector autoregression (LSTVAR) model. Taylor and Peel (2000) find that the exponential smooth transition autoregressive (ESTAR) model explains the behavior of the deviations of the dollar-mark and dollar-sterling exchange rates from the long-run equilibrium rate. Sarantis (1999) finds that STAR models approximate the nonlinearity in the effective real exchange rate for eight of the G10 countries. Byers and Peel (2000) model the hyperinflation in Germany, Brazil, and Argentina using the ESTAR model. Other recent applications of smooth transition models are in Chen and Wu (2000), Öcal and Osborn (2000), van Dijk and Franses (1999), Lutkepohl et al (1999), Leybourne and Mizen (1999), Bradley and Jansen (1998), and Greenaway et al (1997).

These are the logistic and the exponential transition or indicator functions. Notice that the indicator function has been restricted to contain only one transition variable. This is equivalent to assuming that the transition variable, *TV*, and the delay parameter, *d*, are known. A model combining (4.1) and (4.2) is a logistic smooth transition vector error correction (LSTVEC) model. When using (4.1) and (4.3), the model is the exponential smooth transition vector error correction (ESTVEC) model. The LSTVEC model allows the VEC to behave differently when the transition variable takes low values. That is, two regimes can be defined: the low regime and the high regime. The ESTVEC models, instead, assume that the VEC behaves the same when the transition variable takes extreme values. This behavior differs from when the transition variable takes values located in the middle of its own range of values. In this case the two regimes are called the outer regime and the middle regime.

In the logistic function, when $(TV_{t-d} - c)$ is large and positive, $Exp[-\gamma(TV_{t-d} - c)]$ tends to zero and the transition function takes a value of one. In the opposite case, $Exp[-\gamma(TV_{t-d} - c)]$ tends to infinity and the transition function goes to zero. Therefore, in the low regime, the estimated regression is given by the set of estimated coefficients in the first and second terms of (4.1). While in the high regime, the whole set of estimated coefficients for all terms in (4.1) describe the dynamics of investment or the variable being analyzed. In the case of the exponential function, when $(TV_{t-d} - c)$ takes either large positive or negative values, $Exp\{-[\gamma(TV_{t-d} - c)]^2\}$ tends to zero and the transition function takes a value of one. Thus, this function restricts the dynamics of the equation to be the same when the transition variable takes extreme values. When TV_{t-d} takes values close to *c*, $Exp\{-[\gamma(TV_{t-d} - c)]^2\}$ tends to one and the transition function goes to zero.

Between the logistic and the exponential transition functions, we have chosen the logistic function to investigate nonlinearities in the VEC. This choice is based on the theory discussed previously.

4.2 The choice of transition variable

The search for a transition variable will be done focused on possible nonlinearities in the VEC model due to nonlinearities in the private investment equation.[21] We suspect that the investment equation behaves differently when the interest rate takes high as opposed to low values. It could also be that the investment equation behaves differently when there is a credit constraint and when constraints are relaxed. One additional possibility is that whether the economy is expanding or contracting could define the state of the world or regime. That is, the theory of financial constraints states that the severity of agency costs should vary with the general macroeconomic conditions. It is expected that during recessions a firm's internal finance falls and the demand for external funds rises. Since the cost of external finance increases when the firm's balance sheet deteriorates, investment falls and thus intensifies the magnitude of the recession (Bernanke and Gertler (1989) and Walsh (1998), pp 298–302). Consequently, during recessions, the investment equation may be more sensitive to credit than in periods of expansion. This implies a nonlinear relationship between investment and credit with changes in output defining the state of the economy. Finally, public investment can be the transition variable depending on its impact on the credit market.

[21] Weise (1999) shows that in a structural multiple-equation model, a nonlinear equation in at least one of its coefficients may lead to a nonlinear representation for all equations in the reduced form of the system.

We have not found a theoretical explanation for using private investment itself as the transition variable. However, we do not rule out this possibility. Provided that the investment function is nonlinear, differential impacts of real interest rates and credit availability on investment can arise from the dynamic interactions of the other variables included in the model. Therefore, all lagged variables explaining investment other than CIV are considered potential transition variables.

5. Estimation

Teräsvirta (1994) elaborates on the procedure for estimating a smooth transition model in the univariate case. Granger and Teräsvirta (1993) discuss this procedure in the multivariate context. The technique consists of the following three broad stages. First, specify the linear model. Second, apply the test for linearity against STR models following the third order test procedure introduced by Luukkonen et al (1988), but using only one transition variable each time for all possible values of *d*. And third, if linearity is rejected, then choose between the logistic smooth transition regressive (LSTR) and the exponential smooth transition regressive (ESTR) model by testing a sequence of hypotheses.

5.1 The linear model

Since no evidence for seasonal unit roots are found in the Venezuelan data, cointegration and the number of cointegrating vectors are tested within a linear VEC model from one to four lags.[22] Cointegration is tested using the maximum likelihood procedure proposed by Johansen (1988, 1991) and well documented in Hamilton (1994). Evidence of cointegration is found for one and three lag specifications with LPRIVINV, LPUBINV, and LPRIVGDP as endogenous variables. The CIV for one lag is discarded because its coefficients do not look reasonable. Therefore, the selected CIV comes from a system specification with three lags and it is $LPRIVINV_t = 0.191 - 0.759 * LPUBINV_t + 0.861 * LPRIVGDP_t$.The trace statistic is 33.772, significant at 5%.[23]

As a second step, given the existence of one cointegrating vector, the term $LPRIVINV_{t-1} + 0.759 * LPUBINV_{t-1} - 0.861 * LPRIVGDP_{t-1}$ is used to estimate a linear version of (4.1) where dummies for some special events and structural economic reforms are introduced.[24] The

[22] In general, it is recommended that the lag length of the VAR in levels should be chosen before testing for cointegration (see, for instance, Enders (1995), page 396). However, when using the Akaike information criterion (AIC) and Schwarz information criterion (SIC) for lag length selection, with the same sample size and up to six lags in the VAR, both criteria indicate one lag in the VAR in levels. This implies zero lags in the VEC model. Since a longer lag is preferable to one that is too short (Banerjee et al (1993), page 286), an alternative procedure is followed to test and estimate the cointegrating vector. That is, using the same effective sample size (1984:2–2000:4), cointegration is tested from one up to four lags in the VEC model and the cointegrating vector with more reasonable coefficients is selected.

[23] The maximum eigenvalue does not indicate evidence for cointegration.

[24] The dummy variables are DC and DPC, which attempt to control for structural economic reform as specified in Section 3. The dummies to control for special events (See Mendoza Lugo (2001), Section 2.3) are introduced only after an initial stimation evidences the need to control for some outliers in those periods. These dummies are D891 and D942 in the real interest rate equation, D944 and D962 in the credit equation, and D861 in the public investment equation. D891 is defined as +1 in 1989:1, –1 in 1989:2 and 0 otherwise. D944 takes the value of +1 in 1994:4, –1 in 1995:1 and 0 otherwise. D962 is specified as +1 in 1996:2, –1 in 1996:3 and 0 otherwise. And finally, D861 is defined as +1 in 1986:1, –1 in 1986:2 and 0 otherwise. D942 is specified as 1 in 1994:2 and 0 otherwise. After the introduction of these dummies, all equations pass the diagnostic check in terms of normality, serial correlation, and heteroskedasticity. The subset VEC model is re-estimated, starting

VEC lag length is set arbitrarily equal to 4.[25] Furthermore, insignificant coefficients are eliminated using the modified version of the likelihood ratio test suggested by Sims (1980). This second step is performed using generalized least squares or seemingly unrelated regressions (SUR). As we can observe, the procedure applied differs from the two-step Engle and Granger (1987) method only in the method of estimation applied in each step. The resulting estimated subset VEC model is shown in Table 5.1.[26]

5.2 Linearity test

A linearity test is performed using its one equation and system version. For the multivariable equation setup, we use the augmented first order test proposed by Luukkonen et al (1988), which is more suitable for small samples and has more power under the null hypothesis. This test can be performed using the following auxiliary regression.

$$dv_t = \phi_0 + \phi_1 H + \phi_2 H TV_{t-d} + \psi_d TV^3_{t-d} + \upsilon^*_t \tag{5.1}$$

where,

$H = [dv_{t-1}, \ldots, dv_{t-p}, dw_{t-1}, \ldots, dw_{t-q}, dx_{t-1}, \ldots, dx_{t-r}, dy_{t-1}, ..., dy_{t-s}, dz_{t-1}, \ldots, dz_{t-k}, CIV_{t-1}]'$;

ϕ_0 and ψ_d are scalars and ϕ_i , i = 1,2 are 1 x k^* vector of coefficients, $k^* = p + q + r + s + k$. The test consists of a hypothesis contrast, using the F statistic, in which the null for linearity is set as the coefficients of ϕ_2 and Ψ_d are zero λ_2, λ_3 and λ_4 are zeros. This test is performed for each possible TV_{t-d}. With this test we cannot perform nested hypothesis tests for model selection. However, both models can be estimated and the final model can be chosen based on a forecast evaluation. In the particular case of investigating nonlinearities of the investment equation on financial factors, the theory suggests the use of a logistic model. Therefore, we restrict estimation to this kind of model and without any complication for model selection when using the augmented first order linearity test.[27]

from a full coefficient or unrestricted VEC model accounting for those especial events that the new dummies attempt to control for.

25 One problem encountered when specifying an unrestricted VEC model using the Venezuelan data is related to the lag length selection. Both SIC and AIC suggest a VAR in levels with one lag or its corresponding VEC with no lags. However, it is observed that when estimating the unrestricted VEC with a higher number of lags that significant coefficients are not uniform with respect to the lag length for the lagged values of each variable in each regression in the VEC model. The main problem in continuing with an unrestricted VEC with lag length selected arbitrarily, say four lags, is the presence of too many insignificant coefficients. The price of too many insignificant coefficients is higher variance and consequently imprecise impulse response functions. But proceeding with too short a lag specification may lead us to conclude that a variable, or variables, does not affect the others because of a misspecification in the lag order for such a variable. Thus, it may be preferable to choose the lag length arbitrarily, which we set equal to 4, and estimate with a restricted-in-coefficients version or subset VEC model. An early proponent of subset VAR is Hsiao (1981), who proposes a procedure for choosing, different number of lags for each variable in the VAR based on the final prediction error (FPE) criterion. McMillin (1985) applies a subset VAR to investment in the United States. Lütkepohl (1993, Chapter 5), discusses specification procedures, advantages, and disadvantages for restricted VAR, which are also applicable to a VEC.

26 E-views is used for all computational procedures but the impulse response functions. In this case, we use GAUSS.

27 In general, third order linearity test proposed by Luukkonen et al (1988), which is based on the following multivariate auxiliary regression. However, in a multivariate context the auxiliary regression contains 1 + 4*k** parameter estimates, which in small samples implies the use of too many degrees of freedom.

Table 5.1

Venezuela: estimated subset VEC model for private investment and its determinants

Period 1984:3–2000:4

	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$	
	Coeff.	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**
C	–0.273	–6.844	–0.004	–0.601	0.008	1.308	–0.115	–8.181	–0.563	–9.858
DS2	0.575	5.722	–	–	–	–	0.175	7.013	0.866	8.197
DS3	–	–	0.028	1.969	0.020	1.750	0.142	8.218	0.804	10.613
DS4	0.422	6.231	–	–	–0.043	–3.720	0.191	8.745	0.737	8.533
D861									0.359	5.705
D891					–0.211	–12.417				
D942					–0.098	–4.124				
D944			–0.246	–7.220						
D962			–0.230	–6.853						
DPC	–	–	–	–	–	–	–	–	–	–
$DLPRIVINV_{t-1}$	–0.321	–3.669	–	–	–	–	0.043	2.211	–	–
$DLPRIVINV_{t-2}$	–0.190	–2.157	–	–	–	–	–	–	–	–
$DLPRIVINV_{t-3}$	–	–	–	–	–	–	0.079	4.528	0.182	2.634
$DLPRIVINV_{t-4}$	–0.304	–3.591	–	–	–	–	–	–	0.157	2.090
$DDLCREDIT_{t-1}$	0.520	2.881	–0.201	–2.776	–0.103	–2.682	–	–	–0.270	–1.730
$DDLCREDIT_{t-2}$	–	–	–	–	–0.117	–3.041	–	–	–	–
$DDLCREDIT_{t-3}$	–	–	–0.158	–2.230	–0.087	–2.266	–	–	–	–
$DDLCREDIT_{t-4}$	–	–	–	–	–0.069	–1.849	–	–	–	–
$DRIQ_{t-1}$	–	–	0.294	2.436	–	–	–	–	0.873	3.475
$DRIQ_{t-2}$	–	–	–	–	–	–	–	–	1.184	4.613
$DRIQ_{t-3}$	–0.783	–2.581	–	–	–0.184	–2.901	–	–	–0.542	–1.926
$DRIQ_{t-4}$	–	–	–	–	–	–	–0.151	–2.331	–0.661	–2.524
$DLPRIVGDP_{t-1}$	1.876	3.800	–	–	–	–	–0.206	–2.141	1.992	5.105
$DLPRIVGDP_{t-2}$	1.115	2.764	–	–	0.231	2.629	–	–	1.702	4.806
$DLPRIVGDP_{t-3}$	2.420	5.521	–0.397	–3.377	–0.228	–2.537	–	–	–	–
$DLPRIVGDP_{t-4}$	–	–	–	–	–	–	–0.189	–1.928	–1.509	–3.999
$DLPUBINV_{t-1}$	0.172	1.787	–	–	0.045	4.276	0.082	4.098	–0.350	–4.388
$DLPUBINV_{t-2}$	–0.279	–4.566	–	–	–	–	0.064	3.554	–0.136	–1.917
$DLPUBINV_{t-3}$	–	–	–	–	–	–	0.085	4.826	–0.178	–2.669
$DLPUBINV_{t-4}$	–	–	–	–	–	–	–	–	–	–
CIV	–	–					–0.036	–2.841	–0.174	–3.493

Table 5.1 (cont)

Venezuela: estimated subset VEC model for private investment and its determinants

Period 1984:3–2000:4

	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$	
	Coeff.	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**
R^2adj.		0.482		0.647		0.738		0.763		0.917
Q(1)		0.121		0.474		1.547		1.020		0.346
Q(4)		1.064		2.422		5.489		3.158		3.835
Qsr(1)		1.678		0.416		0.169		0.867		1.517
Qsr(4)		4.032		1.371		0.405		4.866		2.515
Hausman				–0.196						0.756
JB		2.076		2.645		1.652		2.278		0.092

Notes: The restricted VEC model is estimated using seemingly unrelated regressions (SUR). R^2 adj. is the adjusted R^2. Q(i) (Qsr(i)) is the Ljung-Box Q-statistic for the *i*th lag of the residuals (squared of residuals). JB accounts for the Jarque-Bera statistic for normality. JB is distributed as a χ^2 with two degrees of freedom. The Q-statistics are distributed as χ^2 with *i* degrees of freedom. The critical values for $\chi^2_{I,0.05}$ ($\chi^2_{i,0.1}$), for *i* = 1 and 4 are 3.84 and 9.49 (2.71 and 7.78) respectively. CIV denotes the cointegrating vector. Hausman corresponds to the t-statistics for the Hausman test. The Hausman test is performed for the credit and public investment equations. Due to the way interest rates are calculated in this research (see Mendoza Lugo (2001, Appendix A) RIQ_{t-1} contains information for one month of quarter *t*, then there exists the possibility that $DRIQ_{t-1}$, which enters in the credit and public investment equations, is an endogenous variable. For the Hausman test: (i) $DRIQ_{t-1}$ is regressed on the right hand side variables of each of the above-mentioned equations plus the variables on the right hand side of the interest rate equation (all of them lagged one period); contemporaneous variables to $DRIQ_{t-1}$ are omitted from the regression; (ii) the residuals from the estimated interest rate equation are retrieved; and (iii) the credit or public investment equation augmented for the residuals from the previous step is estimated. The Hausman statistic is the t-statistic on the estimated coefficient for the residuals obtained from the interest rate equation. If the estimated coefficient is not statistically different from zero, we must conclude that $DRIQ_{t-1}$ is not an endogenous variable. The test statistics do not indicate evidence for endogeneity in $DRIQ_{t-1.}$

Weise (1999) introduces a linearity test for a multiple-equation framework. This is a likelihood ratio test. Instead of a first order test extended to a multiple-equation framework proposed by Weise, we use a multi-equation version of the augmented first order test and correct for small sample bias.[28]

Table 5.2 reports the results of the linearity tests for each equation, the F test, and for the whole system, the LR test. The first 10 columns show the linearity test statistics and their respective P-values for each dependent variable described at the top of the table. The last two columns contain information about the LR statistics for each transition variable and their

[28] Due to the cumbersome joint tests for no cointegration and linearity against cointegration and nonlinear (threshold) specification, where not only nostationarity and nuisance parameters are present under the null but there is also a large class of nonlinear (threshold) specifications, Balke and Fomby (1997) suggest breaking up this analysis into two parts. These are: (i) a test for cointegration; and (ii) a test for nonlinear behavior. An important argument in favor of this separation is that standard time series analysis for linear cointegration is asymptotically valid for the threshold cointegration because the order of integration is not affected by a threshold specification. From a Monte Carlo experiment, they find that no serious problems arise when testing for cointegration using a linear misspecified model. Van Dijk and Franses (1995) use the same procedure to estimate a smooth transition vector error correction model. For other references on threshold and smooth transition EC models, see Franses and van Dijk (2000), page 133.

respective P-values. The LR test suggests the use of DLCREDIT as the transition variable. It reports low P-values for delays of 1, 2, and 4 being the lowest one for $DLCREDIT_{t-1}$. The LR test also reports P-values lower than 5% when DRIQ and DLPRIVGDP are the transition variables with delays of 4 and 1 respectively. On the other hand, the F test does not always suggest using as the transition variable the same variable indicated by the LR test. For instance, the LR test indicates $DLCREDIT_{t-2}$ as a good choice when searching for a common transition variable and delay parameter. However, the F test in the equation for DLPRIVGDP reports a P-value of 0.941, which suggests that the use of $DLCREDIT_{t-2}$ as transition variable may not be a good choice to explain the potential nonlinearity in the output equation, even though this equation is estimated in a multi-equation context.

The F test reports evidence against linearity in all five equations. In the private investment equation, linearity is rejected at the 5% significance level when $DLCREDIT_{t-1}$ and RIQ_{t-4} are the transition variables. For the remaining four equations, only in the output equation does the test fail to reject linearity when financial variables are used as transition variables. However, the test rejects linearity in the output equation when $DLPUBINV_{t-4}$ is the transition variable. In addition, the linearity test for each single equation does not report evidence for the use of a unique transition variable and delay parameter in all equations.

Teräsvirta (1994), following Tsay (1989), recommends choosing the delay parameter, d, in the univariate model as the value with the minimum P-value. Generalizing this decision rule to a multivariate context, it should be to choose the transition variable, TV, and the delay parameter d; that is, TV_{t-d}, as the dth order lagged variable with the minimum P-value. We could also select, among the potential TVs with tests reporting P-values lower than 5%, each variable with the lowest P-value for each potential TV and proceed to estimate the model for each of these candidates and then make the final selection based on specification tests. We explore this possibility by attempting to estimate the nonlinear model equation by equation using as TVs all possible candidates with F tests reporting a P-value lower or equal than 5%. We also attempt to estimate the nonlinear model, within a system procedure, using the same transition variable for all equations as suggested by Weise (1999) according to the LR test. The next subsection explains in detail the estimation procedure for the nonlinear model.

Table 5.2

Venezuela: linearity test using the estimated subset VEC model as benchmark

Transition variable	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$		SYSTEM	
	F-stat.	P-val.	F-stat.	P-val.	F-stat.	P-val.	F-stat.	P-val.	F-stat.	P-val.	LR-stat.	P-val.
$DLPRIVINV_{t-1}$	1.277	0.276	0.551	0.737	0.360	0.947	1.326	0.252	1.546	0.157	57.452	0.219
$DLPRIVINV_{t-2}$	0.735	0.699	0.613	0.691	0.759	0.654	0.996	0.464	1.015	0.470	41.227	0.807
$DLPRIVINV_{t-3}$	1.650	0.125	1.233	0.308	0.695	0.709	1.947	0.068	0.231	0.998	58.078	0.202
$DLPRIVINV_{t-4}$	1.164	0.344	1.306	0.277	0.611	0.780	1.996	0.062	0.720	0.745	59.976	0.158
$DDLCREDIT_{t-1}$	0.908	0.542	0.609	0.693	1.690	0.124	0.692	0.726	0.920	0.554	43.933	0.714
$DDLCREDIT_{t-2}$	0.651	0.773	1.076	0.385	1.452	0.200	0.476	0.895	1.665	0.121	50.648	0.448
$DDLCREDIT_{t-3}$	0.782	0.656	0.673	0.646	1.024	0.438	0.740	0.682	0.674	0.786	42.725	0.758
$DDLCREDIT_{t-4}$	1.311	0.257	1.257	0.298	0.451	0.898	0.912	0.532	0.549	0.888	45.014	0.673
$DRIQ_{t-1}$	0.694	0.735	0.176	0.970	1.044	0.424	0.802	0.628	0.853	0.617	43.830	0.718
$DRIQ_{t-2}$	1.493	0.176	1.253	0.299	1.198	0.324	1.903	0.075	2.153	**0.040**	66.501	0.059
$DRIQ_{t-3}$	1.174	0.338	1.062	0.393	3.942	**0.001**	0.933	0.514	1.046	0.444	64.561	0.081
$DRIQ_{t-4}$	1.535	0.160	2.127	0.078	1.527	0.173	0.990	0.469	0.729	0.736	68.767	**0.040**
$DLPRIVGDP_{t-1}$	1.314	0.255	1.221	0.313	4.340	**0.001**	1.342	0.244	0.761	0.705	68.972	**0.039**
$DLPRIVGDP_{t-2}$	1.288	0.270	1.132	0.356	2.460	**0.025**	0.660	0.753	1.060	0.432	57.201	0.225
$DLPRIVGDP_{t-3}$	0.334	0.972	1.043	0.403	1.121	0.371	0.417	0.930	1.325	0.254	53.271	0.350
$DLPRIVGDP_{t-4}$	0.981	0.481	0.249	0.939	1.622	0.143	1.092	0.393	1.087	0.411	56.573	0.243
$DLPUBINV_{t-1}$	1.750	0.100	1.020	0.416	4.180	**0.001**	0.745	0.678	0.914	0.559	56.082	0.257
$DLPUBINV_{t-2}$	1.016	0.452	0.938	0.465	0.810	0.610	1.204	0.320	0.814	0.655	46.310	0.622
$DLPUBINV_{t-3}$	0.735	0.698	0.357	0.875	0.721	0.687	1.905	0.075	2.322	**0.027**	61.843	0.122
$DLPUBINV_{t-4}$	1.031	0.440	0.112	0.989	4.164	**0.001**	2.227	**0.037**	0.492	0.924	64.271	0.084
$DLCREDIT_{t-1}$	2.088	**0.047**	3.919	**0.005**	1.901	0.081	1.116	0.376	1.372	0.230	87.865	**0.001**
$DLCREDIT_{t-2}$	1.118	0.375	3.169	**0.015**	3.763	**0.002**	0.395	0.941	2.146	**0.041**	76.466	**0.009**
$DLCREDIT_{t-3}$	1.227	0.304	3.438	**0.010**	2.210	**0.042**	0.491	0.885	0.458	0.942	61.725	0.124
$DLCREDIT_{t-4}$	2.013	0.055	2.777	**0.028**	1.008	0.451	1.206	0.318	1.031	0.457	75.493	**0.011**
RIQ_{t-1}	1.836	0.083	1.282	0.287	0.989	0.465	0.926	0.521	0.559	0.880	45.504	0.654
RIQ_{t-2}	0.719	0.713	2.725	**0.030**	1.187	0.330	1.176	0.336	0.700	0.763	47.885	0.559
RIQ_{t-3}	0.869	0.577	0.859	0.516	2.055	0.059	0.765	0.660	1.528	0.164	65.158	0.073
RIQ_{t-4}	2.532	**0.017**	1.378	0.249	2.187	**0.044**	0.949	0.501	0.705	0.758	67.361	0.051

Notes: P-values lower than 5% are reported in dark numbers.

5.3 Estimation procedure for the logistic STVEC model

Due to the lack of evidence for estimating the logistic STVEC (LSTVEC) model for a single TV_{t-d}, the nonlinear system is estimated equation by equation and then the five equations are put together and the logistic STVEC (LSTVEC) model is re-estimated using SUR. We start the estimation procedure by performing a two-dimensional grid search for the transition parameter, c, and the smooth parameter, γ, using as TV_{t-d} all possibilities in Table 4.3 that are associated with linearity tests having P-values lower than 5%. Previously, the argument of the transition function, $F(TV_{t-d})$, is rescaled downward by dividing by the standard deviation of TV_{t-d} as recommended by the estimation of the logistic model when the smooth parameter is large. This rescaling helps the computing process in the model estimation. See for instance, Granger and Teräsvirta (1993), page 123.[29]

We arrange the values of TV_{t-d} in ascending order and divide the range of values taken by that variable into 10 intervals, which gives 11 grid values. We assure all intervals contain information by discarding atypical observations from the range of values for TV_{t-d}. The search for the transition parameter, c, is performed for the nine grids located between both extremes. The search for the smooth parameter, γ, consists of 25 values from 1 to 49 augmenting two by two. For those cases where γ is located in the upper extreme, a new search is made for higher values of γ. Thus, there are at least 225 combinations for c and γ in each two-dimensional grid search. We select that combination of c and γ reporting the maximum log-likelihood.[30]

Those cases where the log-likelihood takes the maximum value for c located in any of the extremes of the range of values for the transition variable are ruled out.[31] We proceed using only those cases where the value of c maximizing the log-likelihood is located between the third and eighth grid values. The best value of c should be a value of TV_{t-d} located in some part within the middle of its observed range of values such that it guarantees both regimes contain enough observations for reliable estimates of the coefficients.

With starting values from the two-dimensional grid search, the parameter γ is allowed to vary while c is fixed to the value obtained in the previous step. Once γ is estimated, a new grid search is performed; this time only for the parameter c. Next, with starting values from the previous step, γ is allowed to vary again. Finally, we allow all parameters to vary setting initial values from the previous step. In each step involving the estimation of γ or the joint

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[29] In previous work, we tried to estimate the nonlinear model by performing a grid search for the transition parameter, c, and fixing the standardized smooth parameter, γ, equal to the standard deviation of TV_{t-d}. However, in most of the cases the value of c maximizing the log-likelihood was located at the extremes of the range of values taken by the transition variable. Such a result suggests that the equation is linear or the value given to γ is not the most adequate.

[30] Other alternative measures of fit are AIC, SIC, and R^2, obtaining similar results.

[31] Within a two-dimensional grid search, a transition parameter taking values in any of the extremes of the range of values of the transition variable is probably a consequence of the presence of outliers. A problem facing the linearity tests for smooth transition models is that they may be biased toward rejecting the null hypothesis due to the presence of outliers. See for instance, Franses and van Dijk (2000), page 105. In the present study, some alternatives for TV_{t-d} are discarded when the transition parameter is found in the extreme values of the range of TV_{t-d} when performing the two-dimensional grid search. The discarded choices for TV_{t-d}, in the credit equation, are all lagged DLCREDIT, but $DLCREDIT_{t-3}$. In addition, RIQ_{t-4}, $DRIQ_{t-2}$, and $DLPUBINV_{t-4}$ are rejected as TV_{t-d} in the equations for DRIQ, DLPUBINV, and DLPRIVGDP. Since the linearity test does not indicate other possible TV for the output growth equation, then this equation is treated as linear. Moreover, information for the estimated equation for DDLCREDIT under the assumption that RIQ_{t-2} is TV_{t-d} is not reported in Table 4.3 since a unique solution for this alternative was not found.

estimation of γ and c, each equation is estimated using nonlinear least squares (NLS). The estimated coefficients $\hat{\gamma}$ and $\hat{c}$ for each equation are reported in Table 5.3.[32]

Fixing the parameters c and γ to those values obtained from the single equation procedure, the LSTVEC model is estimated, using SUR. To alleviate computing problems, insignificant coefficients on lagged variables are eliminated. As a second step, in theory, all coefficients are allowed to vary using the estimated coefficients from the previous step as initial values. However, some computing problems, which may be associated with the estimation of logistic models in small samples and large adjustment parameters, as is the case in general for the logistic smooth transition (LSTR) models, leads us to seek the maximum number of smooth and transition parameters that can be jointly estimated while fixing the remaining ones to those values obtained from the estimation for each single nonlinear equation.

We evaluate three combinations of transition variables and delay parameters in order to proceed to the estimation of the LSTVEC model. These three options are illustrated in Table 5.4. In Option 1 we allow for the same transition variable. In this case it is DLCREDIT but allowing for different delay parameters. Option 2 is selected according to the TV_{t-d} associated with the higher log-likelihood value for each nonlinear equation. Finally, Option 3 differs from Option 2 only in the TV_{t-d} chosen for the private investment equation. In this case, RIQ_{t-4} is used as TV_{t-d}. This option is taken into account because the log-likelihood values are only slightly different from the case when $DLCREDIT_{t-1}$ is TV_{t-d} (see Table 5.3). The final specification(s) for the LSTVEC model will be chosen based on diagnostic tests on the residuals and long-run dynamic evaluation.

32 Teräsvirta (1998), page 527, recommends the use of a two-dimensional grid search to get reasonable starting values for the NLS estimation and to reduce the size of the model by imposing exclusion restrictions.

Table 5.3

Venezuela: summary of the estimation of each single nonlinear equation for each potential TV

	$\hat{\gamma}$	**T-stat.**	$\hat{c}$	**T-stat.**	**P-value, F-test** $(\theta_2^{'} = 0)$	**Loglk**
TV for DLPRIVINV Equation						
$DLCREDIT_{t-1}$	37.543	0.560	0.006	1.228	0.094	66.056
RIQ_{t-4}	44.156	1.122	0.034	19.040	0.400	65.956
TV for DDLCREDIT Equation						
$DLCREDIT_{t-3}$	65.438	0.236	0.036	5.374	0.000	120.467
TV for DRIQ Equation						
$DRIQ_{t-3}$	33.127	0.679	0.036	5.141	0.036	173.960
$DLPRIVGDP_{t-1}$	33.102	0.955	0.014	2.313	0.004	175.100
$DLPRIVGDP_{t-2}$	–3.046	–0.944	0.021	0.897	0.937	167.577
$DLPUBINV_{t-1}$	6.963	0.530	–0.076	–0.563	0.045	172.317
$DLPUBINV_{t-4}$	92.768	0.188	0.132	12.437	0.001	178.846
$DLCREDIT_{t-2}$	60.176	0.467	–0.013	–4.341	0.438	162.068
$DLCREDIT_{t-3}$	84.711	0.308	–0.049	–1.911	0.074	167.728
TV for DLPUBINV Equation						
$DLPUBINV_{t-3}$	10.672	0.944	–0.046	–0.978	0.020	97.364
$DLCREDIT_{t-2}$	3.221	1.992	–0.053	–2.068	0.368	92.275

Notes: Loglk denotes log-likelihood. F-test $(\theta_2^{'} = 0)$ is the test of whether the estimated coefficients accompanying the transition function in each single equation are jointly equal to zero. It tests for the specification of the LSTR models against a linear specification. However, when the equations are estimated in a system, in particular for DLPRIVINV and DLPUBINV equations with RIQ_{t-4} and $DLCREDIT_{t-2}$ as TV_{t-d}, and insignificant coefficients are dropped from the system applying a LR test, there is no evidence that all those coefficients are equal to zero. Even though the t-statistics for the estimated coefficients *c* and γ are reported in this table, the lowest t-statistics cannot be interpreted as evidence for linearity. A precise estimation of γ needs many observations around *c* and becomes more difficult when this parameter is large. See for instance, Franses and van Dijk (2000), page 91 and Granger and Teräsvirta (1993), page 123. Another element we should consider is that these parameters are not identified under the null hypothesis of linearity (Davies problem), so they do not follow the standard distribution.

Table 5.4

Venezuela: estimation options for the nonlinear system according to the selection of transition variables

	Transition variables		
Equation for:	**Option 1**	**Option 2**	**Option 3**
$DLPRIVINV_t$	$DLCREDIT_{t-1}$	$DLCREDIT_{t-1}$	RIQ_{t-4}
$DDLCREDIT_t$	$DLCREDIT_{t-3}$	$DLCREDIT_{t-3}$	$DLCREDIT_{t-3}$
$DRIQ_t$	$DLCREDIT_{t-3}$	$DLPUBINV_{t-4}$	$DLPUBINV_{t-4}$
$DLPUBINV_t$	$DLCREDIT_{t-2}$	$DLPUBINV_{t-3}$	$DLPUBINV_{t-3}$

After estimation, we evaluate each of the three specifications. For such purposes, we use diagnostic tests on the residuals and evaluate the long-run properties while computing impulse response functions.[33] Only in Option 1 is convergence achieved. Options 2 and 3 are discarded because they are globally unstable. How the impulse response functions are computed is the subject of the next section. A diagnostic test is performed on the residuals of Option 1. We apply the F test version of the LM serial correlation test proposed by Eitrheim and Teräsvirta (1996) in the four nonlinear equations. This test can be seen as a generalization of the Breusch and Pagan LM test for autocorrelation for linear specifications (Franses and van Dijk (2000), page 110). In addition, the Jarque-Bera normality test and the Engle's ARCH-LM test are applied to all five equations.[34] All equations passed diagnostic tests except the credit equation, which presented serial correlation. Adding own lag values omitted in the linear specification, $DDLCREDIT_{t-2}$ and $DDLCREDIT_{t-4}$, solves serial correlation, in the credit equation. The residuals of this equation also present an important outlier in 1989:1, the period of implementation of the structural reform program. Thus, D891 was included to control for this effect. Under the new specification all equations pass the diagnostic test. The statistics for these tests are reported in the bottom of Table 5.5.

[33] The evaluation of the long-run dynamic of smooth transition models cannot be done analytically. A numerical solution is instead recommended. See Teräsvirta et al (1994), page 2945 and Granger and Teräsvirta (1993), page 128. Also, we can evaluate the dynamic properties of the model when computing the impulse responses. That is, if the effects of a shock die out, this implies the model is stationary.

[34] Eitrheim and Teräsvirta (1996) do not recommend using the Ljung-Box Q-statistic to analyze the residuals of smooth transition models because its distribution is unknown under the null. Eitrheim and Teräsvirta also propose a test for remaining nonlinearity and parameter constancy for smooth transition models. However, because of data limitations and the large number of additional parameters to be estimated in this research, their application is impractical.

Table 5.5

Venezuela: estimated logistic smooth transition subset vector error correction (LSTVEC) model for private investment and its determinants with lagged rate of growth of real stock of credit used as transition variable (Option 1)

Period 1984:3–2000:4

	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$	
	Coeff.	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**
C1	–0.300	–8.719	–0.002	–0.385	0.013	2.281	–0.112	–7.798	–0.515	–14.110
DS2	0.582	6.843	–	–	–	–	0.171	6.755	0.897	13.401
DS3	–	–	0.026	2.347	0.041	3.495	0.141	8.001	0.917	14.237
DS4	0.481	8.110	–	–	–0.036	–3.078	0.185	8.277	0.666	13.768
D861	–	–	–	–	–	–	–	–	0.346	7.159
D891	–	–	–0.089	–3.635	–0.220	–13.853	–	–	–	–
D942	–	–	–	–	–0.077	–3.388	–	–	–	–
D944	–	–	–0.237	–9.846	–	–	–	–	–	–
D962	–	–	–0.296	–10.003	–	–	–	–	–	–
$DLPRIVINV_{t-1}$	–0.500	–4.644	–	–	–	–	0.043	2.190	–	–
$DLPRIVINV_{t-2}$	–	–	–	–	–	–	–	–	–	–
$DLPRIVINV_{t-3}$	–	–	–	–	–	–	0.080	4.446	0.832	4.853
$DLPRIVINV_{t-4}$	–0.194	–2.253	–	–	–	–	–	–	0.170	3.167
$DDLCREDIT_{t-1}$	0.523	3.213	–0.147	–2.362	–	–	–	–	–	–
$DDLCREDIT_{t-2}$	–	–	–0.088	–1.547	–0.085	–2.081	–	–	–	–
$DDLCREDIT_{t-3}$	–	–	–0.240	–3.597	–	–	–	–	–	–
$DDLCREDIT_{t-4}$	–	–	–0.074	–1.007	0.203	2.360	–	–	–	–
$DRIQ_{t-1}$	–	–	0.367	4.046	–	–	–	–	2.251	5.926
$DRIQ_{t-2}$	–	–	–	–	–	–	–	–	2.839	9.431
$DRIQ_{t-3}$	–0.706	–2.770	–	–	–0.150	–2.403	–	–	–	–
$DRIQ_{t-4}$	–	–	–	–	–	–	–0.149	–2.242	2.099	3.667
$DLPRIVGDP_{t-1}$	1.680	3.878	–	–	–	–	–0.220	–2.258	–	–
$DLPRIVGDP_{t-2}$	1.331	3.270	–	–	0.292	2.480	–	–	–	–
$DLPRIVGDP_{t-3}$	2.321	5.183	–0.201	–2.265	–0.153	–1.712	–	–	–	–
$DLPRIVGDP_{t-4}$	–	–	–	–	–	–	–0.167	–1.666	–	–
$DLPUBINV_{t-1}$	0.182	2.262	–	–	0.097	5.458	0.080	3.925	–	–
$DLPUBINV_{t-2}$	–0.389	–6.672	–	–	–	–	0.062	3.397	0.781	5.689
$DLPUBINV_{t-3}$	–	–	–	–	–	–	0.079	4.394	–	–
$DLPUBINV_{t-4}$	–	–	–	–	–	–	–	–	–	–

Table 5.5 (cont)

Venezuela: estimated logistic smooth transition subset vector error correction (LSTVEC) model for private investment and its determinants with lagged rate of growth of real stock of credit used as transition variable (Option 1)

Period 1984:3–2000:4

	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$	
	Coeff.	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**
CIV	–	–	–	–	–	–	–0.038	–2.924	–0.452	–4.790
C2 F(.)	–	–	–0.055	–2.936	–0.021	–2.687	–	–	–0.074	–1.741
$DLPRIVINV_{t-1}$ F(.)	0.471	2.940	–	–	–	–	–	–	–	–
$DLPRIVINV_{t-2}$ F(.)	–	–	–	–	–	–	–	–	–	–
$DLPRIVINV_{t-3}$ F(.)	–	–	–	–	–	–	–	–	–0.770	–3.823
$DLPRIVINV_{t-4}$ F(.)	–0.565	–2.973	–	–	–	–	–	–	–	–
$DDLCREDIT_{t-1}$ F(.)	–	–	–0.653	–3.252	–0.165	–2.708	–	–	–	–
$DDLCREDIT_{t-2}$ F(.)	–	–	–0.468	–2.145	–0.184	–2.168	–	–	–	–
$DDLCREDIT_{t-3}$ F(.)	–	–	0.341	2.436			–	–	–	–
$DDLCREDIT_{t-4}$ F(.)	–	–	0.080	0.638	–0.243	–2.570	–	–	–	–
$DRIQ_{t-1}$ F(.)	–	–	–3.674	–5.136	–	–	–	–	–3.662	–4.672
$DRIQ_{t-2}$ F(.)	–	–	–	–	–	–	–	–	–2.437	–4.069
$DRIQ_{t-3}$ F(.)	–	–	–	–	–0.251	–1.997	–	–	–	–
$DRIQ_{t-4}$ F(.)	–	–	–	–	–	–	–	–	–4.586	–4.456
$DLPRIVGDP_{t-1}$ F(.)	–	–	–	–	–	–	–	–	2.065	5.418
$DLPRIVGDP_{t-2}$ F(.)	–1.569	–2.187	–	–	0.196	1.752	–	–	2.172	5.234
$DLPRIVGDP_{t-3}$ F(.)	1.387	2.624	–	–	–	–	–	–	–	–
$DLPRIVGDP_{t-4}$ F(.)	–	–	–	–	–	–	–	–	–2.004	–5.123

Table 5.5 (cont)

Venezuela: estimated logistic smooth transition subset vector error correction (LSTVEC) model for private investment and its determinants with lagged rate of growth of real stock of credit used as transition variable (Option 1)

Period 1984:3–2000:4

	$DLPRIVINV_t$		$DDLCREDIT_t$		$DRIQ_t$		$DLPRIVGDP_t$		$DLPUBINV_t$	
	Coeff.	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**	**Coeff.**	**T-stat.**
$DLPUBINV_{t-1}$ F(.)	–	–	–	–	–0.075	–3.480	–	–	–0.377	–4.749
$DLPUBINV_{t-2}$ F(.)	0.312	2.492	–	–	–	–	–	–	–0.997	–5.957
$DLPUBINV_{t-3}$ F(.)	–	–	–	–	–	–	–	–	–0.346	–4.520
$DLPUBINV_{t-4}$ F(.)	–	–	–	–	–	–	–	–	–	–
CIV F(.)	–	–	–	–	–	–	–	–	0.392	2.835
$\hat{\gamma}$	33.295	0.819	65.438	(fixed)	87.711	(fixed)	–	–	3.110	3.792
$\hat{c}$	0.008	2.223	0.035	22.195	–0.049	(fixed)	–	–	–0.047	–5.366
R^2adj	0.600		0.789		0.788		0.767		0.949	
JB	1.067		4.009		0.404		1.982		1.484	
FAR(1)	0.001		2.449		0.541		1.298		0.064	
FAR(4)	0.325		1.048		0.541		0.722		0.117	
FARCH(1)	0.002		0.015		1.132		0.611		0.510	
FARCH(4)	0.369		0.753		0.466		0.851		1.159	

Notes: To calculate FAR(*i*), *i* = 1,4, missing observations at the beginning of the series of lagged residuals are replaced by zeros as recommended by Teräsvirta (1998), page 520. C1 and C2 denote the constant term in the linear and augmented part of each equation, respectively. R2 adj. is the adjusted R2. F(.) denotes the logistic smooth transition function. JB accounts for the Jarque-Bera statistic to test for normality. It is distributed as a χ^2_2. CIV denotes the cointegrating vector.

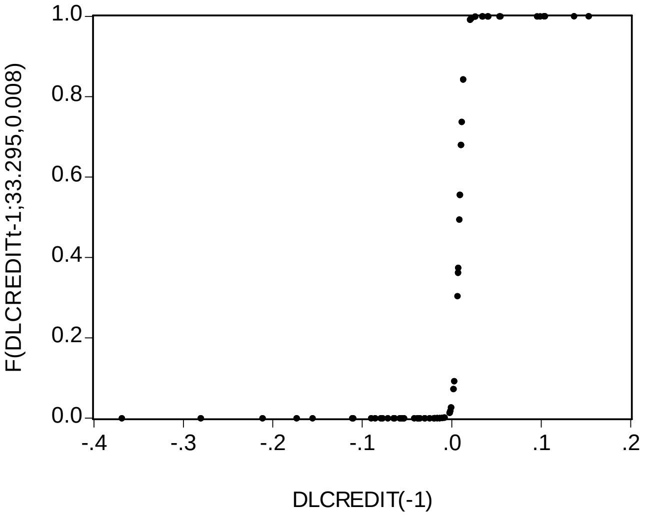
The estimated transition functions

Figures 5.1 and 5.2 depict the four estimated transition functions for Option 1. Transition is very fast from one regime to the other in all equations but public investment. In the credit and interest rate equations, with too few observations around the estimated transition parameters and a high speed of adjustment given by the estimated smooth parameters, the transition function takes mainly values of zero and one, indicating threshold specifications. The transition function for the private investment equation depicts a fast transition from the low to the high regime.

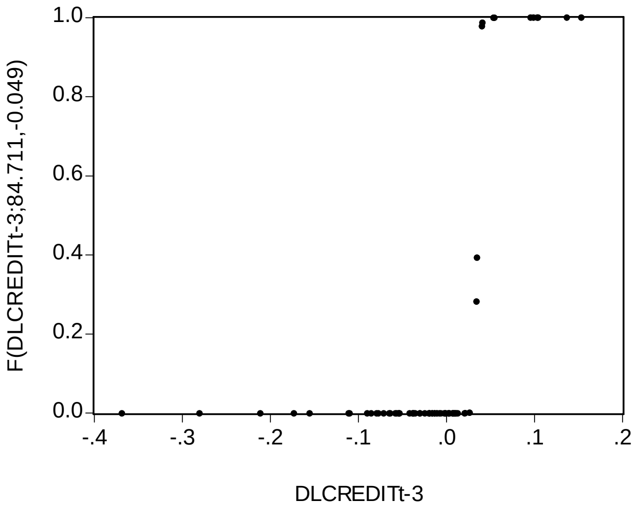
In the private investment equation, the estimated value of c = 0.008 – which is close to zero – allows the association of these two regimes to credit contraction (F(.) = 0) and credit expansion (F(.) = 1). However, this cannot be generalized to other equations in the system because estimated transition parameters close to zero are not observed in those equations. For instance, the estimated value of *c* has similar negative values, –0.047 and –0.049, in the public investment and interest rate equations respectively while it is positive and equal to 0.035 in the credit equation.

Figure 5.1

Private investment and credit equations: estimated logistic transition functions versus transition variables



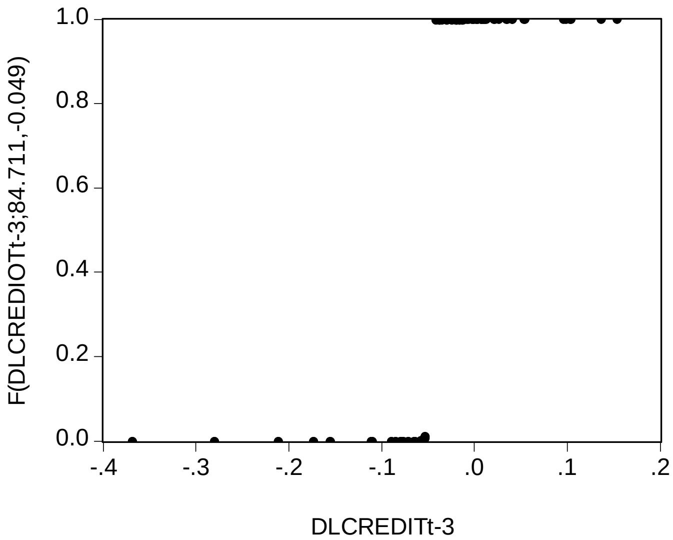
(a) Transition function for DLPRIVINV equation



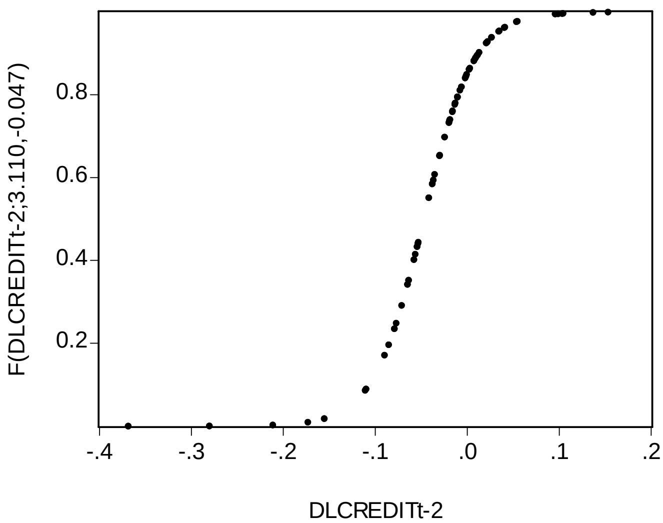
(b) Transition function for DDLCREDIT equation

Figure 5.2

Real interest rate and public investment equations: estimated transition functions versus transition variables



(c) Transition function for DRIQ equation



(d) Transition function for DLPUBINV equation

6. Testing for differential effects of real interest rates and credit availability on private investment

To investigate the differential effects of interest rates and credit availability on private investment, we compute generalized impulse response functions[35] using the Monte Carlo

[35] Generalized impulse response functions can be used for linear and nonlinear models. However, they are particularly recommended for computing the effect of shocks in one variable on the forecast of another

technique described in Koop et al (1996) and applied by Weise (1999) to study the asymmetric effects of monetary policy using data for the US. We explore how private investment responds to shocks of different sizes and signs and how different this response is when there is a credit contraction or expansion. In addition to shocks to financial variables, we also investigate how the growth rate of private investment responds to shocks to the growth rate of public investment, private GDP, and to its own growth rate.[36]

This section presents the impulse response functions for one-standard-error positive, negative, and average shocks.[37] Negative shocks are multiplied by minus one to make them comparable to the responses to one-standard-error shocks. We also compute impulse response functions to two-standard-error shocks and normalize them by dividing by two to make them comparable to the responses to one-standard-error shocks.

However, these results are not shown because, in general, we found similar impulse response functions to one-standard-error shocks.

6.1 Response of DLPRIVINV to shocks of different sign to DRIQ

Shocks to DRIQ have the opposite sign on DLPRIVINV. Figure 6.1 reports the effect of shocks of different signs to DRIQ on DLPRIVINV. This figure shows that DLPRIVINV is more responsive to negative shocks than to positive shocks to DRIQ, and this effect is stronger for both positive and negative shocks when the shock is caused in the low credit regime. At longer periods, a negative shock has a cumulative positive effect on DLPRIVINV, and this effect seems to be stronger when the shock occurs in the low credit regime. Positive shocks are also found to be stronger in the lower credit regime, but this effect, in absolute terms, is smaller than the effect of negative shocks to DRIQ.

6.2 Response of DLPRIVINV to shocks of different signs to DDLCREDIT

Figure 6.2 reports that positive shocks to DDLCREDIT have positive impacts on DLPRIVINV and that these impacts are stronger and less volatile when the economy is initially in the high credit regime. While negative shocks cause a contraction in DLPRIVINV in earlier periods, the cumulative response of DLPRIVINV to DDLCREDIT oscillates between positive and negative values in later periods. We interpret this last result as having no effect on the rate of growth of private investment.

When the economy is initially facing a credit contraction, in earlier periods, a negative shock to DDLCREDIT has a stronger effect on DLPRIVINV than a positive shock (see Figure 6.2.c). This result is mild evidence for a more responsive private investment to credit when credit restrictions are more severe, as the theory of financial liberalization predicts.

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variable when using a nonlinear model. Generalized impulse response functions take into account that in a nonlinear model impulse response functions depend on the initial conditions and on the sign and magnitude of the shocks.

[36] Structural shocks are identified using a Choleski decomposition following the order DLPUBINV, DLPRIVGDP, DLPRIVINV, DRIQ, DDLCREDIT. With this ordering, it is assumed that the government takes investment decisions based on the past information of private sector variables. Also, it is probable that DLPRIVGDP affects DLPRIVINV rather than the other way around in the short run. Since the correlation between DLPRIVINV and DRIQ is contemporaneously positive, then DLPRIVINV should affect DRIQ. The converse does not make theoretical sense even though we investigate whether the effects of the real interest rate on private investment can be positive given some economic conditions. A similar ordering is used for the ordering of DRIQ and DDLCREDIT. For more specific details on how the generalized impulse response functions are constructed in this study, see Mendoza Lugo (2001), Chapter IV.

[37] One-standard-error shock to these five variables, in the same order as is listed, are of the following size: 1.044, 1.074, 0.996, 1.178, and 1.018.

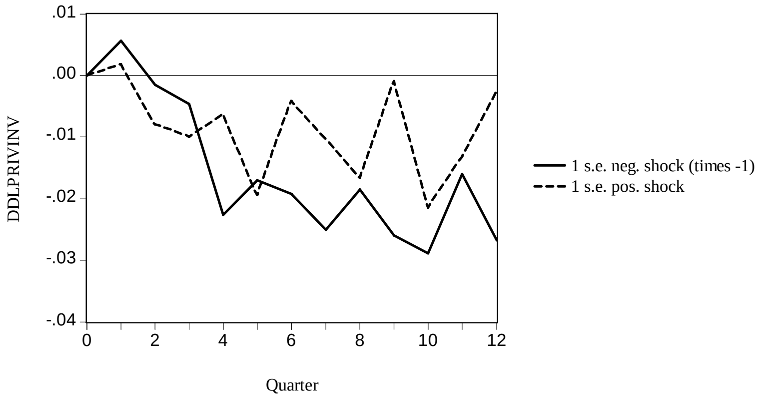
6.3 Response of DLPRIVINV to shocks of different signs to DLPUBINV

Shocks to DLPUBINV have opposite effects on DLPRIVINV. A negative shock to DLPUBINV has an important cumulative positive effect on DLPRIVINV up to period 12. Some asymmetries are observed after the third period between positive and negative shocks. That is, DLPRIVINV is more volatile with positive shocks and more responsive to negative shocks to DLPUBINV (Figure 6.3).

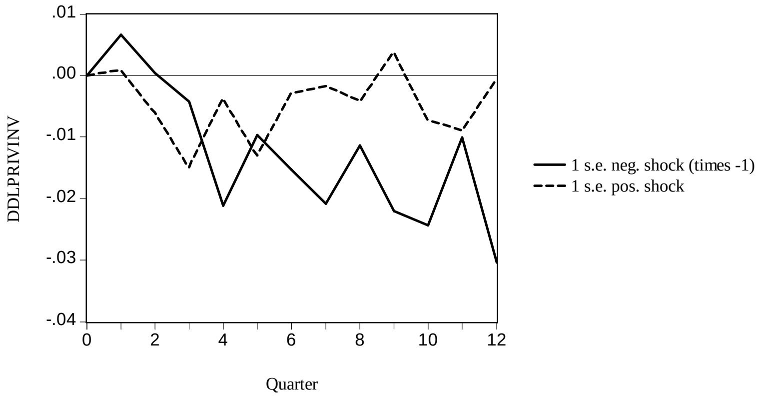
Figure 6.1

Venezuela: effects of one-standard-error positive and negative shocks to DRIQ on DLPRIVINV

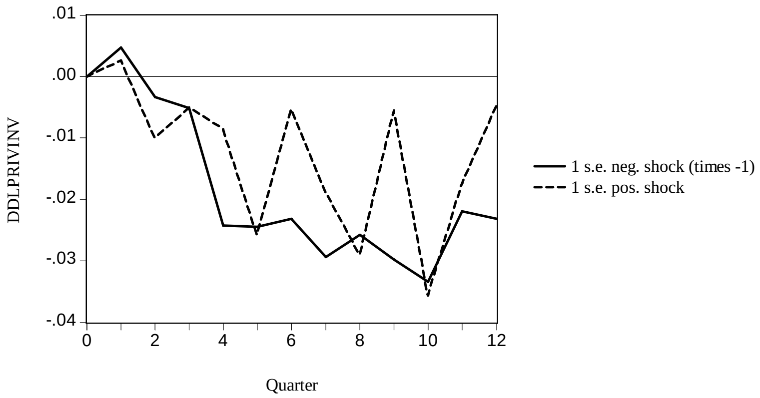
Total average and given the initial state of the economy



(a) Cumulative response of DLPRIVINV to DRIQ: Total average



(b) Cumulative response of DLPRIVINV to DRIQ: High credit regime

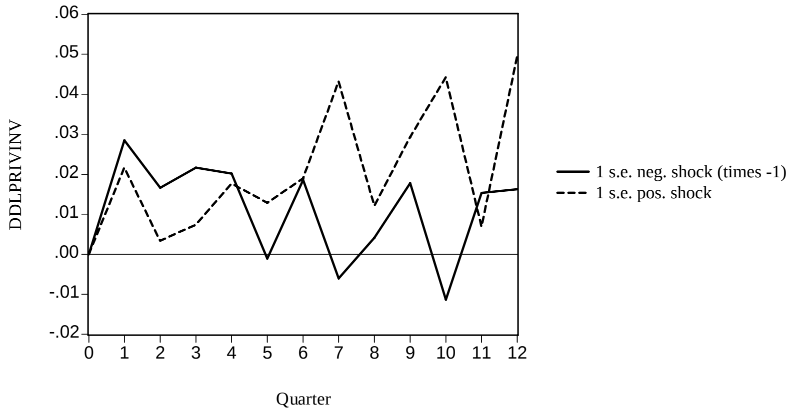


(c) Cumulative response of DLPRIVINV to DRIQ: Low credit regime

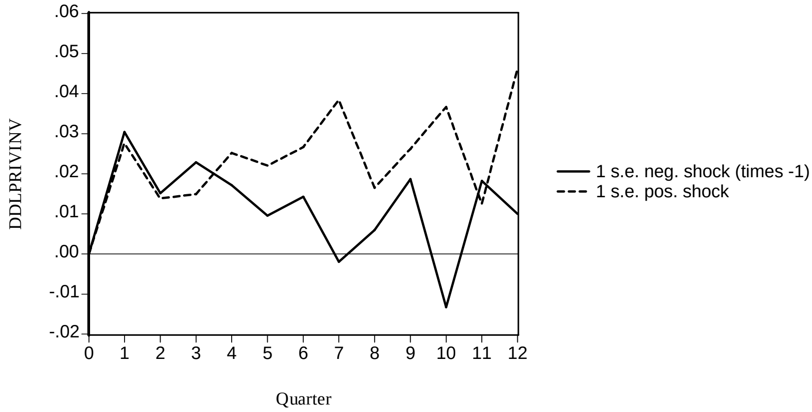
Figure 6.2

Venezuela: effects of one-standard-error negative and positive shocks to DDLCREDIT on DLPRIVINV

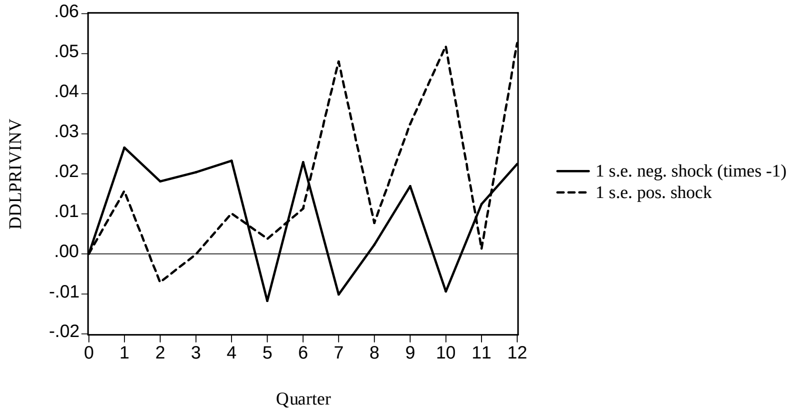
Total average and given the initial state of the economy



(a) Cumulative response of DLPRIVINV to DDLCREDIT: Total average



(b) Cumulative response of DLPRIVINV to DDLCREDIT: High credit regime

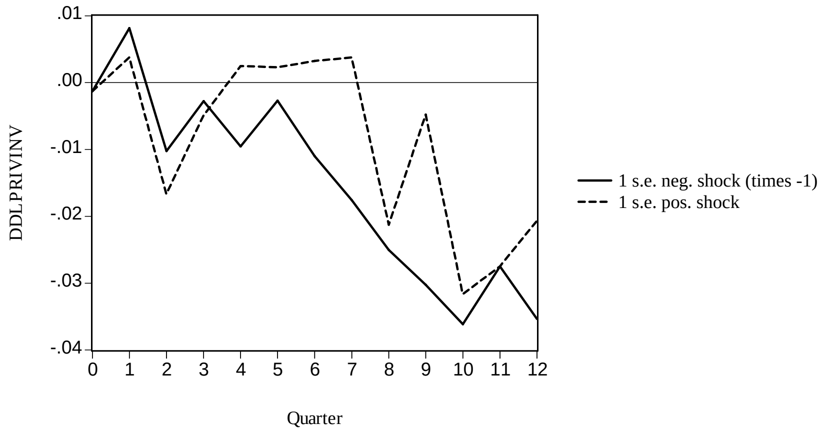


(c) Cumulative response of DLPRIVINV to DDLCREDIT: Low credit regime

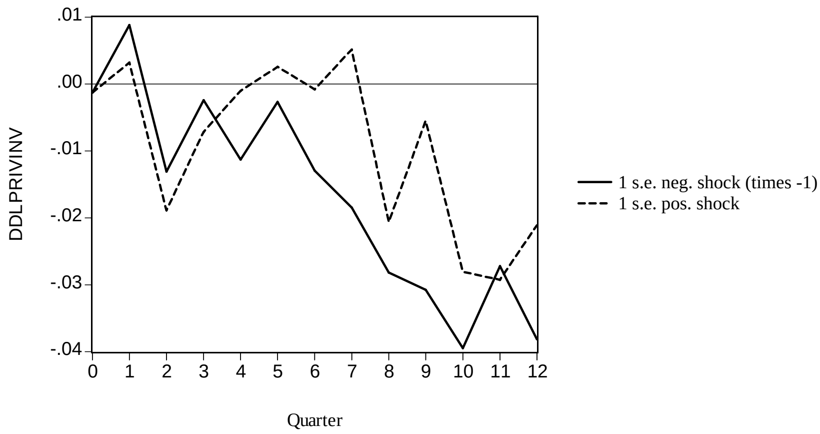
Figure 6.3

Venezuela: effects of one-standard-error positive and negative shocks to DLPUBINV on DLPRIVINV

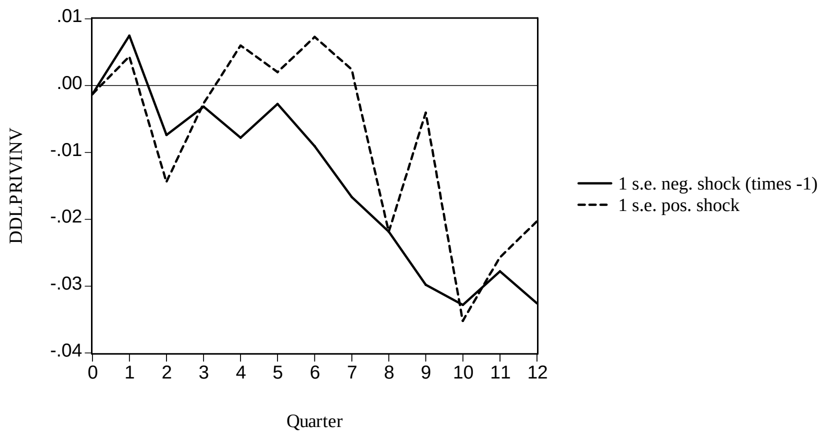
Total average and given the initial state of the economy



(a) Cumulative response of DLPRIVINV to DLPUBINV: Total average



(b) Cumulative response of DLPRIVINV to DLPUBINV: High credit regime



(c) Cumulative response of DLPRIVINV to DLPUBINV: Low credit regime

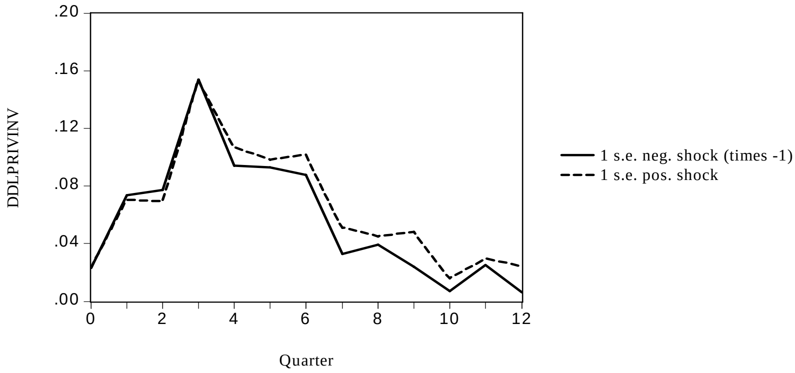
6.4 Responses of DLPRIVINV to shocks to DLPRIVGDP and DLPRIVINV

Even when private investment causes private GDP in the long run without causality observed in the opposite direction, impulse response functions of DLPRIVINV to shocks to DLPRIVGDP reveal this variable to be the most important determinant of private investment in the short run. A standard error shock to DLPRIVGDP causes a cumulative response in DLPRIVINV of 16% by the third period. After that period, this effect starts to decrease, achieving values near zero by the 12th period (Figure 6.4). Furthermore, DLPRIVINV has an important immediate response of the same sign to its own shocks. This, however, vanishes as time passes and reaches near zero by the 12th period (Figure 6.5). In both cases, responses are symmetric and independent of the initial state of the economy.

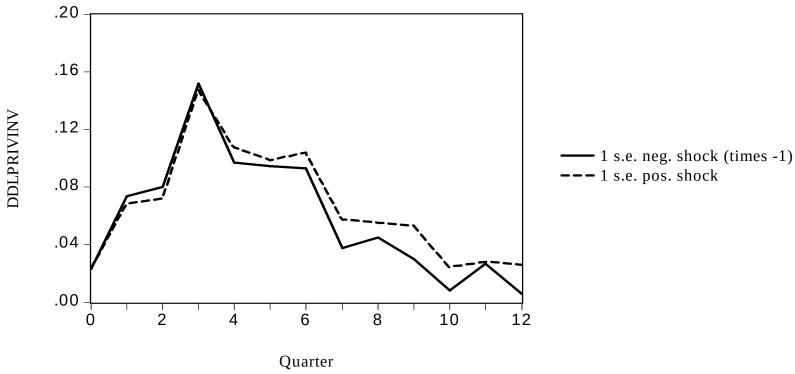
Figure 6.4

Venezuela: effects of one-standard-error positive and negative shocks to DLPRIVGDP on DLPRIVINV

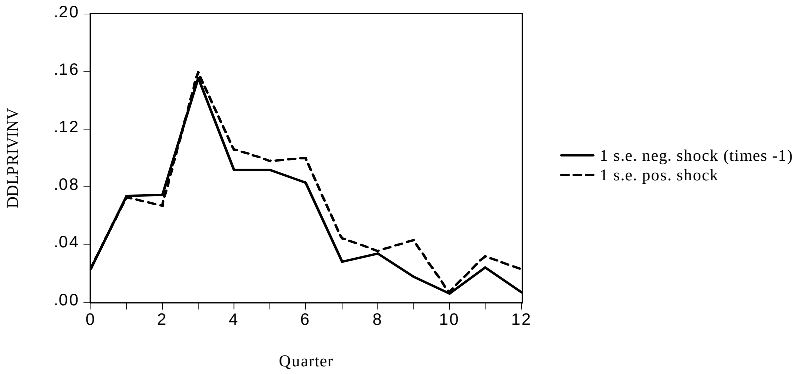
Total average and given the initial state of the economy



(a) Cumulative response of DLPRIVINV to DLPRIVGDP: Total average



(b) Cumulative response of DLPRIVINV to DLPRIVGDP: High credit

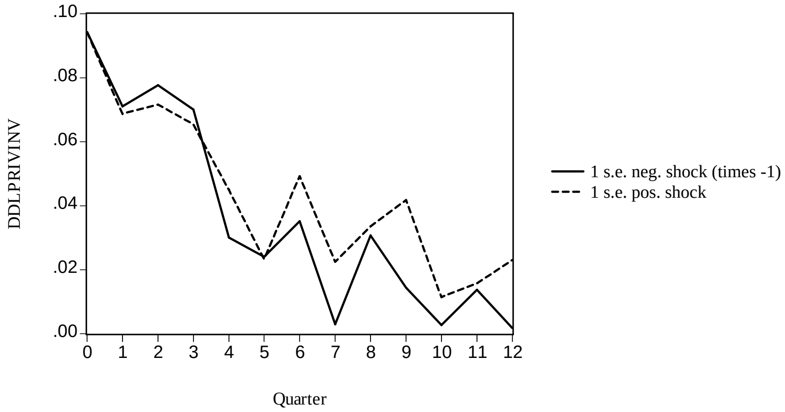


(c) Cumulative response of DLPRIVINV to DLPRIVGDP: Low credit

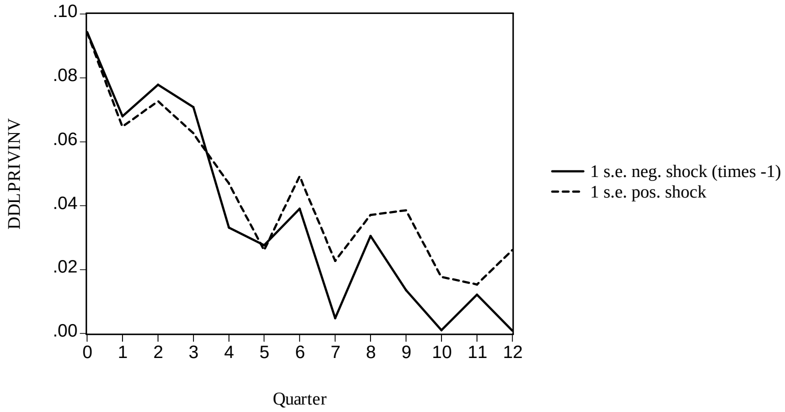
Figure 6.5

Venezuela: effects of one-standard-error positive and negative shocks to DLPRIVINV on DLPRIVINV

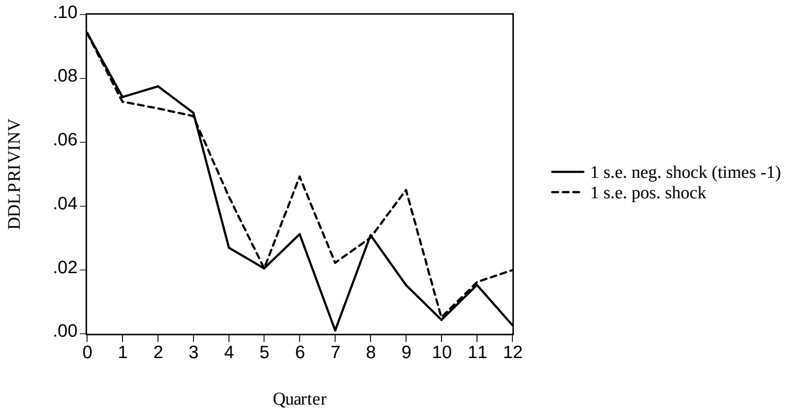
Total average and given the initial state of the economy



(a) Cumulative response of DLPRIVINV to DLPRIVINV: Total average



(b) Cumulative response of DLPRIVINV to DLPRIVINV: High credit regime



(c) Cumulative response of DLPRIVINV to DLPRIVINV: Low credit regime

7. Conclusions

Venezuela is a developing country that had very low average real interest rates in the past. Part of the period of study, 1983:1–1988:4, was characterized by administrative controls on nominal interest rates. Since 1989, more flexible interest rate policies have been adopted. According to the financial liberalization theory, we should expect that in those economies with very low or negative real interest rates, a positive shock to interest rates would cause a positive effect on private investment while the same effect is negative, according to the traditional theory, at higher rates. This theory suggests a nonlinear relationship between private investment and real interest rates with real interest rates describing the states of the economy. However, from the Venezuelan data we did not find evidence for using the real interest rate as a transition variable in a smooth transition logistic vector error correction (LSTVEC) model. Evidence was in favor of using lagged values of DLCREDIT as a transition variable. Under such a specification with two regimes – low credit and high credit – we have estimated the effects of shocks to changes in real interest rates, DRIQ, on the growth rate of private investment, DLPRIVINV. We should expect that in periods of credit contraction, a positive shock to real interest rates will have a positive effect on private investment. However, we did not find evidence for such an effect using Venezuelan data. In both regimes positive shocks to DRIQ have negative effects on DLPRIVINV, and this accumulated effect is more negative in the lower regime. Furthermore, the effect of positive shocks to DRIQ on DLPRIVINV is lower in absolute values than the response to negative shocks. Negative shocks to DRIQ on DLPRIVINV have a stronger cumulative effect when they start in the low regime.

Despite the fact that we have found evidence for asymmetric effects between positive and negative shocks to DRIQ on DLPRIVINV, those results do not support McKinnon's argument of positive shocks on DRIQ causing a rise in DLPRIVINV, even in periods of credit contraction.

In addition, the Venezuelan data provides evidence for an asymmetric response of DLPRIVINV to shocks in DDLCREDIT for immediate periods after a negative shock to credit when the economy is already facing credit contractions, as was expected. On the other hand, the cumulative response of DLPRIVINV to positive shocks to DDLCREDIT becomes bigger in later periods when the high credit regime prevails. Why investment is more responsive to negative shocks to interest rates when facing credit contraction and more responsive to positive shocks to DDLCREDIT when facing credit expansion is difficult to explain.

While the responses of the rate of growth of private investment to shocks to the rate of growth of private GDP and to its own shocks are symmetric, they emerge as the most important forces driving investment spending in the short run.

Furthermore, the fact that the cointegrating vector does not enter into the private investment equation tells us that the opposite effect on DLPRIVINV of shocks to DLPUBINV is temporal. This is evidence that public investment acts as a substitute for private investment in the Venezuelan economy. Public investment has a negative effect on private investment when the government competes with the private sector to obtain the resources to finance investment projects or when it provides goods that can be produced by the private sector. Shocks to DLPUBINV of opposite effect on DLPRIVINV invite us to study the effects of public investment policy in more detail using disaggregate data on public investment spending.

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