

Fiscal Reaction Function in Mexico: A structural change analysis

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Abstract

The sustainability of fiscal policy as it is applied in Mexico is examined by estimating a fiscal reaction function that considers the presence of structural change. A positive response by public debt in the fiscal balance would indicate stationarity in the debt/GDP relationship, thereby demonstrating that fiscal policy is sustainable. Yet this relationship is affected by the presence of structural change, accounted for by estimations undertaken by the Bai and Perron procedure (1998; 2003) and the Kalman Filter estimation. Results point to a fiscal policy that is not compatible with the intertemporal budget constraint and also exhibits fiscal unsustainability. Under the current conditions of fiscal policy, characterized by fiscal-revenue weakness, the federal government cannot use public debt permanently as a way of jump-starting the economy.

Key words: fiscal balance, sustainability of fiscal policy, fiscal reaction function.

JEL Classification: C50, E62, H60.

INTRODUCTION

Fiscal variables have an important bearing on how an economic cycle evolves. Collecting taxes and granting subsidies produce varying effects on output and private consumption; likewise, public expenditure can be used to respond to social demands and the general population's living standards. Government investment has multiplier effects within a number of sectors and induces greater private investment. Yet the government is always hampered by a budgetary constraint. Budget spending is limited by the ability to generate public revenue necessary to cover administrative expenses and invest in productive activities. This relationship between revenue and expenditures translates into a positive fiscal balance (surplus) or a negative one (deficit) (Hamilton and Flavin, 1986;

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Hakkio and Rush, 1991; Quintos, 1995). In this approach, public debt is used to compensate weaknesses in revenue and, for this reason, its movement is linked to past budget deficits, *i.e.*, it increases or decreases as a function of current fiscal needs (Bohn, 1998).

A permanent deficit in public finances creates negative effects in savings and investment and therefore in long-term capacity for economic growth. One of the topics of greatest interest in empirical research in fiscal policy is determining whether the government can maintain a fiscal deficit indefinitely, by refinancing it through public debt without restriction (Solís and Villagómez, 1999). Thus, the sustainability of long-term fiscal policy is assured if the present value of future fiscal balances is equal to the present value of total public debt.

For this reason, the present value of debt tends to zero over time (Hamilton and Flavin, 1986; Solís and Villagómez, 1999; Bohn, 2005; Uctum, Thurston, and Uctum, 2006). In this regard, the sustainability of public finances over the mid-term is understood to be a trajectory of the primary balance that is compatible with a relatively stable public debt/gross domestic product (GDP) ratio.

Empiric proof of this hypothesis is based on the specification of a fiscal-policy reaction function that measures the relationship between the primary balance and the debt/GDP ratio, including the output gap and the public-expenditure gap as control variables (Doi, Hoshi, and Okimoto, 2011; Ghatak and Sánchez-Fung, 2007; Câmpeanu and Stoian, 2010; Celasun, Debrun, and Ostry, 2007; Mendoza and Oviedo, 2009; Sakuragawa and Hosono, 2011; Shizume, 2011; Kia, 2008). Fiscal policy is sustainable if the primary balance reacts positively to an increase in public debt. In other words, given an unforeseen shock that increases the public debt/GDP ratio above its median value, fiscal authorities register a surplus, which would allow the primary balance to return to its initial level over the mid-term. Fulfilling this condition means that fiscal policy is aligned with the intertemporal budget restraint and is sustainable over the mid-term (Hamilton and Flavin, 1986; Mendoza and Oviedo, 2009). If fiscal policy turns out to be unsustainable, it should be adjusted to guarantee that the fiscal balance is consistent with the long-term budget.

In the case of Mexico's economy, over the past three decades one of the principal objectives of the federal government has been to attain equilibrium in the fiscal balance. Decisions made by fiscal authorities have centered mainly on reducing income taxes and widening the range of products subject to consumption taxes. Yet structural weaknesses continue, such as the low tax rate

and a significant dependence on indirect taxes and on revenue derived from the sale of oil. Given the current crisis resulting from the international crisis that began in 2008, Mexico's fiscal authorities have increased public expenditure (Chávez, Rodríguez and Fonseca, 2010). Given the weakness of fiscal revenue, the budgetary balance registered a deficit equivalent to 2.4% of GDP in 2012, and the primary balance ran a deficit beginning in 2009. This deficit has been financed with greater debt, and total debt to GDP is at 34%; these figures in the debt/GDP ratio and in the fiscal balance had not been seen since the crisis in 1995, thus indicating a change in the fiscal stance of Mexico's economy.

Recent research abroad shows that the 2008 global financial crisis led to a deterioration in the fiscal stance and to an increase in the level of public debt in developed countries as well as in emerging and low-income countries. In this regard, Furceri and Zdzienicka (2012) estimate that the international crisis will lead to an increase of up to 37 percentage points in the public debt/GDP ratio over the coming ten years. Tagkalakis (2013) states that in the face of a severe financial crisis, the volume of debt of the Organization for Economic Cooperation and Development (OECD) countries will increase at an annual average between 2% and 4%, leading to pressure on the fiscal balance. Given this situation, the objective of this paper is to specify and estimate a fiscal policy reaction function for the Mexican economy, and determine, by means of structural change tests, if the international financial crisis has generated a change in the fiscal position of the Mexican economy and what the mid-term implications might be in terms of fiscal sustainability. The results of these estimates show that, in the past four years, fiscal policy has generally remained in a risk zone, mainly associated with the impacts of the global financial crisis. The paper is divided into four sections, including this introduction. We next turn to a theoretical grounding and the specification of the fiscal reaction function, followed by a presentation of the empirical evidence, and, finally, to conclusions.

SPECIFICATION OF A FISCAL REACTION FUNCTION

The sustainability of public finances has been a much debated topic and it continues to be an imprecise concept. The empirical literature has proposed different methods for defining and evaluating the sustainability of public finances. The methodology used herein is based on the work of Bohn (1998; 2005), which specifies a fiscal balance reaction function as a share of the GDP

as a function of the public debt/GDP ratio of a previous period, the output gap, and the public expenditure gap (Doi, Hoshi, and Okimoto, 2011; Ghatak and Sánchez-Fung, 2007; Câmpeanu and Stoian, 2010; Celasun, Debrun, and Ostry, 2007; Mendoza and Oviedo, 2009; Sakuragawa and Hosono, 2011; Shizume, 2011; Kia, 2008). This type of specification is based on the identity between the fiscal balance (revenue minus expenditures) and public debt, as shown in equation [1]:

$$D_t = D_{t-1} + i_t D_{t-1} - B_t \quad [1]$$

where D_t represents the level of public debt; i_t is the nominal interest rate of government bonds, and B_t is the fiscal balance. Equation [1] states that the current level of public debt depends of the value observed in a previous period, plus interest payments, less the current fiscal balance. If the balance is a deficit (surplus), the level of debt rises (falls). Further, equation [1] can be modified to account for variables as a share of GDP:

$$\frac{D_t}{Y_t} = \frac{D_{t-1}}{Y_{t-1}} + \frac{(r_t - g_t)}{(1 + g_t)} \frac{D_{t-1}}{Y_{t-1}} - \frac{B_t}{Y_t} \quad [2]$$

an equation in which Y_t is the nominal GDP; r_t is the real interest rate, and g_t is the real rate of growth of GDP. Therefore, the expression $(r_t - g_t)/(1 + g_t)$ is defined as the *ex post* real interest rate adjusted for actual output growth. Equation [2] defines the ratio between debt and fiscal balance as a share of GDP. A negative fiscal balance raises the debt/GDP ratio; with a surplus, debt diminishes. Reordering equation [2], we get:

$$\Delta \left(\frac{D_t}{Y_t} \right) = \frac{(r_t - g_t)}{(1 + g_t)} \frac{D_{t-1}}{Y_{t-1}} - \frac{B_t}{Y_t} \quad [3]$$

and, assuming that the objective of the fiscal authorities is to maintain a constant debt/GDP ratio, *i.e.*, $\Delta(D_t/Y_t) = 0$, then we obtain the following result:

$$\frac{B_t}{Y_t} = \frac{(r_t - g_t)}{(1 + g_t)} \frac{D_{t-1}}{Y_{t-1}} = \alpha^* \frac{D_{t-1}}{Y_{t-1}}, \text{ where } \alpha^* = \frac{(r_t - g_t)}{(1 + g_t)} \quad [4]$$

Expression [4] states that if the objective of fiscal policy is to maintain a constant debt/GDP ratio, authorities should follow a “fiscal rule” by which the public balance would be equal to the level of debt of a previous period. Estimation of equation [4] allows us to compare current fiscal-policy practices with values generated by this reaction function. A positive α^* coefficient would indicate that the authorities are taking steps to make fiscal policy sustainable over time. In effect, a positive coefficient indicates that greater indebtedness is related to a governmental fiscal surplus, while a negative coefficient would generate a deficit and thus fiscal authorities would not be raising public revenue that could cover current indebtedness in the future. Greater indebtedness does not improve the government’s fiscal position, but rather tends to increase the deficit.

Equation [3] also is the framework for applying a basic test regarding the condition of fiscal sustainability (Hamilton and Flavin, 1986; Solís and Villagómez, 1999; Bohn, 2005; Uctum, Thurston, and Uctum, 2006). Equation [3] can be expressed:¹

$$\Delta\left(\frac{D_t}{Y_t}\right) = \rho \frac{D_{t-1}}{Y_{t-1}} + \varepsilon_t \tag{5}$$

Equation [5] corresponds to the specification of a Dickey-Fuller type unit-root test (Dickey and Fuller, 1981). If the public debt/GDP ratio time series is

¹ Equation [3] can be defined as $\Delta d_t = \rho_t d_{t-1} - b_t$, where d_t is the debt/GDP ratio, b_t is the fiscal balance to GDP and ρ_t is the actual *ex post* interest rate, adjusted by actual output growth. By resolving the equation recursively in a forward manner, (Hamilton y Flavin, 1986; Solís y Villagómez, 1999; Bohn, 2005; Uctum, Thurston, and Uctum, 2006), we obtain:

$$d_t = \delta_{t,n} d_{t+n} - \sum_{i=1}^n \delta_{t,i} b_{t+i}, \text{ where } \delta_{t,n} = \prod_{s=1}^n (1 + \rho_{t+s})^{-1}$$

Applying the expected value:

$$d_t = E_t \delta_{t,n} d_{t+n} - E_t \sum_{i=1}^n \delta_{t,i} b_{t+i}$$

Fiscal sustainability is incompatible with governmental Ponzi schemes, thus requiring that when n tends to infinity, the discounted value of the debt with respect to output will converge to zero, *i.e.*, $\lim_{n \rightarrow \infty} E_t \delta_{t,n} d_{t+n} = 0$, and thus:

$$d_t = -E_t \sum_{i=1}^n \delta_{t,i} b_{t+i}$$

The government cannot contract debt indefinitely, and revenue must be generated in the future to pay the cost of servicing the debt.

a stationary stochastic process, fiscal policy is sustainable over time, and if the random-walk hypothesis is not rejected, then fiscal policy is unsustainable. This empirical test is based on the hypothesis that the present value of the debt/GDP ratio should be equal to the future expected value of the fiscal balance, and, therefore, the government cannot contract debt indefinitely. Similarly, fiscal sustainability can be empirically proved by estimating the reaction function, which, in addition to public debt, includes other explanatory variables (Barro, 1986; Bohn, 1998 and 2005).

$$b_t = \alpha_0 + \alpha_1 d_{t-1} + \beta' Z_t + \varepsilon_t \quad [6]$$

Equation [6] states that the fiscal balance as a share of GDP, $b_t = (B_t/Y_t)$, depends on the total debt/GDP ratio, $d_{t-1} = (D_{t-1}/Y_{t-1})$, of a preceding period, and on a series of Z_t explanatory variables. Economic theory holds that demand pressures and public expenditure are the main factors that can influence the balance of fiscal accounts (Barro, 1986; Bohn 1998 and 2005; Ghatak and Sánchez-Fung, 2007; Kia, 2008).

One of the relevant variables is the public-spending gap (*GVAR*), defined as the difference between actual public expenditure (G_t) and its potential growth (G^*), divided by actual GDP: Y_t : $GVAR_t = (G_t - G^*)/Y_t$. The public sector balance will foreseeably respond negatively to this variable, *i.e.*, an expansion of expenditure above its long-term trajectory exercises fiscal pressure, creating a negative balance; similarly, a contraction of expenditure with respect to its long-term value allows for improvement in the government's fiscal position.

Also included as an explanatory variable is the cycle of the economy through the proxy of an output gap (*YVAR*), defined as the difference between the actual level of GDP, Y_t , and its potential value² (Y^*) with respect to actual GDP: $YVAR_t = (Y_t - Y^*)/Y_t$. The specification of the fiscal reaction function to be estimated is based on the following equation (Doi, Hoshi y Okimoto, 2011; Ghatak and Sánchez-Fung, 2007; Câmpeanu and Stoian, 2010; Celasun, Debrun, and Ostry, 2007; Mendoza and Oviedo, 2009; Sakuragawa and Hosono, 2011; Shizume, 2011; Kia, 2008):

$$b_t = \alpha_0 + \alpha_1 d_{t-1} + \beta_1 GVAR_t + \beta_2 YVAR_t + \varepsilon_t \quad [7]$$

² Potential GDP can also be calculated through the Hodrick-Prescott filter (1997).

where b_t is the fiscal balance with respect to GDP; d_t is the resulting public debt as a share of GDP; $GVAR_t$ is the public-expenditure gap to GDP, $(G_t - G^*)/Y_t$ and $YVAR_t$ is the output gap $(Y_t - Y^*)/Y_t$.

In the context of equation [7], the sustainability hypothesis states that the fiscal balance should respond positively to an increase in public debt, *i.e.*, $\alpha > 0$ should hold (Uctum, Thurston and Uctum, 2006; Bohn, 1998; Mendoza and Oviedo, 2009; Ghatak and Sánchez-Fung, 2007; Kia 2008). Fiscal policy is sustainable when the federal government generates a surplus when the public debt/GDP ratio increases, indicating that revenue is being generated that, in the future, will allow the public debt/GDP ratio to return to its initial level. When this condition holds, fiscal policy is consistent with the intertemporal budget restraint (Ghatak and Sánchez-Fung, 2007; Kia 2008; Mendoza and Oviedo, 2009).

It is expected that the public balance will respond negatively to the public expenditure gap, $\beta_1 < 0$. An expansion of expenditure above its long-term trajectory will create fiscal pressure and, therefore, a negative balance; likewise, a contraction of expenditure with respect to its long-term value will create a surplus. In the case of the output gap, when GDP is below its potential growth, fiscal revenue should be reduced in the same proportion, which would generate a deficit and therefore the estimator should be negative ($\beta_2 < 0$). Validating the restrictions of equation [7] for the Mexican economy would lend empirical evidence in favor, or against, the sustainability of fiscal policy. Yet it is important to consider that the value of the parameters is subject to change due to policy decisions or to external events, such as the global crisis that began in 2008, which should be considered in the process of estimation (Greiner and Kauermann, 2007; Uctum, Thurston, and Uctum, 2006; Shizume, 2011).

EMPIRICAL EVIDENCE

During the past forty years, public finances in Mexico have undergone significant changes. The 1980s are characterized by excessive indebtedness and a persistent fiscal-balance deficit resulting from the huge dependence on revenue from exported oil³ and excessive public spending. The economy's pronounced contraction due to the 1982 crisis led to negative effects on the long-term trajectory of public revenue, which fell drastically during the eighties, reaching approximately 22 percent.

³ In 1982, Petróleos Mexicanos (PEMEX) contributed 22% of total public revenue.

Public debt grew rapidly, from 25% of GDP in 1980 to 61% in 1982. This increase can be explained by the rise in international interest rates, leading to a worldwide credit squeeze, worsened by the fact that interest and principal payments became much more onerous for debtor countries. In 1982, the Mexican government paid around 7% of GDP in foreign debt interest in a context of mounting pressure on the exchange rate and a drop in revenue from oil exports. These factors led to massive capital flight that was covered with short-term foreign debt.

Starting in 1987, total debt tended to fall quickly due to adjustment programs and to the renegotiation of the foreign debt. Similarly, revenue derived from privatizations, together with relief for foreign debt servicing (provided by the 1989 Brady Plan), and fiscal adjustments, allowed the government to reduce the debt as a share of GDP to 34% in 1991. The 90s began a period of solid stability in public finances. The main fiscal variables in Table 1 indicate that public revenue from 1990 to 2004 stabilized around 20% of GDP due to the standstill in the tax burden. The equilibrium in public finances achieved in this period was due to the restriction in public expenditure, which also stabilized at about 20% of GDP.

TABLE 1
Principal fiscal variables, 1990-2012
(as a share of GDP)

<i>Years</i>	<i>Revenue</i>	<i>Expenditure</i>	<i>Primary balance</i>	<i>Budget balance</i>	<i>Total debt</i>
1990-1994	20.67	19.64	4.92	1.04	31.78
1995-1999	18.86	19.38	2.76	-0.52	28.98
2000-2004	19.99	20.70	2.00	-0.71	22.71
2005-2008	22.08	22.09	2.15	-0.02	22.49
2009-2012	22.64	25.13	-0.53	-2.49	33.61

Source: prepared by the author based on data from the Secretary of the Treasury and Public Credit (SHCP) and the National Institute of Statistics and Geography (INEGI).

On the other hand, the public debt/GDP ratio shows an unmistakable downward tendency until 2008, when it stabilized at around 22.5% of GDP. Yet, in spite of the positive results of public finances, structural problems persisted, such as low and stagnant tax revenues at about 9% of GDP, and a similar situation with income taxes⁴, which made up only 4.6% of GDP. Further, an enormous

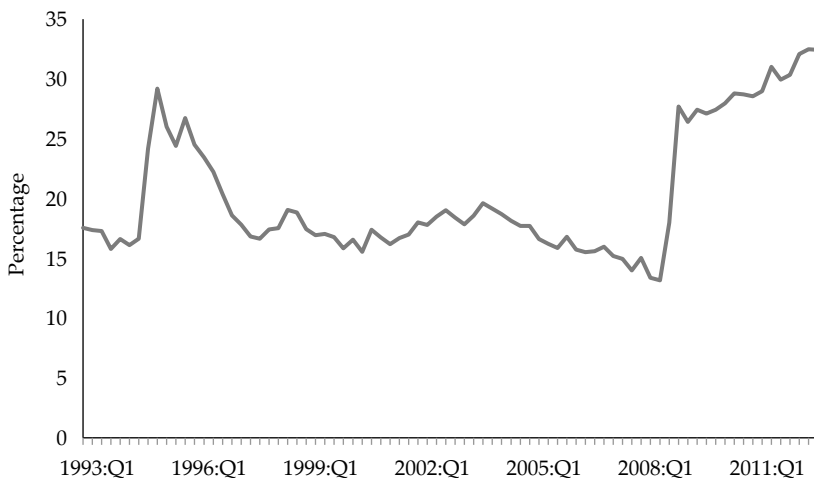
⁴ In OECD countries, income taxes contribute on average 11% of GDP.

dependence on oil revenues continued, insofar as they contributed 33% of public revenue. These restrictions hindered greater expansion of public expenditure within the economy.

In the face of the 2008 global crisis, tax authorities implemented a series of measures to mitigate the negative effects of the economic downturn. These included a countercyclical fiscal policy (Chávez, Rodríguez, and Fonseca, 2010), based on expanding public expenditure to a level of 25% of GDP (see Table 1), through fiscal stimulation. Yet, given stagnating public revenue, the government's primary balance had run a deficit during the past three years. Linked to this result in the fiscal balance, we see that between 2008 and 2012, the debt/GDP ratio rose by 9 percentage points of GDP.

The trajectory of the total debt/GDP ratio can be seen in Graph 1. With quarterly information from 1993:Q1 to 2012:Q4, we can see a clear break in the trajectory of the ratio in the first quarter of 2009, which produced a change in the level of the series. Given the limited fiscal flexibility in terms of public revenue and the climate of recession, Mexico's fiscal authorities raised the level of debt. Within the scope of the fiscal reaction function, greater debt should be associated with a fiscal surplus, but should a deficit occur, this would mean that in the future situations of risk would occur and, thus, problems of fiscal unsustainability would arise.

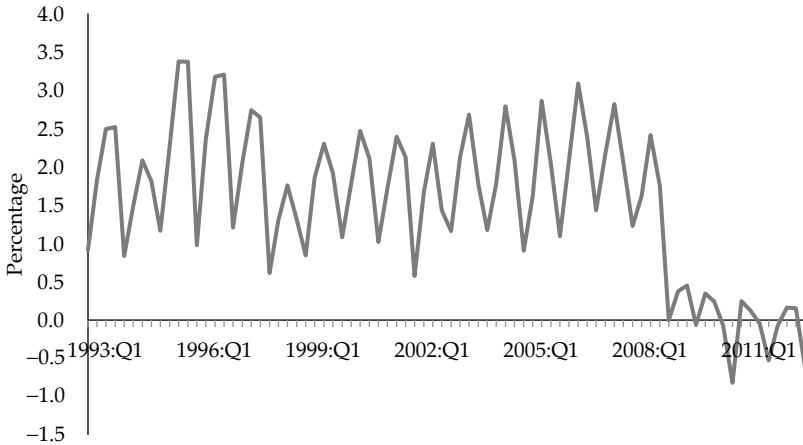
GRAPH 1
Evolution of the public debt/GDP ratio



Source: author's calculation based on information provided by SHCP and INEGI.

In terms of the primary balance⁵ as a share of GDP (see Graph 2), after several years of posting a surplus (following the start of the global crisis in the fourth semester of 2009), the primary balance developed a deficit. Although the deficit is less than 1% of GDP, the current administration’s fiscal policy allows for a temporary deficit through 2016, in an effort to create a countercyclical stimulus that will jumpstart economic growth (SHCP, 2013). This will have important repercussions on debt levels. Thus, if a significant increase in public revenue cannot be achieved, management of fiscal policy might lead the country into a situation of risk.

GRAPH 2
Evolution of the primary balance-GDP



Source: author’s calculations based on information from SHCP and INEGI.

A basic empiric test to check for fiscal sustainability would determine if the debt/GDP ratio is stationary over time, which would show weak evidence in favor of a sustainable fiscal policy over time (Afonso, 2005). A test of stationarity is backed by the hypothesis that the present value of the debt/GDP ratio should be equal to the expected value of the sum of future balances that varies from

⁵ The primary balance is an indication of the fiscal position, excluding the cost of servicing the public debt and other liabilities guaranteed by the federal government associated with programs of support to debtors and savers.

one period to the next. The condition of sustainability for fiscal policy stipulates that the debt/GDP ratio should remain relatively stable over time (Hamilton and Flavin, 1986; Solís and Villagómez, 1999; Bohn, 2005; Afonso, 2005; Uctum, Thurston, and Uctum, 2006). This assertion was verified by applying unit root tests to the series. Table 2 shows results of the unit root tests applied to the quarterly public-debt data, following the ADF (Dickey and Fokler, 1981) and KPSS (Kwiatkowski, Phillips, Schmidt, and Shin, 1992) procedures.

TABLE 2
Unit root test on the public debt
(as a share of GDP and in real terms)

Variable	ADF			kpss(9)	
	A	B	C	m	t
d_t	-2.00(1)	-1.71(1)	0.64(2)	0.260	0.157
Δd_t	-6.83(0)	-6.82(0)	-6.83(0)	0.150	0.071
D_t	-1.15(2)	-0.07(2)	1.61(2)	0.636	0.162
ΔD_t	-7.43(1)	-7.37(1)	-7.12(1)	0.183	0.081

Note: bold type indicates rejection of the null hypothesis at a 5% significance level. Augmented Dickey-Fuller test $T = 100$, model A = -3.45, model B = -2.89, and model C = -1.95. kpss model m = 0.463 and model t = 0.146 (Maddala and Kim, 1998). Model A and model t (constant and trending), Model B and model m (constant), Model C only includes the constant. Quarterly series: 1993:Q1-2012:Q4.

The unit-root tests were applied to a set of debt/GDP ratios (d_t), as well as to a series in real terms (D_t) (in millions of pesos at 2008 prices). Solís and Villagómez's investigation (1999) uses a discounted and undiscounted debt, but results are similar. In the present paper, we use undiscounted debt, following the work of Hamilton and Flavin (1986). The ADP test statistics indicate that both series can be considered non-stationary, *i.e.*, they are of an order of integration I(1), which would indicate that fiscal policy has not been sustainable during 1993-2012. The KPSS test posits a null hypothesis that the series is stationary, thus minimizing the possibility of making statistically erred inferences (Maddala and Kim, 1998). The KPSS statistics indicate that the total-debt series, measured in millions of pesos at 2008 prices, is a series of order of integration I(1), while the debt/GDP-ratio series, with its specification that includes a constant, denotes stationarity.

Results show evidence that is series is non-stationary, *i.e.*, given any external shock that alters the public debt/GDP ratio, the latter will not return to its initial value. This result is similar to the one reported by Solís and Villagómez

(1999), who analyze the 1980-1997 period with quarterly data, using both the real debt/GDP ratio and GDP levels. The study by Uctum, Thurston, and Uctum (2006), with annual data from 1970 to 2000, using the real discounted debt/GDP ratio, also concludes that the series are non-stationary in the case of the Mexican economy.

It is important to note that the presence of an abrupt change in the trajectory of the series, as seen in Graph 1, affects the statistics of the unit-root tests. Perron (1989; 1997) demonstrated the importance of correctly specifying the tendency in unit-root tests, given the permanent effects of external shocks on the time series. Thus, rejecting stationarity in the unit-root tests can be explained by the presence of structural change in the series, giving rise to the need to apply unit-root tests that account for the possibility of structural change. Table 3 lists the results of the Zivot and Andrews test (1992), based on the specification of the augmented Dickey-Fuller that considers a constant and a tendency, as well as both pulse and level dummy variables.⁶

The Zivot-Andrews (ZA) test for structural change shows that in the specification of model A (with a change in the intercept), the presence of a unit root is rejected, and so the debt/GDP ratio can be considered a stationary series, assuming a change in the level of the series: the date of the change corresponds to the fourth quarter of 2008, *i.e.*, when the world crisis began.

The ADF and KPSS unit-root tests applied to the debt/GDP ratio and in real terms for 1993:Q1-2012:Q4 reveal non-stationarity and thus place the economy in a situation of deteriorating public finances. Nonetheless, the presence of structural change in the series could affect the test results, as the statistics of the ZA test demonstrate. In effect, the 2008 global crisis produced a change in the debt levels of the Mexican economy, and so too in public finances, which may have negative consequences in the mid-term. For example, should a pronounced contraction in the flow of international capital occur, as well as a lower level of economic activity and a rise in the cost of servicing the public debt, public finances might quickly be placed in a situation of unsustainability.

⁶ Three models are considered: model A identifies a change in the level of the tendency; model B assumes a change in the slope of the tendency; and model C includes changes both in the level and the slope of the tendency. The date of structural change is determined when the value of the t-statistic value of the ADF test (Zivot and Andrews, 1992) is minimized.

TABLE 3
Unit-root test for an unknown structural change
 Zivot-Andrews (1992)

Variable	A	B	C
d_t	-5.382*	-3.095	-4.393
TB	2008:Q4	2007:Q1	2008:Q4
D_t	-5.168*	-3.688	-4.287
TB	2008:Q4	2007:Q3	2008:Q4
Valor crítico 5%	-4.80	-4.42	-5.08

Note: (*) rejection of the null hypothesis at 5%. TB = date of structural change; Model A assumes a change in the intercept, model B assumes a change in the tendency and model C assumes a change in both the intercept and the tendency. Critical values correspond to those found in Zivot y Andrews (1992: 256-7, Tables 2, 3 y 4).

Unit-root test provide information on the trajectory of the debt but do not allow us to relate the evolution of the fiscal debt to indebtedness. So a more robust test regarding fiscal sustainability over time would estimate the fiscal reaction function defined in equation [7]. Data⁷ used for the estimation are quarterly frequency variables for⁸ 1993:Q1 to 2012:Q4. The primary balance (defined as the difference between revenue and expenses in the public sector, leaving aside debt-interest payments) is considered the variable for fiscal balance, and is reported as a share of GDP and expressed in millions of pesos at 2008 prices. The public-debt variable corresponds to the public sector's total net debt in millions of pesos, expressed as the debt/GDP ratio; the expenditure variable corresponds to net expenditure accruing to the public sector. With respect to the output and expenditure gaps, the Hodrick-Prescott filter (1997) is used to calculate the potential value of both series.

The estimation of equation [7] was undertaken by ordinary least squares in two stages with instrumental variables,⁹ in order to avoid the problems of endogeneity between the fiscal balance and the output gap, as well as the lag in total debt, which is also influenced by the balances in previous periods; this problem of endogeneity can lead to a lag in the estimators (Celasun, Debrun, and Ostry, 2006):

⁷ Sources of information are SHCP, INEGI, and the Centro de Estudios de las Finanzas Públicas [Center for Studies of Public Finances].

⁸ The period of estimation is based on the availability of the GDP series at 2008 prices, which begins with the first quarter of 1993.

⁹ This procedure allows us to obtain the most efficient estimators. Lags in the expenditure and GDP gaps are used as instrumental variables.

$$b_t = 5.46 - 0.201d_{t-1} - 0.524GVAR_t - 0.202YVAR_t \quad [8]$$

t-statistic	(11.71)	(-8.76)	(-4.48)	(-3.62)
Probability	[0.000]	[0.000]	[0.000]	[0.000]

$R^2 = 0.632$ period: 1994:Q1-2012:Q4

Autocorrelation: LM(2) chi-square(4) = 0.291[0.961]

Heteroscedasticity: ARCH(4) F(4,67) = 0.285[0.886]

Normality: Jarque-Bera chi-square(2) = 4.013[0.134]

The restriction on the parameters indicates that the fiscal balance should respond positively to an increase in public debt (Ghatak and Sánchez Fung, 2007; Kia, 2008; Mendoza and Oviedo, 2009). The result of the estimation in the case of the public debt/GDP ratio of an earlier period has a negative sign and is statistically significant (-0.201), indicating that the fiscal authority lacks the necessary revenue to return to the public debt's initial level; we say then that fiscal policy does not meet the intertemporal budget restraint (Hamilton and Flavin, 1986; Bohn 1998; 2005).

The coefficient associated with the expenditure gap is negative and statistically significant (-0.521), so that an expansion of public expenditure above its long-term tendency causes significant pressure on public finances. The coefficient for the output gap was negative (-0.202) and significant, which is consistent with the hypothesis that a level of output below its potential growth leads to a contraction of fiscal revenue, leading to a deficit. These results are similar to those reported by Bohn (1998), Greiner and Kauermann (2007), Ghatak and Sánchez-Fung (2007), and Shizume (2011).

Estimation results show that fiscal policy carried out from 1993:Q1 to 2012:Q4 was not compatible with the intertemporal budget restraint, and thus can be considered unsustainable. Yet previous to the global crisis, the Mexican economy had a primary balance surplus and a debt/GDP ratio level of around 23% (see Table 1). Further, the estimation of the reaction function assumes fixed parameters, *i.e.*, the sensitivity of response between the fiscal balance and the debt/GDP ratio does not change over time and is not altered by external shocks. This problem is documented in recent research, such as Greiner and Kauermann's (2007), who apply parametric and semi-parametric methods in estimating the reaction function, and show that, in the case of the United States, the fiscal balance is an increasing non-linear function of the debt/GDP ratio. For their part, Uctum, Thurston, and Uctum (2006) conclude that, for most of

the numerous countries¹⁰ considered in their investigation, incorporating the presence of structural change in the reaction function changes the conclusions regarding sustainability of fiscal policy.

The Ghatak and Sánchez-Fung study (2007), in which the fiscal reaction function is estimated for five countries by means of recursive least squares, finds that the relationship between the fiscal balance and the debt/GDP ratio varies over time. With data from the Japanese economy, Doe, Hoshi, and Okomoto (2011) estimate the reaction function by means of a Markov switching model, and conclude that the α_1 coefficient changes sign in different periods. Shizume (2011) also estimates the reaction function for Japan's economy by including dummy variables that express structural change, and also finds sign changes in the α_1 coefficient. On an international scale, empirical evidence show that the presence of structural change alters the sign of the coefficient over time and, as a result, so too the conclusion regarding fiscal sustainability.

The estimation of equation [7] should consider structural change. So, first, it is important that we establish if the value of the coefficients varies in the reaction function over time. In this regard, Bai and Perron (1998; 2003) developed a method for identifying m structural changes ($m + 1$ regimes) in the context of a multiple linear regression model. This method can be applied to equation [7], assuming that all coefficients can be affected by structural changes (Uctum, Thurston, and Uctum, 2006):

$$b_t = \alpha_0 + \sum_{i=1}^{m+1} \alpha_{1i} d_{t-1} 1_{t \in I_i} + \sum_{i=1}^{m+1} \beta_{1i} GVAR_t 1_{t \in I_i} + \sum_{i=1}^{m+1} \beta_{2i} YVAR_t 1_{t \in I_i} + \varepsilon_t \quad [9]$$

The $1_{t \in I_i}$ indicator takes a value of 1 for part of the sample $t_{i-1} < t \leq t_i$ and zero for any other value. Parameters α_{1i} , β_{1i} , β_{2i} ($i = 1, \dots, m + 1$) are estimated for I_i sub-periods, which denote the dates of structural change. The procedure is sequential and is based on identifying the first point of structural change as one in which the sum of squared errors $\hat{t}_1 = \min SSR(t_1)$ is minimized, taking as its base the estimation of the model for the entire sample.¹¹ At that point

¹⁰ Including seven developed countries, and countries in Latin America and Asia.

¹¹ Bai (1997) defines the Sup F statistic: when it takes on a maximum value, there is evidence of a change in the value of the parameters.

the sample is divided in two separate segments $[1, \hat{t}_1]$ y $[\hat{t}_1, T]$, where in the second part of the sample a similar procedure is followed to find the point at which the sum of squared errors is minimized in order to estimate a new point of structural change.¹²

The Bai-Perron test uses different statistics to evaluate the presence of changes in the value of the parameters. The Bayesian information criteria (BIC) and the modified Schwarz criterion (LWZ) can be used, where the number of changes is obtained when the criterion of information reaches a minimum value. The statistic $\text{Sup } F(0 | \ell)$ is a type of Wald test that defines the null hypothesis as zero changes and the alternative in ℓ changes, and is realized sequentially. The UD-max and WD-max statistics (Bai and Perron, 2003) are also calculated to identify a greater number of m structural changes. Assuming the null hypothesis is the absence of changes in the equation, as opposed to an unknown number of changes greater than m , the statistics are used to determine if at least one structural change exists.

Table 4 indicates the statistics¹³ of the Bai-Perron test (Bai and Perron, 1998; 2003), assuming five structural changes. First, the information criteria indicate the presence of just one structural change in the fiscal reaction function. This result is confirmed by the $\text{Sup } F(0 | \ell)$ statistic, which does not reject the presence of structural change. Further, the UD-max and WD-max statistics eliminate a larger number of structural changes, and so we can conclude that the fiscal reaction function that measures the relationship between the fiscal balance and the public debt/GDP ratio has been modified over time. The date of change falls in the first quarter of 2009 that signals the start of the global crisis, consistent with the results of the ZA test applied to the series of the debt/GDP ratio.

Based on the result of the Bai-Perron test (Bai and Perron, 1998; 2003), we estimated the fiscal reaction function considering one structural change, including the dummy variables that multiply the model's variables. Results appear in Table 5. We see that the coefficient associated with the debt/GDP ratio during 1993:Q1-2008:Q4 is positive, but not statistically significant. In contrast, during the global crisis (2009:Q1-2012:Q4), the coefficient is negative and statistically significant, indicating a shift in the fiscal position of Mexico's economy to

¹² The Bin and Perron (1998) procedure can be applied to each segment of the sample in order to identify structural change in each segment. The procedure is known as "the refinement of Bai."

¹³ Estimations undertaken with Eviews 8.0 software.

one of greater risk. The estimation indicates that since 2009, public-debt growth is associated with a deficit in the primary balance, and that revenue generation is insufficient to guarantee future payments of current debt.

TABLE 4
Statistics of the Bai-Perron test

Changes	Dates of change	Information criteria		Sequential F test	
		BIC	LWZ	Sup F(0 ℓ)	Critical value 5%
$m = 0$		-0.521308	-0.355621		
$m = 1$	2009:Q1	-0.725054*	-0.390831*	F(0 1) = 43.64*	16.19
$m = 2$	1997:Q4, 2009:Q2	-0.661010	-0.155073	F(0 2) = 15.39	18.11
$m = 3$	1997:Q4, 2002:Q2, 2009:Q2	-0.533947	0.147276	F(0 3) = 11.22	18.93
$m = 4$	1997:Q4, 2002:Q2, 2005:Q1, 2009:Q2	-0.468354	0.392194	F(0 4) = 8.39	19.64
$m = 5$	1997:Q4, 2000:Q3, 2003:Q2, 2006:Q2, 2009:Q1	-0.211403	0.833077	F(0 5) = 6.07	20.19
		<i>Critical value</i>			
		5%			
		UD-max = 38.128*	14.23		
		WD-max = 38.128*	15.59		

Note: (*) null hypothesis rejected at a 5% significance level. BIC = Bayesian criterion, LWZ = Modified Schwarz information criterion.

TABLE 5
Estimation of the fiscal reaction function with structural change

Variables	Period	
	1993:Q1-2008:Q4	2009:Q1-2012:Q4
d_{t-1}	0.0111	-0.0608*
	[0.3136]	[-2.6863]
	(0.754)	(0.009)
$GV_{A}R_t$	-0.2586*	0.1751
	[-4.1937]	[0.5375]
	(0.000)	(0.5926)
$YV_{A}R_t$	-0.02313	-0.0175
	[-0.5606]	[-0.2603]
	(0.576)	(0.7953)
C	1.7012	1.7012
	[-0.2603]	[-0.2603]
	(0.7953)	(0.7953)

Note: (*) 5% significance level. Results show the coefficient, the t-student statistic [], and the probability of rejection ().

Results show that the fiscal reaction function has been modified over time and, therefore, the condition of fiscal sustainability has also changed. The Bai-Perron procedure allows us to identify discrete dates of change throughout the sample. An alternative way of estimating a trajectory of the coefficients of the fiscal reaction function is by specifying and estimating a state space model, considering that the parameters are modified over time.

$$b_t = \alpha_0 + \alpha_{1t}d_{t-1} + \beta_{1t}GVAR_t + \beta_{2t}YVAR_t + \varepsilon_t, \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \quad [10.1]$$

$$\alpha_{1t} = \alpha_{1t-1} + \eta_{1t}, \eta_{1t} \sim NID(0, \sigma_{\eta_1}^2) \quad [10.2]$$

$$\beta_{1t} = \beta_{1t-1} + \eta_{2t}, \eta_{2t} \sim NID(0, \sigma_{\eta_2}^2) \quad [10.3]$$

$$\beta_{2t} = \beta_{2t-1} + \eta_{3t}, \eta_{3t} \sim NID(0, \sigma_{\eta_3}^2) \quad [10.4]$$

The coefficients of the model are treated as non-observed series associated with variables from the primary balance, the debt-GDP ratio, and the gaps in expenditure and output. Equation [10.1] represents the measuring equation, and the system of equations from [10.2] to [10.4] are denominated as transition equations, which describe the trajectory of the model's coefficients, assuming that they follow a random-walk process. The error terms of each equation are not correlated and are normally distributed with zero mean and constant variance. This estimation process is based on the Kalman filter (Kalman, 1960; Harvey, 1999; Hamilton, 1994), which is a recursive estimation procedure for linear projections of a system using available information in time t , consisting of a model known as “state space” (representing non-observed components) that includes measuring and transition equations. Thus, the Kalman filter provides smoothed estimates of the coefficients.

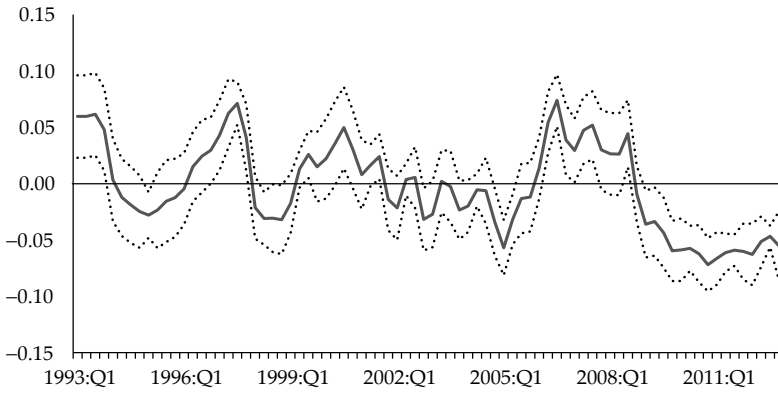
Table A1 (see the appendix) shows results from the Kalman filter estimation of the fiscal reaction function for the Mexican economy. Graph 3 describes the estimated trajectory of the coefficient associated with the debt-GDP ratio for 1993:Q1 to 2012:Q4. The first half of the 90s stands out, where the coefficient is negative, and most noticeably in 1995. This period is characterized by a bank and foreign-debt crisis, and strong hikes in the exchange rate, the interest rates, and inflation. At the end of 1993, debt levels begin to increase,

from 23% to 39% of GDP in 1995. Fiscal policy had an important role in the economic adjustment program, mainly in the increase in the rate of the value added tax (VAT), from 10% to 15%, and in a very significant cut to projected expenditure.

The adjustment program led to economic recovery and relative stability in public finances. The coefficient continued to fluctuate around zero and, during 2006-2008, its sign was positive, indicting a situation of primary balance sustainability. In effect, this period of fiscal policy was much more stable, posting a primary balance surplus and a debt/GDP ratio that fell to a level of 21% of GDP. By contrast, during the last four years the coefficient becomes negative and it quickly pulls away from zero, indicating that the relationship between the fiscal balance and the debt/GDP ratio has become incompatible with the intertemporal budget constraint; similarly, the final value of the estimation (-0.052) is very similar to the estimated value generated by the Bai-Perron procedure, confirming that the 2008 global crisis placed the Mexican economy in a position of fiscal unsustainability, insofar as the federal government should generate in the future the revenues necessary to return the debt/GDP ratio to its pre-crisis value, but, given the weakness of fiscal revenue, this would mean increasing public debt even further or raising taxes to generate greater revenue.

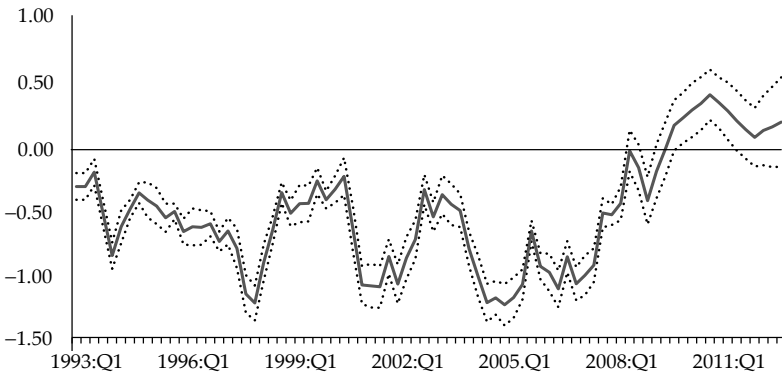
The estimation by means of a state-space model confirms that the relationship between the primary balance and the debt/GDP ratio has been modified over time and is subject to external shocks. The coefficient becomes negative in the first quarter of 2009, confirming the date as the point of inflexion in the fiscal balance. Although a similar situation occurred in 1995, important differences exist that merit consideration. In the first period (1995-1996), the fiscal balance did not run a deficit, in 2005 the debt/GDP ratio increased, and the following year began to decrease. Now, however, the primary balance has run a deficit since 2009; the debt/GDP ratio grew by 9 percentage points of GDP in just four years (2008 to 2011), with a clear upward tendency; and the economy has dropped below its potential growth level of 3.5% (SHCP, 2013). This situation is a different scenario in which, over the mid-term, the financial situation of the Mexican economy could be in a weaker position.

GRAPH 3
 α_1 coefficient: debt/GDP ratio

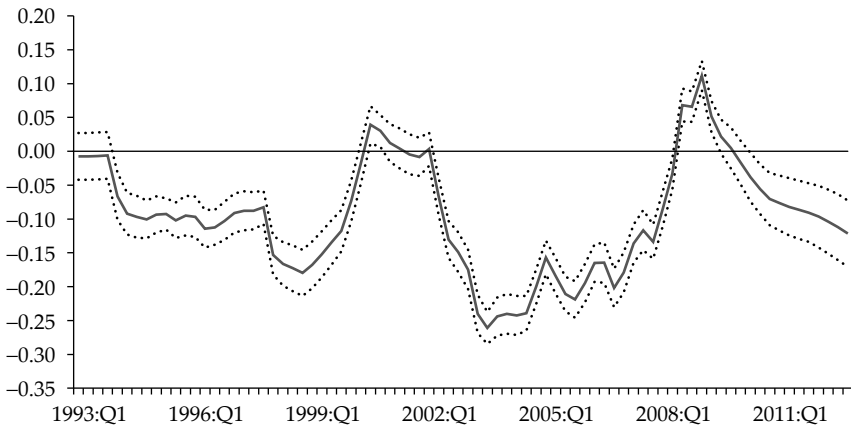


The expenditure gap parameter (see Graph 4) remains negative in a large portion of the sample, compatible with the model’s restriction, but changes sign starting in the first quarter of 2009, during the global crisis, and associated with a slight expansion of expenditure (Chávez, Rodríguez, and Fonseca, 2010). This has modified the relationship between the primary balance and the expenditure gap, but towards the end of the sample tends to a value of zero. Similarly, the coefficient associated with the output gap (see Graph 5), is positive for most of the sample observations, but is consistent with the fiscal-reaction function hypothesis. Nonetheless, it briefly (2008:Q3 to 2009:Q3) changes sign, also related to the impacts of the global crisis.

GRAPH 4
 β_1 coefficient: public expenditure gap



GRAPH 5
 β_2 coefficient: output gap



Results of the estimation of the state-space model confirm that the fiscal-reaction function has been modified over time and, therefore, the condition of unsustainability has also changed. The global crisis and the decreased rate of growth of the Mexican economy have led the country's fiscal authorities to fall back on increased debt. These changes show that fiscal policy has been unable to generate sufficient revenue to cover greater public expenditure and so public debt has been incurred.¹⁴ Although management of the internal public debt (SHCP, 2012) has been based on fixed-rate instruments and on a maturity period of 7.6 years, with interest rates that do not imply excessive costs for the federal government, if the economic slowdown continues into the mid-term, the country's public finances could enter a situation of risk.

CONCLUSIONS

Empirical evidence presented in this paper shows that in the case of the Mexican economy, a relationship exists over time between the primary balance expressed as a share of GDP and the public debt/GDP ratio; further, the public expenditure and output gaps also provide relevant information regarding the trajectory of the fiscal balance. The relationship between the set of variables can be modeled

¹⁴ Currently, internal debt makes up 70% of total public debt.

as a fiscal reaction function that has not been stable over time; changes have occurred in the coefficient that influence the relationship between the primary balance and the public debt/GDP ratio.

The Bai and Perron procedures (1998; 2003), as well as the Kalman filter (Kalman, 1960; Harvey, 1999; Hamilton, 1994), show that a shock attributable to the global crisis that began at the close of 2008 changed the sustainability of public finances, placing them in a position of greater risk. Estimations show that from 1996 to 2007 public finances could be characterized as sustainable, with low levels of indebtedness, an average debt/GDP ratio of 23%, a surplus in the primary balance (2% of GDP), and public expenditure at 21% of GDP. The 2008 global crisis modified these variables, creating a deficit in the fiscal balance and an increase in public debt to 9 percentage points of GDP.

In the estimation of the reaction function, assuming the presence of structural change, the coefficient associated with the debt/GDP ratio from a previous period changes its sign after the 2008 crisis, indicating that fiscal authorities are not generating the revenue required for the debt/GDP ratio to return to its initial level over the mid-term. Therefore, we can posit that fiscal policy does not fulfill the intertemporal budget constraint and, as a result, is in a position of unsustainability. Currently, although the Mexican government's debt management has been successful in reducing the cost and the risk level of its liabilities, the levels of indebtedness have seen rapid growth in the past four years. The current administration's projections (SHCP, 2013) assume a temporary deficit until 2016 in order to generate a stimulus that will jumpstart the economy, in the hope that structural reforms will take hold and increase fiscal revenue.

Given the current conditions of fiscal policy, characterized by weakness in fiscal revenue, the federal government cannot hope to use public debt indefinitely as a means of jumpstarting the economy. In the mid-term, it will have to cover its liabilities, which will restrict fiscal policy itself. The reaction function shows that public finances are already in a risk zone, and in a position of unsustainability that could affect the economy over the mid-term. In this context, careful consideration should be given to possible future scenarios that involve the impact of reforms, the generation of fiscal revenue, and contingent liabilities (the pension system), all of which demonstrate that the fiscal viability of the Mexican economy is extremely precarious.

APPENDIX

TABLE A1
Kalman Filter (KF) estimations
 Final state

State variable	Final state	Z-statistic
α_1	-0.052	-138.1 (0.00)
β_1	0.212	17.34 (0.00)
β_2	-0.121	-45.70 (0.00)

Note: values in parenthesis show Z-statistic probabilities.

Log likelihood = -241362.5

$\hat{\sigma}_{\alpha_1}^2 = 0.000301$, $\hat{\beta}_{\alpha_1}^2 = 0.005113$, $\hat{\beta}_{\alpha_2}^2 = 0.001011$

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