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Original Paper

Forecasting Moroccan Tax Revenues: An Analysis Using International Institutions Methodologies and VECM

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Abstract

The forecast of tax revenues is based on several methodologies. The literature review of empirical studies has concluded that the main ones are; the effective tax rate approach, the marginal tax rate approach, the elasticity approach, the regression approach and the analysis of co-integration. These approaches are advocated by International institutions, especially the International Monetary Fund (IMF) in its technical assistance of developing countries and its trainings to officials. Thereby, this paper aims to examine these different approaches, to apply them on Moroccan data and to compare their results in order to improve the forecasting system of Moroccan tax revenues. It turns out that the forecast of government revenue is a tough task that relies on the perfect knowledge of the predictable variables context and the awareness of the various external factors that can influence the future achievements. Moreover, regular comparisons of the forecasts and the revenue recorded are found to be fundamental to assess the quality of the estimates in order to increase the accuracy of predictions.

Keywords

Forecasting revenue, GDP, IMF, error correction model

1. Introduction

In many developing countries, tax revenues forecasting remains an important issue. Several researchers concluded that a persisting under or over-prediction of tax revenues in government budgets is a problem that emerged in both developed and developing countries. Indeed, high forecast errors can result from institutional vulnerability, inefficient tax administration and technical errors.

In fact, setting up a precise tax revenue forecast is a challenging task that requires taking into account a wide set of macroeconomic variables, tax structure and the conducted fiscal policy. The IMF addresses these questions in its paper IMF (2013) (Note 1) by presenting four approaches that improve tax revenue forecasting in developing countries.

This paper review the four approaches used by the IMF; the effective tax rate approach, the marginal tax rate approach, the elasticity approach and the regression approach, and uses finely co-integration procedures to find long term relationship between taxes and their tax base for the Moroccan case.

2. Literature Review

Forecasting future tax revenues is very important to conduct macroeconomic regulation efficiently. In this chapter, we conduct a brief review of literature about optimal tax policy, based on the work of Ramsey (1927) and Mirrlees (1971), and on a tax revenues analysis.

2.1 The Theory of Optimal Taxation

The literature on optimal taxation suggests that a tax system should be chosen to maximize a social welfare function subject to a set of constraints (Note 2). The social welfare function is a nonlinear function of individual utilities. Nonlinearity allows, for example, to consider a social planner who prefers more equal distributions of utility. However, an approach taken up by Werning (2007) (Note 3) addresses a more restricted schema presuming that the social planner is only concerned about average utility. This statement implies that a social welfare function is linear in individual utilities. To simplify the problem facing the social planner, it is often assumed that the economy is populated by identical individuals, having the same preferences over consumption and leisure.

The next step in setting up a tax system is to specify the constraints of the function. Ramsey (1927) (Note 4), in his very early contribution, suggested that the planner must raise tax revenues through taxes on commodities only. However, we cannot rule out income from various sources by assumption.

If the social planner is at liberty in choosing a tax system, the optimal tax would be simply a “lump-sum tax”, which is a tax that have a fixed amount, no matter the change in circumstance of the taxed entity. Then again, the rich and the poor are taxed equally, placing a higher burden on the latter.

As the model still fails to deliver useful and realistic prescriptions, a second wave of optimal tax models, lunched by James Mirrlees (1971) (Note 5), enables the planner to deal with unobserved heterogeneity among taxpayers. The basic version of the model considers that individuals are different depending on their ability to earn income.

Thereby, Mirrlees approach formalizes the balance between equality and efficiency that governments should keep. In fact, even though the planner would like to target high-ability taxpayers he needs to make sure the tax system provides sufficient incentive the group with higher taxes to keep producing at the high levels. The Mirrlees framework allows the planner to consider all conceivable tax systems, but makes the optimal tax problem much complex. Since the Mirrlees contribution, much progress has been made using this approach, especially in Kaplow (2008) (Note 6).

2.2 Evaluation of Tax Policy Revenues

A country's tax system reflects its response to the evolution of social, economic, and political influences. Therefore, the form of a tax system, has wide economic, political, and social implications.

A well-designed tax regime should encourage competitive growth across various sectors of the economy, in order to stimulate higher economic growth. This can be achieved by expanding savings and leading investment to high return activities. However, the tax should create neither major distortions in consumption and production behavior nor change private investment decisions, it has to be neutral.

Moreover, a tax system should be transparent so that it is easy to administer and simple for the taxpayers to comprehend and comply with. The simpler and the more transparent a tax system, the lower its administration and compliance costs.

Besides, taxes are supposed to be sufficient in order to finance the expenditure needs of the government over time. In fact, revenues should rise with national income, and the entire tax system should evolve to enhance the revenue yield over time. Therefore, tax revenues should increase at a rate equal to or greater than the growth of the GDP. To ensure this, the government should adopt tax policies that include growing sectors of the economy in the tax base.

The stability of tax revenues over time is equally important in order to maintain the continuity of the fiscal policies of the government. If the tax revenue tends to fluctuate over time, it becomes a source of risk and imposes another element of economic inefficiency on the country that adversely affects government programs.

For any tax system to be able to provide stable revenues to its government, it is desirable that the tax revenue can respond automatically to increases in the national income which result from economic growth. The pace of such an increase in revenue would depend on the revenue elasticity of the tax system (Note 7).

The evaluation of the relationship between revenue and national income gives the government a valuable insight into the overall tax system. This understanding assists the government in planning for tax reforms to drive inclusive growth.

As a rule, the total of government tax revenues is determined by the size of the tax base, the levels of tax rates adopted within the tax system, administrative efficiency, and the compliance rate. Revenue estimates are undertaken with respect to the level of the expected GDP growth rate, the rate of inflation, and other macroeconomic variables.

The preparation of tax revenues forecasts is done according to selected methodologies -approaches used by International Institutes and VECM- and common assumptions of a tax system. These assumptions are made for certain macroeconomic variables, such as growth of the national income and the inflation.

3. International Institutes Methodologies

Tax analysis and tax revenue forecast are crucial in ensuring adequacy and stability in tax policies. However, forecasting government revenues is a challenging task that requires taking into account a wide set of macroeconomic variables, tax structure and the conducted fiscal policy. The IMF addresses these questions in its paper IMF (2013) (Note 8) by presenting four approaches; the effective tax rate approach, the marginal tax rate approach, the elasticity approach the regression approach.

3.1 Effective Tax Rate Approach

The effective tax rate (ETR) represents the amount of revenues actually collected as a percentage of the tax base. Using the ETR in revenue forecasting allows taking into account certain factors, such as tax exemptions and tax evasion.

We can postulate that a relationship exists between the tax base and the tax revenue if the ETR is stable over time. Once ETR stability is confirmed, we can use it to forecast revenues by multiplying the tax base by the tax rate.

However, the forecast is constrained by the difficulty of determining the tax base, forasmuch that we need a large amount of very detailed information to assess the evolution of different tax bases. Especially since these data are not always available or published. And even if it is possible to determine the tax base for several years, it is not always possible to forecast it.

For these reasons, IMF (2013) uses a tax base substitution in order to analyze the behavior of tax revenues and forecast future revenues. This tax base is an economic variable that is closely related to the actual tax base and for which data are available. The following table lists the categories of taxes and the tax bases suggested by the IMF.

Table 1. Suggested Proxy Tax Bases for Tax Revenues

Taxes		Suggested proxy taxes base
Tax on net income and profits	Corporate	The profits derived from the national accounts or nominal GDP
	Individual	Wages or nominal GDP
Taxes on goods and services		Private consumption at current prices or nominal GDP
Excise duties		Private consumption at current prices or nominal GDP
Import duties		Value and volume of imports in local currency

Source: IMF (2013).

Thus, to forecast tax revenues, we first calculate the ETR, which is defined as the amount of taxes recipes divided by the proxy tax base:

$$Effetive\ Tax\ Rate = \frac{Tax\ Revenue}{Proxy\ Tax\ Base}$$

The forecast of tax revenue (Tax) using the ETR and forecasts of the tax base (Taxbase) is achieved using the following formula:

$$Tax_t = Taxbase_t * (ETR)/100$$

Once we conclude that the ETR is stable, we can forecast tax recipes by multiplying the estimated tax base by the tax rate. If the effective tax rate is not stable, it may be substituted by the marginal tax rate.

3.2 Marginal Tax Rate Approach

The marginal tax rate (MTR) is expressed by the ratio of the change in tax revenues to the change in the tax base:

$$Marginal\ taxe\ rate = \frac{\Delta\ Tax\ revenue}{\Delta Proxy\ taxe\ base}$$

The forecast of tax revenue (Tax) using the marginal tax rate (MTR) and the change in forecast of the tax base (Taxbase) is based on the following formula:

$$\Delta Tax = MTR * \Delta Taxbase$$

If the MTR is stable, we estimate the future evolution of revenues by multiplying the forecast of the tax base by the MTR. It is important to note that the change in income tax is divided into two parts: one corresponding to a change in the tax base and its impact on income and the other corresponding to a change in the tax system (in the tax rate, the tax structure, coverage of tax, etc.).

3.3 Elasticity Approach

The tax elasticity is defined as the ratio of the percentage change in tax revenue to the percentage change in the tax base, assuming that the tax system remains unchanged during the period. Considering the GDP as a variable of the tax base, the elasticity with respect to GDP is written as follows:

$$Elasticity = \frac{\Delta T/T}{\Delta GDP/GDP}$$

Where T indicates tax revenues issued from an unchanged tax system, meaning that actual tax revenues excludes the estimated impact of changes in the tax system during the analyzed period. The IMF recommends an estimation of elasticity using "rough averaging" of the ratio over a period witch there was no regime change.

Once we estimate the elasticity of the tax and we forecast the growth rate of the tax base, we can predict tax revenues by multiplying the growth rate of the tax base by the elasticity applying the following formula:

$$Tax_t = Tax_{t-1} * (1 + elasticity * \Delta\%Taxbase_t)/100$$

3.4 Regression Approach

The IMF uses Regression analysis to estimate the quantitative effect of tax base variables on tax revenues. The accuracy of this method depends on the existence of a relationship between the explanatory variables, say GDP (the proxy tax base), and the total tax revenues.

$$lnT_t = \beta_0 + \beta_1 lnPIB_t + \beta_2 lnT_{t-1} + \beta_3 lnPIB_{t-1} + \varepsilon_t$$

Thereby, tax revenue forecasting is made using the estimated regression coefficients, the GDP forecast and tax revenues of the previous year. However, estimates using the Ordinary Least Square Method (OLS) are only meaningful if the variables involved are stationary. If not, OLS estimation will generate fallacious regressions.

Since the nominal revenue and GDP series are often non-stationary variables, a more appropriate alternative to the OLS method is to use co-integration procedures to find a long-term relationship between revenue and GDP. The existence of a co-integration relationship implies that the linear combination of the log of taxes and the log of GDP is stationary.

4. Vector Error Correction Model (Johansen's Approach)

Johansen's approach is a method for estimating more than one co-integration relationship between variables on the long-term using the maximum likelihood test.

In the following, we present the main steps of the co-integration approach. Thus, we estimate error correction models and study the long-term relationships between revenues (total tax revenue, VAT, Corporate Taxes (IS) and Income Taxes (IR)), the real Gross Domestic Product (GDP) and the Consumer Prices Index (CPI). Johansen's methodology takes its starting point in the VAR (Vector Auto Regressive) of reduced rank (the number of co-integration relationships). The steps generally followed are:

- Determination of lag length in the VAR representation.
- Co-integration test and determining long-term relationships.
- Estimation of the vector error correction model (VECM).
- Model validation.

4.1 Models Estimation

Before determining models linking tax revenues to real GDP and the CPI over the period 1990-2016, one must begin by testing the stationary and the order of integration of the series. Thus, we examine Augmented Dickey Fuller (ADF) (Note 9) test results, using E-Views software, in order to determine the stationarity properties of the variables. The results of the ADF test as reported in the table below shows that all series are stationary integrated of order one, except the CPI which is found to be stationary in its level:

Table 2. ADF Test Results

Time series	Model used for the test	ADF test	critical value at the 5%	Order of Integration
		ADF Statistics		
Total Tax revenues (rec)	with trend with constant	-4.212116	-3.580623	*Stationary I (1)*
VAT		-4.402664	-3.603202	*Stationary I (1)*
IS		-4.402585	-3.603202	*Stationary I (1)*
IR		-5.245292	-3.603202	*Stationary I (1)*
GDP		-7.471209	-3.587527	*Stationary I (1)*
CPI		-4.212116	-3.580623	*Stationary I (0)*

Source: Author's estimates.

Step 1: Lag length selection

This first step is to determine the order of the VAR representation. The calculation of the information criteria LR (Note 10) FPE (Note 11) AIC (Note 12) SC (Note 13) and HQ (Note 14) for the four models indicates that the optimal number of lags is 1 or 2 (Appendix 2). Taking into account the small sample size, we opted for one lag that allows us to find better results and to obtain models with signs consistent with theory.

Step 2: Johansen co-integration tests

The trace test and the maximum eigenvalue established for the four models reveals the existence of at least one co-integration relationship (the tables in Appendix 3 summarizes the results obtained).

The presence of co-integration between variables suggests a long-term relationship among the variables under consideration. Then, the VEC models, with one lag, can be applied on total tax revenue, VAT, IR and IS for one co-integrating vector. All series are transformed into logarithms, which can be useful in verifying the characteristics of partial short-term and long-term elasticities of the models.

Our basic models would be:

- Total Tax revenues: $lrec = F(lpib, lipc)$
- VAT: $ltva = F(lpib, lipc)$
- Corporate taxes: $lis = F(lpib, lipc)$
- Income taxes: $lir = F(lpib, lipc)$

with:

Pib = *GDP*, $lpib = dlog(pib)$, $lipc = log(ipc)$, $lrec = dlog(rec)$, $ltva = dlog(tva)$, $lir = dlog(ir)$, $lis = dlog(is)$

Step 3: Estimation results

The estimation results of the four models are consistent with the theory. The estimated coefficients of the long-term relationship are globally significant with intuitive signs. In addition, the term error-correction is negative and significantly different from zero for all models (see Appendix 4, which contains the four VECM and their coefficients).

Step 4: Models validation

For model validation, the usual verifications were carried out;

- Regarding the normality of residuals and autocorrelation test residues, we opted for Jarque-Bera and LM tests (Lagrange-Multipliar). According to E-Views outputs of these tests, we cannot reject the null hypothesis of normality or that of non-autocorrelation of residuals at a significance level of 5% for the four models (see Appendix 5 and 6).
- For the stability of the models, the inverse roots of the polynomial characteristic of the four models are well within the unit circle. These results confirm the correct model specification (see Appendix 7).
- The co-integration relations of the equilibrium models are stationary (see Appendix 8). This confirms the existence of a stable long-term relationship between the revenues, the GDP and the CPI.

4.2 Results Interpretation

The estimation of Vector Error Correction Models for tax recipes provides an error-correction term coefficient is significant, meaning that the GDP and the CPI have long run influence on government tax revenues. This coefficient is equal to -0.47 for total tax revenues, -0.31 for VAT, -0.54 for corporate tax, and -0.63 for income tax. These results confirm the stationarity of the co-integrating vectors of estimated models.

There by the speed of adjustment towards long run equilibrium indicate that total tax revenues adjust at a rate of 49% to their equilibrium levels after any shock from exogenous variables. For VAT, the IS and IR, they are adjusting at a speed of 31%, 54% and 63% respectively, compared to their equilibrium levels.

These coefficients also indicate that the shock is completely absorbed at the end of aft two years (Note 15, Note 16) for total tax revenues and corporate tax, 3 years (Note 17) for VAT and one year and half (Note 18) for income tax.

The results of the regression analysis indicate the value of the coefficient of determination R2, which is equal to 0.40 for total tax revenues, indicating that 40% of the fluctuations of this revenue is explained by the model variables. This coefficient is equal to 0.30 for the VAT, 0.34 for corporate tax and 0.46 for the income tax recipes. We conclude that the models are a good fit and that the explanatory power and the overall significance of the model is strong enough to conduct a forecast.

4.3 Forecasting Tax Revenues

After estimating and validating the VECM models of government revenues, we proceed by forecasting total tax revenues, VAT, corporate tax and income recipes for the years 2017 and 2018, using real GDP and CPI forecasts.

Figure 1. Results of Tax Revenue Forecasting

Source: author's estimates.

5. Analysis of Forecasting Results of the Different Approaches

The table below presents revenue forecasts results for 2017 and 2018.

Table 3. Revenue Forecasts Results

	2017					2018				
	ETR	**MTR**	**Elasticity**	**VECM**	**Average**	**ETR**	**MTR**	**Elasticity**	**VECM**	**Average**
Rec (Note 19)	223714	227297	212 489	224 922	220 375	234350	241295	212 592	237257	228 066
IS	47530	47396	45196	45542	46089	49789	51291	49029	47907	48908
IR	40724	42474	42,159	40484	41122	42,660	46051	45555	42,398	43538
VAT	79827	83,808	80806	79808	80,147	83,622	91 336	85577	83,971	84,390

Source: author's estimates.

The steps of tax revenue forecasts are; evaluation of tax elasticity, evaluation of changes in economic conditions, and evaluation of the effect of inflation and price changes.

When calculating the MTR we noticed that this rate is not stable during the period, which means we cannot use it to predict futures tax revenues. Moreover, we note that the forecast provided by the MTR approach have the highest values.

The revenues forecasts can be obtained through the average of the results of the three methods, ETR, Elasticity and VECM, in order to have more accurate forcasts. This average can be improved by taking into account future adjustments and tax measures.

Ultimately, regular comparisons of the forecasts and the revenue recorded are fundamental to assess the quality of the estimates. Furthermore, the effectiveness of tax revenues forecast is based on the judgment and expertise of those who make them. The knowledge of the context of the variables allows for adjustments to quantitative results based on various external factors that can influence the future achievements.

6. Conclusion

This analysis begun with a brief review of literature about optimal tax policy, based on the foundational work of Ramsey (1927) and Mirrlees (1971). We can put forward the general lessons suggested by optimal tax theory as it has been presented in the work of Glenn P. (2000) (Note 7):

- Optimal marginal tax rate programs depend on society's ability distribution;
- the optimal tax system would feature declining marginal tax rates;
- the optimal tax schedule, with a universal lump-sum transfer, is found to be close to be optimal;
- The optimal extent of redistribution rises with wage inequality;
- In stochastic, dynamic economies, optimal tax policy requires increased sophistication.

Afterwards, this study forecast Moroccan tax revenues using the approaches that are recommended by the IMF for developing countries and expend this analysis by applying a co-integration approach to overcome stationarity problems.

The results of the different approaches are based on past observations taking into account the expected impact of the macroeconomic situation approached by the real GDP and the CPI. The accuracy of the forecast is a difficult goal that depends largely on the knowledge and the expertise of the economist who conduct the analysis.

These approaches can be used to assess the quality of tax revenues prediction in order to gradually reduce forecast errors. The development of such approaches is necessary to support the draft of Finance Low with detailed economic analysis. Thereby, it is necessary to instore a database of financial, economic and social data containing the most detailed and documented information in order to meet the growing requirements for forecasts and studies of impacts of fiscal policy.

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Note 9. See Appendix 1.

Note 10. LR sequential modified LR test statistic.

Note 11. FFO Final prediction error.

Note 12. AIC: Akaike information criterion.

Note 13. SC: Schwarz information criterion.

Note 14. HQ: Hannan-Quinn information criterion.

Note 15. 1 / 0.47 = 2.13.

Note 16. 1 / 0.54 = 1.85.

Note 17. 1 / 0.31 = 3.23.

Note 18. 1 / 0.63 = 1.59.

Note 19. Total tax Revenues.

Appendix

Appendix 1. Augmented Dickey Fuller

tax revenues I (1)

Null Hypothesis: D (REC): has a unit root
Exogenous: Constant Linear Trend
Lag Length: 0 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-4.514723	0.0074
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

VAT I (1)

Null Hypothesis: D (VAT): has a unit root
Exogenous: Constant Linear Trend
Lag Length: 0 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-4.402664	0.0094
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

* MacKinnon (1996) one-sided p-values.

IS I (1)

Null Hypothesis: D (IS): has a unit root
Exogenous: Constant Linear Trend
Lag Length: 0 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-4.402585	0.0094
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

* MacKinnon (1996) one-sided p-values.

IR I (1)

Null Hypothesis: D (IR): has a unit root
Exogenous: Constant Linear Trend
Lag Length: 0 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-5.245292	0.0014
Test critical values:	1% level	-4.374307	
	5% level	-3.603202	
	10% level	-3.238054	

* MacKinnon (1996) one-sided p-values.

Real GDP I (1)

IPC I (0)

Null Hypothesis: D (GDP): has a unit root
Exogenous: Constant Linear Trend
Lag Length: 3 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-3.302803	0.0097
Test critical values:	1% level	-4.394309	
	5% level	-3.012199	
	10% level	-3.003079	

* MacKinnon (1996) one-sided p-values.

Null Hypothesis: CPI: has a unit root
Exogenous: Constant Linear Trend
Lag Length: 0 (Automatic - based on CIS maxlag = 6)

		Does Statistic	Prob. *
Augmented Dickey-Fuller test statistic		-4.212116	0.0129
Test critical values:	1% level	-4.323979	
	5% level	-3.580623	
	10% level	-3.225334	

* MacKinnon (1996) one-sided p-values.

Appendix 2. Lag Length Criteria

Tax revenues

Lag	LogL	LR	FPE	AIC	SC	HQ
0	27.18710507595956	NA	2.90e-05	-1.934968	-1.788703	-1.894401
1	166.4677280051047	233.9914*	8.70e-10*	-12.35742*	-11.77236*	-12.19515*
2	174.9113838108442	12.15886	9.44e-10	-12.31291	-11.28906	-12.02894

* indicates lag order selected by the criterion.

VAT

Lag	LogL	LR	FPE	AIC	SC	HQ
0	17.19142201477803	NA	6.45e-05	-1.135314	-0.989049	-1.094746
1	162.1862084445787	243.5912*	1.23e-09	-12.01490	-11.42984*	-11.85263
2	173.340429203331	16.06208	1.07e-09*	-12.18723*	-11.16338	-11.90326*

* indicates lag order selected by the criterion.

IS

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-4.711037	NA	0.000372	0.616883	0.763148	0.657451
1	145.9174	253.0558*	4.50e-09	-10.71339	-10.12833*	-10.55112*
2	155.6913	14.07446	4.39e-09*	-10.77531*	-9.751451	-10.49133

* indicates lag order selected by the criterion.

IR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	24.41134526315707	NA	3.62e-05	-1.712908	-1.566643	-1.672340
1	156.4871829618125	221.8874*	1.93e-09*	-11.55897*	-10.97391*	-11.39670*
2	163.9024762312982	10.67802	2.28e-09	-11.43220	-10.40834	-11.14822

* indicates lag order selected by the criterion.

Appendix 3. Trace Test

Tax revenues

Selected (0.05 level *) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	1	2	3
Max-Eig	1	1	1	2	3

* Critical values are based MacKinnon-Haug-Michelis (1999).

VAT

Selected (0.05 level *) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	1	1	2
Max-Eig	1	1	1	1	2

* Critical values are based MacKinnon-Haug-Michelis (1999).

IS

Selected (0.05 level *) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	2	1	3	2	3
Max-Eig	1	1	1	2	3

* Critical values are based MacKinnon-Haug-Michelis (1999).

IR

Selected (0.05 level *) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	3	3	2	2	2
Max-Eig	3	3	2	2	2

* Critical values are based MacKinnon-Haug-Michelis (1999).

Appendix 4. VECM Models

VAT

Cointegrating Eq:	CointEq1		
DLOG (VAT (-1))	1.000000		
DLOG (PIBRE (-1))	-9.990071		
	(1.40404)		
	[-7.11521]		
LOG (CPI (-1))	0.246933		
	(0.12057)		
	[2.04812]		
C	-0.823564		
Error correction:	D (DLOG (VAT))	D (DLOG (PIBRE))	D (LOG (IPC))
CointEq1	-0.307568	0.299991	-0.045097
	(0.23575)	(0.05704)	(0.03248)
	[-1.30465]	[5.25947]	[-1.38850]
D (DLOG (VAT (-1)))	-0.267026	-0.150714	0.021775
	(0.23583)	(0.05706)	(0.03249)
	[-1.13227]	[-2.64137]	[0.67018]
D (DLOG (PIBRE (-1)))	-1.305637	0.616742	-0.186970
	(1.03276)	(0.24987)	(0.14228)
	[-1.26422]	[2.46823]	[-1.31407]
D (LOG (CPI (-1)))	-2.268848	-0.004236	0.173461
	(2.27996)	(0.55163)	(0.31411)
	[-0.99512]	[-0.00768]	[0.55223]
C	0.218079	-0.004027	0.045352
	(0.17187)	(0.04158)	(0.02368)
	[1.26883]	[-0.09683]	[1.91527]
DUMREC	-0.173443	0.027625	-0.032467
	(0.15077)	(0.03648)	(0.02077)
	[-1.15038]	[0.75729]	[-1.56303]
DUM1	-0.029117	-0.026295	0.000268
	(0.04871)	(0.01178)	(0.00671)
	[-0.59782]	[-2.23135]	[0.03995]
R-squared	0.325291	0.912338	0.435464
Adj. R-squared	0.087159	0.881399	0.236216
Sum sq. resids	0.158909	0.009302	0.003016
SE equation	0.096683	0.023392	0.013320
F-statistic	1.366009	29.48789	2.185539
log likelihood	26.15519	60.21216	73.72719
Akaike AIC	-1.596266	-4.434347	-5.560599
Schwarz SC	-1.252667	-4.090748	-5.217000
Mean dependent	-0.003653	0.001390	0.021201
SD dependent	0.101193	0.067924	0.015241
Determinant resid covariance (dof adj.)		5.95E-10	
Determinant resid covariance		2.12E-10	

log likelihood	165.1502	
Akaike information criterion	-11.76251	
Schwarz criterion	-10.58446	

Tax revenues

Cointegrating Eq:	CointEq1		
DLOG (REC (-1))	1.000000		
DLOG (PIBRE (-1))	-5.973431		
	(0.79855)		
	[-7.48032]		
LOG (CPI (-1))	0.163795		
	(0.09523)		
	[1.71992]		
C	-0.581574		
Error correction:	D (DLOG (REC))	D (DLOG (PIBRE))	D (LOG (IPC))
CointEq1	-0.470064	0.338007	-0.013878
	(0.21609)	(0.08731)	(0.04055)
	[-2.17531]	[3.87141]	[-0.34222]
D (DLOG (REC (-1)))	-0.285235	-0.197960	0.021375
	(0.19124)	(0.07727)	(0.03589)
	[-1.49150]	[-2.56199]	[0.59555]
D (DLOG (PIBRE (-1)))	-1.435134	0.208651	-0.068355
	(0.67781)	(0.27386)	(0.12721)
	[-2.11732]	[0.76189]	[-0.53735]
D (LOG (CPI (-1)))	-1.045720	-0.381911	0.542057
	(1.08726)	(0.43929)	(0.20405)
	[-0.96179]	[-0.86938]	[2.65648]
C	0.062115	0.005267	0.009057
	(0.04387)	(0.01773)	(0.00823)
	[1.41582]	[0.29715]	[1.10004]
DUMREC2	-0.066862	0.006966	-0.000388
	(0.03926)	(0.01586)	(0.00737)
	[-1.70319]	[0.43921]	[-0.05268]
R-squared	0.400243	0.849146	0.353558
Adj. R-squared	0.233643	0.807243	0.173990
Sum sq. resids	0.098060	0.016008	0.003454
SE equation	0.073809	0.029822	0.013852
F-statistic	2.402428	20.26421	1.968943
log likelihood	31.94826	53.69827	72.10143
Akaike AIC	-2.162355	-3.974856	-5.508452
Schwarz SC	-1.867842	-3.680342	-5.213939
Mean dependent	-0.004229	0.001390	0.021201
SD dependent	0.084313	0.067924	0.015241
Determinant resid covariance (dof adj.)		4.74E-10	
Determinant resid covariance		2.00E-10	

log likelihood	165.8255	
Akaike information criterion	-12.06879	
Schwarz criterion	-11.03800	

IS

Cointegrating Eq:	CointEq1		
DLOG (IS (-1))	1.000000		
DLOG (PIBRE (-1))	-11.43442		
	(1.94964)		
	[-5.86489]		
LOG (CPI (-1))	0.421270		
	(0.22710)		
	[1.85500]		
C	-1.575479		
Error correction:	D (DLOG (IS))	D (DLOG (PIBRE))	D (LOG (IPC))
CointEq1	-0.543853	0.129122	-0.012724
	(0.32890)	(0.04638)	(0.02012)
	[-1.65354]	[2.78377]	[-0.63242]
D (DLOG (IS (-1)))	-0.367894	-0.119135	0.006936
	(0.22551)	(0.03180)	(0.01380)
	[-1.63136]	[-3.74601]	[0.50279]
D (DLOG (PIBRE (-1)))	-2.690319	-0.011117	-0.108697
	(1.95130)	(0.27518)	(0.11937)
	[-1.37873]	[-0.04040]	[-0.91061]
D (LOG (CPI (-1)))	0.933261	0.061611	0.560647
	(2.75666)	(0.38876)	(0.16863)
	[0.33855]	[0.15848]	[3.32463]
C	-0.045001	-0.004241	0.006871
	(0.08160)	(0.01151)	(0.00499)
	[-0.55152]	[-0.36853]	[1.37658]
DUMIS3	0.044600	0.015416	0.007074
	(0.12467)	(0.01758)	(0.00763)
	[0.35774]	[0.87680]	[0.92759]
R-squared	0.342948	0.844144	0.417552
Adj. R-squared	0.160434	0.800851	0.255761
Sum sq. resids	0.831576	0.016539	0.003112
SE equation	0.214939	0.030312	0.013149
F-statistic	1.879021	19.49823	2.580806
log likelihood	6.295314	53.30678	73.35235
Akaike AIC	-0.024609	-3.942232	-5.612696
Schwarz SC	0.269904	-3.647718	-5.318182
Mean dependent	-0.008489	0.001390	0.021201
SD dependent	0.234578	0.067924	0.015241
Determinant resid covariance (dof adj.)		3.27E-09	
Determinant resid covariance		1.38E-09	

log likelihood	142.6729	
Akaike information criterion	-10.13941	
Schwarz criterion	-9.108615	

IR

Cointegrating Eq:	CointEq1		
DLOG (IR (-1))	1.000000		
DLOG (PIBRE (-1))	6.947405		
	(0.59426)		
	[11.6908]		
LOG (CPI (-1))	0.076166		
	(0.07677)		
	[0.99207]		
C	-0.687085		
Error correction:	D (DLOG (IR))	D (DLOG (PIBRE))	D (LOG (IPC))
CointEq1	-0.632810	-0.341030	0.039454
	(0.23796)	(0.04745)	(0.01757)
	[-2.65932]	[-7.18779]	[2.24542]
D (DLOG (IR (-1)))	-0.081923	0.173914	-0.010924
	(0.20548)	(0.04097)	(0.01517)
	[-0.39869]	[4.24491]	[-0.72000]
D (DLOG (PIBRE (-1)))	1.992393	0.259147	-0.111262
	(0.82481)	(0.16445)	(0.06090)
	[2.41559]	[1.57580]	[-1.82684]
D (LOG (CPI (-1)))	-3.522107	1.396372	-0.500246
	(2.76733)	(0.55176)	(0.20434)
	[-1.27275]	[2.53074]	[-2.44811]
C	0.142005	-0.053314	0.083902
	(0.17077)	(0.03405)	(0.01261)
	[0.83158]	[-1.56584]	[6.65392]
DUM	-0.015035	0.067823	-0.057897
	(0.12958)	(0.02584)	(0.00957)
	[-0.11603]	[2.62511]	[-6.05095]
DUMIR	-0.078343	-0.043650	-0.004667
	(0.05897)	(0.01176)	(0.00435)
	[-1.32861]	[-3.71266]	[-1.07196]
R-squared	0.460405	0.926227	0.799044
Adj. R-squared	0.269959	0.900190	0.728118
Sum sq. resids	0.196918	0.007828	0.001074
SE equation	0.107626	0.021459	0.007947
F-statistic	2.417516	35.57293	11.26591
log likelihood	23.58175	62.28212	86.12218
Akaike AIC	-1.381813	-4.606843	-6.593515
Schwarz SC	-1.038214	-4.263244	-6.249916
Mean dependent	-0.007343	0.001390	0.021201

SD dependent	0.125963	0.067924	0.015241
Determinant resid covariance (dof adj.)		1.63E-10	
Determinant resid covariance		5.78E-11	
log likelihood		180.7243	
Akaike information criterion		-13.06036	
Schwarz criterion		-11.88231	

Appendix 5. Normality Test for the Four Models

Tax revenues

Component	Jarque-Bera	df	Prob.
1	10.33517	2	0.0057
2	0.260379	2	0.8779
3	1.740852	2	0.4188
joint	12.33640	6	0.0549

VAT

Component	Jarque-Bera	df	Prob.
1	5.423351	2	0.0664
2	1.184614	2	0.5531
3	2.728125	2	0.2556
joint	9.336090	6	0.1555

IS

Component	Jarque-Bera	df	Prob.
1	0.298577	2	0.8613
2	1.033972	2	0.5963
3	1.623734	2	0.4440
joint	2.956283	6	0.8143

IR

Component	Jarque-Bera	df	Prob.
1	1.094420	2	0.5786
2	0.238981	2	0.8874
3	0.253417	2	0.8810
joint	1.586818	6	0.9535

Appendix 6. Residuals Autocorrelation Test for the Four Models

Tax revenues

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order pm
Date: 09/08/17 Time: 12:26
Sample: 1990 2016
Included observations: 24

lags	LM-Stat	prob
1	13.85933	0.1274
2	7.993951	0.5348

Probs from chi-square with 9 df.

VAT

lags	LM-Stat	prob
1	16.70569	0.0535
2	5.785537	0.7612

Probs from chi-square with 9 df.

IS

lags	LM-Stat	prob
1	17.39272	0.0429
2	5.949008	0.7450

Probs from chi-square with 9 df.

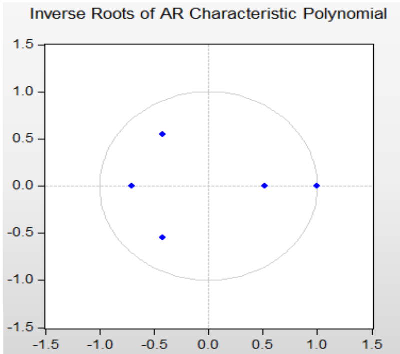
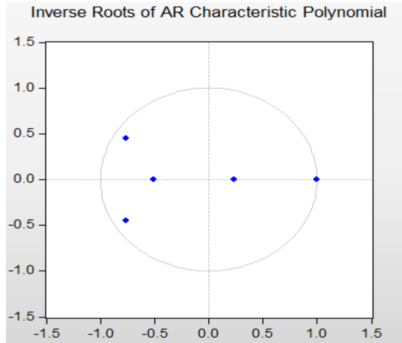
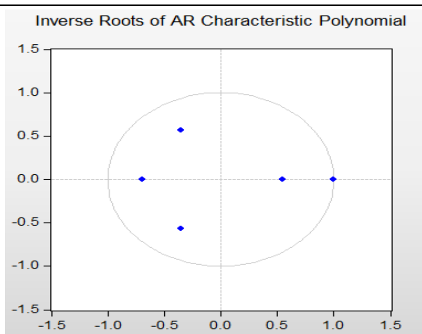
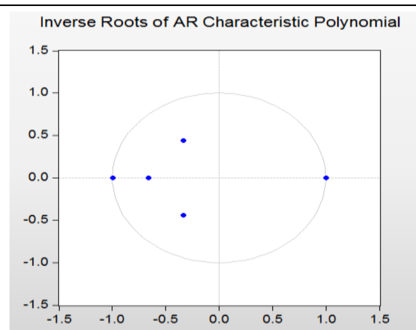
For the SI, the residue was corrélogrames asimulé to confirm idependance view that the LM test P-value is less than 5%.

IR

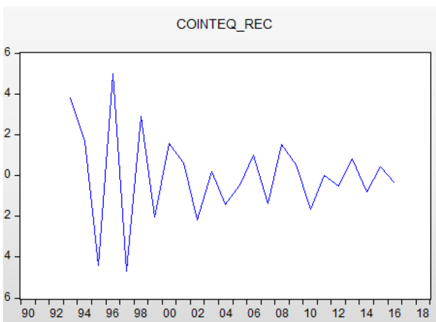
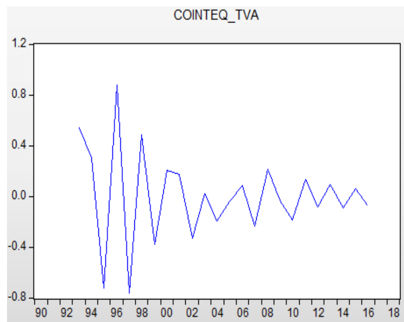
lags	LM-Stat	prob
1	6.443088	0.6949
2	8.736137	0.4620

Probs from chi-square with 9 df.

Appendix 7. ECM Stability Test

Tax revenues	VAT
	
IS	IR
	

Appendix 8. Equilibrium Co-Integration Relationships

Tax revenues	VAT
	
IS	IR