MINISTRY FOR FINANCE
MALTA

STEMM: Short-Term Quarterly Econometric Forecasting Model for Malta

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Ministry for Finance

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Abstract

The Short-Term Quarterly Econometric Forecasting Model for Malta (STEMM) is the basis for the official macroeconomic projections, the fiscal projections and the fiscal targets of the Government of Malta. STEMM is a Keynesian model where aggregate demand determines output in the presence of price rigidities in the short-term. The model was originally developed in 2001 by the Economic Policy Department through the assistance of Cambridge Econometrics (UK). The model is medium-scale, consisting of six main blocks. It is composed of 47 identity equations and 69 behavioural equations, most of them specified as an error correction model specification estimated on quarterly European System of Accounts (ESA) 2010 chain-linked data from 1995 to 2016 in accordance with the Engle-Granger two-stage approach. Moreover, there are 47 exogenous variables, consisting of economic variables related to our trading partners, exchange rates, commodity prices, fiscal variables and dummy variables.

JEL classification: C3, C5, E1, E2, E3, E6, F1, H6, J2, J3.

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List of Acronyms

ACF	Autocorrelation Function
ADF	Augmented Dickey-Fuller
AR	Autoregressive
ARIMA	Autoregressive Moving Average Integrated by some order
DF	Dickey-Fuller Test
EC	European Union Council Regulation
EPD	Economics Policy Department
ESA	European System of National and Regional Accounts
EU	European Union
GDP	Gross Domestic Product
HICP	Harmonised Index of Consumer Prices
MA	Moving Average
MFAC	Malta Fiscal Advisory Council
MFIN	Ministry for Finance
MIG	Main Industrial Groupings
OLS	Ordinary Least Squares
PACF	Partial Autocorrelation Function
RPI	Retail Price Index
SGP	Stability and Growth Pact
STEMM	Short-Term Econometric Model for Malta
VAT	Value Added Tax

1. Introduction and Objectives

1.1 Introduction

The Economic Policy Department (EPD) within the Ministry for Finance of Malta is responsible for producing macroeconomic forecasts for the Government of Malta through its Short-term Econometric Model for Malta (STEMM) – a Keynesian forecasting model developed in collaboration with Cambridge Econometrics in 2002 following a feasibility study (Cambridge Econometrics, 2000). Macroeconomic forecasts are salient as they form the basis of governmental economic policy formulation and analysis and decision-making processes, particularly the annual budgetary process and various policy direction documents: the annual update of the Stability Programme in accordance with European Union Council regulations[1], the Budget Speech, the Medium-Term Budgetary Framework, the National Reform Programme and the Draft Budgetary Plan. Forecasts are produced on a bi-annual basis: in spring and in autumn.

This report is being prepared in fulfilment of the requirements of Article 4(5) of Council Directive 2011/85/EU of the European Union (on the requirements for budgetary frameworks of the Member States) which requires Member States to "make public the official macroeconomic and budgetary forecasts prepared for fiscal planning, including the methodologies, assumptions and relevant parameters underpinning those forecasts". Furthermore, through the Fiscal Responsibility Act (FRA), 2014, Cap 534, the Malta Fiscal Advisory Council (MFAC) was established with effect from 1st January 2015. In terms of Article 13 of the above-mentioned Act, one of the functions of the MFAC is to assess and endorse the macroeconomic forecasts produced by the Government of Malta. As part of the endorsement process, the MFAC regularly assesses the methodology employed by EPD in producing macroeconomic forecasts including both the econometric model used as well as any judgement incorporated by forecasting experts. To this end, this report facilitates the review by the MFAC as intended by the Act.

STEMM is an expenditure-driven model consisting of six main blocks:

- the Trade block, which consists of export and import equations disaggregated at sectoral level;
- the Value-Added block, where value added is disaggregated at sectoral level having behavioural equations for each sector and linked with aggregate expenditure;
- the Employment block, which models employment at sectoral level, creating important links between the dynamics in the domestic and international markets and its effect on value added which in turn determines employment. Furthermore, the employment block models other important headline indicators such as the participation rate, activity rate and the unemployment rate;

[1] European Union Council Regulations – Council Regulation (EC) 1466/97 on the strengthening of the surveillance of budgetary positions and the surveillance and coordination of economic policies, as amended by Council Regulation (EC) 1055/2005 of 27 June 2005 and Regulation (EC) No 1175/2011 – the preventive arm of the Stability and Growth Pact.

- the Price block, which includes equations related to the HICP at MIG level and the RPI classified between tradeables and non-tradeables;
- the Fiscal block, which examines the behaviour of the main revenue and expenditure public finance items in ESA terms; and
- the Final Expenditure block, in which the final expenditure components of GDP and their respective deflators are modelled.

STEMM is composed of a number of identity equations and behavioural equations using quarterly data from 1995 to 2016, following the Engle-Granger two-stage approach. The model solution and forecasts are conditional on a number of exogenous assumptions mainly based on estimates and forecasts of external conditions produced by the IMF, Consensus Economics or the European Commission. The model enables room for expert judgement in line with the Robertson and Tallman (1999) argument that, given the complexities of forecasting models, the distinction between judgement-based and model-based forecasts cannot be pushed too far as no model can be left on automatic pilot for long.

1.2 Objectives

The purpose of STEMM is to provide consistent model solutions and forecasts and a systematic circular basis for incorporating partial and ad hoc information into an assessment of the current and short-term future performance of the economy. Precisely because the information is partial and ad-hoc in nature, the system is flexible (making use of detail where it is available, but not requiring this detail where it is not, while allowing for ease of change when new information of a different structure becomes available), and contains numerous features that vary, for example, from one industry to another. Moreover, STEMM provides the necessary capacity and tools to incorporate expert judgement aimed to bridge gaps not addressed by an aggregate demand model, including potential supply-side factors which may significantly influence the Maltese economy.

Although the main objective of STEMM is to produce short-term forecasts of the main macroeconomic indicators of the Maltese economy, it is also used to help analyse developments within the Maltese economy and evaluate the impact of potential economic shocks on the Maltese economy through quantitative simulations. This helps the Economic Policy Department to better guide the policy-maker on the balance of risks for the Maltese economy over the short- to medium-term while aiding the Department formulate policy recommendations to tackle contemporary economic issues.

This report provides a snapshot of the structural model's development as per Spring 2018 forecast. In the future there are a number of projects planned, including the introduction of potential output and output gap estimates in the model and the introduction of a savings function disaggregated at institutional account level.

The rest of the report proceeds as follows. Section 2 gives an overview of the model and its design while Section 3 discusses the econometric methodology in a more rigorous way, as the report presents a detailed overview of each model block and the main behavioural equations in each block. Section 4 assesses the forecasting accuracy of STEMM by presenting an *ex ante* analysis of past forecast errors as presented in Camilleri and Vella

(2015) and conducts the simulation of three standard macroeconomic shocks. The main conclusions are presented in Section 5, together with a brief overview of future planned refinements. Moreover, there are four appendices: (i) Appendix A provides the estimation results of all the behavioural equations within STEMM together with diagnostic checks, (ii) Appendix B highlights the main exogenous variables within STEMM, (iii) Appendix C provides a list of identities while (iv) Appendix D lists the variables. All results and model equations are based on the Autumn 2017 forecast vintage and do not incorporate changes in the model applied to subsequent published forecasts.

2. Model Overview and Design

In line with a number of structural macro-econometric models, STEMM is a Keynesian economic model with output determined in the short-term by movements in aggregate demand in the presence of price rigidities. Furthermore, the model synthesizes the adaptive expectations theory. The model is medium-scale, consisting of six main blocks populated with over 220 variables. There are 47 identity equations and 69 behavioural equations, estimated using quarterly ESA 2010 chain-linked data from 1995 to 2016 in accordance with the Engle-Granger two-stage approach. Behavioural equations are modelled in error correction form with the exception of certain equations in the price block, which includes HICP disaggregated at MIG level and RPI equations disaggregated between tradeables and non-tradeables. These are modelled through ARIMAX specifications in line with the Box-Jenkins methodology (Box and Jenkins, 1970). The remaining 47 variables are exogenous and consist of economic variables related to Malta's trading partners, exchange rates, commodity prices, fiscal variables and dummy variables.

The purpose of any economic model is to simplify an inherently complex world governed by a multitude of economic relationships into something that, although simple in nature and contingent on several assumptions, can greatly facilitate the interpretation and understanding of the economy. That said, STEMM consists of six main model blocks; i) the Trade block, ii) the sectoral Value Added block, iii) the Employment block, iv) the Price block, v) the Fiscal block and vi) the Final Expenditure block.

The model's structure and inter-linkages are illustrated through the following four charts. Chart 1 provides a schematic overview of the general causality and relationships among quantities in the model. The second chart highlights the links within the price block and how this in turn affect the aggregate demand component deflators. The third chart explains the general relationship between income and employment and their impact on the Maltese economy. The fourth chart provides an illustration at a disaggregated level of the main revenue and expenditure components of public finances and highlights its determinants. The model is defined mostly in terms of seasonally unadjusted variables. The seasonal factors calculated from historical data are applied to the forecast for seasonally adjusted variables to produce forecasts for seasonally unadjusted variables where applicable.

Chart 1: Schematic Representation of the General Causality in the STEMM Model

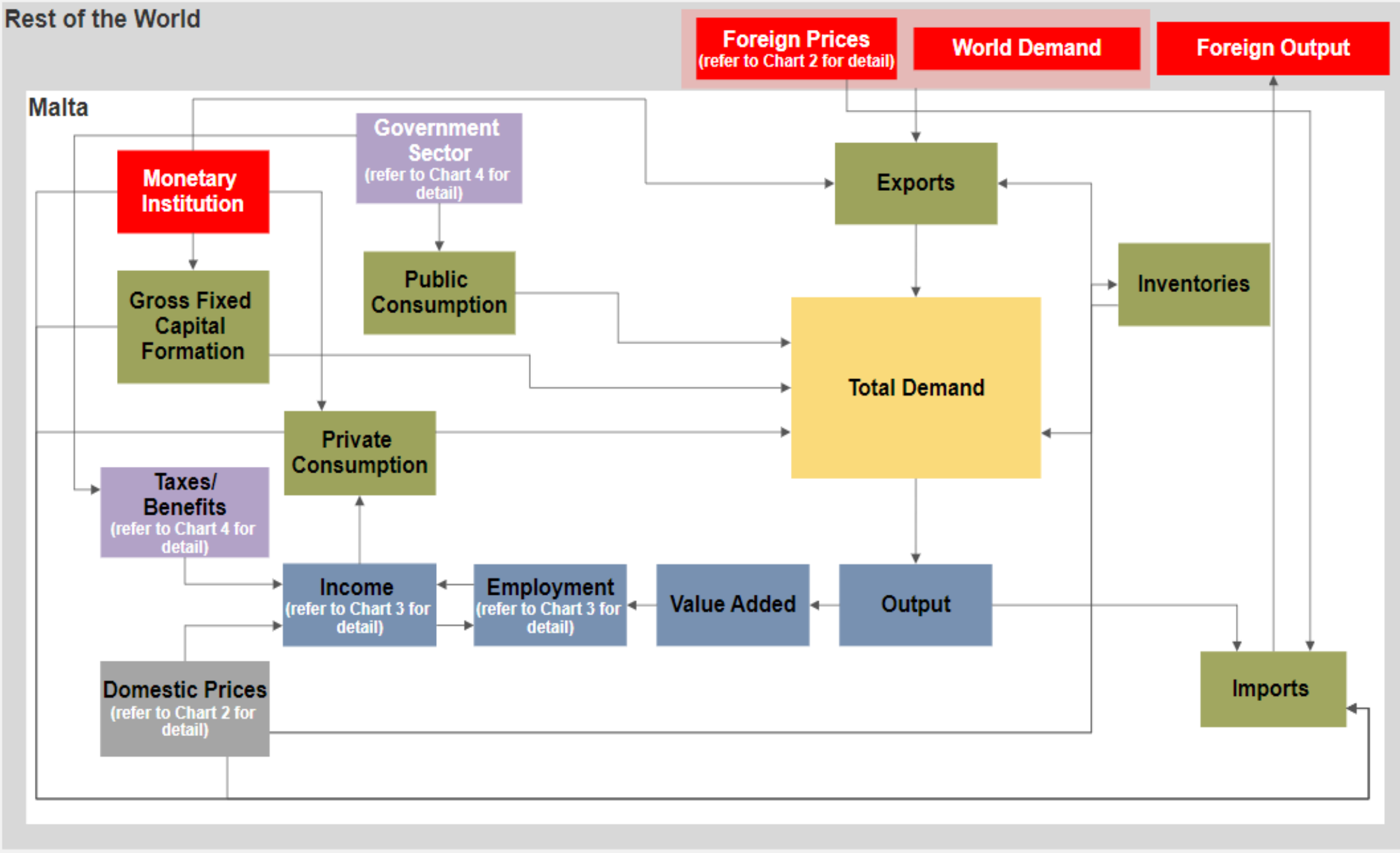


Chart 2: Schematic Representation of the General Causality Among Prices in the Model

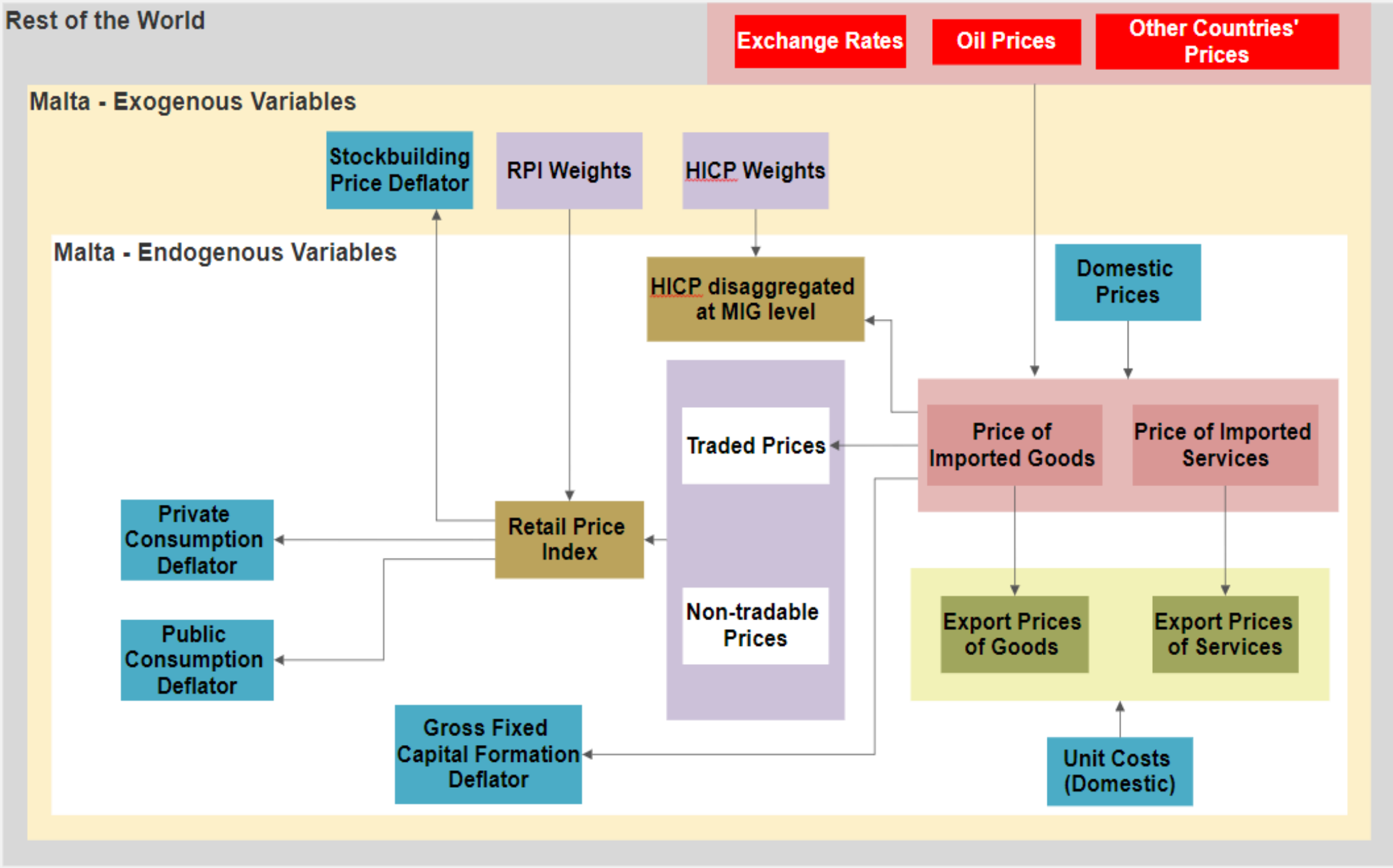


Chart 3: Schematic Representation of the General Causality Among Income and Employment

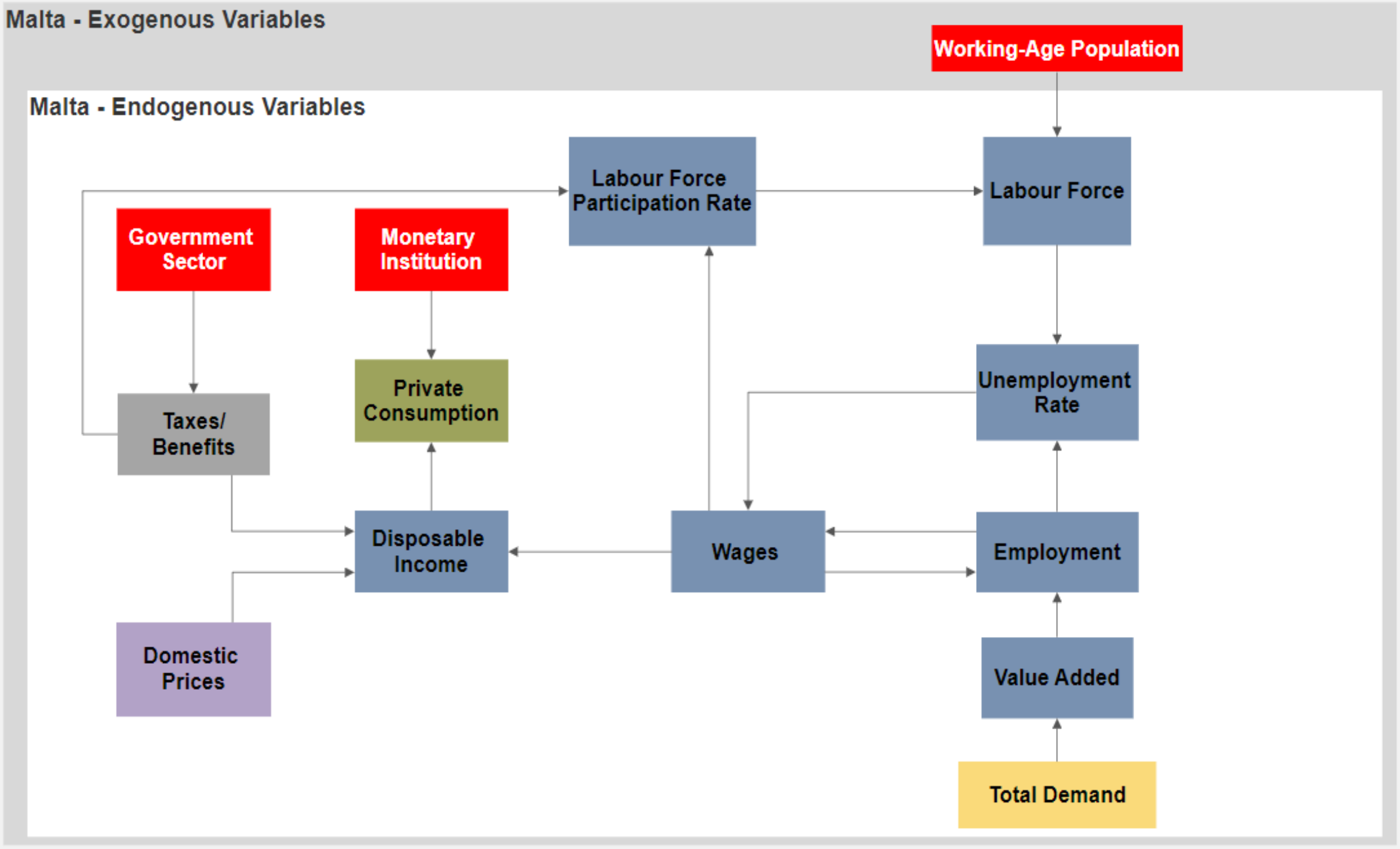
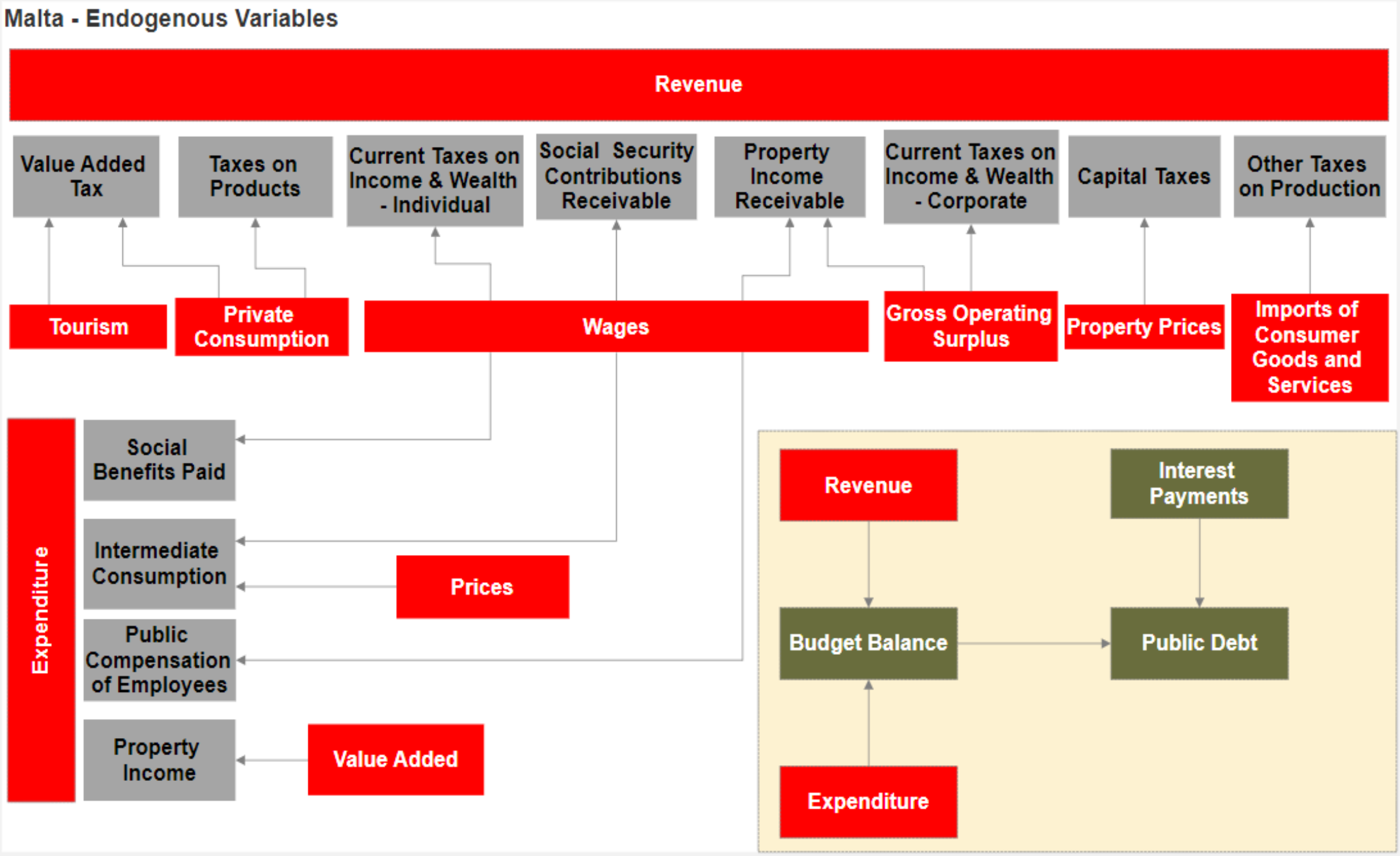


Chart 4: Schematic Representation of the General Causality - Public Sector



2.1 The Trade Block

Exports (SXV) and imports (SMV) are disaggregated by a number of major categories and modelled mainly on world economic activity (WGDP) weighted by both the number of inbound tourists and also by the economic activity of Malta's main trading partners, exchange rates and relative prices in the world and in the domestic economy. Sectoral trade data is only available at current prices and modelled accordingly.

Imports are split into nine categories with each category modelled separately:

- Imports of consumption goods,
- Imports of capital goods,
- Imports of intermediate goods,
- Imports of fuels,
- Imports of other goods,
- Imports of financial services,
- Imports of other business services,
- Imports of remote gaming and
- Imports of other services.

Similarly, exports are split into nine categories:

- Exports of electrical and machinery equipment,
- Exports of fuels,
- Exports of chemicals and pharmaceuticals,
- Exports of other goods,
- Exports of financial services,
- Exports of other business services,
- Exports of remote gaming,
- Tourism earnings, which is derived from separate models for inbound tourist numbers and tourist average spending, and
- Exports of other services.

The other items of the current account balance are treated as a single item and are forecasted by time series methods.

One of the problems typically encountered in national accounts statistics is the lack of disaggregated import and export deflators at product level. Following the decision to disaggregate exports and imports by products, it is not possible to model volumes of exports at this level. Instead, nominal exports and export prices are modelled separately, recognising that the evaluation of the trade equations will include both price and quantity effects. Whilst this is not particularly satisfactory from a theoretical point of view, the emphasis here will be on forecast accuracy. It is however also worth recalling that in this context, to obtain plausible forecasting results for exports and imports in real terms, the solution of the model requires an accurate model of export and import prices. Unfortunately, the need to aggregate export and import deflators undermines the ability to capture different determinants of price movements and can thus lead to inaccurate results at product level in volume terms. This is a

shortcoming, which is to be kept in mind when conducting scenario analysis, particularly those relating to exogenous assumptions such as exchange rate or world price movements.

The problem of being unable to distinguish price and quantity effects requires a careful analysis to determine the expected size and magnitudes of the parameters in the trade equations. A conventional approach to modelling exports in the long run is typically based on the following:

$$\log(X) = a + b.\log(WGDP) + c.log\left\{\frac{XP}{WP \times EX}\right\}$$

and

$$\log(XP) = d + e.\log(XUC) + f.\log(WP) + f.(\log(EX))$$

$$XV = XP \times X$$

Where

X is exports in constant prices

XV is exports at current market prices

WGDP is a measure of foreign demand

XP is the export price

WP is the price of competing products on the international market

EX is the exchange rate

XUC are domestic unit costs of production

$$\log(XV) = \log(XP)+a+b.\log(WGDP)+c.\log(XP)-c.\log(WP)-c.\log(EX)$$

$$\log(XV) = a + b.\log(WGDP) + (1 + c).\log(XP) - c.\log(WP) - c.\log(EX)$$

$$\log(XV) = a + (1 + c).d + b.\log(WGDP) + (1 + c).e.\log(XUC) + \{[(1 + c).f] - c\}.\log(WP) + \{[(1 + c).f] - c\}.\log(EX)$$

$$\log(XV) = \beta_0 + \beta_1.\log(WGDP) + \beta_2.\log(XUC) + \beta_3.\log(WP \times EX)$$

Where:

$$\beta_0 = a + b + (1 + c)d$$

$$\beta_1 = b$$

$$\beta_2 = (1 + c)e$$

$$\beta_3 = f.(1 + c) - c$$

It is customary to assume that e+f = 1 or f = (1-e) and therefore that both e and f are less than unitary. In that case:

$$\beta_3 = (1 - e).(1 + c) - c$$

If we let:

$c < 0$ export demand (X) is inversely related to relative prices in foreign currency (where EX is here defined as domestic currency per unit of foreign currency[2])

$e > 0$ domestic costs (XUC) positively influence export prices (XP)

$f > 0$ exports operate in a competitive market such that export prices move in line with foreign prices.

In this context the elasticity of demand to relative prices in foreign currency determines the sign of β_2:

When demand for exports is price elastic:

$$|c| > 1 \rightarrow \beta_2 < 0$$

When demand is price inelastic:

$$|c| < 1 \rightarrow \beta_2 > 0$$

On the other hand β_3 is very likely to be positive. To be negative it requires concurrently that export demand is price elastic ($|c| > 1$) and that export prices react very strongly to the international price of substitute product (f is sufficiently greater than c(1+c)). It is very improbable that these conditions prevail in a competitive international market. Hence it is safe to presume that $\beta_3>0$.

Unfortunately, neither XUC nor WP are observed and we generally substitute more general measures of inflation for them.

[2] Note that in STEMM it is conventional to use foreign currency per unit of domestic currency.

A similar approach is taken for imports. In the following, the same abbreviations are used to represent the parameters, but of course these are actually different.

$$\log(M) = a + b.\log(GDP) + c.log\left\{\frac{MP}{P}\right\}$$

and

$$\log(MP) = d + e.\log(P) + f.\log(WP \times EX)$$

$$MV = MP \times M$$

Where

M is imports in constant prices

MV is imports at current market prices

GDP is a measure of domestic demand

WP is the import price in foreign currency (at the port before distribution)

MP is the import price in domestic currency

P is the price of competing products produced domestically in domestic currency

EX is the exchange rate

Solving the above leads to the following model of imports in current prices:

$$\log(MV) = a + (1 + c).d + b.\log(GDP) + \{[(1 + c).e] - c\}.\log(P) + \{[(1 + c).f]\}.\log(WP \times EX)$$

$$\log(MV) = \beta_0 + \beta_1.\log(GDP) + \beta_2.\log(P) + \beta_3.\log(WP \times EX)$$

In the original equations:

$c < 0$ import demand (M) is inversely related to relative prices in domestic currency (where EX is here defined as domestic currency per unit of foreign currency[3])

$e > 0$ the price of competing products produced domestically in domestic currency (P) positively influence import prices (P)

[3] Note that in STEMM it is conventional to use foreign currency per unit of domestic currency.

$f > 0$ imports operate in a competitive market such that import prices move in line with foreign prices in domestic currency (WP.EX)

When demand for imports is price elastic:

$$|c| > 1 \rightarrow \beta_3 < 0$$

When demand for imports is price inelastic:

$$|c| < 1 \rightarrow \beta_3 > 0$$

On the other hand β_2 is very likely to be positive. To be negative it requires concurrently that import demand is price elastic ($|c| > 1$) and that import prices in domestic currency (MP) react very strongly to movements in the price of domestically produced substitute products (e is sufficiently greater than c/(1+c)). The high price elasticity means that the product in question does not have many substitutes, in which case there will probably be lack of domestic competition with importers having sufficient market power to absorb any shocks without adjusting prices or at least not to adjust them in excess of domestic price movements. Indeed it is customary to assume that e+f=1 such that e=1-f and e<1. This would imply that β_2 is positive.

2.2 The Sectoral Value Added Block

The sectoral value added (YVAV) block distinguishes between a number of salient sectors within the Maltese economy and essentially models the supply side (output) of the model:

- Value added of the electrical and machinery sector,
- Value added of the pharmaceutical and chemicals sector,
- Value added of the other goods sector,
- Value added of the domestic sector,
- Value added of the real estate and construction activities sector,
- Value added of the wholesale and retail trade sector,
- Value added of the remote gaming sector,
- Value added of the other business services sector,
- Value added of the public sector,
- Value added of the tourism sector,
- Value added of the financial and insurance services sector and
- Value added of the other services sector.

Output for each sector is generally estimated with the following specification, with the main demand determinants being the corresponding exports (XV) or household consumption (SCV) and own lagged term:

$$YVAV = f(YVAV(L), SCV, XV)$$

Quarterly data for value added are only available in current prices. For each sector, an error correction model links value added to its appropriate final expenditure component, this generally being exports, but may also include other domestic expenditure components such as consumption or investment spending, depending on the industry. Domestic demand components influence sectors which predominantly cater for the domestic market whilst exports determine the output of export oriented sectors of the economy.

In principle, current priced value added is also affected by the price of intermediate inputs. For example, a sector which heavily relies on imports for its inputs but whose output is primarily domestically demanded might see its profits, and therefore value added squeezed if say, the exchange rate depreciates and producers face elastic demand to the extent that they have to absorb the increase in costs. The specification presented above does not take this into account, even as a reduced-form equation. Nonetheless, the formulation has proved acceptable for the purposes of short-term forecasting.

2.3 The Labour Market Block

Employment in each sector (Ye0) typically depends on the sector's value added and average wages (AW) and is generally specified as follows:

$$Ye0 = f(Ye0(L), YVAV, AW)$$

As highlighted in the previous sub-section, current priced value added is also affected by price factors. Yet again, while this may prove to be an important variable for long-term forecasting, this specification has yielded acceptable performance for the purposes of short-term forecasting.

Average wages (AW) is currently determined as last year's average wage plus COLA plus a further element of adjustment capturing growth over and above cola for private (AWPadj) or public sector (AWGadj). Both elements are exogenous and hence AW is essentially exogenous in this version of STEMM.

$$AW = AW_{t-4} + (COLA * 13) + AWadj$$

The employment block distinguishes between ten different sectors, four of them being domestically-driven, while the rest being export-driven sectors. The domestically driven sectors include:

- Employment in the real estate and construction activities sector,
- Employment in the public sector,
- Employment in the wholesale and retail trade sector and
- Employment in other domestic sectors.

The export-driven category includes:

- Employment in the manufacturing sector,
- Employment in the tourism sector,
- Employment in the other business services sector,

- Employment in the remote gaming sector,
- Employment in the financial and insurance activities sector and
- Employment in the other services sector.

Furthermore, this block also includes the modelling of key headline indicators such as aggregate employment, the unemployment rate, the activity rate and average wages distinguished between public and private.

All sectoral employment variables are provided by NSO in (unpublished) full-time equivalent estimates and aggregate employment (SE) is first estimated as an identity summing up the sectoral employment.

$$SE = \sum Ye0$$

Nevertheless, a headcount aggregate employment based on the LFS measure is also modelled separately and determined by the economy's total gross value added (GDPFCV) and average wages (AW)[4].

$$SE_{lfs} = f(SE_{lfs}(L), AW, GDPFCV)$$

This is required to produce the official LFS unemployment rate. The labour force participation rate depends on the economy's average effective tax rate, aggregate employment and average wages. On the other hand, the unemployment rate is an identity based on total unemployed divided by the labour force while average wages is equivalent to compensation of employees divided by the number of employed persons.

2.4 The Price Block

Retail Price Inflation (RPI) is split into:

(i) tradeables (RP_traded) and

(ii) non-tradeables (RP_nontraded).

Both are modelled through an error-correction specification. Tradeables are primarily determined by import prices (SMP) whereas non-tradeables are primarily determined by domestic costs proxied by per capita average wage costs (AW) and are specified thus:

$$RP_{traded} = f(AR1, SMP)$$

$$RP_{nontraded} = f(AW)$$

Furthermore, there are also the main industrial groupings of the HICP generally modelled with an ARIMAX specification including a measure of imported prices of goods or oil prices

[4] Alternative version of STEMM modelled SElfs as a function of SE, though the present specification is deemed to provide more precise forecasts

(MP_gds or WOILP/DEX), with the exception of industrial goods and processed food, modelled using the ARIMA equation form.

$$HICP_{serv} = f(MA1, MP_{serv})$$

$$HICP_{en} = f(AR1, Trend, WOILP/DEX)$$

$$HICP_{unprocfd} = f(AR1, MP_{gds})$$

$$HICP_{ind} = f(AR1, MA1)$$

$$HICP_{procfd} = f(AR1)$$

2.5 The Government Block

The main government revenue and expenditure category items in ESA terms are distinguished and modelled separately. From the revenue side, there are individual models for taxes on products (TX_prod), VAT (TX_vat), other taxes on production (TX_otxprod), current taxes on income and wealth (TX_inc), capital taxes (TX_cap), property income receivable (PROP_inc), other general government revenue, social security contributions receivable (SS_cont) and other current taxes. The following are the revenue components determined endogenously in the model:

$$TX_{vat} = f(XV_{tour}, SCV)$$

$$TX_{inc_{ind}} = f(IFE, AR4)$$

$$TX_{inc_{corp}} = f(GOS, AR1)$$

$$SS_{cont} = f(IFE)$$

$$TX_{prod} = f(SCV)$$

$$TX_{otxprod} = f(MV_{cons}, AR1)$$

$$TX_{cap} = f(AVG_{prop})$$

$$TX_{prop_{inc}} = f(AR4, DEX)$$

Indirect taxes are typically determined by household consumption or imports of consumer goods (MV_cons). Personal income taxes and social security contributions are determined primarily by income from employment (IFE). Corporate income tax is mainly determined by gross operating surplus (GOS). An internal measure of the value of property transactions (AVG_prop) based on contracts is used to determine capital taxes.

From the expenditure side, there are separate models for compensation of employees, intermediate consumption (INTCOMP_ps), subsidies payable, property income expenditure (PROPINCEXP_ps), social benefits payable (SOCBEN_ps), other current transfers, capital

transfers, interest on property income, public investment expenditure and other public expenditure. The following is the general specification for the endogenous components of public spending, the rest being exogenously determined[5].

$$SOCBEN_{ps} = f(AW, SU)$$

$$PROPINCEXP_{ps} = f(YVAV_{rcons}, AR1)$$

$$INTCOMP_{ps} = f(HICP_{phar}, AWG)$$

In particular, social benefits are determined by the unemployment (SU) and average wages (AW).

2.6 The Final Expenditure Block

GDP at chain-linked volumes is estimated by separately forecasting and aggregating the individual expenditure components following the conventional national accounts identity, after netting out the effect of price changes via implicit deflators. Similarly, GDP at current market prices is forecasted by aggregating the current price final expenditure components. The following are the main expenditure components and their prices determined endogenously.

The determination of exports and imports has already been described earlier in the trade block. Notwithstanding this, the separate import and export deflators are reproduced hereunder since they cannot be disaggregated by the corresponding trade components due to data limitations but are estimated separately for goods and services. The change in inventories is determined exogenously and is assumed not to contribute to forecast GDP growth, in line with similar practices followed by other institutions producing forecasts for Malta. It is to be noted that the inventory component in statistics includes the statistical discrepancy between the GDP estimates from the output and the expenditure approach and past attempts to model this have never produced reasonable results.

$$SC = f\left(IFE \times \frac{1 - EFTR}{SCP}, AR4\right)$$

$$SCP = f(RPI, AR1)$$

$$SGV = f(COMPOFEMP_{PS} + INTCOMP_{PS}, AR1)$$

$$SGP = f(AWG, RPI)$$

$$KV_{NONGOV} = f(MSE, LRINT, SXV)$$

$$SKP = f(SMP, AR1, AR5)$$

[5] The fiscal block is only employed for simulations and fiscal risk assessments and may differ from the actual fiscal projections produced by the Government of Malta which are based on a different and more disaggregated fiscal model employed by the EPD. Nevertheless, the macroeconomic projections feed directly into the alternative fiscal model and hence are directly linked.

$$XP_{gds} = f(MP_{gds,} WP)$$

$$MP_{gds} = f(AR4, WOILP)$$

$$XP_{serv} = f(MP_{serv}, WGDP, WP)$$

$$MP_{serv} = f(WP, WOILP\ )$$

Consumption (SC) is the only component modelled in real terms and follows a traditional Keynesian function with real household disposable income (IFE X (1-EFTR)/SCP) as its main determinant. However, an AR term is added to allow for consumption smoothing. Consumer prices (SCP) are determined primarily by the RPI. Whilst conceptually the HICP should be closer to the SCP due to the allowance for variable weights in consumption, the HICP gives more weight to tourism expenditure compared to the RPI. Since tourism consumption is deducted from personal consumption and included with exports, it was decided to use the RPI instead of the HICP as the main determinant of the SCP.

Government consumption (SGV) is modelled as a behavioural equation because not all of its components are identified separately in STEMM and thus cannot be determined as an identity. It is however based on the largest components of government expenditure that is, compensation of employees (COMPOFEMP_ps) and intermediate consumption (INTCOMP_ps). It is modelled at current prices because its fiscal determinants are only available in nominal terms. Similarly to SCP, the government expenditure deflator (SGP) is mainly determined by the RPI but also by average wages in the public sector (AWG).

The private investment (KV_nongov) function is modelled as a function of the Malta Stock Exchange (MSE) index as a measure of expected future return on investment, the long-term interest rate (LRINT) and exports (SXV) which can be construed as either a measure of economic competitiveness or a measure of current strength of external demand conditions which influences the willingness and ability of foreign investors to increase their presence in Malta as a base to export their output. Since most investment is made up of imported goods, the investment deflator (SKP) is determined by import prices (SMP).

Total exports of goods and services is forecasted by a summation of the total exports categories. Total imports of goods and services follows the same methodology with the exception that it sums up the total import categories. The import deflator is disaggregated between goods and services with the goods deflator regressed against an auto-regressive term and world oil prices while the services deflator depends on world prices and world oil prices. Likewise, the export deflator is disaggregated between goods and services with the former regressed against imports of goods deflator and world prices while the latter is regressed against imports of services deflator, world GDP and world prices.

GDP at current factor cost (GDPFCV) is forecasted as an identity, summing up the total sectoral value added. The factor cost adjustment is calculated as the difference between GDP at current market prices and GDP at current factor cost. It is indeed a residual which has to be monitored closely as it indicates the level of inconsistencies between the output and the expenditure side of GDP. This component partly reflects the changes in the inventories component, for which a zero contribution to economic growth is assumed over the forecast horizon.

3. Model Equations and Estimation

3.1 Modelling Strategy

STEMM was designed to provide a flexible environment through which the users could address alternative functions which require different econometric methodologies. The main purposes of STEMM are the following:

a. Forecasting purposes

The main purpose of STEMM is to produce short-term economic forecasts. Assessing forecast performance on data characterised by frequent structural deterministic shifts such as is the case for the Maltese economy, is not a good yardstick for model selection, unless the objective is purely short-term economic forecasts. Models that omit causal factors including cointegrating relations by imposing additional unit roots, adapt quicker in the face of un-modelled shifts and as a result, yield more accurate predictions after a break (Hendry, 2000). Consequently, it might well be the case that a model which ranks high on the basis of forecasting performance might not be suitable for other purposes such as theory testing and policy analysis. The analysis of the model's forecast performance is currently being updated with the aim to investigate further model selection biases and their contribution to forecast errors.

b. Theory Testing

As an econometric tool, STEMM is also used by practitioners to test economic theories within the Maltese context. For example: Is there evidence for the Balassa-Samuelson effect in Malta? This research question and other similar questions are restricted by the fact that STEMM is a demand-driven model which is designed to model short-term economic conditions. Whilst short-term adjustments to shocks are important, they remain partial.

Contextually, although not normally perceived as an issue for model selection, tests of economic theories based on goodness of fit comparisons can be seriously undermined by structural breaks. Within the Maltese context, this is something which preoccupies a number of economic data users given Malta's small sample which over and above is characterised by a number of structural shifts partly attributed to rapid structural changes experienced in recent years. If un-modelled, shifts can distort statistical tests determining the significance of important determinants and lead to model mis-specification. For instance if cointegration tests fail, then long-run relationships which are supported by economic theory will receive no statistical support (Hendry, 2000).

c. Policy Analysis

Within this context, STEMM is used both to deepen the understanding of how the Maltese economy operates and also to examine how the Maltese economy would respond to shocks including for policy analysis. The model is based on the theory-related, congruent modelling principle (Hendry, 1995) which environment is conducive to conduct simulations which are aimed at evaluating the short-term response of the Maltese economy to various shocks. Section 4.2 explores three standard simulations including an exchange rate shock, a foreign

demand shock and a monetary policy shock. It is however pertinent to note that from a policy perspective, STEMM can only capture short-term impacts and short-term adjustments to policy shocks. Whilst these are very important, policy-making requires the determination of longer-term general equilibrium adjustments which the EPD determines by a different set of models[6].

3.2 Time series properties

Before equation estimation takes place, the data sets are analysed to assess their time series properties. In this context, the term 'time series properties' refers to characteristics of a stationary process, which involves ensuring that the series has constant mean, variance and covariance over time. If not handled properly, this leads to regression spuriousness, which implies that the regression results would be misleading (Granger & Newbold, 1974). A good rule of thumb to recognise incorrect regression results is a high coefficient of determination coupled with a low Durbin-Watson statistic of autocorrelation.

The time-series properties have important implications for the way in which variables are modelled and are therefore a necessary part of the pre-estimation data investigation process. This process involves three stages:

1. Looking at a plot of the level of the variable (in logs where possible) to make sure no anomalies exist, such as unexpected spikes in the data, which could adversely influence subsequent statistical tests and hence, final estimation results.

2. Using statistical tests to assess the nature of the stationarity of the variable. Before estimating an error correction model, variables need to be pre-tested for their order of integration. Cointegration necessitates that the variables are integrated of the same order. The Augmented Dickey–Fuller (ADF) (1979, 1981) test based on unit root testing is used to determine the time series properties and determine the number of unit roots in each variable. If the variables are integrated of the same order, standard time series methods are applied. If not, one could conclude that the variables are not cointegrated.

An inherent limitation of the ADF test is that it suffers from low power in small samples, so it is important to avoid the inclusion of too many lags (augmentations) to the standard regression, although for quarterly data it is worth using five lags to detect any possible autocorrelation. When performing the ADF tests, one should typically work at the 5.0 per cent confidence range. However, since the low degrees of freedom creates problems with the power of the test, inferences made at the 10.0 per cent level are still considered acceptable. Furthermore, the ADF test is also limited by a relatively higher probability of performing a type II error, i.e. not rejecting a false hypothesis. Notwithstanding these limitations, it is still the most frequently used test applied in economic literature for testing stationarity.

Where such tests are inconclusive, further plots and correlograms of differenced series are examined to provide additional evidence.

[6] One such model is QUEST, a DSGE model developed by the European Commission which EPD often uses to test the impact of structural reforms. Such models are based on a new-Keynesian approach.

It is noteworthy that for the majority of STEMM variables, the ADF test suggests first difference stationary with intercept specification, with the exception of the price variables (e.g. WOILP), where the majority are second difference stationary with intercept.

3.3 Econometric Methodology

i. Engle-Granger two-stage approach

Given that the majority of the variables in the model are integrated of order 1 and the modelling objective is to determine whether there exists an equilibrium relationship between the variables estimated, the Engle-Granger two-stage approach is generally employed.

Suppose that the dependent variable (y_t) and the regressor (z_t) are integrated of order 1, then one could proceed to estimate the long-run relationship in the form:

$$y_t = \beta_0 + \beta_1 z_t + e_t$$

where e_t is a white noise error process.

Provided there are no negative values, the variables are usually converted to logs and the estimation is done using OLS. If the variables are cointegrated, then the OLS regression yields a consistent estimator of the cointegrating parameters β_0 and β_1. For a long-run relationship between economic variables to hold, the equation must be cointegrating. To determine this, the stationary properties of the series of the estimated residuals of the long-run relationship must be tested. If the deviations from the long-run equilibrium are stationary, then one can conclude that there exists a cointegrating relationship of order (1, 1) between variables (y_t) and (z_t).

If the variables are cointegrated then the residuals from the equilibrium regression can be used to estimate the error-correction model. If (y_t) and (z_t) are cointegrated of order (1, 1), then the variables have the following error-correction form:

$$\Delta y_t = \alpha_1 + \alpha_y (y_{t-1} - \beta_1 z_{t-1}) + \alpha_{11}(i)\, \Delta y_{t-i} + \sum_{i=1} \alpha_{12}(i)\, \Delta z_{t-i} + \varepsilon_{yt}$$

$$\Delta z_t = \alpha_2 + \alpha_z (y_{t-1} - \beta_1 z_{t-1}) + \sum_{i=1} \alpha_{21}(i)\, \Delta y_{t-i} + \sum_{i=1} \alpha_{22}(i)\, \Delta z_{t-i} + \varepsilon_{zt}$$

where:

β_1 = the parameter of the cointegrating vector given by the first equation

ε_{yt} and ε_{zt} = white-noise disturbances (which may be correlated with each other)

α_1, α_y, α_2, α_z, $\alpha_{11}(i)$ $\alpha_{12}(i)$, $\alpha_{21}(i)$, and $\alpha_{22}(i)$ are all parameters

The speed of adjustment coefficients α_y and α_z have important implications for the dynamics of the system.

ii. The Box Jenkins Methodology

In specific instances, ARIMA models are employed. ARIMA methods do not assume knowledge of any underlying economic or structural relationships. Instead, they are built on the assumption that past values of the series plus previous error terms contain information for the purposes of forecasting. The Box Jenkins approach is a three-step formal specification used for evaluating the stationarity of a univariate time series and subsequently selecting an appropriate, parsimonious ARIMA model for forecasting. The goal is to find an appropriate formula such that the residuals are as small as possible and exhibit no pattern. The following procedure must be adhered to:

- **Model Identification:** A preliminary analysis with a plot of the initial data is performed as a starting point in determining an appropriate model. The series is controlled for any evident trends or structural breaks. If, at first glance, the time series appears non-stationary, Box and Jenkins recommend differencing 'ϱ' times until the series exhibits properties which are invariant with time. With a stationary series in place, a basic model can be identified, which can be any one of an AR specification, MA specification, or a combined ARMA specification. If any differencing was applied to make the initial model stationary, the resulting specification is referred to as ARIMA, with the 'I' indicating that the original model was integrated by some order ϱ. [7]

- **Model Estimation:** After shortlisting the plausible specifications, each of the tentative models are estimated and the various coefficients examined until a satisfactory model is derived. Several criteria may be specified for choosing a model format, given the simple ACF and PACF correlogram for a series.

    - If the ACF is not significantly different from zero for any observation, the series is essentially a white noise series;
    - If the ACF decreases linearly, passing through zero to become negative, or if the ACF exhibits a wave-like cyclical pattern, the series is non-stationary;
    - If the ACF exhibits seasonality, the series is non-stationary;
    - If the ACF decreases exponentially but gradually dies down, while the PACF is significantly non-zero for a small number of lags, beyond which it is not significantly different from zero, the series should be modelled with an AR process;
    - If the PACF decreases exponentially but gradually dies down, while the ACF is significantly non-zero for a small number of lags, beyond which it is not significantly different from zero, the series should be modelled with a MA process;

[7] An AR model attempts to predict the output of a system based on previous outputs, defined as:

$$y_t = \beta_0 + \sum_{\rho=1} \emptyset_\rho \, y_{t-\rho} + e_t$$

A MA model depends only on inputs to the system, showing a combination of white noise error terms.

$$y_t = \beta_0 + \mu_t + \sum_{i=1} \theta_q \;\; \mu_{t-q}$$

A model which depends both on inputs and outputs is an ARMA model, defined as:

$$\emptyset(L)y_t = \beta_0 + \theta(L)\mu_t$$

where (L)is the lag operator.

- If the ACF and PACF both die down to zero for successively longer lags, but neither actually reaches zero after any particular lag, the series may be modelled using a combination of AR and MA processes.

- **Diagnostic Checking:** It is important that the properties of any specified model are evaluated using a number of diagnostic checks to assess goodness of fit and to ensure that the residuals are random and serially uncorrelated. If the diagnostic checks indicate problems with the identified model, then one should return to the model identification stage. This suggests that the Box Jenkins methodology should be an iterative process. Once a satisfactory model is chosen, this is used to forecast the time series.

Once a model and econometric methodology is chosen, each behavioural equation is substantiated with a battery of diagnostic checks aimed to test the reliability of the model specification in line with Malinvaud (1981). Although certain equations did produce violations of the normality assumption in the disturbance terms, heteroskedasticity or autocorrelation, the regression estimation results produced in Appendix A reflect the best possible outcome in an environment of a small sample size including multiple time-series breaks and frequent data outliers. All tests are reported separately in a technical appendix reported in the Economy Policy Department website https://mfin.gov.mt/en/epd/Pages/Library.aspx

4. Analysis of Forecast Accuracy and Simulation Analysis

Principles have been identified and established in literature to guide forecasters in selecting a forecasting method (Armstrong, 2001b). Forecasting methodologies have long been proclaimed to be evaluated by examining its inputs or its outputs. However, this has been long debated in literature. Friedman (1953) argues that testing output is the only useful approach for evaluating forecasting methodologies while Machlup (1955) and Nagel (1963) claimed testing input is strictly preferred to output evaluation methods. In general, there is a consensus amongst economists that ideally, forecasting methods are to be evaluated in situations where they are going to be applied.

In essence, there are two important steps which one must go through to evaluate and assess model capabilities, reliability, representativeness and forecasting accuracy: an analysis of *ex ante* forecast errors and simulation analysis to ensure that the results are in line with fundamental economic theory, or, if not, analyse through counterfactual experiments as to why this is the case. According to Armstrong (2001) the model evaluation process usually consists of four important steps: data and method testing, testing assumptions, output replication and assessment of the output derived. In his paper, Armstrong (2001) noted that despite the intuitive appeal of these principles, researchers and practitioners often ignore many of them.

4.1 An Analysis of Forecast Errors of the Economic Policy Department

Camilleri and Vella (2015) presented an analysis of forecasting errors for Malta across a number of institutions and compare the results of the Economic Policy Department within the Ministry for Finance relative to the forecasting results of the European Commission and the Central Bank of Malta. The paper presents a comprehensive *ex ante* analysis of STEMM

forecast accuracy at expenditure component level and interpolates past forecast errors to future forecasts through the application of the two-piece normal distribution in the form of fan charts.

The paper did not find any evidence of significant biases in forecasting real and nominal GDP growth forecasts. Moreover, despite the small sample size and the fact that the period under analysis was characterized by one-off factors such as the unpredicted financial crisis and the subsequent sovereign crisis and the structural acceleration in certain services sectors of the Maltese economy, the forecast performance of the Ministry for Finance relative to forecasts for other small open economies in the EU compared favourably. Additionally, when one excludes the 2009/10 recession, the forecast performance also compared favourably relative to the forecast performances of other institutions forecasting larger and less open economies. While there was no evidence of systematic bias from the Economic Policy Department when forecasting real and nominal GDP growth, the opposite was the case for individual expenditure components.

From the external side of the economy, a tendency to underestimate both exports and imports was discovered though these were found to offset each other. On the other hand, the domestic side of the economy was usually characterized by a tendency to underestimate both private and public consumption but overestimate gross fixed capital formation. The 2015 paper called for increased efforts towards improving *ex ante* information to eliminate the tendency to overestimate investment growth.

The paper also concluded that the constant updating and recalibration of the behavioural equations in STEMM is imperative to improve forecast accuracy while minimising possible biases. Furthermore, the paper called for improvements in statistical data (particularly in the development of sectoral output deflators) given the high influence on forecasting accuracy of substantial statistical data revisions. Finally, regular meetings with major operators in the Maltese economy in order to support EPD's expert judgment was also recommended. These recommendations were all subsequently implemented.

4.2 Simulation Analysis

This section outlines the simulation properties of the model following three standard macroeconomic shocks. The response of the main macroeconomic variables following each shock are recorded.

The shocks are defined as follows:

- The exchange rate shock consists of an increase of a 10% permanent currency appreciation against the US dollar.
- The foreign demand shock is simulated through a permanent increase of a one-time shock of 2.5% in the second half of year *t*[8]. For subsequent periods, real GDP growth is assumed to revert to baseline and remain in line with the views of Consensus

[8] WGDP is an exogenous variable composed of the GDP of Malta's main trading partners weighted by the share of exports. Malta's main trading partners include the United States, the United Kingdom, Italy, Germany, France. No changes are assumed for the GDP deflator of each trading partner.

Economics [9] May 2018 issue. No changes are assumed for the GDP deflator of each trading partner.
- The monetary policy shock consists of a permanent increase of 25 basis points in the long-run interest rate over the forecast horizon.

The objective of these simulations is twofold. First, it allows the users to examine the dynamic properties of the error correction model and to better understand the mechanism and propagation channels of the model. Second, it provides a systematic and quantifiable way of benchmarking the results that the model generates from these shocks against literature and aids interpretation both from a theoretical and from a pragmatic and empirical perspective.

4.2.1 Exchange Rate Shock

Small and open economies such as Malta are typically more susceptible to exchange rate movements compared to larger economies (Hsiao & Han, 2012; Santacreu, 2015). In 2017, Malta had an export to GDP ratio of 150 per cent compared to an EU average of 45.7 per cent and an imports to GDP ratio of 129.1 per cent compared to an EU average of 41.9 per cent making it one of the most open economies in the EU. According to the National Statistics Office, in 2017, Malta had more than 68 per cent of total exports directed towards countries outside the euro zone[10] while in the tourism sector, which is considered a very important market for Malta, 25% of total inbound tourists who visited Malta between January-December 2017 were from the United Kingdom[11]. Concomitantly, oil prices are typically traded in US Dollars which in turn contributes to the role that exchange rates play on Malta's economy. This explains why open economies, especially small and open economies typically experience pronounced impacts on their domestic economy when their currency appreciates relative to the foreign counterpart.

This simulation assumes an increase of 10% permanent currency appreciation against the US dollar and compares the per cent deviation in a number of headline macroeconomic indicators relative to the baseline. The results are presented in table 1 hereunder.

The deterioration in external cost competitiveness has a negative impact on domestic economic activity in particular on the trade balance. In contrast, the increase in private consumption expenditure in year *t,* reflecting the strengthening in purchasing power limits the dampening effect on the labour market. However, the decline in GDP also affects negatively gross fixed capital formation in year *t+1* and *t+2*, respectively.

[9] Consensus economics is a leading international economic survey organization which polls a vast number of forecasts to obtain projections for several key macroeconomic variables on a monthly basis.

[10] NSO News Release NR021/2018.

[11] NSO News Release NR016/2018.

Table 1: Exchange Rate Shock

(per cent deviation from baseline unless otherwise stated)

	Year 't'	Year 't+1'	Year 't+2'
Economic Activity (chain-linked volumes)			
Real GDP	**-0.2**	**-0.1**	**0.0**
Private Consumption Expenditure	0.1	0.0	0.0
Government Consumption Expenditure	0.0	0.0	0.0
Gross Fixed Capital Formation	0.0	-0.1	-0.1
Exports of Goods and Services	-0.7	-0.1	-0.1
Imports of Goods and Services	-0.6	-0.1	-0.1
Prices			
HICP	0.0	0.0	0.0
Labour Market			
Employment Growth	-0.1	-0.1	-0.1
Unemployment Rate	0.0	0.0	0.0
Fiscal Developments (as % of GDP)			
Budget Balance	0.0	0.0	-0.1

Source: Authors' Calculations

4.1.1 Foreign Demand Shock

Small economies such as Malta tend to rely heavily on international trade more than large economies do. One reason for this is the relatively small size of the domestic market rendering it essential to find larger markets to support production. Another reason is the large import bill due to limited natural resource endowment (Briguglio, 2011). As was the case with the exchange rate shock, this high degree of trade openness amplifies the exposure of small open economies from conditions in the rest of the world.

This simulation features a positive foreign demand shock through a permanent increase of a one-time shock of 2.5% in the second half of year *t*. For the outer years, real GDP growth is assumed to remain in line with the views of Consensus Economics May 2017 issue. No changes are assumed for the GDP deflator of each trading partner. The results can be found in table 2 hereunder.

Table 2: Foreign Demand Shock

(per cent deviation from baseline unless otherwise stated)

	Year 't'	Year 't+1'	Year 't+2'
Economic Activity (chain-linked volumes)			
Real GDP	**0.3**	**0.6**	**0.5**
Private Consumption Expenditure	0.1	0.3	0.3
Government Consumption Expenditure	0.0	0.0	0.0
Gross Fixed Capital Formation	0.1	0.3	0.3
Exports of Goods and Services	0.3	0.9	0.9
Imports of Goods and Services	0.1	0.5	0.6
Prices			
HICP	0.0	0.0	0.0
Labour Market			
Employment Growth	0.1	0.4	0.3
Unemployment Rate	-0.1	-0.2	-0.1
Fiscal Developments (as % of GDP)			
Budget Balance	0.1	0.3	0.2

Source: Authors' Calculations

Higher foreign demand leaves a distinct impact on domestic economic activity as real GDP increases by 0.3 percentage points in year *t*, by 0.6 percentage points in year *t+1* and by 0.5 percentage points in year *t+2* respectively. This is mainly due to higher export volumes and improvements in the trade balance as the growth in exports more than outpaced the growth in imports. Moreover, higher foreign demand leads to increases in gross value added which in turn boosts employment. This leads to an increase in private consumption. Buoyant economic activity also leaves its desired impact on gross fixed capital formation and on the fiscal balance.

An increase in foreign demand leaves prices relatively unchanged. Furthermore, the elasticity of world GDP on sectoral exports is relatively high when compared to literature, exacerbating the response of exports to changes in foreign demand.

4.1.2 Interest Rate Shock

The interest rate shock is effected through a permanent increase of 25 basis points in the long-run interest rate over the forecast horizon. This is not assumed to derive from ECB monetary policy but can be effectively thought of as an idiosyncratic shock to risk premia in Malta, with no effect whatsoever on external demand. The increase in the interest rate leads to an increase in the cost of capital to obtain financing leading to a drop in gross fixed capital formation. This in turn leads to a decrease in the imports of capital goods but not enough to offset the impact of investment such that economic activity declines by 0.1 percentage points in year *t* and by 0.3 percentage points in year *t+2* and year *t+3,* respectively. The fiscal balance is also affected marginally negatively in year *t+2*.

Table 3: Interest Rate Shock

(per cent deviation from baseline unless otherwise stated)

	Year 't'	Year 't+1'	Year 't+2'
Economic Activity (chain-linked volumes)			
Real GDP	**-0.1**	**-0.3**	**-0.3**
Private Consumption Expenditure	0.0	0.0	0.0
Government Consumption Expenditure	0.0	0.0	0.0
Gross Fixed Capital Formation	-0.1	-1.7	-2.6
Exports of Goods and Services	0.0	0.0	0.0
Imports of Goods and Services	-0.1	-0.1	-0.2
Prices			
HICP	0.0	0.0	0.0
Labour Market			
Employment Growth	0.0	0.0	0.0
Unemployment Rate	0.0	0.0	0.0
Fiscal Developments (as % of GDP) Budget Balance	0.0	0.0	-0.1

Source: Authors' Calculations

Literature also points towards a negative impact on prices mainly arising through the exchange rate channel. (Grech et al., 2013). Since exchange rates are exogenous, there is no pass-through relationship between exchange rates, prices and interest rates. Notwithstanding this, a similar study on the Maltese economy found nearly no impact on prices even though a more pronounced monetary policy shock is assumed (Grech et al., 2013).

5. Conclusions and Future Refinements

The process of economic modelling is a dynamic process and consequently, this necessitates the constant improvement of the model to reflect latest developments within both the domestic and the external economy. From time to time, certain developments occur that will necessitate changes in economic models. The nature of these developments ranges from purely economic phenomena such as the emergence of new sectors which can quickly change the structure of a small economy, to frequent and substantial changes in the statistical data due to changing international methodologies and constant improvements in data sources and sampling techniques. For this reason, this report is only intended to present a snapshot of the structure of STEMM at a point in time.

In future, there are further refinements planned. Of the most immediate is the introduction of the supply-side into the model through an expectations-augmented Phillips curve as currently average wages are determined exogenously in the model. This would enable the modelling of direct effects between structural developments in the Maltese economy and developments in the price level in particular, the domestic price component part of the economy. Further disaggregation in the price block is also envisaged to widen the analysis both in the HICP and also in the RPI component. Moreover, if sector specific deflator statistics become available, further disaggregation would also become possible and would help us to improve the deflator equations and to move towards the modelling of sectors of exports and imports in volume terms. Furthermore, there are also research plans to introduce a savings function disaggregated at institutional account level. Additionally, given the dynamic nature of Malta's economy and the need to increase statistical robustness due to the short time series available, constant assessment and revisions are regularly carried out to ensure that the model is still a reliable representation of the Maltese economy. At this stage, the model presents results which are consistent with literature for other small and open economies but which may conflict with studies conducted for larger economies in some aspects.

In macroeconometric models, one crucial step is the testing part whereby one evaluates whether the improvements and updates implemented in STEMM over the past years have contributed or hindered the production of reliable and accurate macroeconomic forecasts. In line with Hendry's golden rules of econometrics, each behavioural equation in Appendix A is substantiated with a battery of diagnostic checks aimed to test the reliability of the model specification in line with Malinvaud (1981). Although certain equations did produce violations of the normality assumption in the disturbance terms, heteroskedasticity or autocorrelation, the regression estimation results produced in Appendix A reflect the best possible outcome in an environment of a small sample size including multiple time-series breaks and frequent data outliers.

In general, the overall reliability and accuracy of macroeconomic model is best measured through an analysis of the forecast errors. However, due to the constant economic and statistical developments, past forecast errors as outlined in Camilleri and Vella (2015) may not be representative of current or future forecast accuracy of the model. In this context the Economic Policy Department regularly updates its analysis of forecast performance and publishes it in successive Stability Programmes and Draft Budget Plans wherein the official bi-annual forecasts are documented.

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Appendix A: Model Equations

Var.	Short Run							Long Run						Adj R^2
XV_EM	Cons	WGDP	XP_ST/DEX	IFE/SE	D09EM	D14on	ECM	WGDP	XP_ST/DEX	IFE/SE				
	0.13	2.39	0.17	0.80	-0.12	-0.12	-0.48	1.59	0.25	-0.53				0.13
	(0.09)	*(1.80)*	*(0.75)*	*(1.19)*	*-(1.97)*	*-(1.91)*	*-(4.38)*	*(3.10)*	*(1.24)*	*-(0.91)*				
XV_FUEL	Cons	MV_FUEL	WOILP/DEX	D05	D05		ECM	WGDPV	WOILP/DEX	MV_FUEL				
	-13.82	0.67	0.82	-1.47	-1.47		-0.72	2.55	1.10	0.59				0.40
	-(2.03)	*(2.96)*	*(2.04)*	*-(4.07)*	*-(4.07)*		*-(5.44)*	*(1.66)*	*(2.60)*	*(2.03)*				
XV_CHEMPHAR	Cons	HICP_PHAR	XV_CHEMPHAR(-4)	D16-D16Q4	D16Q4		ECM	WGDP	WP/SEK	HICP_PHAR				
	-32.78	7.56	-0.17	0.74	-0.75		-0.58	3.26	1.94	10.04				0.69
	-(4.04)	*(1.93)*	*-(1.78)*	*(5.81)*	*-(3.21)*		*-(5.25)*	*(2.22)*	*(3.62)*	*(5.28)*				
XV_OG	Cons						ECM	XV_FUEL	XV_CHEMPHAR + XV_EM	MV_INT	D11Q4	DSUMMER * D2011ON	DWINTER	
	1156102.00							-135395.00	-308931.00	350302.00	-298263.00	-124924.00	47510.00	0.80
	(0.73)							*-(5.32)*	*-(3.41)*	*(2.86)*	-(3.51)	-(3.30)	(1.55)	

Var.	Short Run							Long Run						Adj R^2
XV_FIS	Cons	XV_FIS(-4)					ECM	WGDP	INT	STG				
	-9.21	0.29					-0.32	5.26	0.21	2.48				0.30
	-(1.15)	(2.37)					-(3.52)	(1.93)	(3.79)	(2.73)				
XV_OBS	Cons	GDPV	D06EURO	D2010ON			ECM	WP	HICP_SERV	IFE/SE				
	3.19	4.44	0.42	-0.34			-0.60	-1.76	-1.31	4.57				0.43
	(5.15)	(3.28)	(4.33)	-(4.86)			-(7.59)	-(1.77)	-(3.83)	(9.68)				
XV_RG	Cons	XV_RG(-4)	WP/CHF	DWINTER			ECM	WGDP	WP/CHF	TIME				
	-14.86	0.26	1.75	-0.07			-0.42	6.25	1.51	0.10				0.53
	-(2.51)	(2.27)	(3.24)	-(1.81)			-(3.20)	(4.53)	(3.69)	(2.48)				
TNUM	Cons	TNUM(-4)	D16Q4ON	DAUTUMN	DWINTER		ECM	WGDPTV	WGDPTV * D13Q2ON					
	4.07	0.32	0.12	-0.51	-0.47		-0.37	0.39	0.04					0.99
	(6.83)	(3.72)	(3.67)	-(7.88)	-(7.33)		-(7.64)	(3.18)	(5.56)					
TAVSPEND	Cons	HICP	STG	TAVSPEND(-4)	D2020ON * DSUMMER		ECM	TAVSPEND(-4)						
	1.04	0.90	-0.55	0.69	0.10		-0.77	0.79						0.90
	(2.34)	(2.17)	-(3.08)	(9.09)	(3.19)		-(6.92)	(8.63)						

Var.	Short Run							Long Run						Adj R^2
XV_OS	Cons	XV_OS(-4)	DAUTUMN				ECM	WGDP						
	-1.77	0.47	-0.47				-0.60	1.94						0.79
	-(0.48)	(6.14)	-(3.66)				-(6.32)	(2.39)						
MV_CONS	Cons	SCV	DAUTUMN	MV_CONS(-4)	D_INTC		ECM	SCV	WP/DEX					
	-1.02	0.92	0.05	0.24	0.02		-0.52	1.04	-0.10					0.52
	-(3.30)	(6.80)	(4.18)	(3.58)	(1.67)		-(5.77)	(28.73)	(1.44)					
MV_CAP	Cons	SK	LRNT_MT	DSPRING	DSUMMER		ECM	SK	WP/EFEX	LRINT_MT				
	6.36	0.67	-0.75	0.17	0.21		-0.84	0.38	1.57	-0.50				0.46
	(2.33)	(2.67)	-(2.49)	(2.29)	(3.09)		-(7.39)	(1.51)	(2.68)	-(3.89)				
MV_INT	Cons	XV_EM+XV_CHEMPHAR	D16	DAUTUMN			ECM	XV_EM+XV_CHEMPHAR	HICP_IND					
	2.40	0.40	-0.17	-0.06			-0.67	0.72	-1.20					0.58
	(3.16)	(6.47)	-(4.17)	-(3.64)			-(7.36)	(9.50)	-(5.06)					
MV_FUEL	Cons	GDP	WOILP/DEX	D12ON	D11Q4	D16Q3	ECM	GDP	WOILP/DEX	(1-DSUP)*WOILP/DEX				
	6.00	0.47	0.48	0.58	1.05	0.37	-0.95	0.15	0.75	0.25				0.60
	(1.59)	(1.71)	(2.96)	(4.83)	(4.95)	(1.77)	-(8.29)	(0.56)	(8.52)	(8.61)				

Var.	Short Run							Long Run						Adj R^2
MV_FIS	Cons	XV_FIS	INT				ECM	XV_FIS	WP/DEX					
	2.66	0.63	-0.09				-0.47	0.46	0.96					0.51
	(3.13)	*(5.80)*	*-(2.21)*				*-(3.76)*	*(5.63)*	*(2.35)*					
MV_OBS	Cons	XV_OBS	D2010ON	MV_OBS(-4)	HICP_SERV		ECM	XV_OBS	EFEX	HICP_SERV	XV_OBS*D06EURO			
	3.75	0.22	0.39	0.15	0.61		-0.56	0.39	2.21	1.24	0.06			0.23
	(3.44)	*(2.14)*	*(4.15)*	*(1.65)*	*(1.98)*		*-(5.22)*	*(2.89)*	*(1.81)*	*(3.41)*	(4.13)			
MV_RG	Cons						ECM	XV_RG	MV_RG(-4)	D13ON				
	-0.77							0.52	0.33	0.79				0.96
	-*(1.34)*							*(7.06)*	*(3.86)*	*(5.65)*				
MV_OS	Cons	XV_OS	HICP_SERV	D2011ON			ECM	XV_OS	WP/DEX	HICP_SERV				
	4.88	0.03	0.86	0.06			-0.45	0.09	0.73	1.89				0.42
	(5.53)	*(1.93)*	*(4.50)*	*(1.66)*			*-(5.61)*	*(2.16)*	*(3.61)*	*(6.29)*				
YVAV_EM	Cons	YVAV_EM	XV_EM				ECM	XV_EM						
	0.34	0.20	0.70				-0.15	0.66						0.29
	(0.34)	*(2.07)*	*(5.08)*				*-(2.61)*	*(1.26)*						

Var.	Short Run							Long Run						Adj R^2
YVAV_CHEMPHAR	Cons	XV_CHEMPHAR	D16-D16Q4	D17Q1+D17Q2	D08CHPH		ECM	XV_CHEMPHAR	XV_CHEMPHAR*D0507					
	1.51	0.41	0.44	-0.22	0.26		-0.46	0.60	0.04					0.55
	(5.51)	*(7.65)*	*(5.17)*	*-(2.68)*	*(3.91)*		*-(6.71)*	*(19.17)*	*(5.00)*					
YVAV_OG	Cons	SCV	D07Q4	D08CHPH	DSPRING	D10EM	ECM	SCV						
	0.86	0.37	-0.15	0.12	0.06	-0.07	-0.64	0.75						0.71
	(1.43)	*(2.29)*	*-(3.60)*	*(5.65)*	*(4.54)*	*-(3.10)*	*-(8.09)*	*(11.68)*						
YVAV_OD	Cons	SCV	D_INTC	DSUMMER	D12Q1Q2	D13ON	ECM	SCV						
	0.49	0.74	0.17	0.12	-0.15	0.15	-0.73	0.79						0.64
	(0.71)	*(3.12)*	*(3.90)*	*(5.46)*	*-(2.37)*	*(4.27)*	*-(8.15)*	*(11.28)*						
YVAV_RCONS	Cons	YVAV_RCONS	D15+D16				ECM	HICP	IFE					
	0.92	-0.23	0.04				-0.30	-0.55	0.67					0.31
	(1.38)	*-(1.86)*	*(3.83)*				*-(3.66)*	*-(1.51)*	*(4.26)*					
YVAV_WRT	Cons	SCV	D12ON				ECM	YVAV_WRT	SCV	HICP_SERV	DEX			
	-0.62	0.16	0.06				-0.71	0.54	0.48	-0.20	-0.08			0.43
	-(0.73)	*(1.66)*	*(3.55)*				*-(8.06)*	*(5.35)*	*(3.67)*	*-(2.70)*	-(1.74)			

Var.	Short Run							Long Run						Adj R^2
YVAV_RG	Cons	YVAV_RG					ECM	XV_RG						
	0.85	-0.21					-0.62	0.81						0.40
	(2.21)	*-(1.71)*					*-(4.25)*	*-(17.93)*						
YVAV_OBS	Cons	YVAV_OBS	XV_OBS	D2010ON	D00Q1ON		ECM	YVAV_OBS	XV_OBS					
	0.52	0.32	0.04	0.06	0.03		-0.38	0.77	0.10					0.20
	(2.28)	*(2.99)*	*(1.60)*	*(2.56)*	*(1.74)*		*-(4.38)*	*(6.98)*	*(1.64)*					
YVAV_PS	Cons	YVAV_PS	COMPOFEMP_PS	DSPRING	DSUMMER		ECM	YVAV_PS	COMPOFEMP_PS					
	0.35	0.22	0.85	0.01	0.01		-0.95	0.19	0.80					0.94
	(4.26)	*(3.94)*	*(16.26)*	*(4.19)*	*(4.72)*		*-(8.02)*	*(2.93)*	*(13.30)*					
YVAV_TOUR	Cons	XV_TOUR	DAUTUMN	DWINTER			ECM	XV_TOUR	WGDPTV*D13ON					
	1.18	0.55	0.40	0.43			-0.31	0.54	0.03					0.95
	(2.76)	*(17.10)*	*(11.97)*	*(11.25)*			*-(6.14)*	*(8.57)*	*(4.67)*					
YVAV_FIS	Cons	XV_FIS	STG	D00Q4ON			ECM	XV_FIS	INT	MSE				
	2.03	0.10	-0.61	0.10			-0.33	0.31	-0.10	0.28				0.20
	(3.63)	*(2.00)*	*-(2.17)*	*(2.06)*			*-(3.97)*	*(5.54)*	*-(5.72)*	*(2.45)*				
YVAV_OS	Cons	YVAV_OS	D13Q1-D2010ON				ECM	WGDPV	XV_OS*D14ON					
	1.00	0.39	-0.06				-0.39	1.17	0.02					0.45
	(5.31)	*(4.80)*	*-(4.36)*				*-(6.24)*	*(24.85)*	*(7.40)*					

Var.	Short Run							Long Run						Adj R^2
YE0_RCONS	Cons	YVAV_RCONS	D06EURO-D12ON	D12Q1Q2			ECM	YVAV_RCONS	AWG	SCV				
	3.00	0.17	0.02	0.02			-0.52	0.12	0.18	0.13				0.73
	(6.99)	*(3.52)*	*(5.98)*	*(2.18)*			*-(9.56)*	*(2.79)*	*(3.38)*	*(2.33)*				
YE0_WRT	Cons	YVAV_WRT					ECM	YVAV_WRT	AWP					
	0.17	0.19					-0.12	0.77	-0.44					0.24
	(0.52)	*(4.51)*					*-(2.30)*	*(3.58)*	*-(1.92)*					
YE0_OD	Cons	YVAV_OD	(1-D_SUP)	D12ON			ECM	YVAV_OD	IFE					
	1.52	0.06	0.02	-0.02			-0.64	0.07	0.50					0.36
	(2.68)	*(3.06)*	*(1.96)*	*-(2.19)*			*-(5.23)*	*(2.18)*	*(6.30)*					
YE0_MANUF	Cons	YVAV_CHEMPHAR+EM+OG	AWP	D09EM	D04ON		ECM	YVAV_CHEMPHAR+EM+OG						
	2.20	0.07	-0.07	-0.02	-0.03		-0.83	0.12						0.99
	(3.37)	*(2.65)*	*-(2.22)*	*-(2.76)*	*-(3.59)*		*(18.79)*	*(4.41)*						
YE0_TOUR	Cons	DSPRING	YE0_TOUR(-4)				ECM	YVAV_TOUR	AWP	D0507*YVA_TOUR	(1-D_SUP)*YVA_TOUR			
	2.44	0.03	0.48				-0.32	0.15	0.22	0.01	0.01			0.89
	(4.61)	*(3.99)*	*(5.07)*				*-(5.24)*	*(2.58)*	*(1.90)*	*(3.07)*	(2.52)			

Var.	Short Run							Long Run						Adj R^2
YE0_OBS	Cons	YVAV_FIS	YVAV_OBS	D0507			ECM	IFE	D2011ON * IFE	YVAV_RG				
	-2.90	0.03	0.38	0.04			-0.33	1.27	-0.01	0.07				0.62
	-*(4.90)*	*(1.87)*	*(5.95)*	*(4.80)*			*-(5.98)*	*(9.44)*	*-(2.96)*	*(2.88)*				
YE0_RG	Cons	AW(-4)	D06EURO	D15Q3ON			ECM	YVAV_RG(-4)	AW					
	0.83	0.45	0.09	0.08			-0.28	0.10	2.36					0.34
	(5.47)	*(1.88)*	*(4.37)*	*(4.09)*			*-(5.25)*	*(1.60)*	*(6.23)*					
YE0_FIS	Cons						ECM	YVAV_FIS	YE0_FIS(-1)					
	0.02							0.02	0.97					0.99
	(0.14)							*(1.40)*	*(32.37)*					
YE0_OS	Cons						ECM	YVAV_OS	IFE	DSUMMER	YVAV_FIS	DWINTER		
	-1.44							0.15	0.57	0.10	0.12	-0.06		0.96
	-*(1.95)*							*(1.37)*	*(3.75)*	*(6.64)*	(2.79)	-(4.02)		
SE_LFS	Cons						ECM	SE_LFS(-4)	AW	GDPFCV				
	3.72							0.54	0.12	0.12				0.99
	(4.67)							*(5.56)*	*(2.63)*	*(3.12)*				

Var.	Short Run							Long Run						Adj R^2
SLFR_LFS	Cons	SE	EFTR				ECM	AWG	SE					
	-3.38	0.38	-0.11				-0.51	0.16	0.49					0.38
	(3.13)	*(3.47)*	**2.02*				*-(4.22)*	*(2.62)*	*(4.79)*					
HICP_IND	Cons						ECM	Trend	AR(1)	MA(1)				
	-0.13							0.00	0.95	-0.64				0.94
	(5.86)							*(7.33)*	*(21.56)*	*-(7.16)*				
HICP_PROCFD	Cons						ECM	Trend	AR(1)					
	-0.61							0.01	0.93					0.99
	(4.42)							*(2.52)*	*(8.34)*					
HICP_EN	Cons						ECM	Trend	WOILP(-1)/DEX(-1)	AR(1)				
	-0.40							0.001	0.10	0.82				0.99
	(3.30)							*(1.55)*	*(3.47)*	*(14.96)*				
HICP_UNPROCFD	Cons						ECM	DWINTER	DAUTUMN	HICP_UNPROCFD(-1)	MP_GDS			
	0.00							0.05	0.03	0.98	0.12			0.98
	(0.72)							*(5.71)*	*(3.68)*	*(55.62)*	*(2.28)*			

Var.	Short Run							Long Run						Adj R^2
HICP_SERV	Cons						ECM	MP_SERV	DSUMMER	DAUTUMN	MA(1)			
	0.09							0.63	0.06	-0.07	0.75			0.97
	(19.66)							*(22.50)*	*(12.05)*	*-(15.04)*	*(10.25)*			
RP_TRADED	Cons						ECM	MP_GDS+ MP_SERV	RP_TRADED(-1)					
	-0.23							0.54	0.54					0.90
	-(5.23)							*(6.01)*	*(7.12)*					
RP_NONTRADED	Cons	D09Q1	D08Q3	DWINTER			ECM	AWG	D14ON	AWG*(1-D06EURO)	D05			
	-0.05	-0.04	0.03	-0.01			-0.15	0.51	-0.15	-0.05	0.12			0.45
	-(1.65)	*-(3.61)*	*(2.64)*	*-(3.28)*			*-(2.52)*	*(4.00)*	*-(3.10)*	*-(1.62)*	*(2.49)*			
SC	Cons	WAGE*(1-EFTR)/SCP	SC(-4)				ECM	WAGE*(1-EFTR)/SCP	SC(-4)					
	0.80	0.75	0.56				-0.37	0.28	0.57					0.56
	(2.89)	*(6.26)*	*(7.08)*				*-(4.78)*	*(2.42)*	*(4.33)*					

Var.	Short Run							Long Run						Adj R^2
SCP	Cons						ECM	RPI	DSPRING	DAUTUMN	SCP(-1)			
	-0.29							0.74	0.03	0.04	0.22			0.99
	-*(8.68)*							*(8.73)*	*(9.01)*	*(9.69)*	*(2.46)*			
SGV	Cons	COMPOFEMP_PS+INTCOMP_PS	D16Q3-Q4	SGV(-1)			ECM	COMPOFEMP_PS+INTCOMP_PS						
	0.72	0.15	-0.13	-0.25			-0.41	0.86						0.63
	(3.21)	*(8.42)*	*-(5.23)*	*-(3.19)*			*(4.52)*	*(28.78)*						
SGP	Cons	AWG	SGP(-4)				ECM	RPI	AWG					
	-0.43	0.19	0.48				-0.42	0.24	0.54					0.73
	-*(4.31)*	*(3.36)*	*(4.80)*				*-(4.53)*	*(2.94)*	*(11.87)*					
KV_NONGOV	Cons	MSE	D10EM				ECM	LRINT_MT	MSE	SXV				
	5.05	0.47	0.16				-0.74	-0.37	0.28	0.27				0.38
	(4.29)	*(2.62)*	*(2.33)*				*-(6.55)*	*-(5.97)*	*(3.33)*	*(3.44)*				
SKP	Cons	SKP(-1)					ECM	SMP	SKP(-4)					
	0.01	0.57					-0.12	0.45	0.81					0.39
	(4.00)	*(4.13)*					*-(2.27)*	*(1.92)*	*(5.12)*					

Var.	Short Run							Long Run						Adj R^2
XP_GDS	Cons	MP_GDS	DSUMMER	WP			ECM	MP_GDS	WP					
	-0.02	0.57	-0.25	1.11			-0.67	0.40	0.47					0.91
	-(0.77)	(5.67)	-(14.86)	(1.83)			-(10.20)	(2.00)	(3.61)					
XP_SERV	Cons	MP_SERV	DAUTUMN	WGDP	WP		ECM							
	-1.19	0.66	-0.01	0.15	0.23									0.98
	-(2.02)	(11.72)	-(2.32)	(1.94)	(3.24)									
MP_GDS	Cons	MP_GDS(-4)					ECM	WOILP						
	-0.21	0.59					-0.62	0.08						0.72
	-(3.72)	(7.81)					-(6.05)	(4.49)						
MP_SERV	Cons	WP	DAUTUMN				ECM	WP	WOILP					
	0.00	0.36	0.04				-0.06	2.51	-0.16					0.94
	(0.25)	(5.06)	(27.71)				-(2.93)	(10.15)	-(4.07)					
TX_PROD	Cons	SCV	D11Q1	DSPRING	DAUTUMN	D10Q2	ECM	SCV						
	-5.53	0.90	-0.14	-0.09	-0.12	-0.29	-0.64	1.53						0.75
	-(4.68)	(2.51)	-(1.93)	-(3.94)	-(4.06)	-(2.35)	-(5.28)	(18.09)						

Var.	Short Run							Long Run						Adj R^2
TX_VAT	Cons	XV_TOUR					ECM	SCV						
	-9.46	0.11					-0.70	1.83						0.68
	-(11.12)	(5.67)						(20.67)						
TX_CAP	Cons	AVG_PROP(-1)	D10Q2	D05Q2			ECM	AVG_PROP(-1)						
	-4.70	0.32	0.82	0.88			-0.53	1.46						0.50
	-(3.75)	(1.79)	(3.96)	(4.27)			-(6.22)	(9.18)						
TX_INC_IND	Cons	DWINTER					ECM	IFE	TX_INC_IND(-4)					
	-4.09	0.14						0.79	0.42					0.90
	-(4.17)	(3.33)						(5.40)	(4.03)					
TX_INC_CORP	Cons	D07Q4	TX_INC_CORP(-1)				ECM	GOS						
	-3.74	0.35	-0.73				-0.29	1.82						0.81
	-(3.05)	(2.44)	-(10.08)				-(3.02)	(6.13)						
PROP_INC	Cons	DAUTUMN	DSPRING	PROP_INC(-4)			ECM	DEX						
	8.80	0.66	0.36	0.34			-0.90	0.66						0.81
	(116.20)	(6.35)	(3.35)	(5.37)				(2.19)						

Var.	Short Run							Long Run						Adj R^2
SS_CONT	Cons	IFE(-4)	DWINTER	DAUTUMN	SS_CONT(-1)		ECM	IFE(-4)						
	-0.11	1.31	0.14	0.50	-0.17		-0.80	0.87						0.83
	(0.39)	*(3.03)*	*(9.48)*	*(2.39)*	*-(1.57)*		*-(4.94)*	*(33.38)*						
TX_OTXPROD	Cons	TX_OTXPROD	MV_CONS				ECM	MV_CONS	TX_OTXPROD(-4)					
	-6.24	0.39	-1.34				-0.70	1.25	0.28					0.51
	(1.86)	*(3.13)*	*-(1.77)*					*(2.29)*	*(1.09)*					
PROPINCEXP_PS	Cons	PROPINCEXP_PS(-1)	D09Q4				ECM	YVAV_RCONS	PROPINCEXP_PS(-4)					
	1.68	-0.49	-0.38				-0.70	0.41	0.32					0.75
	(1.51)	*-(7.60)*	*-(2.43)*					*(2.64)*	*(2.21)*					
SOCBEN_PS	Cons	DWINTER	DSPRING				ECM	SU	AW					
	9.73	0.07	0.10					0.04	1.48					0.97
	(44.19)	*(5.30)*	*(7.40)*					*(2.04)*	*(35.06)*					
INTCOM_PS	Cons	HICP_PHAR	AWG	D09Q1	DWINTER		ECM	AWG	HICP_PHAR					
	2.83	0.82	0.44	-0.30	0.22		-0.91	1.94	1.01					0.69
	(1.52)	*(0.31)*	*(0.70)*	*-(2.21)*	*(4.47)*		*-(8.92)*	*(12.16)*	*(2.26)*					

Appendix B: Exogenous Variables

Denotation	Historical Data Source	Forecast Method/Source	Time Series	Explanation
AWPadj	NSO	Forecast based on judgment of economic experts in the Ministry of Finance	1995 - 2016	Increase in average private sector wages in excess of COLA increase
AWGadj	NSO	Forecast based on judgment of economic experts in the Ministry of Finance	1995 - 2016	Increase in average public sector wages in excess of COLA increase
HICPW_ind	Eurostat	Forecast assumes the same weight of the last quarter	1995 - 2016	Weight of non-energy industrial goods in HICP
HICPW_en	Eurostat	Forecast assumes the same weight of the last quarter	1995 - 2016	Weight of energy in HICP
HICPW_unprocfd	Eurostat	Forecast assumes the same weight of the last quarter	1995 - 2016	Weight of unprocessed food in HICP
HICPW_procfd	Eurostat	Forecast assumes the same weight of the last quarter	1995 - 2016	Weight of processed food in HICP
HICPW_serv	Eurostat	Forecast assumes the same weight of the last quarter	1995 - 2016	Weight of services in HICP
HICP_phar	Eurostat	Forecast assumes the same average growth rate of the previous year	1995 - 2016	A measure of price growth for pharmaceutical goods
HICP_trans	Eurostat	Forecast assumes the same average growth rate of the previous year	1995 - 2016	A measure of price growth for transport goods
RPW_traded	NSO	Forecast assumes the same weight of the last quarter	1995 - 2016	Retail Price Index of Traded Goods weighted by Food, Beverages and Tobacco, Clothing and Footwear, Durable Household Goods, Personal Care and Health, Education, Entertainment and Recreation, Other Goods and Services
RPW_nontraded	NSO	Forecast assumes the same weight of the last quarter	1995 - 2016	Retail Price Index of Non-Traded Goods, weighted by Housing, Fuel, Light and Power, Transport and Communication
XP_st	United States Department of Labour	Forecast based on trend	1995-2016	Export prices of semiconductors, reflecting export prices quoted by Malta's manufacturing sector
MP_st	United States Department of Labour	Forecast based on trend	1995-2016	Import prices of semiconductors, reflecting import prices incurred by Malta's manufacturing sector

Denotation	Historical Data Source	Forecast Method/Source	Time Series	Explanation
XPW_gds	NSO	Forecast assumes the weight of the last quarter	2000-2016	Weight of exports of goods to overall exports
XPW_serv	NSO	Forecast assumes the same weight of the last quarter	2000-2016	Weight of exports of services to overall exports
MPW_gds	NSO	Forecast assumes the same weight of the last quarter	2000-2016	Weight of imports of goods to overall imports
MPW_serv	NSO	Forecast assumes the same weight of the last quarter	2000-2016	Weight of imports of services to overall imports
TIME	-	Forecast based on consecutive number series	1995 - 2016	Time trend
SS	NSO	Contribution to GDP growth over the forecast horizon is zero	1995 - 2016	Contribution from the inventories component over the forecast horizon is assumed zero
SSP	NSO	Forecast assumes the same level as the previous year	1995 - 2016	Over the forecast horizon, the deflator for the inventories component is assumed the same as the previous year.
Ye0_ps	NSO	Input is given by the Budget Office	1995 - 2016	Budget Office conducts Ministerial discussions
WPOP	Eurostat	Eurostat forecast updated every three years	1995 - 2016	Population on 1st January by age and sex
WGDP	Consensus Forecasts, NSO	Weighted based on the most recent export trade shares	1995 - 2016	Measures the real growth in Malta's main trading partners (Germany, France, UK, Italy and USA) weighted by historical export trade shares.
WGDPV	Consensus Forecasts, NSO	Weighted based on the most recent export trade shares	1995 - 2016	Measures the nominal growth in Malta's main trading partners (Germany, France, UK, Italy and USA) weighted by historical export trade shares.
WGDPT	Consensus Forecasts, NSO	Weighted based on the most recent tourism trade shares	1995 - 2016	Measures the real growth in Malta's main trading partners (Germany, France, UK, Italy and USA) weighted by inbound tourists.
WGDPTV	Consensus Forecasts, NSO	Weighted based on the most recent tourism trade shares	1995 - 2016	Measures the nominal growth in Malta's main trading partners (Germany, France, UK, Italy and USA) weighted by inbound tourists.
WP	Consensus Forecasts, NSO	Weighted based on the most recent trade shares	1995 - 2016	A trade-weighted measure of producer price growth in Malta's main trading partners (Germany, France, UK, Italy and USA)

Denotation	Historical Data Source	Forecast Method/Source	Time Series	Explanation
EFEX	European Central Bank	Regression based forecast	1995 - 2016	A measure of the nominal value of the Euro weighted against a basket of foreign currencies
WOILP	United States Energy Information Administration	Consensus Forecasts	1995 - 2016	Europe Brent Spot Price (Dollars per Barrel)
EFTR	NSO	Forecast assumes the same growth of the last quarter	1995 - 2016	The summation of employees National Insurance and Income Tax expressed as a ratio of the difference between Compensation of Employees and Employers Contribution Rate
ECR	NSO	Forecast assumes the same growth of the last quarter	1995 - 2016	Compensation of Employees divided by the Total Employer Contributions
KV_gov	NSO	Projected investment provided by Budget Office	1995 - 2016	Investment made by the Government
COLA	NSO	Forecast is based on retail price inflation	1995 - 2016	The annual increment to salaries to reflect changes in the cost of living
INT	European Central Bank	Forecast is based on information available at the time of forecast	1995 - 2016	Reflects the cost of borrowing for fixed rate tenders with a maturity of less than one-year
WCONSP	Consensus Forecasts, NSO	Weighted based on the most recent trade shares	1995 - 2016	A measure of general inflation, weighted by Malta's key trading partners
MSE	Malta Stock Exchange	Regression based forecast	1995 - 2016	Malta Stock Exchange equity total return index
MV_og	NSO	Forecast based on judgment of economic experts in the Ministry of Finance	2004-2016	Imports of Other Goods at current market prices
TX_ocr	NSO	Forecast based on input from the fiscal model in the Ministry of Finance	2000-2016	The Fiscal Model in the Ministry for Finance provides the other current revenue component
otherexp_ps	NSO	Forecast based on input by the Budget Office	2000-2017	Budget Office provides information based on set expenditure targets
LRINT_MT	Eurostat	Forecast assumes the same growth of the last quarter	1995 - 2016	The return on investment earned on long term Maltese bonds, a measure of Malta's attractiveness for investment
LRINT_DE	Eurostat	Forecast assumes the same growth of the last quarter	1995 - 2016	The return on investment earned on long term German bonds, a measure of Germany's attractiveness for investment

Denotation	Historical Data Source	Forecast Method/Source	Time Series	Explanation
VIXX	Cboe Global Markets, Inc.	Forecast assumes the same growth of the last quarter	1995 - 2016	A measure of the stock market's expectation of volatility implied by S&P 500 index options
SRI	Eurostat	Forecast assumes the same growth of the last quarter	1995 - 2016	A measure of risk, computed using the difference between the yield on Maltese bonds and German bonds
STG	European Central Bank	Consensus Forecasts	1995 - 2016	British Pound denominated in Euro
DEX	European Central Bank	Consensus Forecasts	1995 - 2016	The relative value of the Euro against the United States Dollar
CHF	European Central Bank	Consensus Forecasts	2000-2016	Swiss Franc denominated in Euro
DKK	European Central Bank	Consensus Forecasts	2000-2016	Danish Krone denominated in Euro
NOK	European Central Bank	Consensus Forecasts	2000-2016	Norwegian Krone denominated in Euro
SEK	European Central Bank	Consensus Forecasts	2000-2016	Swedish Krone denominated in Euro
REER	European Central Bank	Regression based forecast	1995 - 2016	A measure of the real (deflated) value of the euro against a weighted average of prominent foreign currencies

Appendix C: List of Identities

Trade

i) XV_tour = TNUM * TAVSPEND / 1000

ii) SXV = $\sum XV$

iii) XV_netoffuel = SXV - (XV_fuel)

iv) SMV = $\sum MV$

v) MV_netoffuel = SMV - (MV_fuel)

vi) MV_serv = MV_fis + MV_obs + MV_rg + MV_os

vii) BP = SXV – SMV + NETINVINC

Value Added

i) GDPFCV =$\sum YVAV$

Gross Operating Surplus

i) GOS = GDPV - (TX_prod + TX_otxprod) + subs_ps - IFE

Labour Market

i) SE = $\sum YE0$

ii) Ye0_gamfisobs = Ye0_rg + Ye0_fis + Ye0_obs

iii) SLF = SU + SE (used to create actual data)

iv) SLF = SLFR * WPOP (used for forecasting purposes)

v) SLFR = SLF/WPOP

vi) SURATE = 100 * SU / SLF

vii) WPOP_lfs = POP1564

viii) SLFR_lfs = SLF_lfs / WPOP_lfs

ix) SLF_lfs = SLFR_lfs * WPOP_lfs

x) SU_lfs = SLF_lfs - SE_lfs

xi) SURATE_lfs = 100 * SU_lfs / SLF_lfs

xii) SU = SLF - SE

Income from Employment

i) AWP = (IFE - CompofEmp_ps) / (SE - YE0_ps) (used to create actual data)

ii) AWP = AWP(-4) + (13 * COLA / 1000) + AWPadj (used for forecasting purposes)

iii) AW = ((YE0_PS / SE) * AWG) + ((SE - YE0_PS) / SE) * AWP

iv) AWGadj = AWG - AWG(-4)-(13*COLA/1000) (used to create actual data; forecasts are exogenous)

v) AWPadj = AWP - AWP(-4)-(13*COLA/1000) (used to create actual data; forecasts are exogenous)

vi) CompofEmp_ps = YE0_ps * AWG

vii) AWG = CompofEmp_ps / YE0_ps (used to create actual data)

viii) AWG = AWG(-4) + (13 * COLA / 1000) + AWGadj (used for forecasting purposes)

ix) IFE = TIE_private + CompofEmp_ps

x) TIE_private = AWP * (SE – YE0_ps)

xi) WAGE = IFE * (1 - ECR)

Prices

i) RPI = (RPW_traded * RP_traded) + (RPW_nontraded * RP_nontraded)

ii) HICP = (HICP_ind*HICPW_ind) + (HICP_en*HICPW_en) + (HICP_unprocfd*HICPW_unprocfd) + HICP_procfd*HICPW_procfd +HICP_serv*HICPW_serv

iii) SXP = (XP_gds*XPW_gds) + (XP_serv*XPW_serv)

iv) SMP = (MP_gds*MPW_gds) + (MP_serv*MPW_serv)

Public Finances

i) BUDG = (TX_Prod + TX_ocr + TX_VAT + TX_Cap + TX_INC_Ind + TX_INC_Corp + Prop_Inc + SS_Cont + TX_otxprod + TX_oggr) - (CompofEmp_ps + Intcomp_ps + Subs_ps + PropIncExp_ps + socben_ps + currtrans_ps + captrans_ps + kv_gov + otherexp_ps)

ii) GDEBT = GDEBT(-1) - BUDG + GDEBTADJ

iii) TX_inc = TX_Inc_ind + TX_Inc_corp

Expenditure

i) SG = SGV / SGP

ii) SK = (KV_nongov + KV_gov) / SKP

iii) SKV = SK * SKP

iv) SX = SXV / SXP

v) SM = SMV / SMP

vi) GDP = SC + SG + SK + SS + SX - SM

vii) SCV = SC * SCP

viii) SSV = SS * SSP

ix) GDPV = SCV + SGV + SKV + SSV + SXV - SMV

x) FCAV = GDPV - GDPFCV

Interest Rate

i) RINT = 100*(((1+INT/100)/(SCP/SCP(-4)))-1)

Appendix D: List of Variables

MV_CONS	Imports of Consumption Goods
MV_CAP	Imports of Capital Goods
MV_INT	Imports of Intermediate Goods
MV_FUEL	Imports of Fuels
MV_OG	Imports of Other Goods
MV_FIS	Imports of Financial Services
MV_OBS	Imports of Other Business Services
MV_RG	Imports of Remote Gaming
MV_OS	Imports of Other Services
MV_NETOFFUEL	Imports Net of Fuel
XV_NETOFFUEL	Exports Net of Fuel
XV_EM	Exports of Electrical and Machinery Equipment
XV_FUEL	Exports of Fuels
XV_CHEMPHAR	Exports of Chemicals and Pharmaceuticals
XV_OG	Exports of Other Goods
XV_FIS	Exports of Financial Services
XV_OBS	Exports of Other Business Services
XV_RG	Exports of Remote Gaming
XV_TOUR	Exports of Tourists
TNUM	Inbound Tourist Numbers
TAVSPEND	Tourists Average Spending
XV_OS	Exports of Other Services
BP	Balance of Payments
YVAV_EM	Value Added of the Electrical and Machinery Sector
YVAV_CHEMPHAR	Value Added of the Pharmaceutical and Chemicals Sector
YVAV_OG	Value Added of the Other Goods Sector
YVAV_OD	Value Added of the Domestic Sector
YVAV_RCONS	Value Added of the Real Estate and Construction Activities Sector
YVAV_WRT	Value Added of the Wholesale and Retail Trade Sector

YVAV_RG	Value Added of the Remote Gaming Sector
YVAV_OBS	Value Added of the Other Business Services Sector
YVAV_PS	Value Added of the Public Sector
YVAV_TOUR	Value Added of the Tourism Sector
YVAV_FIS	Value Added of the Financial and Insurance Services Sector
YVAV_OS	Value Added of the Other Services Sector
YE0_RCONS	Employment in the Real Estate and Construction Activities Sector
YE0_PS	Employment in the Public Sector
YE0_WRT	Employment in the Wholesale and Retail Trade Sector
YE0_OD	Employment in Other Domestic Sectors
YE0_MANUF	Employment in the Manufacturing Sector
YE0_TOUR	Employment in the Tourism Sector
YE0_OBS	Employment in the Other Business Services Sector
YE0_RG	Employment in the Remote Gaming Sector
YE0_FIS	Employment in the Financial and Insurance Activities Sector
YE0_OS	Employment in the Other Services Sector
HICP_IND	Prices of Industrial Goods
HICP_PROCFD	Prices of Processed Food
HICP_EN	Energy Prices
HICP_UNPROCFD	Prices of Unprocessed Food
HICP_SERV	Services of Prices
RP_TRADED	Retail Prices of the Tradable Sector
RP_NONTRADED	Retail Prices of the Non-Tradable Sector
SC	Real Private Consumption Expenditure
SCP	Private Consumption Deflator
SGV	Public Consumption Expenditure
SGP	Public Consumption Deflator
KV_NONGOV	Private Gross Fixed Capital Formation
SKP	Gross Fixed Capital Formation Deflator

XP_GDS	Exports of Goods Deflator
XP_SERV	Exports of Services Deflator
MP_GDS	Imports of Goods Deflator
MP_SERV	Imports of Services Deflator
TX_PROD	Taxes on Production
TX_VAT	Value Added Tax
TX_CAP	Capital Taxes
TX_INC_IND	Current Taxes on Income and Wealth – Individual
TX_INC_CORP	Current Taxes on Income and Wealth – Corporate
PROP_INC	Property Income Receivable
SS_CONT	Social Security Contributions Receivable
TX_OTXPROD	Other Taxes on Production
PROPINCEXP_PS	Property Income Expenditure
SOCBEN_PS	Social Benefits Paid
INTCOMP_PS	Intermediate Consumption
AVG_PROP	Average Property Prices
AW	Average Wages
AWG	Public Average Wages
AWG_ADJ	Adjustment – Public Average Wages
AWP	Private Average Wages
AWP_ADJ	Adjustment – Private Average Wages
BASEWAGELM	Base Wage in Maltese Lira
BUDG	Government Budget Balance
CAPTRANS_PS	Public Capital Transfers
COLA	Cost of Living Adjustment
COMPOFEMP_PS	Public Compensation of Employees
CURRTRANS_PS	Public Current Transfers
D_SUP	Dummy Variable – 1995 to 2007
D00Q1	Dummy Variable – 2000 Quarter 1

D00Q1ON	Dummy Variable – 2000 Quarter 1 onwards
D00Q1Q3	Dummy Variable – 2013 Quarter 1 to Quarter 3
D00Q4ON	Dummy Variable – 2000 Quarter 4 onwards
D02Q2	Dummy Variable – 2002 Quarter 2
D03Q1	Dummy Variable – 2003 Quarter 1
D0408RG	Dummy Variable – 2004 to 2008
D04on	Dummy Variable – 2004 onwards
D05	Dummy Variable – 2005
D0507	Dummy Variable – 2005 to 2007
D05Q1	Dummy Variable – 2005 Quarter 1
D05Q2	Dummy Variable – 2005 Quarter 2
D06EURO	Dummy Variable – 2006 onwards
D06Q1	Dummy Variable – 2006 Quarter 1
D07Q1	Dummy Variable – 2007 Quarter 1
D07Q4	Dummy Variable – 2007 Quarter 4
D08CHPH	Dummy Variable – 2008
D08Q1	Dummy Variable – 2008 Quarter 1
D08Q3	Dummy Variable – 2008 Quarter 3
D08Q4FIS	Dummy Variable – 2008 Quarter 4
D09	Dummy Variable – 2009
D09Q1	Dummy Variable – 2009 Quarter 1
D09Q2	Dummy Variable – 2009 Quarter 2
D09Q4	Dummy Variable – 2009 Quarter 4
D10EM	Dummy Variable – 2010
D10Q2	Dummy Variable – 2010 Quarter 2
D11	Dummy Variable – 2011
D11Q1	Dummy Variable – 2011 Quarter 1
D11Q3	Dummy Variable – 2011 Quarter 3
D11Q4	Dummy Variable – 2011 Quarter 4

D12ON	Dummy Variable – 2012 onwards
D12Q1	Dummy Variable – 2012 Quarter 1
D12Q1Q2	Dummy Variable – 2015 Quarter 1 and Quarter 2
D12Q2	Dummy Variable – 2012 Quarter 2
D12Q3	Dummy Variable – 2012 Quarter 3
D12Q4	Dummy Variable – 2012 Quarter 4
D13ON	Dummy Variable – 2013 onwards
D13Q1	Dummy Variable – 2013 Quarter 1
D13Q2	Dummy Variable – 2013 Quarter 2
D13Q2ON	Dummy Variable – 2013 Quarter 2 onwards
D14ON	Dummy Variable – 2014 onwards
D15	Dummy Variable – 2015
D15Q1	Dummy Variable – 2015 Quarter 1
D15Q3	Dummy Variable – 2015 Quarter 3
D15Q3ON	Dummy Variable – 2015 Quarter 3 onwards
D16	Dummy Variable – 2016
D16Q1ON	Dummy Variable – 2016 Quarter 1 onwards
D16Q1Q2	Dummy Variable – 2016 Quarter 1 and Quarter 2
D16Q2	Dummy Variable – 2016 Quarter 2
D16Q3	Dummy Variable – 2016 Quarter 3
D16Q4	Dummy Variable – 2016 Quarter 4
D16Q4ON	Dummy Variable – 2016 Quarter 4 onwards
D17Q1	Dummy Variable – 2017 Quarter 1
D17Q2	Dummy Variable – 2017 Quarter 2
D2009ON	Dummy Variable – 2009 onwards
D2010ON	Dummy Variable – 2010 onwards
D2011ON	Dummy Variable – 2011 onwards
D911	Dummy Variable – 2009 to 2011
D97Q4ON	Dummy Variable – 1997 Quarter 4 onwards

D98Q1	Dummy Variable – 1998 Quarter 1
D98Q4	Dummy Variable – 1998 Quarter 4
D_Spring	Seasonal Dummy - Spring
D_Summer	Seasonal Dummy - Summer
D_Autumn	Seasonal Dummy - Autumn
D_Winter	Seasonal Dummy - Winter
GDEBT	Government Debt
GDEBTADJ	Adjustment for Government Debt
GDP	Real Gross Domestic Product (chain-linked volumes)
GDPFCV	Nominal Gross Domestic Product at Factor Cost
GDPV	Nominal Gross Domestic Product
GOS	Gross Operating Surplus
GR_EXT	Public Extraordinary Revenue
HICP	Harmonised Index of Consumer Prices
HICP_PHAR	Harmonised Index of Consumer Prices - Pharmaceuticals
HICP_TRANS	Harmonised Index of Consumer Prices - Transport
IFE	Income from Employment
INTCOMP_PS	Public Intermediate Consumption
INTPROPINC	Public Interest on Property Income
KV_GOV	Public Gross Fixed Capital Formation
KV_NONGOV	Private Gross Fixed Capital Formation
MP_GDS	Import Deflator - Goods
MP_SERV	Import Deflator - Services
NETINVINC	Net Investment Income
OTHEREXP_PS	Public Other Expenditure
POP014	Young-Age Population (0-14 years)
POP1564	Working Age Population
POP6500	Old-Age Population (65+ years)
PROPINCEXP_PS	Public Property Income Expenditure

RINT	Real Interest Rate
RP_NONTRADED	Retail Prices - Nontraded
RPI	Retail Price Index
SC	Real Private Consumption Expenditure
SCP	Private Consumption Expenditure Deflator
SCV	Nominal Private Consumption Expenditure
SE	Employed
SE_LFS	Employed (Labour Force Survey Definition)
SG	Real Government Consumption Expenditure
SGP	Public Consumption Deflator
SK	Real Gross Fixed Capital Formation
SKP	Gross Fixed Capital Formation Deflator
SKV	Nominal Gross Fixed Capital Formation
SLF	Labour Force
SLF_LFS	Labour Force (Labour Force Survey)
SLFR	Labour Force Participation Rate
SLFR_LFS	Labour Force Participation Rate (Labour Force Survey)
SM	Real Imports of Goods and Services
SMP	Imports of Goods and Services Deflator
SMV	Nominal Imports of Goods and Services
SOCBEN_PS	Public Social Benefits
SSV	Nominal Inventories
SU_LFS	Unemployed – Labour Force Survey
SUBS_PS	Public Subsidies
SURATE	Unemployment Rate
SURATE_LFS	Harmonised Unemployment Rate (Labour Force Survey)
SX	Real Exports of Goods and Services
SXP	Exports of Goods and Services Deflator
SXV	Nominal Exports of Goods and Services

TIE_PRIVATE	Private Total Income
TIME	Time Trend Variable
TX_INC	Public Taxes on Income
TX_OGGR	Other General Government Revenue
TX_OTXPROD	Public Other Taxes on Production
WAGE	Compensation of Employees
WPOP_LFS	Working Age Population (Labour Force Survey)
XP_GDS	Exports Deflator - Goods
XP_SERV	Exports Deflator - Services