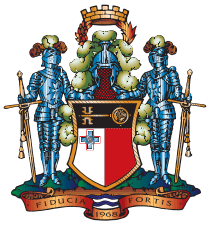

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STREAM: A MACROECONOMETRIC MODEL OF THE MALTESE ECONOMY

Article published in the Research Bulletin 2019, pp. 5-12

STREAM: A MACRO-ECONOMETRIC MODEL OF THE MALTESE ECONOMY

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This article presents an update of STREAM, the Central Bank of Malta's macro-econometric model of the Maltese economy. The model's database has been updated until 2018Q4 and the behavioural equations, specified in error-correction form, have been re-estimated. The newly estimated model generally features smaller error-correction terms mainly due to longer time-series used for estimation. The properties of the re-estimated model are illustrated using four standard simulations to foreign demand, interest rates, oil prices and the exchange rate. Despite considerable changes in the macroeconomic environment in recent years, including a period of very strong economic growth and the decline in the unemployment rate to historical lows, many of the key relationships underlying the Maltese economy have remained broadly unchanged.

Introduction

Modern economies are considerably complex and Malta is no exception. Economies allocate limited resources and output produced is consumed by a large number of agents, mainly individuals, firms and governments, with the action of these agents being interlinked. A macro-econometric model is a simplified description of this complex interaction in reality. It is intended to capture the key economic relationships underpinning an economy, usually on the basis of both economic theory and empirical evidence, and thus serves to assist analysts and policymakers in understanding the dynamics observed in the data and the linkages between the various agents and sectors of the economy.

This article presents an update of STREAM, the Central Bank of Malta's core macro-econometric model of the Maltese economy.[1] This model was developed with three key uses in mind. First, the model is used to conduct simulations and thus assess the impact of various shocks on the domestic economy. Examples of such studies include the impact of the reduction in electricity tariffs (Grech, 2014) and income taxes (Grech, 2015), the extension of hotel height limitations (Micallef and Attard, 2015) and the potential impact of Brexit on the Maltese economy (Rapa, 2017a). Second, the model is used for forecasting purposes, such as in the projection exercises carried out by the Bank as part of the Eurosystem staff macroeconomic projection exercises. Although other tools are used in the forecasting process, such as satellite models, complemented by expert judgement, the model serves as a useful input, particularly with regards to the medium-to-long run where the role of economic theory becomes prevalent. Finally, it is intended to deepen our understanding of how the Maltese economy functions and to stimulate further debate in this regard.

"One of the key features of STREAM is that it contains fully-fledged fiscal and financial blocks, which is not common in traditional structural models of this kind"

STREAM is a traditional macro-econometric model built around the neo-classical synthesis, in other words, output is driven by supply in the long-run but by demand forces in the short-run. The model's database has been updated until 2018Q4 and the behavioural equations, specified in error-correction form, have been re-estimated. Economic agents are assumed to have adaptive expectations. One of the key features of STREAM is that it

[1] STREAM refers to 'Structural and Traditional Econometric model for Malta'. A detailed description of the model is available in Grech and Rapa (2016).

contains fully-fledged fiscal and financial blocks, which is not common in traditional structural models of this kind. These features were introduced following the last two economic crises in Europe, the global financial crisis and the sovereign debt crisis, which served as a bitter reminder of the strong inter-linkages that exist between the financial and fiscal sectors, respectively, and the broader economy.

The model is composed of five blocks: (i) a supply block, (ii) a demand block, (iii) a price-wage block, (iv) a fiscal block, and (v) a financial block. It consists of 257 equations, 29 of which are estimated behavioural equations, and 319 variables; 257 of them are determined endogenously, while the remaining 62 are exogenous. STREAM can thus be considered a medium-scale model that strikes a reasonable balance between containing sufficient detail to capture the key economic relationships characterising the domestic economy, while at the same time remaining manageable and tractable. This is in line with the current modelling practice among many central banks worldwide.

Re-estimation of STREAM

The previous version of the model, documented in Grech and Rapa (2016) and denoted below as Version 3, was estimated until 2013Q4. In the current exercise, the database has been updated until end-2018 and all equations were re-estimated over the period between 2000Q1 and 2016Q4.[2] The update of the database and the re-estimation of the model with recent data were meant to ensure that STREAM remains a faithful representation of how the domestic economy functions. Despite considerable changes in the macroeconomic statistics during this period, including a period of very strong economic growth and the decline in the unemployment rate to historical lows, many of the key relationships underlying the Maltese economy have remained broadly unchanged.

"The update of the database and the re-estimation of the model with recent data were meant to ensure that STREAM remains a faithful representation of how the domestic economy functions"

Table 1 describes the key short run elasticities in STREAM and compares them with those in the previous version. Despite some difference in point estimates, most elasticities remain broadly similar. The main differences refer to a somewhat stronger response of prices to domestic cyclical conditions, measured by the output gap, and a weaker response of prices to foreign price pressures. This is most likely due to two factors. First, in these last years, the Maltese economy has continued its shift toward becoming a more service-oriented economy, a process which has reduced its reliance on imported goods but increased its dependence on labour as the main factor of production (Grech and Rapa, 2019). Secondly, as shown in the simulation results below, the economy has become less sensitive to oil price fluctuations, most probably due to a restructured energy production setup and oil hedging agreements that are intended to keep utility prices stable. These two factors are expected to reduce local price sensitivity to foreign prices while increasing the contribution that wage dynamics are likely to have on domestic price pressures. On the contrary, most long-run elasticities are calibrated in line with economic theory.

Table 1
SHORT RUN ELASTICITIES

	Version 3	Updated
Consumption wrt disposable income	0.30	0.30
Consumption wrt unemployment rate	-1.42	-1.58
Exports wrt world demand	1.04	1.18
GDP deflator wrt foreign prices	0.14	0.09
GDP deflator wrt output gap	0.34	0.41
Import deflator wrt foreign prices	0.50	0.44

Source: Authors' calculations.

[2] The last two years were not included in the estimation period given the tendency of most recent data vintages to be revised. See Grech (2019) for an analysis of revisions to GDP data in Malta.

Table 2
ERROR-CORRECTION TERM IN KEY EQUATIONS

	Version 3	Updated
Private consumption	-0.55	-0.22
Non-dwelling private investment	-0.52	-0.42
Non-SPE exports of goods and services	-0.24	-0.36
GDP deflator	-0.35	-0.34
Import deflator	-0.23	-0.19
Employment	-0.36	-0.35
Private wages	-0.51	-0.42

Source: Authors' calculations.

Furthermore, the re-estimation has improved the fit of most equations, mostly as a result of more degrees of freedom due to longer time series used for estimation. In most instances, the re-estimated behavioural equations also feature a lower error-correction term, implying a more gradual adjustment of any imbalances towards the long-run equilibrium, also mostly due to the longer time series used in the estimation.

"The Maltese economy has continued its shift toward becoming a more service-oriented economy, a process which has reduced its reliance on imported goods but increased its dependence on labour as the main factor of production"

Table 2 describes the error-correction terms in key equations in STREAM. The error-correction term is a principal feature of co-integrated variables and influences the time it takes for any short-run disequilibrium to be corrected before the relationship returns to its long-run equilibrium. For stability purposes, the error-correction term has to be negative and less than one in value. Larger values of this term imply that the endogenous variable in question moves faster to its long-run equilibrium. For instance, an error-correction term of -0.33 implies that 33% of any short-run disequilibrium will be corrected in each quarter. With few exceptions, Table 2 shows that the updated version of STREAM has smaller speed-of-adjustment coefficients, implying a more gradual adjustment towards the long-run equilibrium, which tends to improve its forecasting and simulation properties.

Simulation properties of STREAM

This section presents the results of four simulations to illustrate the properties of the re-estimated model. The simulations are standard: a foreign demand shock, an interest rate shock, an oil price shock and an exchange rate shock. The scope of simulation analysis is largely twofold. First, it sheds light on the dynamic properties of the model and the main propagation channels. Second, it allows us to examine the plausibility of the simulation results the model generates, both from a theoretical and an empirical perspective.

A word of caution is in order in the interpretation of the simulation results. The individual shocks in the simulations are assumed to be orthogonal to the other shocks in the system. In other words, the simulations reported below will only have an impact on one exogenous variable, leaving the other shocks unchanged. To give an example, changes in, say, monetary policy in the euro area by the European Central Bank will affect not only the policy interest rates but will also have an impact on the exchange rate, other asset prices, demand conditions and, eventually, prices, reflecting the usual lags in the monetary policy transmission mechanism. In this particular example, the design of the simulation will only report how domestic endogenous variables react to an increase in interest rates, while keeping the other exogenous foreign variables, such as foreign demand and prices, unchanged. These simulations are best interpreted as a partial equilibrium analysis and should not be construed as representing real-life scenarios, the design of which would require considerable expert judgement.

Foreign demand shock

This shock is defined as a permanent 1% increase in foreign demand for Maltese goods and services. An increase in foreign demand has a positive impact on exports, which in turn raises GDP (see Table 3). This

Table 3
THE MACROECONOMIC IMPACT OF AN INCREASE IN FOREIGN DEMAND
Percentage change from baseline levels unless otherwise specified

	Year 1	Year 2	Year 3	Year 4
Economic Activity				
Real GDP	0.58	0.68	0.59	0.49
Private consumption	0.09	0.40	0.39	0.18
Government consumption	0.21	0.23	0.08	0.14
Gross fixed capital formation	0.27	0.64	0.57	0.41
Exports of goods and services	1.08	0.87	0.64	0.57
Imports of goods and services	0.73	0.67	0.48	0.36
Prices and Costs				
HICP	0.01	0.11	0.34	0.53
GDP deflator	0.03	0.27	0.62	0.76
Unit labour costs	-0.21	0.23	0.47	0.59
Labour Market				
Unemployment rate	-0.04	-0.12	-0.11	-0.05
Employment	0.16	0.52	0.69	0.71
Compensation per employee	0.20	0.39	0.37	0.37
Fiscal Developments				
Balance[(1)]	0.05	0.13	0.18	0.19
Gross debt[(1)]	-0.32	-0.63	-0.93	-1.11

Source: Authors' calculations.
[(1)] Absolute change from baseline as per cent of GDP.

boosts employment and wages, and hence disposable income, which, in turn, raises private consumption. Higher GDP results in lower unemployment. Buoyant economic activity stimulates investment and also gives rise to an increase in government consumption. These developments stimulate GDP further although this is partially offset by an increase in imports, given the relatively high import content of domestic demand components, which is usually the case in small and open economies. The increase in GDP exerts upward pressure on prices and cost pressures, which eventually leads to a loss in competitiveness and consequently to a gradual slowdown in export growth. Turning to fiscal developments, buoyant economic activity boosts government revenues. At the same time, government expenditure also increases due to the rise in public compensation of employees, public intermediate consumption and government investment. The net effect translates into an improvement in the government balance, which causes the government debt ratio to fall.

Interest rate shock

This shock is defined as a permanent increase in the policy interest rate by 50 basis points.[3] A contractionary monetary policy shock set by the European Central Bank raises bank lending rates and thus reduces the demand for credit. In line with results shown in Micallef et al. (2016), the transmission of monetary policy shocks to Maltese market rates is imperfect. Following the shock, private consumption falls as a result of the higher lending rate to households, as well as lower demand for credit and the deterioration in the labour market, with lower employment and a slight increase in the unemployment rate (see Table 4). Investment also contracts due to an increase in the user cost of capital together with weaker demand for credit by businesses. The decline in private consumption and investment lowers GDP, which in turn leads to a decrease in employment and wages, albeit with a lag. All these effects dampen GDP even further though the effects are to some degree offset by lower imports and a slight improvement from exports, owing to the downward pressure on prices that improves the country's competitiveness.

On the fiscal side, government revenue shrinks due to weaker macroeconomic performance. This adverse impact on government finance is reinforced by an increase in government expenditure as a result of higher

[3] This shock differs from the monetary policy shock reported in Grech and Rapa (2016). In the latter study, the simulation consisted of a 50 basis point increase in interest rate combined with an appreciation of the euro against the other currencies by 0.5%.

Table 4
THE MACROECONOMIC IMPACT OF AN INCREASE IN INTEREST RATES
Percentage change from baseline levels unless otherwise specified

	Year 1	Year 2	Year 3	Year 4
Economic Activity				
Real GDP	0.00	-0.11	-0.20	-0.21
Private consumption	-0.31	-0.92	-1.19	-1.26
Government consumption	0.00	-0.04	-0.08	-0.08
Gross fixed capital formation	-0.10	-0.63	-0.87	-0.90
Exports of goods and services	0.00	0.02	0.09	0.13
Imports of goods and services	-0.17	-0.46	-0.52	-0.51
Prices and Costs				
HICP	0.00	0.00	-0.02	-0.08
GDP deflator	-0.01	-0.03	-0.06	-0.11
Unit labour costs	0.00	0.04	-0.02	-0.10
Labour Market				
Unemployment rate	0.00	0.01	0.03	0.03
Employment	0.00	-0.03	-0.12	-0.19
Compensation per employee	0.00	-0.04	-0.10	-0.12
Fiscal Developments				
Balance[(1)]	-0.08	-0.18	-0.28	-0.35
Gross debt[(1)]	0.08	0.32	0.64	1.01

Source: Authors' calculations.
[(1)] Absolute change from baseline as per cent of GDP.

interest payments. As a result, the deterioration in the fiscal balance leads to an increase in the government debt ratio.

Oil price shock

This shock is defined as a permanent increase in oil prices by 10% from the price level of €85. As expected from a supply-side shock, higher oil prices lead to an upward pressure on prices and an adverse effect on economic activity (see Table 5). The increase in price pressures translates into a loss in competitiveness and a decline in export growth. The labour market situation also deteriorates, with a decline in employment and a slight increase in the unemployment rate. The increase in nominal compensation per employee is outweighed by higher prices, resulting in a decline in the real wage and in real household disposable income, which depresses private consumption. Subdued economic activity also leads to a drop in investment. The overall contraction in GDP is offset to some degree by lower imports.

With regard to fiscal developments, even though GDP shrinks, government revenue increases because some macroeconomic bases expand in nominal terms on the back of higher prices. Similarly, government expenditure rises, albeit with a lag, due to an increase in nominal public compensation of employees, brought about by the gradual pass-through of elevated prices, coupled with higher social benefits resulting from rising unemployment. Overall, these developments give rise to a slight improvement in the government balance ratio in the first year but a deterioration thereafter. The government debt ratio follows similar dynamics, though in the opposite direction.

It is also likely that the impact of oil prices on prices and economic activity is dependent on the starting level of oil prices. In other words, the pass-through from, say, a 10% increase in oil prices is different at oil prices of €50 per barrel and €150 per barrel. One explanation for this level-dependency is the presence of fixed excise taxes in consumer energy prices, which imply a larger direct impact of oil price changes on consumer prices at higher price levels.[4] These effects are modelled by first estimating the impact on consumer prices using the Narrow Inflation Projection Exercise (NIPE) satellite framework, which is used by the Bank to prepare highly disaggregated inflation

[4] See Structural Issues Report (2010) for further details on energy level dependency.

Table 5
THE MACROECONOMIC IMPACT OF AN INCREASE IN OIL PRICES
Percentage change from baseline levels unless otherwise specified

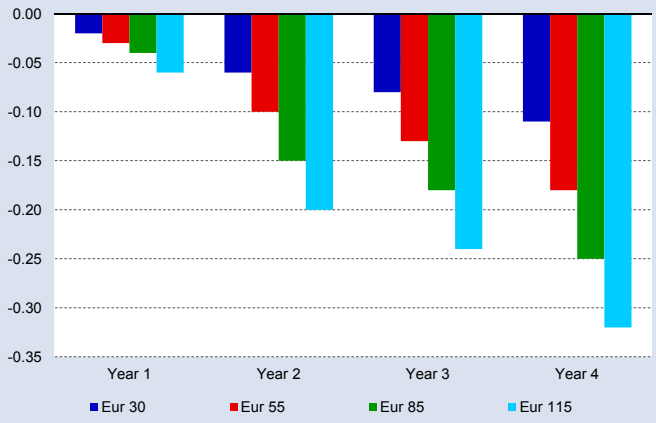
	Year 1	Year 2	Year 3	Year 4
Economic Activity				
Real GDP	-0.04	-0.15	-0.18	-0.25
Private consumption	-0.10	-0.17	-0.26	-0.27
Government consumption	-0.01	-0.01	-0.09	-0.11
Gross fixed capital formation	-0.01	-0.17	-0.19	-0.26
Exports of goods and services	-0.10	-0.20	-0.21	-0.27
Imports of goods and services	-0.12	-0.20	-0.24	-0.27
Prices and Costs				
HICP	0.15	0.22	0.23	0.24
GDP deflator	0.12	0.06	0.06	0.03
Unit labour costs	0.09	0.21	0.17	0.21
Labour Market				
Unemployment rate	0.00	0.02	0.04	0.04
Employment	0.00	-0.08	-0.17	-0.24
Compensation per employee	0.05	0.14	0.15	0.20
Fiscal Developments				
Balance[(1)]	0.02	-0.01	-0.02	-0.02
Gross debt[(1)]	-0.05	0.03	0.06	0.12

Source: Authors' calculations.
(1) Absolute change from baseline as per cent of GDP.

forecasts at a monthly frequency. In a second step, the shocks to energy in STREAM are calibrated to replicate the impact on consumer prices obtained from NIPE.

Chart 1 shows the impact of a 10% increase in oil prices on GDP from four different oil price levels: €30, €55, €85 and €115. By the fourth year, the adverse impact of higher oil prices range from 0.11% if the increase takes place from a very low oil price (€30 per barrel) to 0.32% in the high oil price scenario (€115 per barrel). The spirit of these results is in line with Rapa (2017b), who noted that the macroeconomic effects of energy reforms in Malta are dependent on both the generation setup but also on the level of oil prices.[5]

Chart 1
IMPACT OF 10% INCREASE IN OIL PRICES ON GDP AT DIFFERENT PRICE LEVELS
(per cent deviation from baseline levels)



Source: Authors' calculations.

An exchange rate shock

The exchange rate shock is defined as a permanent appreciation of the euro vis-à-vis the dollar by 10%. The appreciation of the euro leads to a deterioration in the country's price competitiveness and a subsequent decline in exports and GDP (see Table 6). The slowdown in economic activity dampens investment and leads to a softening in labour market conditions. Despite the reduction in employment and wages, real disposable income rises on the back of lower consumer prices. The latter is due to the effects of lower import prices from the exchange rate appreciation. The rise in real disposable income exerts a positive effect on private consumption, which increases through-

[5] Expectations in STREAM are adaptive and backward-looking. Hence the model does not take into account forward buying practices or longer term contracts between economic agents.

Table 6
THE MACROECONOMIC IMPACT OF A EURO APPRECIATION AGAINST US DOLLAR

Percentage change from baseline levels unless otherwise specified

	Year 1	Year 2	Year 3	Year 4
Economic Activity				
Real GDP	-0.11	-0.21	-0.17	-0.03
Private consumption	0.13	0.13	0.11	0.17
Government consumption	-0.06	-0.13	0.01	0.12
Gross fixed capital formation	-0.02	-0.09	-0.12	0.01
Exports of goods and services	-0.21	-0.36	-0.21	-0.05
Imports of goods and services	-0.07	-0.17	-0.06	0.08
Prices and Costs				
HICP	-0.23	-0.40	-0.51	-0.62
GDP deflator	-0.15	-0.22	-0.39	-0.53
Unit labour costs	-0.06	-0.32	-0.53	-0.66
Labour Market				
Unemployment rate	0.01	0.02	0.02	0.01
Employment	-0.03	-0.10	-0.15	-0.14
Compensation per employee	-0.13	-0.43	-0.54	-0.55
Fiscal Developments				
Balance[(1)]	-0.04	-0.06	-0.08	-0.10
Gross debt[(1)]	0.16	0.31	0.45	0.54

Source: Authors' calculations.

[(1)] Absolute change from baseline as per cent of GDP.

out the simulation horizon. Subdued economic activity exerts downward pressure on prices, which compensates for some of the loss in competitiveness from the exchange rate appreciation, in turn gradually reducing the negative impact of the shock on exports. On the fiscal front, government revenue shrinks due to weaker macroeconomic performance, which outweighs the decline in government expenditure. Consequently, the government balance ratio deteriorates, which causes the government debt ratio to increase.

Conclusion

This article presented an update of STREAM, the Bank's traditional macro-econometric model of the Maltese economy. Since its development, STREAM has become a valuable input in the Bank's forecasting toolkit and has been used to assess the impact of various policies on the Maltese economy.

"Areas of further model development include aspects related to migration, the housing market and supply side aspects of the model"

When compared to the current model, the newly estimated STREAM generally features smaller error-correction terms mainly due to longer time-series used for estimation. Moreover, results indicate that Malta's price dynamics have become less dependent on foreign prices, reflecting its reduced reliance on imported goods but increasingly sensitive to developments in the domestic labour market. Moreover, results to oil price shocks also indicate that in the last few years Malta has become less sensitive to oil price fluctuations. The latter results reflect the continued transformation of Malta's economy into an increasingly services oriented one, reforms in the energy sector and long-term agreements between government and energy providers on electricity prices. All in all, the overall conclusion is that despite the update of the underlying dataset and the re-estimation of the behavioural equations, this process has not substantially changed our view of how the domestic economy works.

Models can always be improved and we anticipate to further our research to refine STREAM in the future. Areas of further model development include aspects related to migration, the housing market and supply side aspects of the model.

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