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MEDSEA: A SMALL OPEN ECONOMY DSGE MODEL FOR MALTA

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BOX 3: MEDSEA: A SMALL OPEN ECONOMY DSGE MODEL FOR MALTA[1,2]

The popularity of traditional large scale macro-econometric models as tools for policy analysis among central banks has been eroding rapidly, especially in the light of the several critiques aimed at these types of models. Most notably, Lucas (1976)[3,4] criticized the policy recommendations derived from traditional models on the basis that the latters' estimated coefficients are not policy-invariant, leading to potentially misleading policy conclusions. As an answer to these criticisms, Kydland and Prescott (1982) proposed a new paradigm based on private optimizing agents that benefit from rational expectations whilst behaving in a general equilibrium environment. This gave rise to the Real Business Cycle (RBC) models. With time these models have been augmented with monopolistic market structures and nominal rigidities leading to the New Keynesian Dynamic Stochastic General Equilibrium (DSGE) Model.

As part of its general modelling strategy, the Central Bank of Malta has embarked on a project aimed at constructing a DSGE model for the Maltese economy. At their core, DSGE models are built around three interrelated blocks: a demand block, a supply block and a monetary policy equation. The demand block determines real activity by explaining how much households choose to consume and invest. The supply and demand blocks are jointly responsible for the formation of wages and prices, which are then used as an input in the monetary policy equation. The latter explains how the central bank sets the nominal interest rate in response to deviations of inflation and output from their targets or equilibrium levels. The equations that derive these blocks are based on micro-foundations, implying that they are theoretically consistent while explicitly setting out all assumptions about the behaviour of the main agents in the economy. The agents within these blocks interact in markets that clear in every period, thus leading to the "general equilibrium" feature of this class of models. Contrary to traditional macro-econometric models, New Keynesian DSGE models include an explicit treatment of expectations allowing the study of anticipatory or precautionary behaviour of agents in response to expected shocks – hence the "dynamic" aspect of the DSGE label. This feature, together with the fact that all equations are rigorously micro-founded, makes this class of models especially suited for counterfactual simulations and policy evaluations that are immune to the Lucas' critique. The "stochastic" component of DSGE models is captured by the presence of random shocks that perturb the equilibrium in every block, injecting uncertainty in the economy and creating economic fluctuations.

MEDSEA, the DSGE model developed by the Central Bank of Malta, benefitted from a three-year technical co-operation agreement with experts from the Banca d'Italia. It is intended to be a first step in this modelling strategy and will serve as a basis for future extensions that will allow for a more detailed treatment of policy relevant questions.

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2 A detailed discussion of MEDSEA is available in Rapa, N. (2016). MEDSEA: A small open economy DSGE model for Malta. *Working Paper* WP/05/2016, Central Bank of Malta.

3 Lucas, R.E. (1976). The Phillips Curve and Labor Markets. *Carnegie-Rochester Conference Series on Public Policy*, 19-46.

4 Kydland, F.E., & Prescott, E.C. (2016). Time to Build and Aggregate Fluctuations. *Econometrica*, *Vol. 50, No. 6*, 1345-1370.

The core features of MEDSEA are similar to those found in similar small open economy models. The model contains five types of agents: households, intermediate good producers, final good firms, aggregators and the government. Households maximize a lifetime utility over an infinite life horizon. Labour is differentiated over a continuum of households introducing some degree of monopoly power over wages, which in turn allows the introduction of sticky wages. Intermediate goods firms are of three types namely, those producing tradable and non-tradable output, and those responsible for importing foreign production. All firms in the intermediate sector optimise prices subject to some nominal rigidities. The economy produces three final goods: consumption, investment and exports. These are produced by final good firms that combine a continuum of heterogeneous products, produced by the tradable and non-tradable intermediate firms, with imports. Producers of final export goods require distribution services produced by perfectly competitive producers that purchase a basket of non-tradables to deliver the final export goods to the rest of the world. The treatment of government is fairly simplistic and is aimed at making the calibration of the great ratios implied by the model easier. At this stage, the government is assumed to pursue a balanced budget and to finance public spending through a lump-sum tax. The model allows for habit persistence, price and wage indexation, as well as investment adjustment costs in an effort to capture the persistence and dynamics usually found in the data. MEDSEA also allows for deviations in the law of one price by introducing a sluggish pass-through of foreign to import prices.

The DSGE model for Malta also contains key modifications designed to account for the country's specific characteristics. The Maltese economy is modelled within a monetary union, thereby lacking an independent inflation targeting rule. Furthermore, the model features a modified export sector specifically designed to account for the characteristics of the Maltese export sector. Unlike similar models in its class, the tradable production of the model is explicitly targeted to be exported and is therefore not complementary to other production meant for local household consumption, investment or government expenditure. This reflects the fact that the goods and services meant for Maltese consumption and investment are intrinsically different from those that are exported. Also, through its export production process the model is able to reflect the reliance of Maltese exports on imported content. The model also assumes that the capital input of the tradable sector is decided exogenously, reflecting the fact that in small open economies, capital input decisions of export-oriented firms are not necessarily made domestically. This provides a role for exogenous changes in foreign direct investment. Finally, the model features goods market separation through the presence of distribution costs in the tradable sector. This implies that price changes in the non-tradable sector are transmitted, with an imperfect degree of pass-through, to the tradable sector.

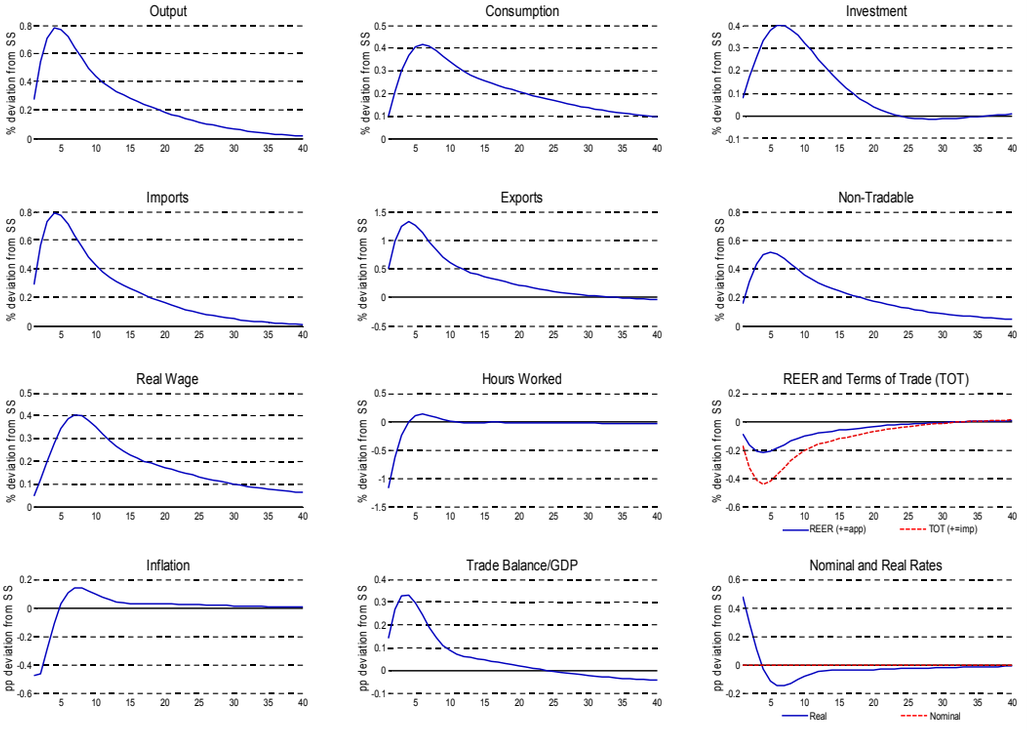
The model is calibrated to replicate the specific features of the Maltese economy. The parameters meant to pin down the values for the steady-state ratios were calibrated so as to replicate the long-run average (2000-2015) observed from the national accounts statistics. The parameters governing the dynamics of the model were calibrated consistently with existing DSGE literature on the euro area and in line with the Maltese economy calibration

of the EAGLE model, described in Micallef (2013).[5] Parameters related to the frequency of price and wage re-optimisation were set in line with the findings of the Wage Dynamic Network.[6]

In order to illustrate the transmission channels operating in MEDSEA, Chart 1 presents the results of an unanticipated temporary shock to the technology level of both tradable and non-tradable sectors. The chart shows the impulse responses of a number of key variables to a 1 standard deviation positive shock, which temporarily raises the productivity of the tradable and non-tradable sectors by 1%.

The impulse responses show that one year after the productivity shock, GDP increases by almost 0.8%, driven by both the domestic and foreign sectors. Following the shock, the increased level of efficiency with which factors of production are used, leads to an immediate fall in the marginal cost of both tradable and non-tradable sectors, leading to lower price pressures. Efficiency gains in the non-tradable sector have an indirect effect on export price inflation via the distribution channel, thereby amplifying the depreciation of

Chart 1
COMMON TECHNOLOGY SHOCK



Source: Author's calculations.

[5] Micallef, B. (2013). Measuring the Effects of Structural Reforms in Malta: an Analysis Using the EAGLE Model. *Working Paper* WP/01/2013, Central Bank of Malta.

[6] See Central Bank of Malta Annual Report (2014).

the real exchange rate. This improves the competitiveness of the Maltese economy leading to an increase in exports. Higher efficiency results in a downward shift of the labour demand curve, implying a fall in the hours worked.[7] Despite lower labour demand, real wages increase, driven by lower levels of domestic inflation.

The small country assumption implies that euro area inflation, and therefore, nominal interest rates in the euro area are unaffected by the decline in Malta's inflation. Still, lower domestic inflation leads to an increase in Malta's real interest rate. Despite a negative inter-temporal substitution effect, higher real labour income pushes up domestic consumption. In view of the lower domestic inflation, domestic non-tradable goods are perceived as cheaper than imported alternatives, thereby discouraging imports and increasing the production of non-tradables. This, together with a stronger export performance leads to an improved trade balance on impact. Strong economic performance leads to some inflationary pressures to start building up between the second and third years after the initial shock. This starts to gradually erode the country's competitiveness leading to a progressive return to the initial steady-state.

In addition to the above simulation, the model includes a number of shocks such as wage and goods mark-up shocks that are very relevant from a policy perspective. For instance, MEDSEA can be used to quantitatively assess, in a theoretically consistent way, a number of policy reforms aimed at improving the competitiveness of the labour and goods markets in Malta.

Going forward, the model will be further developed to increase the number of policy questions that can be addressed. For instance, at this current juncture MEDSEA completely abstracts from search and matching frictions and is thus unable to explain the existence of involuntary unemployment. Moreover, the treatment of fiscal policy in this model is very stylised and MEDSEA would definitely benefit from a richer modelling of government taxes and revenue components. A further step would be the estimation of the model, which would help to empirically uncover the structural shocks driving the Maltese business cycle as well as some of the parameters governing the dynamics of the model. Eventually, estimation would also allow the model to be used to forecast key economic variables, potentially helping in the generation of macroeconomic forecasts.

Finally, it is important to note that the model presented here together with its future extensions is meant to be used as a complement to the existing policy toolkit available at the Central Bank of Malta. While the Bank's traditional econometric model, STREAM,[8] is envisaged to remain the main tool that assists in the production of forecasts and in other routine applications at the Bank, MEDSEA is expected to aid in answering research questions that require a more theoretically consistent framework that is immune to the Lucas critique.

[7] This is in line with the empirical findings of Gali, J. (1999). Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations? *American Economic Review*, 89(1), 249-271.

[8] Grech, O., & Rapa, N. (2016). STREAM: A Structural Model of the Maltese Economy. *Working Paper* WP/01/2016, Central Bank of Malta.