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Noel Rapa

This article studies the macroeconomic effects of energy market reforms in Malta using a DSGE model augmented with a rich fiscal block. Contrary to previous studies, this article takes into consideration both demand-side effects related to the conversion and construction of upgraded power plants, as well as supply-side effects, which manifest themselves as reductions in the marginal cost of electricity production of Enemalta. It considers two energy setups – an interconnector and gasoil setup and an interconnector and natural gas setup – and three different oil price levels. Under the baseline oil price scenario, the decommissioning of the Marsa power plant and the installation of an undersea interconnector results in a fall in marginal costs, leading to an increase in long-run output of 2.1%. The eventual shift to natural gas-fired turbines leads to more pronounced gains in activity. The estimates are sensitive to two key factors – the prevailing oil price levels and the degree of pass-through from Enemalta to the final customers.

Introduction

The European Union's (EU) energy policy requires all member states to reform existing power systems and decrease their reliance on single, vertically integrated power suppliers. Malta's small size and geographic isolation implies that it does not have to comply with all EC directives; most notably those regarding the unbundling of distribution system operators, third-party access and market opening. However, in line with the EU Energy Roadmap 2050, Malta is required to reduce the vulnerability of its electricity generation to fossil fuel prices and potential import disruptions.

To this end, Maltese authorities have enacted a number of reforms aimed at diversifying the island's exclusive fossil fuel based energy mix and increase the efficiency of its electricity production. First, authorities opted to install a high voltage alternating current undersea cable that connects Malta's energy grid with that of Europe. This, together with an increase in the nominal capacity of the Delimara power plants, have resulted in the possible decommissioning of the Marsa power station. Second, in a bid to reduce the carbon footprint of domestic energy generation, authorities opted to enter into an agreement with Shanghai Electric Power Co. Ltd to convert Delimara 3 power station from one operating on heavy fuel oil to gas and to build a new combined cycle gas-fired power plant, Delimara 4. The macroeconomic effects of these energy reforms have been analysed in a number of studies, such as Grech (2014), the Ministry for Finance (2016), and in Rapa (2017a).[1] While the latter study captures the supply-side effects of these energy reforms owing to a reduction in economy-wide marginal costs, it does not include the demand-side effects of the short-term increase in government investment required to enact these reforms. Moreover, Rapa (2017a) does not take into consideration neither the increase in the long-run government investment ratio to GDP required to maintain the new capital equipment installed, nor the increase in government investment driven by the expansion in long-run output of the economy.

Efficiency gains in electricity production

The energy reforms undertaken by the Maltese government are expected to affect the Maltese economy in two broad ways. First, the installation of the interconnector across the Sicilian channel and the conversion of Enemalta's powerplants to operate on natural gas are expected to boost government investment, leading to significant demand-side effects. Second, and more importantly, since the new energy setup is more efficient than the one it is replacing, marginal costs faced by Malta's energy provider are expected to fall significantly, leading to substantial positive supply-side effects.

In a recently published study, Ries et al. (2016) estimate how these reforms will likely impact Enemalta's marginal cost of electricity production. Enemalta's power plants contain a number of generators with different efficiency rates.

[1] Grech (2014) uses the Central Bank of Malta's macro-econometric model to estimate the macroeconomic effect of the 25% reduction in utility tariffs enacted in 2014, while Ministry for Finance (2016) also takes into consideration the higher government investment carried out to undertake the reforms.

As demand for electricity increases, Enemalta is required to fire the least efficient generator so as to meet energy demand. To arrive at a figure for marginal cost, the authors use a merit order curve that ranks each generator by its marginal cost of production (in ascending order). The marginal cost of producing an extra MWh of electricity is ultimately given by the marginal cost of the last generation unit used to satisfy any level of electricity consumption. To get at an average clearing price, the authors propose an algorithm that runs through the hourly electricity consumption in Malta between 2007 and 2010 and optimally chooses which energy sources are to be used. This experiment is then repeated over a number of energy setups.

"Marginal costs faced by Malta's energy provider are expected to fall significantly, leading to substantial positive supply-side effects"

For the purpose of this article, we will take in consideration three setups: an isolated setup prior to the installation of the interconnector and in which both Delimara and Marsa power stations are operative (EPS 2010), a system in which the Marsa power plant has been decommissioned and where the interconnector gives access to Sicilian energy production (EPS 2015) and a system identical to EPS 2015 but in which Enemalta's powerplants are converted to natural gas (EPS 2015NG). The interconnector grants Enemalta the possibility to either import or export electricity from or to the Italian grid. Since the Italian energy system is "mature" the European spot price is lower than the marginal cost of most of Enemalta's existent generators. Moreover, given the higher efficiency of the gas-fired turbines, the cost per MWh of Enemalta's plants is projected to be lower after the planned conversion. To take in consideration that effects on marginal costs are non-linear in the prevailing oil price level, the authors repeat these experiments with three different oil price levels: a baseline (BOPS), a low price (LOPS) and a high price (HOPS) scenario.[2]

Table 1
RESULTS FOR MARGINAL COST OF ELECTRICITY PRODUCTION FOR DIFFERENT SCENARIOS

	Baseline Oil Prices (BOPS)			Low Oil Prices (LOPS)			High Oil Prices (HOPS)		
	EPS 2010	EPS 2015	EPS 2015 NG	EPS 2010	EPS 2015	EPS 2015 NG	EPS 2010	EPS 2015	EPS 2015 NG
Marginal cost of electricity (€MWh^{-1})	140	105	95	80	85	70	205	125	110
% change in marginal cost vs baseline		-25	-32.1		6.3	-12.5		-39	-46.3

Source: Ries et al. (2016).

Results in Table 1 show that the change in the marginal cost of electricity generation depends on both the generation setup and oil prices. While in both BOPS and HOPS scenarios the EPS 2015 setup is consistent with a reduction in marginal cost, under LOPS, a reduction in marginal costs will only be achievable with the gas-fired setup. In general, the setup of natural gas-fired turbines helps reduce marginal costs across all oil price scenarios. Apart from reducing marginal costs, the setup of the interconnector and the conversion of the existent turbines to natural gas helps reduce Malta's sensitivity to international oil prices.[3] Indeed, prior to these reforms, marginal costs under HOPS are 156% higher than under LOPS. Under EPS 2015 and EPS 2015NG, the difference in marginal costs between HOPS and LOPS falls to 47% and 57%, respectively.

Model and simulation design

Simulations are performed using the fiscal version of MEDSEA (Rapa 2017b). This small open economy New Keynesian general equilibrium model contains a fairly rich fiscal sector. On the government revenue side, the model distinguishes between three types of distortionary taxes – a tax on consumption, labour income and capital/dividend income – and a non-distortionary lump-sum tax. On the government expenditure side, the model allows for three types of government expenditure – government expenditure on goods and services, government employment and public investment. Public investment is modelled in a time-to-build setup, designed to capture the fact that most public capital projects are subject to gestation periods dictated by planning, bidding, contracting and constructing

[2] Further details on the assumptions used are available in Rapa (2017a).
[3] The sensitivity of Maltese economic activity to international oil prices is confirmed by simulation results using STREAM (Grech and Rapa, 2016). Under baseline oil prices, a 20% increase in international oil prices results in a fall of 0.74% in economic activity.

stages. Moreover, in line with Baxter and King (1993), public capital stock enters the production function of private firms with increasing returns to scale:

$$Y_t^i = A_t^i {K_t^i}^{1-\gamma_i} {N_t^i}^{\gamma_i} {K_t^G}^{\gamma_g}$$

Where Y_t^i is output of industry i, A_t^i is total factor productivity, K_t^i is private capital stock of industry i, N_t^i is private labour used by industry i and K_t^G is government capital stock. Parameters γ_i and $1-\gamma_i$ represent the private labour and capital shares in output respectively, while γ_g is a parameter controlling the efficiency of public sector investment.

This implies that an increase in government investment does not only increase output from the demand side (as more public investment goods are demanded), but also from the supply side through an increase in the marginal productivity of private factors of production and a subsequent fall in economy-wide marginal costs. This setup is particularly appropriate to study the effects of large public sector projects, such as the energy sector reforms, which are expected to have a lasting effect on private sector productivity.

"Simulations are performed using the fiscal version of MEDSEA"

The simulations were conducted as follows. First, we estimate how changes in the marginal costs of electricity generation translate into changes in economy-wide average marginal costs. This is done by estimating the share of the value of electricity inputs arising directly and indirectly in total intermediate domestic production.[4] In 2010, this share stood at around 5.8%. Second, we shock government investment by the cost of the capital project which depends on the scenario under analysis. EPS2015 corresponds to a government investment shock equal to the cost of the purchase and installation of the interconnector. Under EPS2015NG government investment is additionally augmented by the cost of the installation of the new gas power station and the conversion of Delimara 3 power plant to natural gas. Since the effectiveness of these capital projects at reducing energy production marginal costs depends on technology installed at the power plants and the prevailing oil price level, the parameter governing the efficiency of government investment (γ_g) is calibrated so that each energy setup scenario reduces economy-wide marginal costs by the amounts corresponding to the study conducted by Ries et al. (2016). To allow for a gestation period, it was assumed that under each energy setup Enemalta would benefit from a reduction in marginal costs only after the capital project was fully commissioned. Moreover, it is assumed that economic agents are aware of the future falls in marginal costs, assuming that there is no uncertainty with regards to the pass-through of these efficiency gains to the rest of the economy.

Results

We report two sets of results, the new long-run values, as well as the transition of a number of variables of interest from the initial to the new steady state.

An increase in government investment produces two opposite effects. Depending on the degree of investment efficiency (γ_g), an increase in government capital stock increases the marginal productivity of the other factors of production, crowding in private investment and private employment and reducing marginal costs faced by firms. This produces positive income effects that push up private consumption of both Ricardian and credit-constrained households, while lower marginal costs positively affect external competitiveness and thus Maltese exports. However, due to the distortionary nature of public expenditure, an increase in government investment also creates a negative wealth effect as Ricardian households expect some degree of increase in taxes in the future.[5] This negative wealth effects could potentially outweigh the positive income effects during the gestation period of the new capital stock. During this period, the interconnector (in case of EPS 2015) and the gas power plants (in case of EPS

[4] Since the simulation exercise features a shock to domestic technology that changes marginal costs faced by local intermediate firms excluding directly imported costs, the share of electricity on overall production costs needs to be computed vis-à-vis total intermediate production excluding direct imports (as opposed to total output). This share is computed on the basis of the 2010 input output tables for Malta published by NSO in 2016.

[5] The scenario analyses undertaken in this study are calibrated so as to reflect the fact that only part of the energy reforms had a direct impact on government debt. This reduces the negative wealth effects of government investment, especially at the start of the simulations when the new government investment is still under construction and is therefore unable to positively contribute to the supply side of the economy.

Table 2
LONG-RUN MACROECONOMIC EFFECTS OF ELECTRICITY GENERATION REFORMS
% deviation from baseline

	Baseline Oil Prices		Low Oil Prices		High Oil Prices	
	EPS 2015	EPS 2015 NG	EPS 2015	EPS 2015 NG	EPS 2015	EPS 2015 NG
Real activity						
GDP	2.1	2.5	-0.3	1.0	3.4	3.7
Consumption	1.5	1.2	-0.7	-0.2	2.6	2.2
Private investment	0.6	0.7	-0.1	0.2	1.0	1.1
Exports	2.0	2.4	-0.2	1.1	3.1	3.5
Imports	1.5	1.8	-0.2	0.8	2.3	2.7
Labour market						
Real wages	1.7	1.8	-0.4	0.5	2.7	2.8
Employment	0.1	0.2	0.1	0.2	0	0.2

Source: Author's calculations.

2015NG) were still being installed, implying that the efficiency gains of these reforms were yet not being passed on to the economic agents in the economy.[6]

Results in Table 2 show that in the baseline oil price scenario (BOPS), an energy setup with an interconnector and the decommissioning of Marsa power station (EPS 2015), raises long-run output by 2.1%.[7] In the long term, an increase in the government capital stock raises overall productivity of both private capital and labour, raising long-run real wages and leading to a positive income effect that raises long-run consumption. Improvements in long-run productivity outstrip those in real wages, implying a reduction in unit labour costs. Moreover, efficiency gains in both domestic and foreign oriented sectors, lead to lower price pressures that give rise to a depreciation of the real effective exchange rate (REER) and an improvement in long-run price competitiveness. Finally, higher capital productivity reduces the implicit price of capital, thus leading to higher investment in the long run.

"In the baseline oil price scenario, an energy setup with an interconnector and the decommissioning of Marsa power station, raises long-run output by 2.1%"

Mirroring the results shown in Table 1, the long-term gains in output following the installation of the interconnector are very sensitive to the prevailing oil price level. The estimates range from an output loss of around 0.3% in the case of LOPS, to a gain of around 3.4% in the case of HOPS. On the other hand, the plans to fire a number of generators through natural gas have positive macroeconomic effects in all three oil price scenarios considered. This proposed energy setup is expected to raise economic activity by 1.0% in the case of LOPS, 2.5% in the case of BOPS and by a maximum of 3.7% under HOPS.

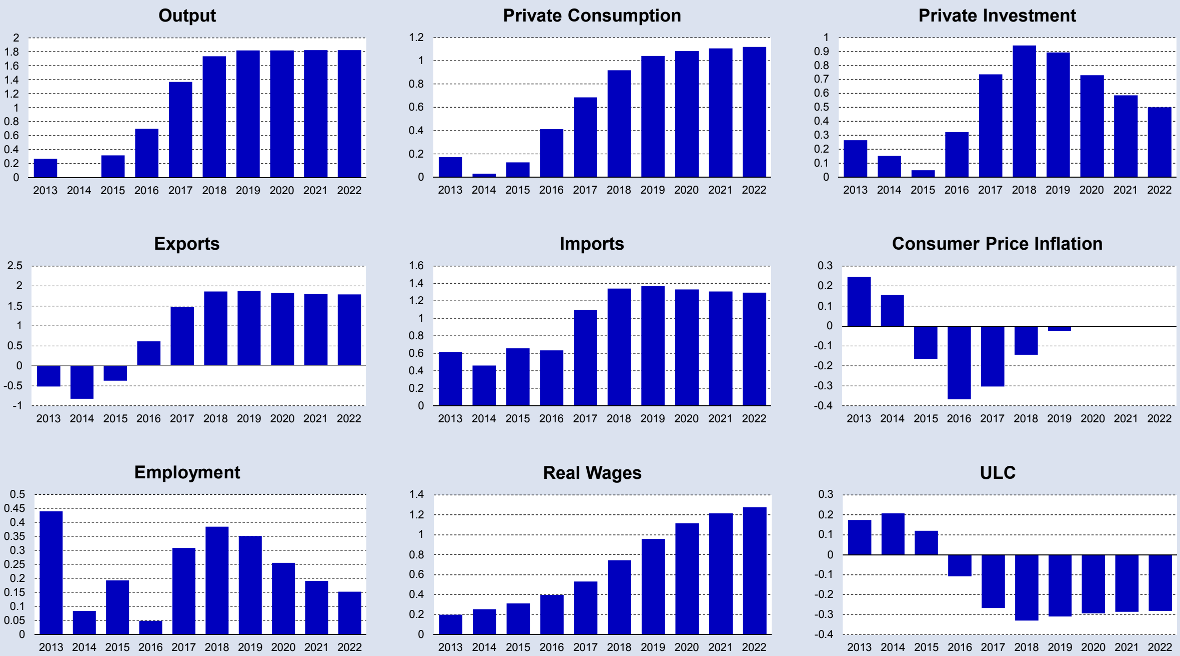
Transition dynamics help us track the transmission mechanism of this shock throughout the economy. Chart 1 illustrates short-term transition dynamics of some key variables under baseline oil prices and under EPS 2015. The impulse responses show that during the first two years after the start of the installation phase of the undersea interconnector, real output increased only marginally, driven solely by demand-side effects which, due to the significant import content of such a capital project, are estimated to be quite small. Despite the significant import intensity of this project, the installation of the interconnector still caused a rather subdued increase in the demand for domestically produced investment goods, mainly related to the construction of the terminal station in Maghtab

[6] During the capital gestation period, the positive income effects are limited to those arising from the forward-looking expectations of households and firms in the economy who expect marginal costs to fall in the near future.
[7] Note that these results differ from the ones published in Rapa (2017a). Unlike the latter study, this article takes in consideration both demand and supply-side effects of an increase in government investment, as well as the long-run increase in public investment driven by the long-run increase in output and that required to maintain the new capital installed by the energy provider. This explains the differences in the results of the two studies, especially those relevant to the short-run transition dynamics.

and its connection with in-land distribution centres. This caused a short-lived increase in demand for employment, driving up wages and causing a short-lived increase in overall prices.

As soon as the interconnector became fully operational in the second quarter of 2015, Enemalta, and consequently the economy as a whole, started to benefit from positive supply-side effects stemming from a reduction in marginal costs of electricity production. This was eventually transmitted to lower overall price pressures, leading to an immediate improvement in Malta's cost competitiveness. Improved economic prospects led consumers to increase consumption, while the increase in productive government capital stock was directly responsible for crowding-in private investment. Moreover, lower local production costs led to somewhat higher demand for domestically produced goods at the expense of imported production. The increase in real wages was driven by higher labour productivity and lower inflation, further reinforcing the positive effects on private consumption. It is interesting to note that both nominal and real rigidities embedded in the model lead to a sluggish transmission mechanism implying that after 10 years from the start of the energy reform, real output is projected to still be below its new steady state shown in Table 2. The slow adjustment of the variables of interest to their new steady state is also attributable to two additional factors. First, part of the long-run improvements in real output are related to an increase in long-run government investment meant to cover the maintenance costs of the new capital equipment. Secondly, there is an endogenous and a two-way positive relation between long-run government investment and real output. These two factors, together with the fact that output in the economy enjoys positive returns to scale vis-à-vis public investment, lead to a very slow correction of government investment, and consequently of public capital stock to their new steady-state level, implying a slow, but gradual adjustment in macro-variables.

Chart 1
TRANSITION DYNAMICS – BASELINE PRICES, EPS 2015



Source: Author's calculations.

As expected, the effects on economic activity under baseline oil prices and under EPS 2015 are stronger than those reported in Grech (2014), which excludes both the demand-side effects of the government investment needed to undertake the energy reforms and does not capture to a full extent the supply-side effects of lower marginal costs accruing to Malta's energy provider.[8] The results pertaining to overall GDP under the same scenario are, however, in line with Ministry for Finance (2016), both in terms of their magnitude and transition dynamics.

[8] Both Grech (2014) and Ministry for Finance (2016) assume a fall in energy tariffs of 25%. Under a perfect pass-through assumption, this is consistent with the results under baseline oil prices with EPS 2015, which predicts a fall in marginal costs of around 25% (see Table 1).

It is important to note that the results in Table 2 are based on the assumption of a full long-run pass-through of Enemalta's efficiency gains to the rest of the economy under all electric power systems (EPS 2015 and EPS 2015NG) and under all oil price scenarios (BOPS, LOPS and HOPS). A lower pass-through assumption would result in higher economic rents accruing to Malta's sole energy provider in lieu of lower economy-wide marginal costs of production, thereby reducing the long-run improvements in Malta's GDP. Moreover, model predictions indicate that the estimated effects of the energy reforms are non-linear in the pass-through assumptions, with the degree of non-linearity depending on the scenario under consideration.[9] Under an imperfect pass-through of around 50%, long-run effects on output seem to fall the most relative to baseline results under a high oil price scenario, while results seem to be almost linear under a low oil price scenario.

Conclusion

This article estimates the impact of an increase in the efficiency of electricity generation in Malta due to the installation of an undersea interconnector between Sicily and Malta and the changeover of Enemalta's powerstations from operating on heavy fuel oil and gasoil to natural gas. These simulations were undertaken with the fiscal version of MEDSEA, the Central Bank of Malta's DSGE model. Since the magnitude of the pass-through of Enemalta's efficiency gains to its customers is still unknown, this note aims to gauge the reaction of Malta's economy should efficiency gains in electricity production be passed on to the rest of the economy. Results show that under baseline oil prices and assuming full pass-through of the efficiency improvements gained through Enemalta's investment in the interconnector, economic activity in Malta is projected to increase by around 2.1% under baseline oil prices. This is estimated to increase to around 2.5% following the conversion of Enemalta's powerplants to natural gas. These estimates depend on two factors – the prevailing oil price level and the extent to which Enemalta will pass on changes in its marginal costs to its final consumers. The long-run results presented in this article are higher than those published in Rapa (2017a). This is due to the fact that unlike the previous study, this article takes in consideration the increase in government investment required to install and maintain the new capital equipment as well as the long-run increase in public investment driven by the long-run increase in output.

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[9] This non-linearity stems from the interplay of the negative wealth effects related to higher government intervention in the economy and positive wealth effects driven by the positive externalities associated with productive government investment. Any degree of imperfection in the pass-through of Enemalta's efficiency gains to the rest of the economy can be interpreted as a reduction in the efficiency and productivity of the new government capital stock, reducing the positive wealth effect associated with government investment. Since the negative effects associated with increased government intervention remain unchanged for each pass-through assumption, the net positive effect of the government investment needed to enact the energy reforms is reduced for lower pass-through assumptions.