

Abela, Glenn; Rapa, Noel

Working Paper

A study on the Exchange Rate Pass-Through to consumer prices in Malta

CBM Working Papers, No. WP/05/2021

Provided in Cooperation with:

Central Bank of Malta, Valletta

Suggested Citation: Abela, Glenn; Rapa, Noel (2021) : A study on the Exchange Rate Pass-Through to consumer prices in Malta, CBM Working Papers, No. WP/05/2021, Central Bank of Malta, Valletta

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A photograph of the interior of the Central Bank of Malta building. The space is characterized by a high ceiling with a dramatic, colorful sky (orange, red, and blue) projected onto it. The walls are made of light-colored stone blocks. In the foreground, there are long, curved, light-colored stone benches. To the right, there are rows of white, rectangular, three-dimensional blocks arranged in a grid pattern. In the background, there is a large, arched stone doorway leading to another part of the building. The overall atmosphere is modern and architectural.

CENTRAL BANK OF MALTA WORKING PAPER



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A study on the exchange rate pass-through to consumer prices in Malta*

Glenn Abela[†]

Noel Rapa[‡]

WP/05/2021

*We would like to thank Prof Edward Scicluna, Mr Alexander Demarco, Dr Aaron Grech and various participants in an internal seminar for comments and suggestions. We also thank Dr Mariarosaria Comunale for peer-reviewing this work. Any remaining errors are our own.

The views expressed in this paper are the authors' own and do not necessarily reflect the views of the Central Bank of Malta. Correspondence: publicrelations@centralbankmalta.org.

[†]Research Economist, Modelling Office, Research Department, Central Bank of Malta.

[‡]Manager, Modelling Office, Research Department, Central Bank of Malta.

Abstract

Exchange Rate Pass-Through (ERPT), commonly defined as the extent to which exchange rate changes are reflected in the price levels of an economy, has important implications in a number of policy-relevant areas. Despite this, estimates of ERPT in the Maltese economy are scarce and do not take into account changes in the monetary regime pertaining to the adoption of the euro. In this paper, we use local projections (LP) to estimate linear and non-linear ERPT to consumer prices in Malta after its accession to the European Monetary Union. In line with literature, results point at incomplete ERPT to headline consumer prices, peaking at around 20% by the end of the first year after the exchange rate shock. ERPT to overall HICP inflation seems to be largely driven by the goods component while ERPT to services prices is largely insignificant across the horizon considered. Allowing for non-linearities, we find evidence of asymmetric pass-through with larger changes to as well as depreciations in the nominal effective exchange rate being consistent with larger pass-through estimates.

JEL Classification: E31, F31

Keywords: Exchange Rate Pass-Through, Inflation, Local Projections, Impulse Response Functions, Non-Linearities

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1 Introduction

Exchange Rate Pass-Through (ERPT) is commonly defined as the extent to which exchange rate changes are reflected in the price levels of an economy, most commonly import and consumer prices. The relationship between changes in exchange rates and local prices has very important implications both from theoretical and policy perspectives. Theoretically, incomplete ERPT estimates might indicate deviations in relative purchasing power parity (PPP) which predicts that changes in prices of goods should be the same across locations when all prices are converted to a common currency. This in turn has important implications on the extent of firm market power, on the market structures operating in an economy as well as on the efficiency in the allocation of goods across countries.

The study of ERPT to local prices also has important implications for monetary policy, especially in an open economy setup. On the one hand, exogenous shocks to the nominal effective exchange rate are a source of inflation fluctuations which need to be stabilised through monetary policy. On the other hand, changes in monetary policy in response to inflationary shocks which are exogenous to exchange rate shocks, have an indirect effect on the nominal effective exchange rate which could help stabilise inflation further. Thus the extent of ERPT to local prices, especially in open economy setups can be both a source and a stabilising force for inflation which needs to be internalised in the monetary policy decisions of monetary authorities.

Colavecchio and Rubene (2020) categorise the transmission of exchange rate movements to consumer prices into three distinct channels. First, exchange rate shocks can be directly transmitted to the overall consumer price level through changes in the prices of imported final consumer goods. Secondly, a movement in the exchange rate is expected to affect the prices of imported intermediate production used for domestically produced commodities which then indirectly affect consumer prices. Finally, developments in the exchange rate also affect the price competitiveness of domestic products on international markets, thus leading to changes in domestic output levels, factor demands and consequently factor prices which are ultimately transmitted to the prices of final domestic production which is consumed locally.

We use local projections (LP) to produce ERPT estimates for consumer prices in Malta after its accession to the European Monetary Union.¹ LP methods are usually more robust to misspecifications of the DGP when compared to AR or VAR setups as they directly estimate

¹In this study we choose to focus exclusively on ERPT to consumer prices. Malta's import basket is predominantly (70%) made up of goods and services that are used as inputs for export goods. The transmission mechanisms of ERPT to export prices are quite different from those of consumer prices since the former are subject to a considerably larger extent to euro invoicing and Global Value Chains, two factors that substantially reduce the exchange rate pass-through. In this light, ERPT to import prices is quite weak and is considerably more complex to estimate, especially since a considerable proportion of imports are services flows that feature as direct re-exports. To this end estimating the ERPT on the import deflator which is made publicly available by the statistics office leads to very low pass-through estimates.

impulse responses at all horizons. They are also very flexible in allowing non-linearities. Indeed, in our specifications, we also allow for non-linear pass-through estimates both in terms of the size and direction of the change in Malta's nominal effective exchange rate. In line with literature, results point at incomplete ERPT estimates for consumer prices, peaking at around 20% by the end of the first year after the shock. Secondly, ERPT to overall HICP inflation seems to be largely driven by the goods component (in particular by the food and energy sub-indices) while ERPT to services are largely insignificant across the horizon considered. Thirdly, we find evidence of asymmetric pass-through with larger changes to as well as depreciations in the nominal effective exchange rate being consistent with larger pass-through estimates.

The rest of the paper is structured as follows. Section 2 provides a discussion on the main factors impacting ERPT estimates and existent estimates for euro area economies. Section 3 describes the methodology utilised in this study. Finally, section 4 provides results for linear and non-linear ERPT estimates for headline HICP and subcomponents together with a battery of robustness tests, while section 5 summarises and concludes.

2 Literature Review

2.1 Factors impacting ERPT

Literature identifies several structural factors that can impact the extent of ERPT to prices in a particular economy. All other factors kept constant, the greater the extent of openness to imports of an economy, gauged by metrics such as the share of imports in GDP and the (direct and indirect) import content of domestic consumption, the greater is the potential exposure of its prices to exchange rate impacts (Ortega and Osbat, 2020). For euro area countries, this is particularly the case with openness to extra-euro-area trade (Campa and González Mínguez, 2006). However, the larger degree of ERPT in open economies is usually attenuated by other factors such as currency of invoicing chosen by foreign exporters, integration in Global Value Chains (GVCs) as well as market power and competitive structure of firms. Both theoretical and empirical evidence suggest that when a large share of the inputs used in the production of exports is sourced from the destination market, the pass-through of exchange rate fluctuations to import (and consequently export) prices will be low. Indeed, a change in the bilateral exchange rate of the export market currency has two counteracting effects, in essence acting as a hedging mechanism for both foreign and local exporter from deviations in their profit mark-ups, ultimately contributing to lower ERPT estimates (Ortega and Osbat, 2020).

The degree of competition and market structures, both in the import and export markets, also impact the extent of ERPT. Smaller importers with weaker bargaining power are less able

to limit ERPT to import prices, all else equal, but the extent of pass-through also depends on the conditions faced by exporters (Özyurt, 2016). Namely, if exporters face strong competition by other exporters or by local competitors in the destination market, the extent of ERPT to the domestic market is likely to be low as exporters will be more likely to choose to absorb the exchange rate changes in their markups. The extent to which exporters adjust prices or absorb exchange rate volatility is often referred to as the degree of pricing-to-market by the exporting firms (Ben Cheikh and Rault, 2017).

Closely tied to this is the currency of invoicing of imports. The literature typically distinguishes between producer currency pricing (PCP), where imports are priced in the currency of the producer, and local currency pricing (LCP), where imports are priced in the currency of the destination market. With PCP, prices are adjusted in the producer’s currency, which theoretically leads to full pass-through since the products automatically become relatively more or less expensive in the currency of the buyer as the exchange rate adjusts. On the other hand, prices quoted in the currency of the buyer will not adjust by default given changes to the exchange rate, with the impact being absorbed by the exporter’s mark-up (Ortega and Osbat, 2020). This gap in pass-through between imports priced in the exporter and the importer’s currency is corroborated empirically, both in the short-run and in the long run (Burstein and Gopinath, 2014; Gopinath et al., 2010; Devereux et al., 2015).

Since exchange rate pass-through tends to vary by sector (Campa and Goldberg, 2002), the aggregate ERPT for an economy is also affected by the composition of its imports.² In turn, sectoral pass-through tends to vary with the degree of homogeneity of the products in question, with ERPT being higher for more homogenous products and lower for highly differentiated products (Ben Cheikh and Rault, 2017).

In general, ERPT is found to be ‘incomplete’, in the sense that both import and retail prices tend to change less-than-proportionately following exchange rate adjustments. This incompleteness is commonly attributed to nominal price rigidities and market characteristics, and is found in both the short run and the long run, although it is particularly pronounced at shorter horizons (Özyurt, 2016; Burstein and Gopinath, 2014; Campa and González Mínguez, 2006). It is also empirically established that a wedge exists between the extent of pass-through to import and consumer prices, with ERPT declining along the pricing chain (Colavecchio and Rubene, 2020; Ortega and Osbat, 2020). The size of this wedge is affected by, amongst others, market conditions and market power in the domestic transportation and storage sectors, and those of producers and retailers.

An aspect which has gained increasing attention in the ERPT literature is the presence of

²For instance, for a sample of 25 OECD countries, Campa and Goldberg (2002) find that pass-through in imports of manufactured products is markedly lower than for energy and raw materials.

non-linearities. In particular, the literature is concerned with whether the size and the dynamics of ERPT differ according to whether the exchange rate change in question is an appreciation or a depreciation (referred to as sign non-linearity), or whether the magnitude of the change is large or small (referred to as size non-linearity). The former type of non-linearity is a consequence of factors leading to downward price rigidities, mainly driven by the competitive structures that exporting firms are operating in, which drive their pricing-to-market decisions. For instance, in imperfectly competitive structures, the higher an exporting firm’s market power in the destination market, the lower the incentive to pass-through exchange rate appreciations, meaning that depreciations result in higher ERPT than appreciations (Delatte and López-Villavicencio, 2012; Brun-Aguerre et al., 2016). Similarly, an exporter facing capacity constraints could keep importers’ prices stable in the event of an appreciation of the importer’s currency, in order to avoid increased demand (Knetter, 1994). On the other hand, Ben Cheikh (2012) postulates that exporters seeking to maintain market share are likely to allow prices to fall if the importing country’s currency appreciates, but adjust mark-ups to maintain prices in the local currency if the importer’s currency depreciates, hence implying a higher pass-through with appreciations of the importer’s currency.

Literature rationalises size non-linearities through the existence of menu costs and the presence of switching costs in import markets (Bussière, 2007; Ben Cheikh, 2012). In the presence of costs associated with price adjustments, exporters may choose to adjust prices only after relatively large exchange rate changes. Conversely, if domestic consumers face costs in switching to rival products, exporters can allow their prices to vary in the importer’s currency as long as the variation does not exceed the switching costs, implying greater pass-through for smaller exchange rate changes.

Another growing branch of the ERPT literature is that relating to shock dependence in ERPT. Shock dependence is the proposition that the degree of ERPT depends on the nature of the underlying or structural shock causing the exchange rate movement in the first place. Shock dependence can therefore provide an explanation to why the degree of pass-through can vary over time for a particular economy. An early contribution to this literature is the work carried out by Shambaugh (2008), who employs a VAR model with long-run restrictions to relate the changes between consumer and import prices and exchange rates to several structural shocks.³

³Whilst conventional ERPT estimates are measured as impulse responses of an exchange rate shock, shock-dependent ERPT is measured differently. Since in studying shock dependence, shocks move both the exchange rate and prices, ERPT is approximated by the price-to-exchange-rate ratio (PERR) (Ortega and Osbat, 2020; Shambaugh, 2008). Given a particular shock j that impacts both prices p and the exchange rate e , PERR is defined as the ratio of the cumulative effect of the shock j on prices to the cumulative effect of j on the exchange rate, or:

$$PERR = \frac{IRF_j(p_t)}{IRF_j(e_t)}$$

More recently, structural VARs have been applied by Comunale and Kunovac (2017) and Forbes et al. (2018) whilst Local Projections have been used by Comunale (2019), to provide evidence on shock dependence in ERPT to prices in the euro area, the UK and Baltic states respectively. A more structural approach to shock dependent ERPT estimates has been used by Burlon et al. (2018) who estimate shock-dependent ERPT through a DSGE model.

2.2 ERPT estimates in the literature

Empirical studies on ERPT have proliferated since the 1970s, when the relationship between exchange rates and prices gained increasing attention in light of growing interest in the effects of exchange rate changes on inflation and external balance positions. Menon (1995) provides a survey of ERPT pass-through studies conducted over a broad sample period spanning from 1974 to 1994. Most studies surveyed yield incomplete pass-through estimates for exchange rate deviations on both import and consumer prices both in the long and short run. Moreover, the survey has identified significant inter- and intra-country differences in ERPT estimates highlighting the importance of country-specific factors in shaping the extent of ERPT in both short and long run.

More recent literature focusing on the euro area shows that ERPT to import and consumer prices for the euro area and its member states are incomplete both in the short and long run. On impact ERPT to import prices for the euro area as a whole vary from 0.20, as reported in Colavecchio and Rubene (2020), to 0.64 in Ben Cheikh and Rault (2017). ERPT to import prices is found to generally increase to between 0.33 in Colavecchio and Rubene (2020) and 0.80 in Comunale and Kunovac (2017) in the first year after the shock. The former study also finds that the response of import prices to exchange rate fluctuations peaks after 1 year, giving rise to a ‘hump-shaped’ pattern that is found for almost all individual euro area states. ERPT estimates to consumer prices are found to increase monotonically after the exchange rate shock and are generally found to be lower than those for import prices in all euro area states. For the euro area as a whole, ERPT to consumer prices after 1 year is of 0.04 (and not significantly different from zero) in Colavecchio and Rubene (2020) and ranges between 0.01 and 0.04 in Ortega and Osbat (2020). Using structural models, Comunale and Kunovac (2017) estimate a coefficient of less than 0.2 a year, whilst Burlon et al. (2018) estimate ERPT to retail prices at around 0.04 per quarter (for non-oil imports from the rest of the world).

Colavecchio and Rubene (2020) and Ortega and Osbat (2020) provide estimates for ERPT to consumer prices for individual euro area countries. In the former, ERPT to consumer prices is less than 0.1 on impact for all countries bar Luxembourg, but significantly different from zero in 12 of the 19 countries. The coefficient slightly increases with the time horizon in most countries, and where significantly different from zero, it ranges between 0.07 and 0.23 after 2 years. The

range of estimates for ERPT after 1 year in Ortega and Osbat (2020) are similar, with estimates most countries except three lying between zero and 0.1.

Naturally, significant heterogeneity exists in the structural characteristics of different euro area countries. Since the present study examines ERPT in Malta, literature which relates in particular to small open economies in Europe is also particularly relevant – especially on countries which, as with Malta, recently acceded to the EU and/or adopted the euro. Several studies estimate ERPT in Central and Eastern European countries (CEECs) or new EU member states, including Billmeier and Bonato (2002), Beirne and Bijsterbosch (2009), Carrière-Swallow et al. (2016), Coricelli et al. (2006), Comunale (2019), Jimborean (2011) and Nalban (2015). Most CEECs joined the EU alongside Malta in 2004, with five of them (Slovakia, Slovenia, Latvia, Estonia and Lithuania) adopting the euro since 2007 alongside Malta and Cyprus. Most of the abovementioned papers typically find ERPT to consumer prices which is higher than the range of estimates in the literature for larger or more advanced economies, with the exception of Jimborean (2011) and Comunale (2019), although results in different studies vary considerably. Additionally, such comparisons of results across studies can only be made whilst acknowledging a number of applicable caveats, particularly in relation to the different methodologies employed, countries surveyed, the time period considered and the applicable monetary regime in different countries during the periods studied. Some studies also consider the importance of institutional and structural factors such as monetary policy credibility and inflationary tendencies in determining ERPT in these countries. Namely, Carrière-Swallow et al. (2016) find that increased monetary policy credibility significantly lowers ERPT beyond the import stage, whilst Maria-Dolores (2008) finds that transition countries that adopt inflation targeting exhibit lower ERPT; the author documents a stronger role for inflation targeting than that found for openness in affecting pass-through. A table summarising the (linear) estimates of ERPT to consumer prices reported in these papers and in other work cited above can be found in Appendix A.

There have been fewer studies specifically focusing on the issue of non-linear ERPT. Most studies find evidence of both size and sign non-linear ERPT to both consumer and import prices. However, evidence is quite mixed and shows a substantial level of heterogeneity across countries and studies. For instance, Ben Cheikh (2012) finds strong evidence of size-non linearities across all euro area states, with larger exchange rate adjustments being consistent with larger ERPT to consumer prices. The same study however finds less clear-cut evidence for sign non-linearities. On the other hand Colavecchio and Rubene (2020) have no clear-cut results, with the effects of both size and sign non-linearities being extremely heterogeneous across countries and not present in all euro area members. Meanwhile, Delatte and López-Villavicencio (2012) examine sign asymmetry in pass-through to consumer prices for four major countries – the US, the

UK, Germany and Japan – finding strong evidence that depreciations are passed through more strongly than appreciations in both the short run and long run in all countries in the sample. Brun-Aguerre et al. (2016) find, for a panel of 19 developed and 14 emerging market countries, that depreciations are generally passed through more than appreciations, with no significant differences between the two groups. Lastly, Caselli and Roitman (2019) assess ERPT to consumer prices in emerging market countries, finding that larger depreciations have a greater effect than smaller ones, and that depreciations are associated with larger ERPT than appreciations.

2.3 The case for Malta

Being a small open economy, the Maltese economy is highly trade-intensive and characterised by firms which are small by international standards, despite the presence of some multinational firms. As of 2019, Malta’s total imports of goods and services as a share of GDP stood at 118.6%, one of the highest values in the euro area. More importantly, as seen in Figure 1, Malta’s share of extra-euro area imports as a proportion of GDP is the second-highest in the euro area. All else equal, these factors point at considerably large exposures of local import and consumer prices to exchange rate fluctuations. Nonetheless, a deeper look at Maltese trade data uncovers that approximately half of all extra-euro-area imports of goods in the Maltese economy are invoiced in euro, again one of the highest in the euro area, as shown in Figure 2. In theory this should act as a counterbalancing factor to the high degree of openness of the economy, thus reducing the expected pass-through to domestic prices.

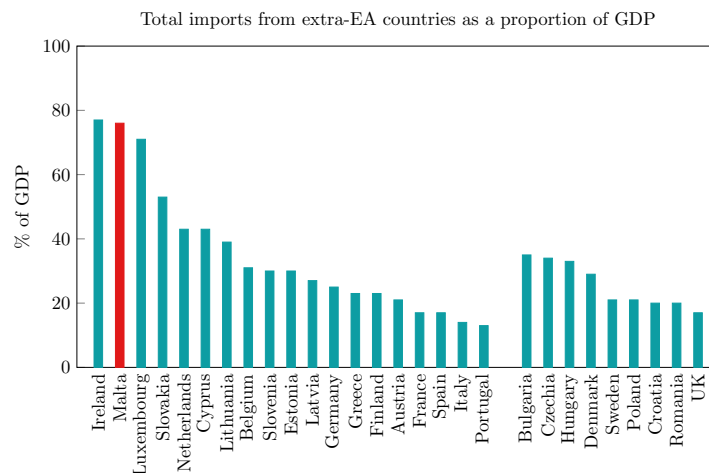


Figure 1: Share of extra-EA imports in GDP by country
Source: Eurostat; Authors’ calculations.

A similar conclusion may be reached when looking at ERPT from a sectoral perspective. Namely, as shown by Figure 3, the vast majority of goods imports for Malta are made up of categories 3 (Mineral fuels, lubricants, and related materials) and 7 (machinery and transport

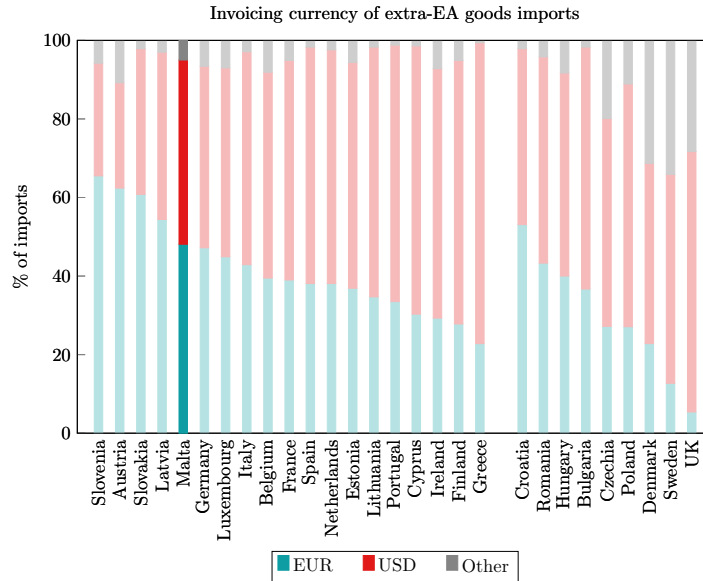


Figure 2: Shares of invoicing currencies of imports from outside the euro area by country
Source: Eurostat; Authors' calculations.

equipment). Looking at sectoral ERPT findings estimated by Ben Cheikh and Rault (2017), one can note that while ERPT estimates for goods falling under SITC category 3 are usually very close to 1 (i.e. perfect pass-through), ERPT for sector 7 goods is often found to be statistically not different from zero. Thus, similar to the previous discussion, it is very likely that even when looking at the sectoral composition of goods imports for Malta, there are compensating forces that on the one hand contribute positively to a high degree of exchange pass-through, while on the other serve to attenuate the effects of exchange rate fluctuations to aggregate domestic prices.

In their cross-country comparisons, Colavecchio and Rubene (2020) and Ortega and Osbat (2020) find that Malta's estimates for ERPT to consumer prices are quite in line with euro area economies peaking at around 0.1. Interestingly, the former study finds that Malta's ERPT to consumer prices is lower than other very small and open economies such as Luxembourg. Moreover, contrary to virtually all other euro area states, Malta's ERPT to consumer prices peak in the first year after the shock, with the second year showing point estimates very close to zero which are also statistically insignificant.

However, it is important to note that both these papers make use of data spanning from 1999 to 2017, a period during which Malta was under two different monetary regimes. The adoption of the euro and consequently of a floating exchange rate regime led to a clear break in the variability of the exchange rate series. We believe that results gleaned from datasets which encompass the different monetary regimes could be affected by this feature of the data and must therefore be treated with a degree of caution. In this light, we attempt to control for this change in monetary regime by starting our estimation period from 2008, the year of Malta's accession

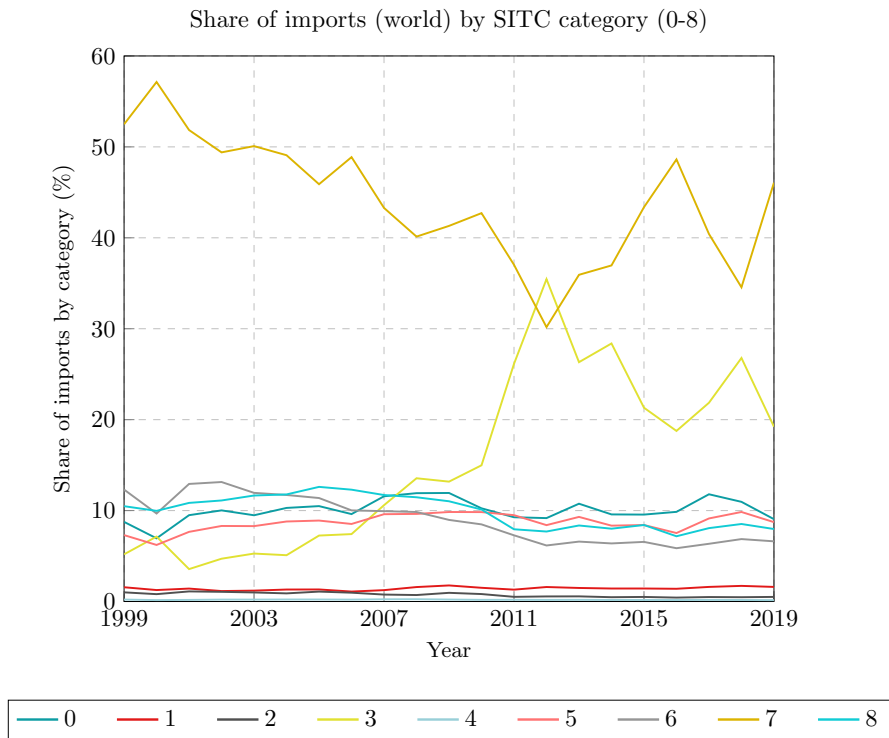


Figure 3: Malta's share of imports from all countries by sector
Source: Eurostat.

to the European Monetary Union.

3 Methodology

3.1 Overview of the model

We make use of an LP specification largely based on the model of Colavecchio and Rubene (2020). LP methods, originally proposed by Jordà (2005), yield estimates of impulse response functions of the variable of interest over chosen forecast horizons. This is achieved by regressing the dependent variable at time $t+h$ given the information set at time t for each value of h , where $t = 1, 2, \dots, T$ denotes the time dimension of the data and $h = 0, 1, 2, \dots, H < T$ denotes each forecast horizon. As illustrated below, the response of the dependent variable at a given forecast horizon to a shock in the variable of interest is given by the path of the estimated coefficient of the explanatory variable in question in each successive regression, pertaining to each value of h .

LP models possess certain advantages over more universal techniques used to estimate IRFs, such as VAR models. The method is more robust to misspecification of the DGP, estimating a new set of coefficients at each forecast horizon. More precisely, LP models directly estimate the pointwise estimates of IRFs, contrary to VARs, which do so through an iterative process that compounds any errors in the parameter estimates as the horizon h increases (Jordà, 2005). Moreover, LP models are considerably more accommodative of non-linear specifications, making them very useful and therefore popular in applied macroeconomic work.

These characteristics make LP estimation particularly suitable for our purposes, although one must also be wary of its weaknesses. The main drawback of LP models is their data consuming nature. While VARs consume degrees of freedom across the lag and number of variable dimensions, LP models actually reduce the sample size as h increases (Caselli and Roitman, 2019). Therefore, LP estimates tend to become more uncertain over longer time horizons h . This loss of efficiency can be addressed by expanding the information set through including in each regression the error term from the previous horizon estimation (Teulings and Zubanov, 2014; Carrière-Swallow et al., 2016).

As previously stated, our model is based on that by Colavecchio and Rubene (2020) and takes the following form:

$$p_{t+h} - p_{t-1} = \alpha(h) + \phi(h)\Delta e_t + \sum_{i=0}^k \mathbf{x}'_{t-i}(h)\gamma_i(h) + u_{t+h}(h) \quad (1)$$

where p_t and e_t are the natural logs of the HICP and NEER indices respectively, \mathbf{x}_t is a vector of control variables and u_{t+h} is the error term in each regression pertaining to each forecast horizon h . The dependent variable therefore measures the cumulative change in the price level between $t-1$ and the forecast period $t+h$. Our control variables are specifically the output gap as a measure of economic slack and the index of foreign prices (in log differences),

to account for different sources of price pressures, lagged values of inflation and log-differenced exchange rates to control for serial dependence, as well as the previous-horizon error terms. We make use of an algorithm to determine the appropriate lag length k for each of our control variables at each forecast horizon by minimising the Akaike Information Criterion (AIC) for each estimated regression. This process excludes the lagged error terms, where only the previous-horizon residuals are included in each equation.

The impulse response of cumulative price inflation at each forecast horizon given an exchange rate change at time t is given by:

$$IR_{h,t} = \mathbb{E}(p_{t+h} - p_{t-1} | \Delta e_t \neq 0) - \mathbb{E}(p_{t+h} - p_{t-1} | \Delta e_t = 0) = \phi(h) \quad (2)$$

Therefore, an IRF of price inflation responses over all forecast horizons given an exchange rate change at time t is obtained by running a collection of H regressions and plotting the path of $\phi(h)$ over all horizons.

To provide a comprehensive analysis of the characteristics and dynamics of ERPT to consumer prices in Malta, we first use headline HICP as our dependent variable, and subsequently dig deeper by re-estimating the model for different HICP sub-indices. The first two sub-indices we consider are the goods and services prices sub-indices. We then also estimate ERPT to two measures of core inflation, being HICP excluding energy only and HICPX (which excludes energy and food), as well as pass-through to separate subcomponents of the goods prices sub-index. Subsequently, we allow for the possibility of non-linear responses of ERPT to headline consumer price inflation, as detailed in the following section. In all these instances, for the purpose of interpreting our results, it should be noted that since our NEER index is defined in terms of foreign currency per euro, an increase in the NEER signifies an appreciation of the euro, such that *a priori* our ERPT coefficients are expected to be negative.

We estimate our model using data from 2008Q1 to 2019Q4. We choose 2008Q1 as the start of our sample period in order to account for Malta's adoption of the euro on 1 January 2008. The adoption of the euro signified a change in Malta's monetary regime from a fixed to a floating exchange rate and as expected, materially affected the volatility of the NEER, with a clear break in volatility before and after the start of our sample. Encompassing such volatility within a longer sample would necessarily impact the reliability of our results; hence, we provide estimates using solely data pertaining to 2008 and later.⁴

⁴For completeness, we also derive a set of results for the period 1996-2007. In line with our expectations, ERPT estimates for these years are weak and highly insignificant throughout.

3.2 Testing for non-linearities

Following the estimation of linear ERPT through the model structure described above, we augment our model with relevant indicator variables to test for sign and size non-linearities. We define an indicator variable, δ_t , which takes state-dependent values as follows. In the case of sign non-linearity:

$$\delta_t = \begin{cases} 1 & \text{if the exchange rate appreciates;} \\ 0 & \text{otherwise} \end{cases}$$

Meanwhile, when testing for size non-linearity, we specify:

$$\delta_t = \begin{cases} 1 & \text{if the exchange rate adjustment is large;} \\ 0 & \text{otherwise} \end{cases}$$

The way we define an exchange rate as an appreciation is consistent with the way our model defines a change in the exchange rate and with the definition of our NEER index. Hence, in testing for non-linear responses depending on the direction of the change, the indicator $\delta_t = 1$ if the NEER index increases quarter-on-quarter. Meanwhile, when testing for size non-linearity, we define a change in the exchange rate to be ‘large’ if the absolute value of the change in e_t in a given period exceeds one standard deviation of the series of Δe_t over the sample, in line with Colavecchio and Rubene (2020). Nevertheless, following from the absence of a clear theoretical definition as to what constitutes a ‘large’ change, we employ different definitions in our sensitivity analysis. Once again, Δe_t denotes the quarter-on-quarter change in the log of the NEER index.

We include the indicator variables in our model as follows:

$$p_{t+h} - p_{t-1} = \alpha(h) + \phi_0(h)[(1 - \delta_t)\Delta e_t] + \phi_1(h)[\delta_t\Delta e_t] + \sum_{i=0}^k \mathbf{x}'_{t-i}(h)\gamma_i(h) + u_{t+h}(h) \quad (3)$$

Therefore, our model yields separate estimates of ERPT depending on the value of δ_t . Specifically, $\phi_0(h)$ yields the estimate of ERPT when the exchange rate depreciates (if testing for sign non-linearity) or when the change in the exchange rate is ‘small’ (if testing for size non-linearity), whilst $\phi_1(h)$ accordingly yields ERPT when the exchange rate appreciates or when the change is ‘large’. This permits us to obtain separate IRFs for each state pertaining to each value of the binary indicator δ_t .

3.3 Data

Our reference exchange rate variable is the Nominal Effective Exchange Rate (NEER) on the import side as sourced from the Eurosystem Macroeconomic Projection Database. This NEER

index is an arithmetic single-weighted effective exchange rate with weights reflecting the importance each country of the 36 countries taken in consideration in the Maltese import basket. We rebase this measure in terms of foreign currency per euro such that an increase in the index shows an appreciation of the NEER. The foreign prices variable is an index of extra euro area competitor’s prices on the import side defined in “national currency”, that is, excluding exchange rate movements, obtained from the same Eurosystem database. As our baseline pricing level, we use the Harmonised Index of Consumer Prices for all goods and services (HICP). We further compute exchange rate pass through estimates for core inflation estimated as either HICP excluding energy or HICP excluding energy and food, as well as for HICP goods and HICP services separately. We then subsequently delve deeper into the exchange rate pass-through estimates to the subcomponents making up the HICP goods index, that is Industrial Goods (decomposed into energy and non-energy industrial goods) and food. All consumer price indices are sourced from Eurostat. We use the percentage difference between actual and potential output (the Output Gap) as estimated internally by the Central Bank of Malta as our baseline measure for slack.⁵ For our sensitivity analysis we also use the share of migrants in Malta’s labour force and the unemployment gap, both of which are estimated internally, as well as the price of Brent crude oil, sourced from the Eurosystem Macroeconomic Projection Database and expressed in euro. HICP indices as well as the index of foreign prices and oil prices are seasonally adjusted using the Census X12 procedure.⁶

⁵Potential output is estimated using a Cobb-Douglas approach.

⁶With regards to additional variables used in the robustness tests, migrants’ share of the labour force is estimated on the basis of administrative and National Accounts data whilst the unemployment gap is measured in line with the methods described in Micallef (2016).

Table 1: Data description and sources

Variable	Description	Source
NEER	Nominal Effective Exchange Rate of Malta on the import side. Single weighted with weights covering Maltese import flows from 36 partner countries.	Eurosystem Macroeconomic Database
Consumer Prices	Overall Harmonised Index of Consumer Prices	Eurostat
Consumer Prices ex. energy	Harmonised Index of Consumer Prices excluding energy prices	Eurostat
Consumer goods Prices	Harmonised Index of Consumer Prices - goods only	Eurostat
Industrial Goods prices	Harmonised Index of Consumer Prices - industrial goods only	Eurostat
Non-Energy Industrial Goods prices	Harmonised Index of Consumer Prices - industrial goods excluding energy	Eurostat
Energy prices	Harmonised Index of Consumer Prices - energy only	Eurostat
Food prices	Harmonised Index of Consumer Prices - food only	Eurostat
Index of Competitor Prices	Simple weighted average of competitors' export prices in foreign currency on the import side, with weights covering Maltese import flows from 36 partner countries.	Eurosystem Macroeconomic Database
Output Gap	Difference between actual GDP and Potential Output. Potential output estimated using Production Function approach	Central Bank of Malta internal estimates
Unemployment Gap	Difference between actual unemployment and NAIRU. NAIRU estimated using a Multivariate Filter approach	Central Bank of Malta internal estimates
Migrants' Share	Number of foreigners as a share of total number of employed	Jobsplus, National Accounts, Central Bank of Malta internal estimates
Oil Prices	Brent Crude Oil prices in Dollars	Eurosystem Macroeconomic Database

4 Results

4.1 Linear ERPT to consumer prices

In this section we present linear ERPT estimates, i.e. without including the non-linearity indicator terms in our model. Starting from ERPT to overall (headline HICP) prices, our results imply that ERPT is statistically significant at forecast horizons of one to three quarters after impact. Being insignificant on impact, our point estimate of ERPT increases progressively up to an absolute value of 0.22, or 22%, one year after the shock. However, the estimated coefficient diminishes slightly thereafter and is no longer statistically significant at the conventional 5% level. This is shown graphically in Figure 4 below, which depicts the path of the ERPT coefficient over the projection horizons, together with its 95% confidence interval. This result is, firstly, consistent with the common findings in the literature that ERPT is incomplete, and that pass-through to consumer prices tends to be low. That said, the coefficients above are slightly higher than those found in the literature surveyed. Comparing our results to those found in Colavecchio and Rubene (2020), we note that the highest coefficient for ERPT to consumer prices after a year in this study is of 13%.⁷ Their result for Malta, keeping in mind the caveat noted earlier, is of a pass-through of 9% one year after the shock, with ERPT being lower but significant on impact, and insignificant after two years, yielding a ‘hump-shaped’ pattern which we also observe in this case. This would suggest that exchange rate changes generally tend to be partially reflected in consumer prices in Malta up to a year after the change, but have no significant effect on overall consumer price levels thereafter.

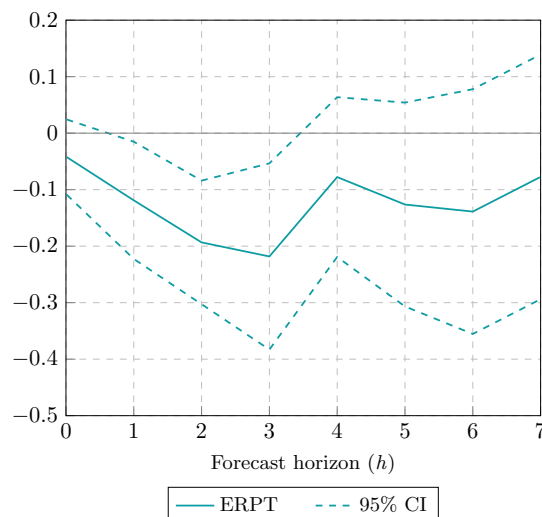


Figure 4: Linear ERPT to overall consumer prices

⁷This statement only considers the results for twelve countries which adopted the euro in 2001 or before. The authors focus on results for these countries in their work, precisely as results for other countries who (as with Malta) joined the euro area in 2007 or later are susceptible to the same issue we point out earlier, i.e. that for most of the study sample, such countries were under a different monetary regime.

As set out above, we take a deeper look by analysing ERPT to consumer prices using HICP disaggregated into goods and services prices as well as measures of core inflation. When separately analysing the impact of exchange rate changes on goods and services prices, our results show that pass-through to goods prices is significantly larger than that to services prices. This is in line with expectations given that import content of services consumption is by its nature much lower than that for goods. We find ERPT to goods prices to be statistically significant at all forecast horizons except on impact, with the effect beyond one year after the shock being estimated at close to 40%. ERPT to services prices is, to the contrary, insignificant throughout except at a forecast horizon of two quarters. This result is driven by the significantly low import content of consumer services that fall under the recreation and personal care (including the accommodation and catering services sub-indices), which drives around 54%. Price dynamics of these consumer services are mainly driven by changes in wages, and thus are more dependent on the local labour market developments. These patterns tie in with the path of overall ERPT, which is strongest at the horizons where ERPT to goods and services prices are cumulatively relatively larger. Subsequently, the aggregate measure declines at later horizons, despite the continued strength of ERPT to goods prices, as that to service prices turns highly insignificant with its coefficient inverting sign. The finding that pass-through to goods prices is prolonged and significant up to two years following an exchange rate adjustment is particularly noteworthy, since it is an effect which is masked when analysing the effect on aggregate prices. The projected paths of ERPT to goods and services prices are shown in Figure 5 below.

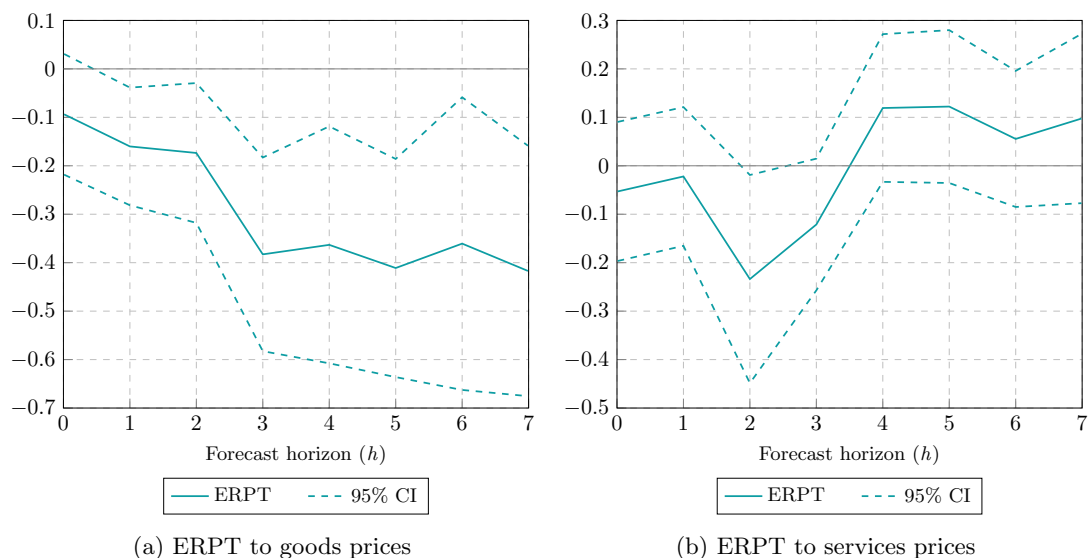


Figure 5: Linear ERPT to goods and services prices

In terms of pass-through to core inflation, we find markedly weaker results when compared to the specification using overall or headline HICP. In fact, as shown in Figure 6 below, we find no significant pass-through at any horizon when our dependent variable is HICP excluding

energy, whilst when we regress HICP excluding energy and food, the relevant coefficient is only significant two quarters after impact. One implication of this outcome could be that our initial finding is somewhat driven by the behaviour of the energy and food components.

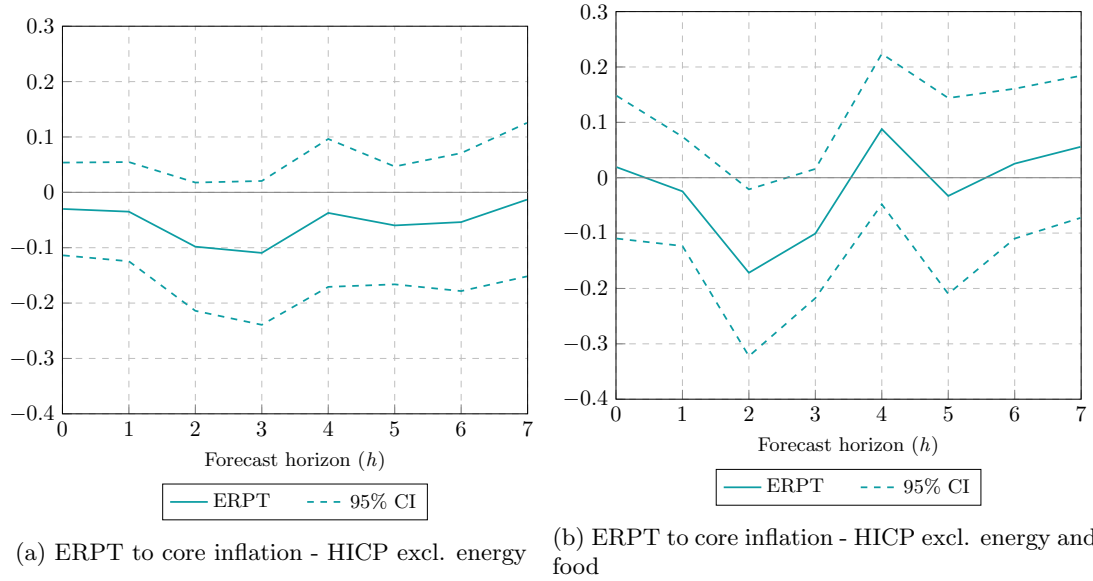


Figure 6: Linear ERPT to core inflation

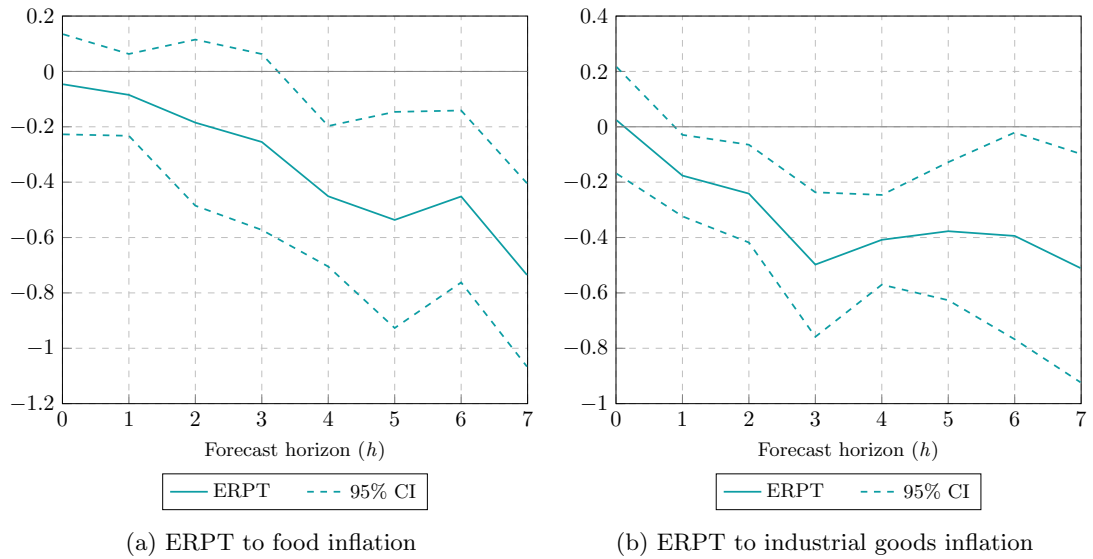


Figure 7: Linear ERPT to goods prices subcomponents

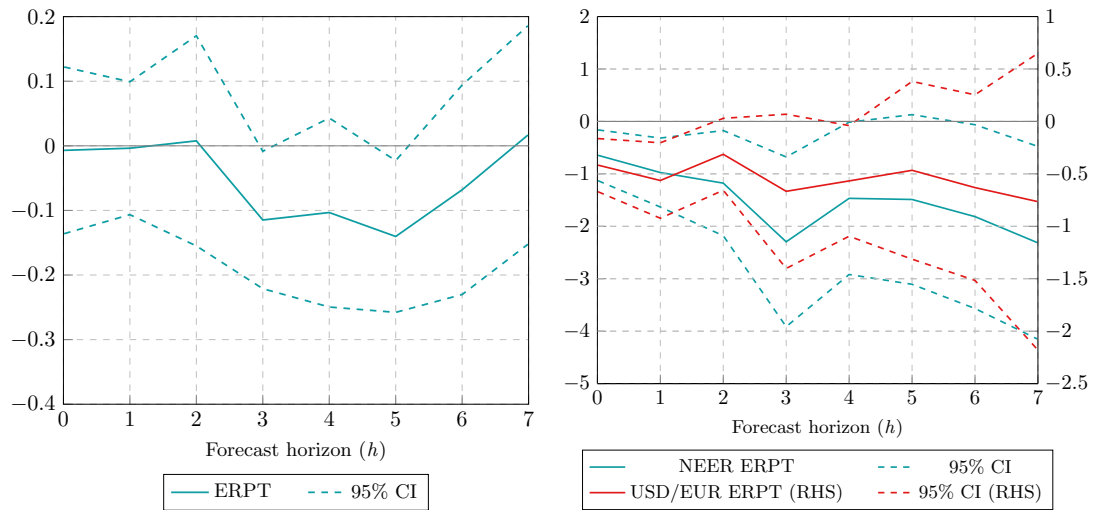
This is confirmed following a deeper analysis of the HICP goods sub-index which can be decomposed into Industrial Goods and Food subcomponents. Results depicted in Figure 7 show that both sub-indices have significant pass-through of exchange rate fluctuations. Results for the food sub-index are statistically insignificant for the first year following changes in the exchange rate with very subdued point estimates. From the second year onwards however, exchange rate shocks lead to considerable and statistically significant pass-through to food prices in Malta.

Industrial goods results feature a similar profile, with pass-through on impact being statistically insignificant before turning considerably negative between the second and fourth quarter in consideration.

Looking more closely at industrial goods inflation, we can see that this profile is nearly wholly driven by developments in the energy subcomponent with the non-energy industrial good subcomponent featuring some weakly significant results only at around a year after the initial shock.⁸ This result is interesting on two grounds. Firstly, despite the fact that the vast majority of non-energy industrial goods in Malta are imported, exchange rate pass-through estimates for the non-energy industrial goods subcomponent are fairly low. This result is not surprising when looking at Direction of Trade (DoT) statistics. Indeed, one can note that only half of manufactured goods (SITC categories 5-8, making up around 98% of non-energy non-food imports in Malta) are imported from outside the euro area. Moreover, out of these, 60% are invoiced in euro implying that at a maximum of 20% of imported manufactured goods are exposed to currency fluctuations. Moreover, one needs to keep in mind that DoT data covers a more comprehensive subset of goods than that entering the non-energy industrial goods HICP basket. In fact, while the latter includes only finished consumer goods, trade data also includes semi-finished manufacturing products (such as production of semi-conductors) which have a greater tendency to be invoiced in US dollars. Moreover, such semi-finished goods are usually part of Global Value Chains, a factor which considerably reduces exchange rate pass-through. In this light, the non-energy industrial goods HICP sub-index might be in fact covering a basket of goods which is even less exposed to exchange rate fluctuations than suggested by the above direction of trade figures.

Secondly, energy prices feature considerable exchange rate pass-through despite the fact that currently energy prices are largely administered by Government. From 2014 onwards, in a bid to offer greater stability to energy prices and reduce uncertainty surrounding the price of fuels and electricity, the Government has significantly reduced the frequency of energy price adjustments. This has culminated in a policy of annual adjustments in energy prices that took place between 2016 and 2019. Still, the results shown in Figure 8 need to be interpreted while taking into consideration that for a substantial part of the estimation sample, energy prices in Malta (while still being largely administered by Government) were still experiencing fluctuations. For instance, between 2008 and 2013, energy prices in Malta were adjusted on a monthly frequency. Moreover, despite the greater element of price stability that ensued in 2014 and 2015, energy prices still

⁸Since international fuel prices are largely exclusively priced in US Dollars, the exchange rate pass-through in the energy subcomponent is likely to be driven by fluctuations in the Euro-Dollar exchange rate. To this end, Figure 8b shows exchange rate pass-through estimates vis-à-vis both the nominal effective exchange rate (ensuring consistency with the rest of this study), as well vis-à-vis the US Dollar, which in this case provides a better measure of exchange rate pass-through.



(a) ERPT to non-energy industrial goods inflation

(b) ERPT to energy inflation

Figure 8: Linear ERPT to industrial goods prices subcomponents

featured some intra-year changes that roughly occurred at a quarterly frequency.

4.2 ERPT to consumer prices: Non-linearities

We now turn to results on size and sign non-linearity in ERPT to overall consumer prices. In terms of sign non-linearity, our results indicate that higher pass-through is observed in episodes of exchange rate depreciation, compared with appreciations. As seen in the left-hand panel of Figure 9, the coefficient for appreciations is statistically insignificant at all horizons, whilst that for depreciation episodes is significant from one quarter after impact to one year after the shock. The projected path of ERPT for depreciations follows a similar pattern to overall pass-through and its coefficient is, as expected, notably higher than that of the aggregate measure, which is dampened by the negligible effect of appreciation episodes. Pass-through for depreciation episodes is in fact estimated to be in excess of 40% at its highest, four quarters after the shock, compared to overall ERPT, which peaks at around 22%. As noted in section 2.2, results for sign non-linearity in the literature tend to exhibit heterogeneity between countries, yet greater pass-through for depreciations is a relatively more common finding.

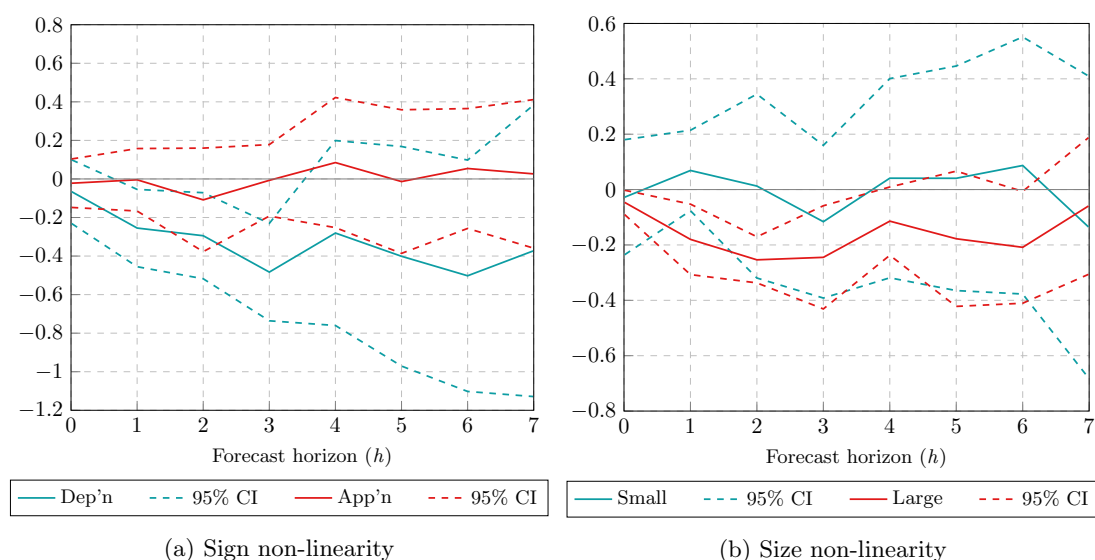


Figure 9: ERPT estimates allowing for sign and size non-linearities

Our results on size non-linearity are also in line with much of the literature, in that we find that large exchange rate changes are passed through to a greater extent than relatively small changes. No significant ERPT is found for small changes at all projected horizons, whilst large changes show a relatively stable pass-through which is significant up to the one-year horizon. With the exception of the impact time period and the subsequent quarter, pass-through in such instances exceeds 20%.

4.3 Sensitivity analysis

In this section, we document a series of sensitivity estimations we conduct in order to assess the robustness of our results. Our first sensitivity test entails including the share of migrants in the labour force as an additional control variable. The migrants' share in Malta grew exponentially over the sample period, potentially alleviating any supply-side constraints during a period of sustained economic growth, and thus possibly also affecting inflation dynamics in Malta. As with the other control variables, the number of lags of the migrants' share variable included in the equation pertaining to each horizon is determined by an automated routine which minimises the AIC subject to the number of lags of each control variable. As a second robustness test, we also re-estimate our model using the unemployment gap, rather than the output gap, as a measure of economic slack. The unemployment gap measures the difference between the rate of the registered unemployed and the NAIRU, where a negative gap signals a lower unemployment rate than the NAIRU and thus proxies a lower level of economic slack, and vice-versa for a positive gap. It should be noted that the two aforementioned adjustments to the model are carried out in separate estimations.

We first carry out these sensitivity tests on our baseline estimates, that is, our estimates of ERPT to headline consumer price inflation. The results are shown in Figure 10 below. Neither the inclusion of the migrants' share as an additional explanatory variable, nor the use of the unemployment gap in lieu of the output gap materially alters the general pattern of the baseline result in Figure 4. In both cases, ERPT to cumulative headline inflation still peaks at the three-quarter horizon and at a magnitude of approximately 20%, with point estimates being statistically significant but lower at the preceding two forecast horizons and insignificant at longer projection periods.

We also conduct two other sensitivity tests. Firstly, we include oil prices as an additional control variable within the main model. Secondly, we check for the robustness of the results for different lags of the control variables. To this end, we re-estimate the baseline model in its original specification with an alternative lag selection algorithm for the vector of controls.⁹ The results are reproduced in Figure 11. Starting from the leftward panel, the inclusion of oil prices in the model slightly changes the pattern of results. The familiar pattern of ERPT being statistically significant at the one to three quarters ahead forecast period is sustained, yet the point estimate strengthens further at subsequent horizons and is again statistically significant at $h = 5$. Controlling for oil prices in the model therefore hints at more sustained pass-through to

⁹The lag-election algorithm employed in the baseline specification picks the best lag (by minimising the Akaike Information Criterion) for each control variable without any cross-variable restrictions. Thus each control variable is potentially allowed to enter the equation at a different lag. The lag-selection algorithm employed in this sensitivity test chooses the lag for the *whole* control vector that minimises the Akaike Information Criterion, thus restricting all control variables to enter the specification at the same lag length.

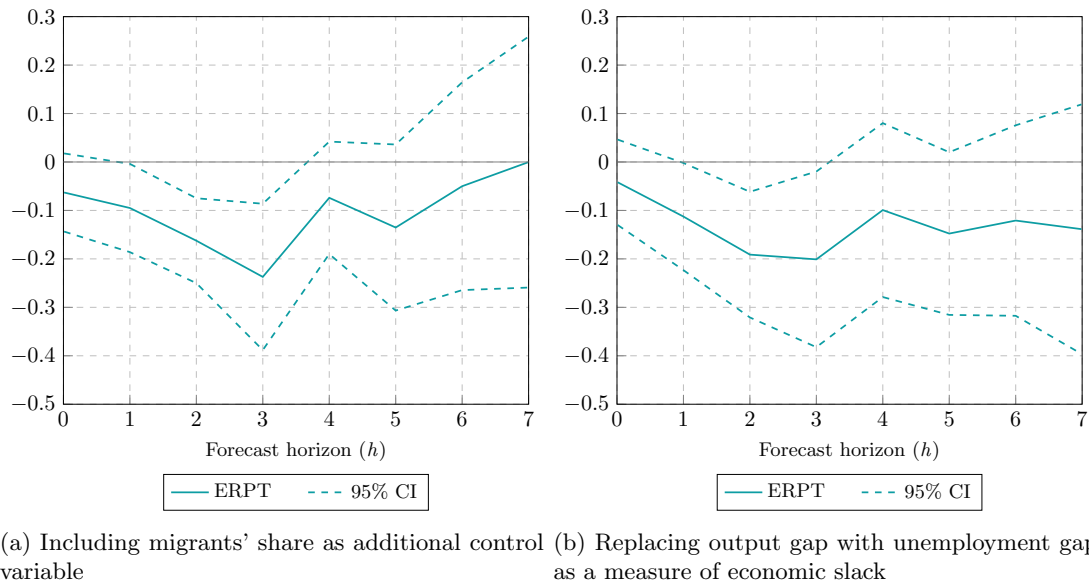


Figure 10: Sensitivity analysis of baseline estimate

consumer prices. Nevertheless, the point estimate of ERPT remains below 30% throughout in absolute terms, and the difference in statistical significance of the effect when comparing to the baseline results is only present at one forecast horizon. It could thus be argued that whilst the inclusion of oil prices could be relevant to the model, their inclusion still does not heavily alter the picture given by our baseline result. In the case of the model estimated with an alternative lag selection routine, meanwhile, the general result is also well in line with our baseline estimates. ERPT peaks at 22% one year after the shock, with the only difference from the baseline result being that the estimate at $h = 1$ is not significant at the 5% level.

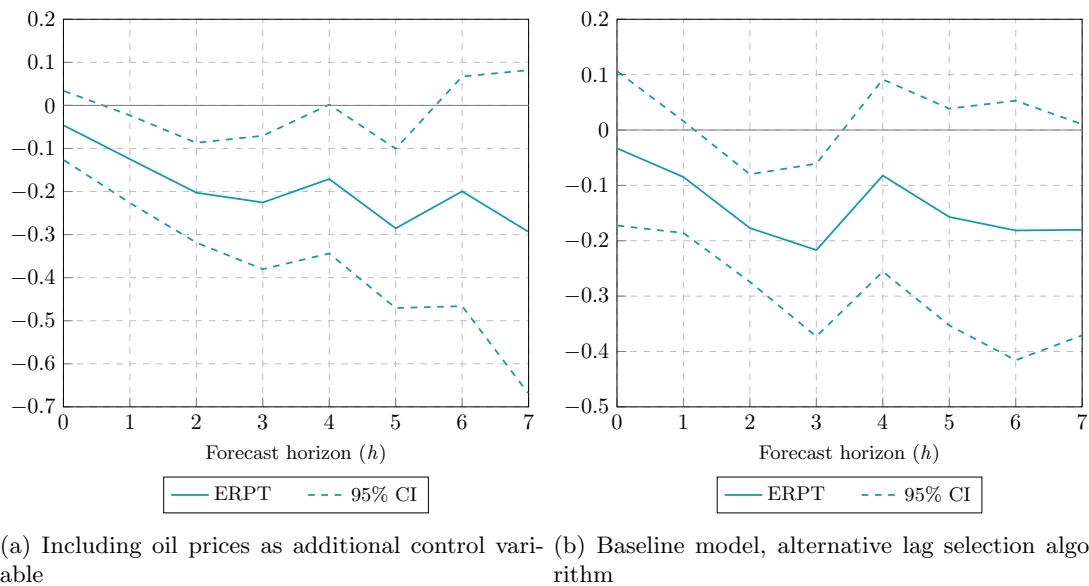


Figure 11: Sensitivity analysis of baseline estimate

The results of this analysis can be summarised in Figure 12, which shows the baseline estimate

of linear ERPT together with the range of point estimates of the above sensitivity estimations. This graph indicates that our estimates are highly robust up to the one year horizon, with the range of estimates being very narrow around the benchmark line. Beyond that, estimates from different specifications become slightly more dispersed as uncertainty increases with the forecast horizon, although in general they still point towards the effect tapering off at longer horizons. Therefore, our exercise robustly demonstrates that the effects of exchange rate adjustments are progressively transmitted into the overall price levels of the Maltese economy over a period of a year, after which time the effect tends to weaken and generally does not tend to have a pronounced effect on price level changes.

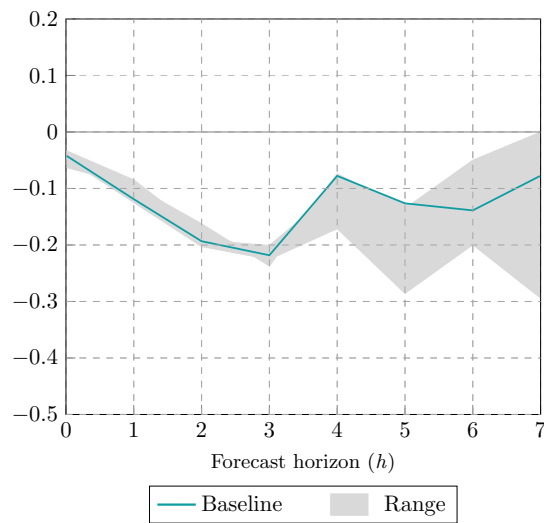


Figure 12: Sensitivity analysis – baseline and range of sensitivity estimates for ERPT to headline HICP

We carry out the above sensitivity analysis on the models estimating ERPT to goods and services prices. For brevity, we present below the baseline point estimates together with the range of point estimates from the four sensitivity estimations, with full results in Appendix B. In panel (a) of Figure 13, the results clearly show that the estimated ERPT to goods prices remains (in absolute terms) well above zero, although the range of results widens significantly towards the latter end of the forecast window. All estimates of ERPT to services prices, meanwhile, remain hovering around zero, with no significant pass-through except for at a horizon of two quarters, reinforcing our baseline result for this sub-index. Therefore, our sensitivity estimates for goods and services prices largely conform with our baseline estimate, especially at shorter time horizons.

Lastly, as alluded to in section 3.2, we examine the results when allowing for size non-linearity under different definitions of what constitutes a ‘large’ change in the exchange rate index. We first revise the threshold such that a ‘large’ change is defined as one that exceeds in magnitude the standard error of the series of *absolute* changes. The result is shown in the left-hand side

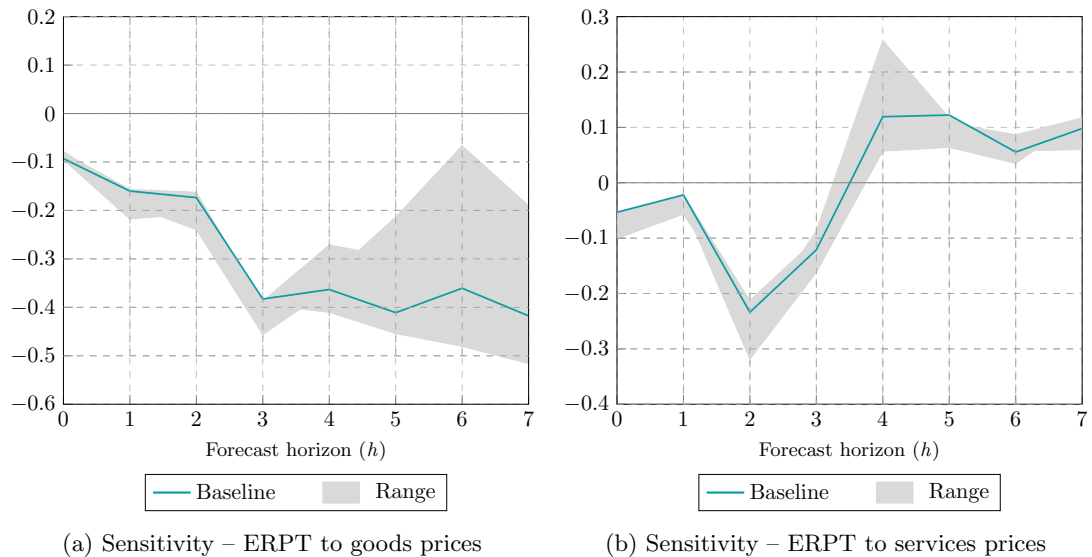
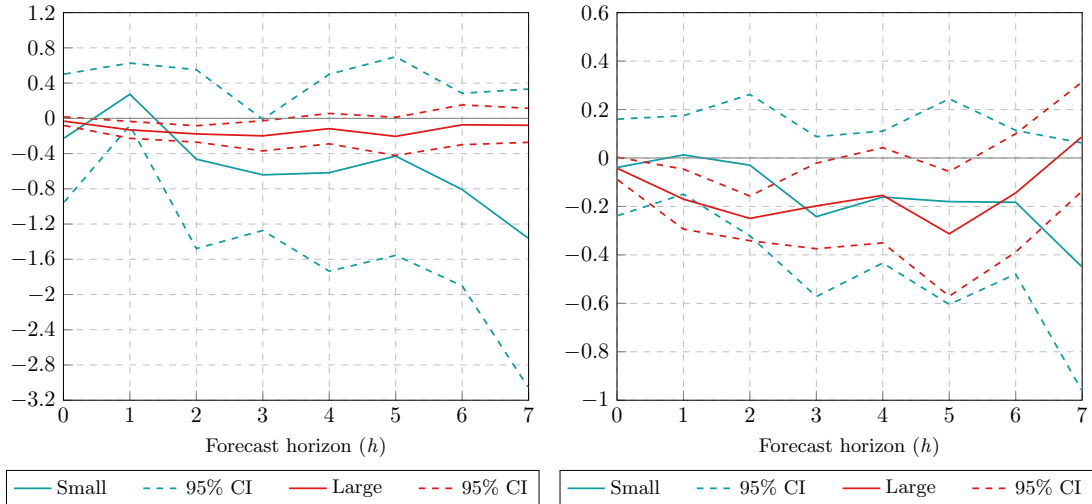


Figure 13: Sensitivity analysis – baseline and range of sensitivity estimates for ERPT to goods and services prices

panel of Figure 14. With respect to the baseline result in Figure 9, only one small difference arises in qualitative terms: the estimate for ‘large’ changes is not statistically significant on impact, but still significant from a forecast horizon of one to three quarters ahead. The estimate for changes which do not qualify as ‘large’ are still insignificant throughout, with noticeably larger confidence bands. As a further check, we also adopt one of the methods used by Pollard and Coughlin (2004) in their robustness estimates. This entails defining as ‘large’ any change in the NEER (again, in absolute terms) that falls in the highest quartile of the distribution of such changes. As seen in panel (b) of Figure 14, this specification returns a result which is similar to the preceding one. ‘Large’ exchange rate changes seem to result in significant ERPT within the first year after the shock, which effect peaks at slightly above 20%, whilst ‘small’ changes do not result in any significant pass-through. As with the baseline case, some residual effect is also detected beyond the one-year mark, with the estimate subsequently declining. Therefore, our result for ERPT when allowing for non-linearity in terms of size is robust to different definitions of a ‘large’ change.



(a) Threshold using series of absolute changes in NEER (b) ‘Large’ change if in largest quartile of changes in NEER

Figure 14: Sensitivity analysis – definition of ‘large’ exchange rate changes

5 Conclusion

Exchange rate pass-through is a key metric in gauging the relationship between exchange rate adjustments and prices in an economy. ERPT estimates have several uses, not least in gauging market conditions, inflation forecasting and as an input to monetary policy decisions. This paper uses Jordà (2005) local projections to estimate ERPT to consumer prices in Malta post-euro adoption, accounting for linear and non-linear ERPT to overall consumer prices as well as to a number of price sub-indices.

The results we obtain can be summarised as follows. Estimating ERPT to headline HICP prices, we indeed find relatively high ERPT in the shorter-term horizon, which however tapers off after a year. Nevertheless, this aggregate estimate seemingly conceals deeper heterogeneity in the transmission of exchange rate shocks to consumer prices, which is uncovered when estimating pass-through to core inflation and to goods and services prices, and also when allowing for non-linear responses to the size and direction of the exchange rate adjustment. We note that pass-through to core inflation is relatively weaker than that to overall prices, whilst as expected, we find that pass-through to goods prices is the main driving force behind overall ERPT; pass-through to goods prices also results to be more persistent over time. Similarly, it results that it is mainly episodes of depreciation and changes of a relatively larger magnitude that are transmitted into inflation, with effects mostly sustained over an eight-quarter forecast horizon, whilst effects for appreciations and small changes are negligible. The sensitivity tests in the previous section show that our results are fairly robust to changes in the model, particularly at shorter horizons. Our results are also mostly consistent with theory and with the empirical literature for euro area countries.

This paper therefore provides an initial set of reduced-form ERPT estimates for the Maltese economy using a robust methodology and accounting for changes in the monetary regime. In so doing, our work also serves as a benchmark for the calibration and estimation of macroeconomic models of the Maltese economy. Future studies can build upon this work by delving into ERPT to import prices, and also potentially exploring methodologies to obtain a longer time series of estimates. Lastly, in line with the latest developments in the literature, future studies can employ structural models to explore the prevalence and characteristics of shock-dependence in ERPT in the Maltese economy.

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Appendix A ERPT estimates in the literature

Table A.1: Literature estimates of linear ERPT to consumer prices

Paper	Countries	Method	Sample Period	ERPT to consumer prices	Range of estimates
Colavecchio & Rubene (2020)	19 EA countries	Local Projections	1997Q1 – 2019Q1	Mean estimates of linear ERPT: 0.05 (impact), 0.08 (1 year), 0.09 (2 years)	0 – 0.13 (impact), -0.09 – 0.18 (1 year), -0.06 – 0.23 (2 years)
Ortega & Osbat (2020)	EU Member States	Time varying estimate using Bayesian single equation	1999Q1 – 2017Q4	-	-0.09 – 0.18 (1 year)
Commuale & Kunovac (2017)	EA and 4 EA countries	Bayesian VAR	1992Q1 – 2016Q2	Approx. 0.2 (EA, 1 year)	-
Bur'lon et al. (2018)	EA	DSGE Model	1999Q1 – 2017Q2	Approx. 0.04 per quarter (non-oil imports from RoW)	-
Billmeier & Bonato (2002)	Croatia	Standard VAR in first differences Cointegrated VAR	1994M1 – 2001M1	N/A (statistically insignificant) 0.33	-
Beirne & Bijsterbosch (2009)	9 CEECs	Cointegrated VAR	1995M1 – 2008 M4	Mean estimates: 0.26 (1 year), 0.39 (2 years), 0.61 (Long run)	0.16 – 0.44 (1 year), 0.23 – 0.57 (2 years), 0.37 – 0.97 (Long run)
Carriere-Swallow et al. (2016)	30 emerging economies (incl. BG, HU, PL, RO, UA) and 32 advanced economies (incl. AT, BE, CZ, DK, EE, FI, FR, DE, GR, IE, IT, LV, LT, LU, NL, NO, PT, SK, SI, ES, SE, CH)	Local Projections	2000M1 – 2015M12	Mean estimates: 0.41 (1 year), 0.41 (2 years) (BG, ..., UA); 0.21 (1 year), 0.24 (2 years) (AT, ..., CH)	0.23 – 0.70 (1 year), 0.26 – 0.72 (2 years) (BG, ..., UA); -0.13 – 0.61 (1 year), -0.25 – 1.15 (AT, ..., CH)
Coricelli et al. (2006)	HU, PL, CZ, SI	Cointegrated VAR	1993 – 2002	Mean estimate: 0.87 (long run)	0.64 – 1.01 (long run)
Commuale (2019)	EE, LV, LT	Reduced-form equations (Bivariate and Phillips Curve specifications) Bayesian VAR (PERR to FX shock) Local Projections (FX shock from BVAR)	1999Q1 – 2017 Q4	Mean estimates: 0.24 (1 quarter), 0.88 (1 year) (Bivariate); 0.20 (1 quarter), 0.77 (1 year) (Phillips Curve) Mean estimates: 0.27 (1 quarter), 0.41 (1 year) Mean estimates: 0.04 (1 quarter), 0.04 (1 year)	0.09 – 0.33 (1 quarter), 1.51 (1 year) (Bivariate); 0 – 0.61 (1 quarter), 0.2 – 1.85 (1 year) (Phillips Curve) 0.22 – 0.32 (1 quarter), 0.28 – 0.59 (1 year) -0.10 – 0.12 (1 quarter), -0.24 – 0.21 (1 year)
Jimborean (2011)	10 New EU Member States	System-GMM Dynamic Panel equation Country-by-country reduced-form equation	1996Q1 – 2010Q2	0.01 (short run), 0.12 (long run) Mean estimate: 0.07 (short run)	- -0.08 – 0.34 (short run)
Nalban (2015)	RU, CZ, HU, PL	Panel Bayesian VAR		Mean estimates: 0.02 (short run), 0.19 (medium run), 0.29 (long run)	0 – 0.06 (short run), 0.13 – 0.24 (medium run), 0.21 – 0.34 (long run)

Appendix B Sensitivity of estimates

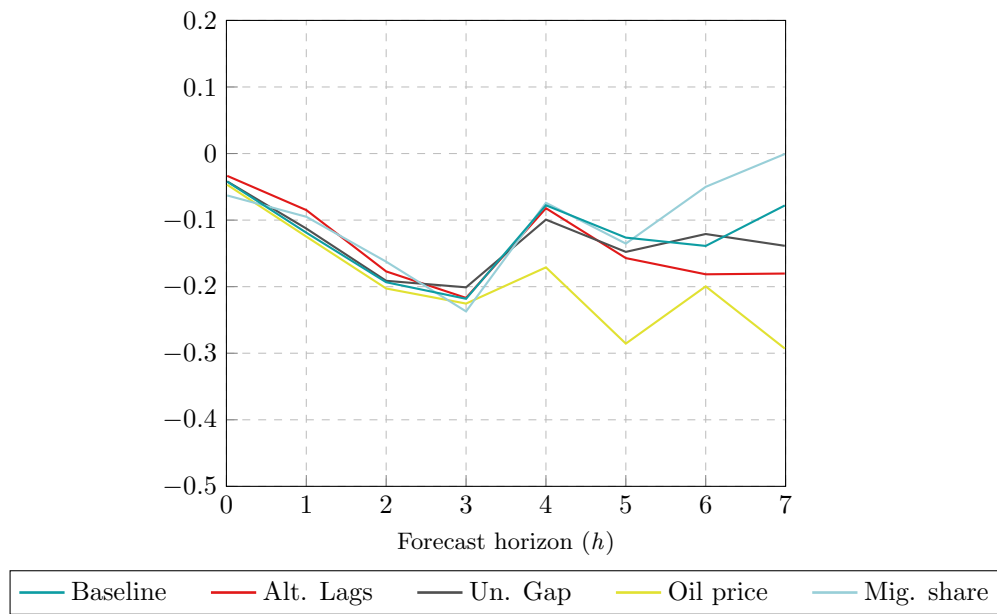


Figure B.1: Estimates of linear ERPT to overall consumer prices from baseline and all sensitivity specifications

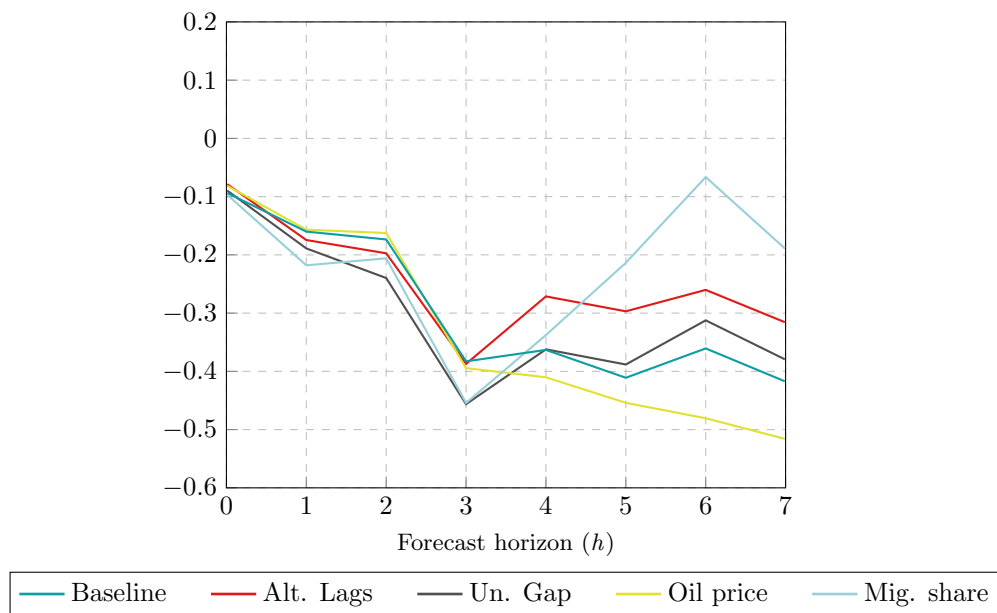


Figure B.2: Estimates of linear ERPT to goods prices from baseline and all sensitivity specifications

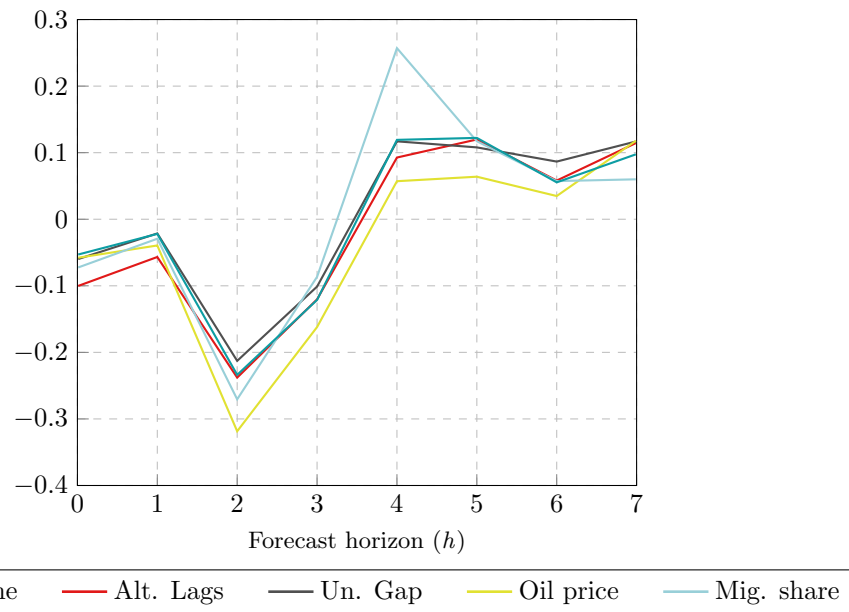


Figure B.3: Estimates of linear ERPT to services prices from baseline and all sensitivity specifications