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## Housing demand shocks, foreign labour inflows and consumption

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# Housing demand shocks, foreign labour inflows and consumption\*

William Gatt<sup>†</sup>

Germano Ruisi<sup>‡</sup>

WP/07/2020

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### Abstract

In this paper we propose a SVAR identification strategy to disentangle two housing demand shocks and their ensuing effect on consumption. This builds on the literature studying the role of the collateral and housing wealth effects on household behaviour. A mix of zero and sign restrictions allows us to disentangle domestic and foreign housing demand shocks, which capture different motivations for owning or using real estate by residents and foreign workers respectively. Using Maltese data over the period 2000Q1–2019Q4 we find that both housing demand shocks generate an increase in consumption, in line with the theoretical predictions from micro-founded models with financial frictions. While a domestic housing demand shock drives consumption via both the collateral and housing wealth channels, a foreign housing demand shock operates mainly via the latter. Moreover, these shocks account for about 40% of the fluctuations in house prices and consumption in the long run. We show that from a historical perspective they match well with the dynamics of foreign worker growth and a selection of events that are associated with activity in the housing market.

**JEL Classification:** C11, C32, G51, R21

**Keywords:** house prices, housing wealth, collateral, identification, SVAR

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# 1 Introduction

A majority of households in Malta own their house, and a subset of these owns at least another property. According to the Survey on Income and Living Conditions (EU-SILC), homeownership in Malta averaged 80.3% over the period 2005-2019, one of the highest across European countries. Besides providing a service, real estate also serves as a store of value. Data from recent waves of the ECB’s Household Finance and Consumption Survey show that homeowners on average hold about 80% of their total wealth in real estate. Moreover, real estate serves an important role as collateral for loans (Spiteri, 2019). In this paper we look at the implications of movements in house prices on household consumption.

There are two main channels through which house prices affect consumption; the collateral channel and the housing wealth channel (Campbell and Cocco, 2007). The collateral channel arises from borrowing limits that are conditional on the value of housing. An increase in house prices raises the borrowing limit absent any other changes, which allows households to use the additional resources to smooth consumption. The wealth channel hinges on the ability of households to realise the capital gain by selling part of their holdings of housing, which frees resources that can be used, *inter alia*, for consumption. Given the importance of housing as an asset for Maltese households, it is pertinent to ask how strong these two channels operate. Figure 1 shows that house prices and consumption appear to co-move over time. Indeed, Georgakopoulos (2019) uses household-level data from the Household Finance and Consumption Survey and finds a positive relationship between consumption and housing wealth in Malta. The coefficient is higher for older households, supporting the wealth channel hypothesis.

Our contribution is to study the role of housing demand shocks in driving consumption from a macroeconomic perspective. As part of our contribution we identify two distinct sources of housing market disturbances; which we label domestic and foreign housing demand shocks respectively. The former captures preference shifters in the demand for housing by permanent residents for long term use, such as desire for higher average homeownership, government housing market initiatives, and socio-economic changes such as separations and divorces. This shock is routinely identified in theoretical and empirical studies of the housing market. On the other hand, a foreign housing demand shock is our novel contribution and captures a rise in demand for accommodation by migrant workers.

We consider this as an important shock to identify as migration flows were positive since Malta’s accession to the European Union (EU), and accelerated substantially since 2012 (see Figure 2). Besides contributing significantly to economic activity (Furlanetto and Robstad, 2019a), and in the case of Malta to its economic boom over the past years (Grech, 2015; Grech and Borg, 2018),<sup>1</sup> migration inflows are likely associated with raises in aggregate house prices as argued in Saiz (2007) and McDonald (2013).<sup>2</sup> For this

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<sup>1</sup>Grech (2015) argues that foreign workers boosted Malta’s potential output growth by between 0.5 and 0.6 percentage points following Malta’s accession to EU.

<sup>2</sup>These two studies focus on aggregate data, which is the approach taken in this paper. However, we

reason, we investigate whether the demand for accommodation exerted by immigrants can also affect consumption through the channels discussed above.<sup>3</sup>

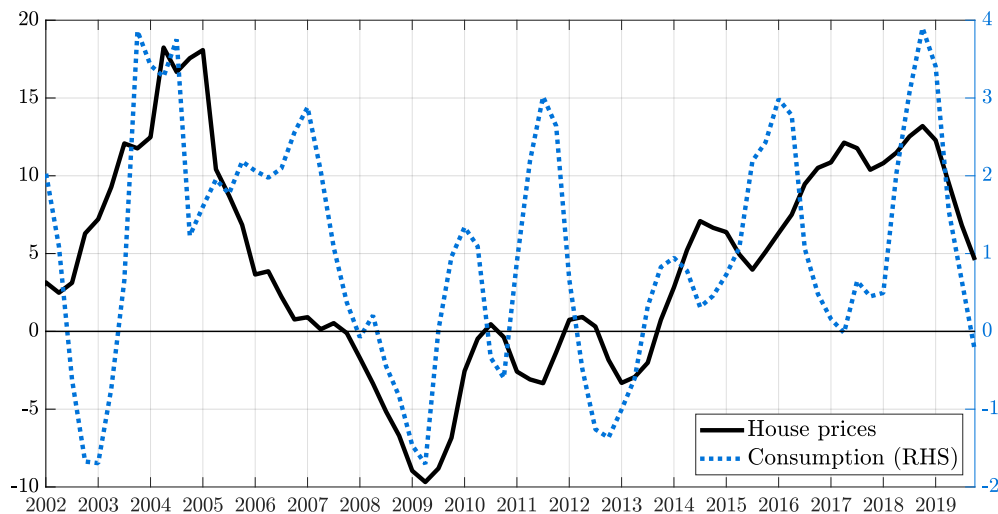


Figure 1: Real house prices and real consumption per capita (% p.a., 4-QMA)

Notes: House price data are based on the Central Bank of Malta’s advertised property price index. Data sources and related information are explained in Appendix A. In this figure annual growth rates are expressed as 4-quarter moving averages. The horizontal axis denotes the first quarter in a given year.

Since the nature of this shock is different to that of a typical demand shock studied in the literature, it follows that the channels through which a foreign housing demand shock propagates could be different. Lumping these two shocks into single housing demand shock risks conflating the different propagation channels and produce misleading results. To our knowledge we are the first to empirically identify two separate housing demand shocks in this context.

Using a Structural Vector Autoregression (SVAR) identified through a mix of zero and sign restrictions, we find a positive consumption response to a domestic housing demand shock which raises house prices and credit, in support of the collateral and housing wealth channels. The reaction of consumption is in line with theoretical predictions from MEDSEA-FIN, a DSGE model with housing and financial frictions calibrated to the Maltese economy (Gatt et al., 2020). Thus, our work also serves as a cross-check on the restrictions imposed in a microfounded model. Additionally, we decompose the rise in consumption into the collateral and housing wealth channels and find they are both equally important in driving the consumption response. A foreign housing demand shock generates a weaker consumption response but contributes significantly to increased economic activity through a positive GDP response. In this case, the shock

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acknowledge that if focusing on metropolitan areas and/or at regional level results are mixed. It is so as migrant inflows can cause locals to move to other regions or metropolitan areas thus contributing to a lower demand for accommodation with an ensuing decrease in house prices (Sá, 2015; Saiz, 2007; Saiz and Wachter, 2011).

<sup>3</sup>See Furlanetto and Robstad (2019b) for an analysis of the impact of migration on the economy.

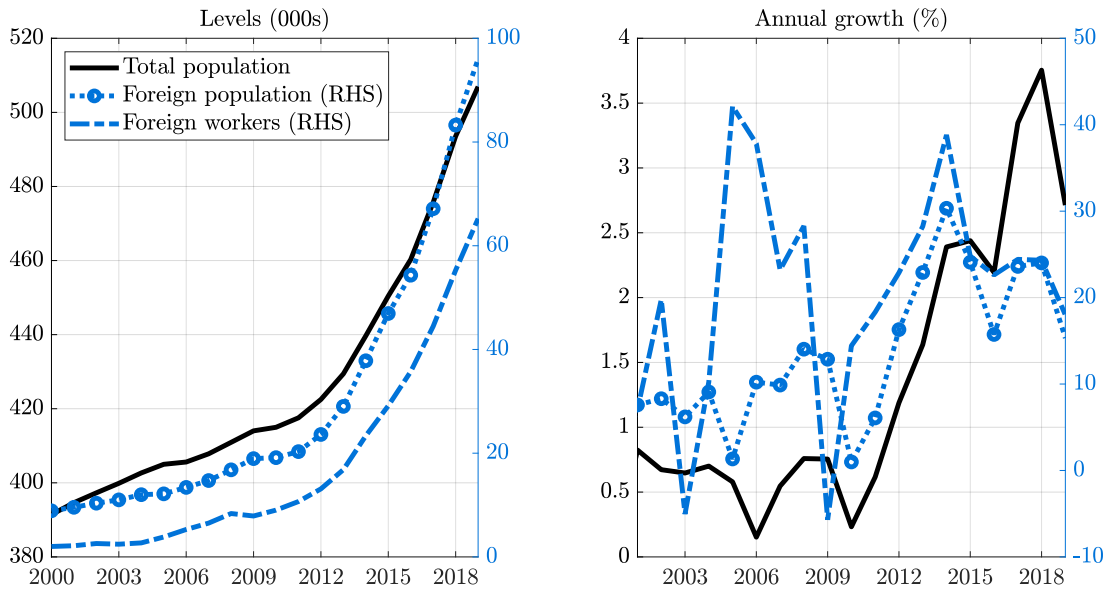


Figure 2: Population dynamics in Malta

Notes: The horizontal axis denotes the first quarter in a given year. Data sources and related information are explained in Appendix A.

operates mainly through the housing wealth channel.<sup>4</sup> The two shocks combined explain about 40% of the fluctuations of house prices and consumption in the long run, results similar to those for Ireland and Spain (Nocera and Roma, 2017). Consequently, our results show that both housing demand shocks were important in explaining movements in house prices, credit and consumption over the past twenty years and, in addition, align well with a set of relevant historical events, such as EU accession and stamp duty reductions.

The rest of the paper is structured as follows. In the next section we discuss the empirical evidence on the elasticity of consumption to changes in house prices based on both microeconomic and macroeconomic studies, while in Section 3 we describe the VAR we estimate, including our identification strategy. We present our main results in Section 4 and then match the contribution of our identified housing demand shocks with a set of events in Section 5. Section 6 concludes.

## 2 Empirical evidence on the role of house prices

There are both microeconomic and macroeconomic estimates that quantify the causal link between house prices and consumption. The literature presents a somewhat wide range of estimates for the marginal propensity to consume (MPC) out of house price changes, differing across countries, households, methodologies and sample periods. We review these briefly in this section.

<sup>4</sup>This could be the result of changing consumption patterns due to changes in the composition of the population. Foreign workers are likely to consume less on average than locals, thus pushing down the aggregate per capital consumption response.

## 2.1 Microeconomic estimates

Campbell and Cocco (2007) document considerable heterogeneity in the consumption elasticity across different age cohorts in the UK. They estimate an elasticity of 1.7 for older homeowners, but a very small response for young households who are renters. Carroll et al. (2011) find an impact MPC from a 1 dollar change in housing wealth of 2 cents in the US, building up to 9 cents in the long run. Similarly, Mian et al. (2013) document an MPC of 5–7 cents for every dollar of housing wealth lost during the financial crisis in the US. On the other hand, Disney et al. (2010) find a smaller MPC out of unanticipated house price gains of around 0.01 for the UK during the period 1994–2003. Andersen and Leth-Petersen (2020) find support for the collateral channel in Denmark by estimating an increase in mortgage borrowing and consumption of between 3–5% out of unanticipated house price gains. They show that younger households with a high loan-to-value ratio are mostly behind this, whereas spending of older households is not sensitive to house price movements.

## 2.2 Macroeconomic estimates

Macroeconomic studies based on estimated SVAR and DSGE models also shed light on the link between house prices and consumption. Goodhart and Hofmann (2008) estimate a panel VAR based on 17 industrialized countries and find that a house price shock tends to increase GDP, credit and consumer prices. However they do not give a structural interpretation to the shock, and so it may capture various factors. Giuliadori (2005) also finds positive consumption responses to house price shocks in a selection of European countries. He shows that in Ireland, the Netherlands, Spain and the UK house prices contribute to the drop in consumption as part of the monetary policy transmission mechanism.<sup>5</sup>

Using an estimated DSGE model, Iacoviello and Neri (2010) find an elasticity of consumption to house prices following a housing demand shock of about 0.07 in the year following the shock. In their model it is mainly the collateral channel that is at play, since borrowers face an endogenous borrowing constraint which is relaxed through the house price appreciation. Jarocinski and Smets (2008) estimate a BVAR model for the US economy and identify a housing demand shock using a mix of recursive and sign restrictions. When they run the VAR in log levels, they estimate a consumption response of 0.075% to a 1% rise in house prices after four quarters, an elasticity that is very close to that estimated by Iacoviello and Neri (2010). Musso et al. (2011) estimate a BVAR for the US and euro area over the period 1986Q1–2009Q2. Using a recursive identification scheme, they find that the structural housing demand shock is synonymous with a house price shock in the euro area, but it corresponds to a residential investment shock in the US. They note that in these two scenarios, the effect on consumption in the euro area is relatively short-lived compared to that in the US, attributing this to a

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<sup>5</sup>Elbourne (2008) on the other hand uses a similar approach but finds a much weaker effect on consumption for the UK. This could be due to the fact that he proxies consumption with retail sales, which make up only a subset of total consumption.



stronger collateral channel in the latter.

More recently, [Nocera and Roma \(2017\)](#) estimate a BVAR for seven euro area countries. The identification strategy also uses a mix of zero and sign restrictions. They find that the consumption response to an identified housing demand shock is generally positive although the magnitude varies significantly across the countries in their sample. They estimate the largest response in Ireland and Spain, with a peak response of around 0.15% following a 1% increase in house prices. In Italy consumption peaks at about 0.1%, and in all three countries the peak response of consumption occurs by the second period following the shock. On the other hand, the consumption response in Germany, which has the lowest homeownership rate, is muted. They also find that historically housing demand shocks contributed positively – and significantly – to consumption and credit growth in Ireland and Spain during the boom periods 2002–2007, and negatively during the crisis period 2008–2013.

### 3 Methodology

This section outlines the methodology we implement in this paper. It shows the reduced form of the VAR model which is estimated using Bayesian techniques, and provides information regarding the choice of the priors as well as the estimation setup. Finally, and more importantly, this section describes how the shocks of interest are identified.

#### 3.1 A Bayesian VAR

The model is relatively standard and includes both endogenous and exogenous variables. The reduced form model has the following VAR representation:

$$y_t = A + Bt + \sum_{l=1}^L C_l y_{t-l} + \sum_{l=1}^L D_l z_{t-l} + u_t \quad (1)$$

for  $t = 1, \dots, T$ , where  $y_t$  is an  $N \times 1$  vector of endogenous variables and  $y_{t-l}$  a number of lagged values of the latter with  $l = 1, \dots, L$ . Similarly,  $z_{t-l}$  represents  $M \times 1$  vectors containing lagged values of exogenous variables.  $A$  is an  $N \times 1$  vector of intercepts,  $B$  an  $N \times 1$  vector of coefficients that loads on a linear time trend  $t$  while  $C_l$  and  $D_l$  respectively represent  $N \times N$  and  $N \times M$  matrices containing the slopes relative to the lagged values of the endogenous and the exogenous variables. Finally,  $u_t$  is an  $N \times 1$  vector of reduced form residuals with  $u_t \sim N(0, \Sigma)$  where  $\Sigma$  is the  $N \times N$  variance-covariance matrix.

We estimate a 5 variable VAR featuring real GDP per capita, the Retail Price Index (RPI), real house prices, real credit per capita and real consumption per capita.<sup>6</sup> Our measure of house prices is based on advertised prices as compiled by the Central Bank of Malta and we choose this index as it is the longest available time series for house prices in

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<sup>6</sup>We remove the housing rent component from the RPI to make sure that the latter reflects only the price level of all goods except housing. By doing so, the RPI index and the real house prices series used in this model are completely distinct from one another. See Appendix A for more details.

Malta.<sup>7</sup> Finally, the model includes the real lending rate as an exogenous variable.<sup>8</sup> All the variables are expressed in logarithms with the exception of the lending rate which is expressed in levels.<sup>9</sup> We use quarterly data and the sample runs from 2000Q1 to 2019Q4. More information on data sources and transformations is available in Appendix A.

The VAR is estimated with a natural conjugate prior in order to guarantee that the posterior distributions belong to the same family of the priors (Kadiyala and Karlsson, 1998). To this end, we use a Normal-inverse Wishart prior. Moreover, the lag length is set to 2 for both endogenous and exogenous variables and the model is estimated by setting the total number of Gibbs sampler iterations in such a way to have a reasonable number of retained draws necessary to conduct a meaningful inference. More information regarding the estimation procedure, such as, choice of the lag length, priors, likelihood and posterior distributions, can be found in Appendix B.

### 3.2 Shock identification strategy

In order to meaningful link the reduced form shocks with the structural ones it is necessary to resort to a reliable identification strategy. In this paper we identify the structural shocks by using a mix of zero and sign restrictions, implemented using the procedure developed in Arias et al. (2018). The zero and sign restrictions impose restrictions on the decomposition of the estimated variance-covariance matrix  $\Sigma$ . To this end, the prediction error  $u_t$  can be written as a linear combination of the underlying structural innovations  $v_t$ , that is,  $u_t = Ev_t$ , with  $v_t$  being distributed as standard Normals,  $v_t \sim N(0, I_N)$ , where  $I_N$  is a  $N \times N$  identity matrix. The objective is to decompose the estimated variance-covariance matrix in a suitable way,  $\Sigma = EE'$ , in order to collect a set of models with elements of  $E$  complying with a number of restrictions that are justifiable from a theoretical standpoint.

We fully identify the system with 5 shocks; the two housing demand shocks, a loan supply shock, and aggregate demand and supply shocks. The two housing demand shocks are the focus of this paper as they help us detect the presence of the wealth and collateral channels that run from house prices to consumption through different transmission mechanisms, and allow us to recover counterfactual paths for the observables. The other three shocks are meant to capture the remaining dynamics in the system. We only impose impact restrictions, following the discussion in Canova and Paustian (2011), and allow the responses at higher horizons to be driven by the data. The joint use of zero and sign restrictions at the same time allows us to distinguish a housing demand shock

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<sup>7</sup>This index generates house price growth dynamics that are broadly consistent with other available measures, such as the hedonic measures discussed in Ellul et al. (2019). However, the latter indices are only available from 2010Q1 onwards, a sample period too short for our estimation.

<sup>8</sup>We do not endogenise the lending rate because is likely driven by conventional and unconventional monetary policy measures, which are not the focus of this paper. Movements in the lending rate capture the transmission of monetary policy, summarising the effect of foreign variables that are relevant to the Maltese housing market.

<sup>9</sup>The inclusion of a time trend in the VAR aims at improving the estimation of the parameters and yields a stable VAR.

from an aggregate demand shock, as we explain further below. Table 1 summarises the identification of these shocks.

Table 1: Impact restrictions to structural shocks

	D.H.D.	F.H.D.	L.S.	A.D.	A.S.
Real GDP per capita	?	?	+	+	+
Retail Price Index	0	0	0	+	-
Real house price	+	+	0	?	?
Real credit per capita	+	-	+	?	?
Real consumption per capita	?	?	?	+	?

Note: The entries refer to the impact response of a variable  $y_{i,t}$  to a structural shock  $v_{j,t}$ ; ‘+’ indicates  $\partial y_{i,t}/\partial v_{j,t} > 0$  while ‘-’ indicates  $\partial y_{i,t}/\partial v_{j,t} < 0$ , and ‘?’ indicates that no restriction is imposed on that variable.

### Domestic housing demand shock

We identify the first housing demand shock, a *domestic housing demand* (DHD) shock, as the classic impulse to preferences as specified in DSGE models with housing or land (Iacoviello and Neri, 2010; Liu et al., 2013). This shock represents taste shifters, such as a desire for homeownership or a desire to upsize or downsize a house that one lives in. We label this ‘domestic’ since we have in mind transactions conducted by residents in Malta who are able to purchase a house through a bank loan.<sup>10</sup> We therefore identify a positive DHD shock as one that raises house prices and credit and has no contemporaneous effect on all other prices.<sup>11</sup> We leave the response of consumption and GDP unrestricted and therefore data-driven. Our prior expectation is that consumption rises in response to this shock, as discussed in the introduction and in line with theoretical predictions from DSGE models (Iacoviello, 2005; Iacoviello and Neri, 2010). The zero impact restriction on the RPI allows us to disentangle housing demand shocks from aggregate demand shocks, since theoretically they exert very similar effects on the endogenous variables in our system. This timing assumption is justified since a rise in housing demand, although potentially spilling over to other markets, is unlikely to affect goods and services prices within the same quarter.<sup>12</sup>

<sup>10</sup>We are aware that, at least recently, a share of housing transactions in Malta were conducted without the need of a bank loan. However, our framework does not allow us to trace the propagation of a cash-financed housing demand shock.

<sup>11</sup>Embedded within house prices are changes in the value of land and other factors that influence the user cost of housing.

<sup>12</sup>This is similar to Nocera and Roma (2017), who impose a zero impact restriction on both inflation and GDP to identify a housing demand shock.

## Foreign housing demand shock

The second is a *foreign housing demand* (FHD) shock. This shock captures shifts in the desire for accommodation by non-Maltese residents, namely migrant workers. Although it raises house prices, it has an immediate negative effect on credit per capita, and we justify the latter identifying restriction as follows. A net rise in inward migration raises housing demand and the population size, but since these workers likely do not intend to buy property, at least immediately, then total household credit is unaffected on impact.<sup>13</sup> This assumption is especially valid since the length of stay of foreign workers in Malta is typically short (Borg, 2019) and therefore unlikely to feature the purchase of real estate through bank financing.<sup>14</sup> As a result, we should observe a fall in credit *per capita* following a FHD shock, all else equal.<sup>15</sup> As in the DHD shock, we assume a zero impact response of inflation. Similarly, the responses of consumption and GDP are also left unrestricted, with the same prior expectation of a positive reaction of consumption to this shock through a wealth effect that spills over to all homeowners. Our identification strategy therefore allows us to separate these two structural shocks which might seem to have the same observational effect on house prices and possibly also on consumption but exert this effect through different channels.<sup>16</sup>

## Loan supply shock

A loan supply (LS) shock increases the amount of credit that banks are willing to extend to households. It is meant to capture changes to bank capital regulation, changes in risk appetite and changes in the degree of competition in the banking sector, as discussed in Gambetti and Musso (2017).<sup>17</sup> Similar to these authors, we identify this shock as one that increases credit per capita and GDP per capita, but we assume that it does not affect house prices and goods price inflation on impact. The latter are timing assumptions reflecting our belief that changes in credit supply volumes are unlikely to have an immediate impact on consumer and house prices. We leave the response of consumption unrestricted.

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<sup>13</sup>The availability of credit to such households is also likely heavily restricted, especially if they do not hold long term employment contracts.

<sup>14</sup>Borg (2019) documents that 25% of migrant workers exit the Maltese labour market within the same year of entry, and around 50% do so by the second year.

<sup>15</sup>Implicit in our assumption is that the population count includes entrants in Malta within the same quarter. This reflects obligations on foreigners to register with Identity Malta, the local immigration authority, shortly upon arrival.

<sup>16</sup>An argument can be made that the two housing demand shocks could be correlated if a foreign demand shock induces ‘buy-to-let’ housing demand behaviour by Maltese residents, implying that DHD and FHD shocks are not orthogonal. However, in this case we view the ‘buy-to-let’ demand a response to the first shock, not another shock in itself. Within the context of a theoretical model, this behaviour would result from the policy function of the landlord reacting to the expected increase in the return on investment. Consequently, we consider these two shocks as orthogonal and our analysis follows through.

<sup>17</sup>See also Mumtaz et al. (2018) for an analysis of this shock.

## Aggregate demand and supply shocks

Finally, we identify aggregate demand (AD) and supply (AS) shocks using the standard approach used in the literature. An AD shock typically raises output and inflation. Since we model housing demand shocks separately, we specify this as a consumption preference shock which boosts non-housing expenditure, and we impose a positive impact response on consumption.<sup>18</sup> This ensures that the AD shock is distinct from a DHD shock. Conversely, an AS shock raises output and lowers inflation, but we leave the responses of the other variables unrestricted. This shock is meant to capture all other unmodelled structural disturbances, such as productivity and foreign commodity price shocks (see [Christiano et al. \(2010\)](#)). The absence of foreign variables implies that these two shocks capture shifts in aggregate demand and supply taking place both domestically and externally.

## 4 Structural analysis

This section shows the main results obtained from the estimation of the model in (1) together with the imposition of the restrictions outlined in Table 1, i.e., impulse response functions (IRFs) and forecast error variance decompositions (FEVD) over a 40-quarter horizon. Furthermore, it shows some counterfactual exercises that are key to highlight the link between house prices and consumption. Results are based on 6755 retained draws from the posterior distributions of the VAR parameters. In this section we focus on impulse response functions and forecast error variance decompositions, and build on these in the following section.

### 4.1 Impulse response functions

We now discuss the behaviour of the variables in our VAR, focusing primarily on the two housing demand shocks. Since the variables are expressed in logarithms, the responses are expressed in percent. In each case we scale the impulse to generate a median increase in real house prices by 1% on impact.

#### Domestic housing demand shocks

A DHD shock, shown in Figure 3, produces a persistent rise in house prices spanning 4 years. It also produces a humped-shaped response of household credit, which persists throughout a 10-year horizon, even though house prices experience a correction after about 4 years. We find a positive median response of consumption to the DHD shock, in line with the collateral and wealth effect channels discussed above. The response is low on impact but peaks at just under 0.2% in the period after the shock. The consumption response is very similar to the results in the literature, and the response at 4 quarters is 0.071%, in the ballpark of the estimates in [Jarocinski and Smets \(2008\)](#) and [Iacoviello and Neri \(2010\)](#) for the U.S. The shock leads to an initial fall in the RPI,

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<sup>18</sup>See [Adolfson et al. \(2013\)](#) for a consumption preference shock within a DSGE framework.

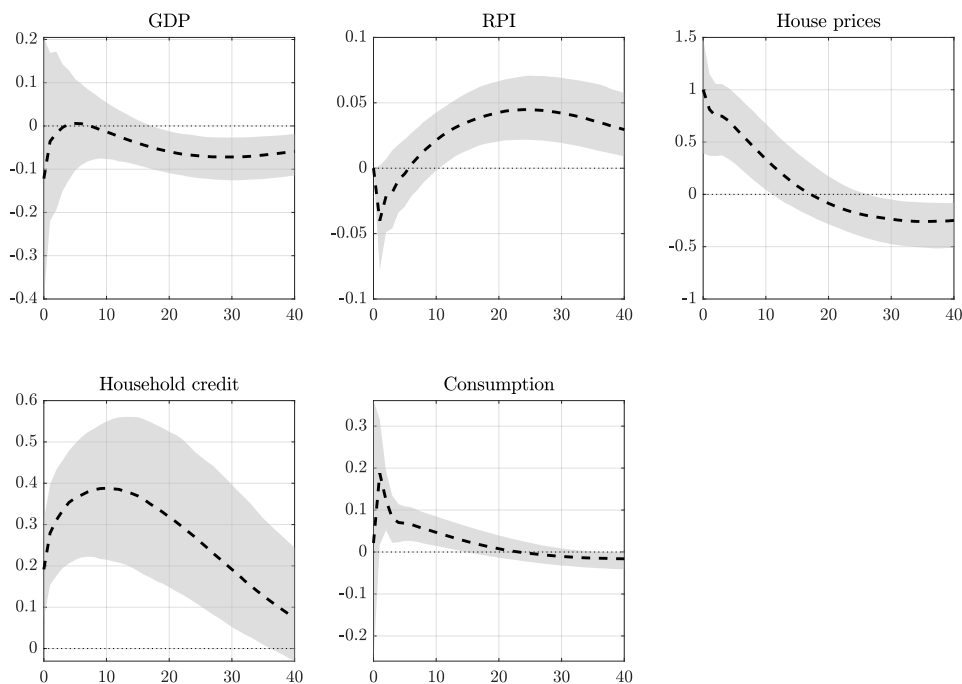


Figure 3: IRFs to a domestic housing demand shock

Notes: The figure shows the median response across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in real house prices on impact.

followed by a humped-shaped rise in the medium term. Associated with this is a short-lived rise followed by a small and relatively persistent drop in GDP, despite the rise in consumption. These two responses likely reflect a build-up of inflationary pressures that leads to a deterioration in Malta's competitiveness.<sup>19</sup> Indeed, these responses are broadly consistent with the theoretical predictions of a housing demand shock in MEDSEA-FIN; see [Gatt et al. \(2020, p.26\)](#).<sup>20</sup> The 10-year cumulated impact of this shock on house prices, credit and consumption are 3.3%, 11.1% and 0.9% respectively.

### Foreign housing demand shocks

The FHD shock leads to a very persistent rise in house prices based on the median response, and remains positive for up to 10 years (Figure 4). The response of consumption is initially negative but surrounded by a high degree of uncertainty, peaking at 0.05% by the second quarter and staying elevated above zero throughout the response horizon. However, the peak median consumption response is lower than in the case of a domestic housing demand shock and the 68% credible bands are wider and cross zero throughout

<sup>19</sup>See Figure C.1 in Appendix C for a counterfactual response of GDP without the effects of rising prices. However, the RPI is likely a poor proxy for export prices, so the counterfactual response only partially purges the GDP response from this channel.

<sup>20</sup>A housing demand shock in MEDSEA-FIN causes output to rise on impact followed by a quick drop due to an increase in wages and prices which erodes the economy's competitiveness on the export market. It is only through a fall in wages that production picks up again and the output response remains positive. In our VAR we do not include wages, so we cannot capture this channel in our GDP responses.

most of the response horizon. This highlights the uncertainty around the effects of this shock on macroeconomic outcomes amongst the set of identified models. This could be due to the fact that although inward labour migration has been positive since the early 2000s, most macroeconomic effects became strong enough in the data only following the recent surge in the inflow of workers starting in 2012. Furthermore, a foreign housing demand shock changes the composition of the population, increasing the share of residents who are not able to borrow against collateral. This therefore dampens the potential rise in credit following a rise in house prices and therefore also lowers the aggregate consumption response.<sup>21</sup> This makes it hard to identify the effect with precision in our model (refer to Figure 8). Therefore, we cautiously interpret the consumption response as suggestive evidence for wealth effects from house price changes arising from foreign demand shocks.

It is interesting to note that the shock also mimics a supply shock, as it raises GDP and lowers inflationary pressures. The response of household credit per capita is negative for the first three years, in line with the nature of the shock which increases the population but does not change the total stock of household credit. This shock yields a 10-year cumulated impact on house prices and GDP of 9.3% and 2.1% respectively.

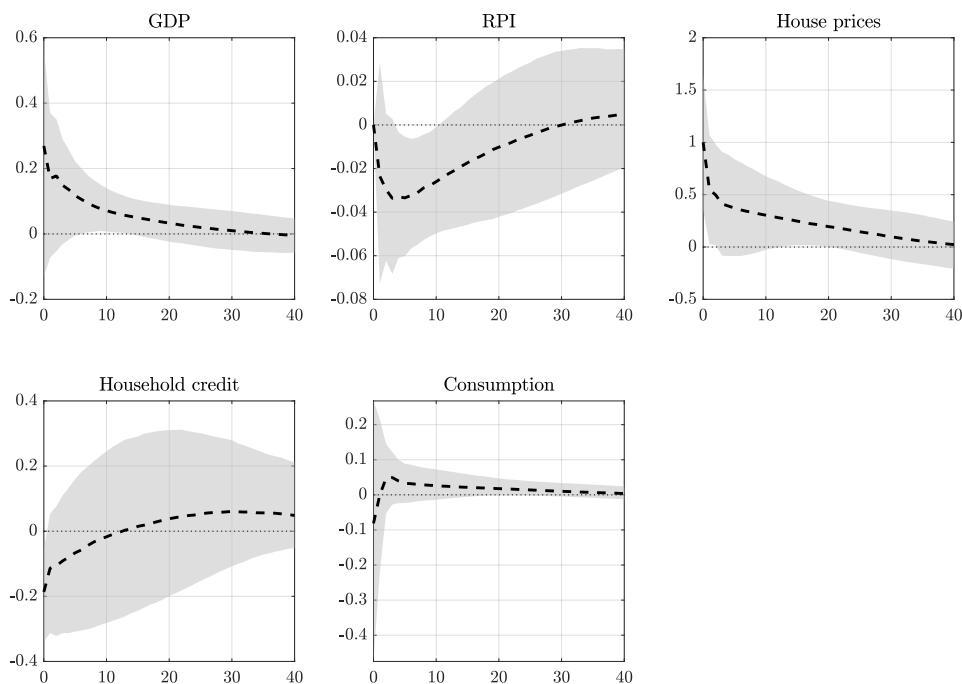


Figure 4: IRFs to a foreign housing demand shock

Notes: The figure shows the median responses across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in real house prices on impact.

<sup>21</sup>Conversely, we conjecture that a large share of homeowners in Malta do not refinance their mortgage when the value of their housing wealth rises. This could also explain the muted response of credit and therefore of consumption to this shock.

## Loan supply, aggregate demand and aggregate supply shocks

In the interest of space we relegate the responses to LS, AD and AS shocks to Appendix C, since they are not central to the research question. Here we sketch the key take-aways. A loan supply shock generates a persistent increase in credit and to a lesser extent in GDP in median terms. House prices rise and then experience a correction after about 3 years. Consumption and the RPI fall initially but the latter then becomes positive and follows a hump-shaped response over the medium term. The credible bands however are wide and include zero in most cases, and therefore the responses are highly uncertain. An aggregate demand shock, as hinted above, behaves like a consumption preference shock as it raises consumption, the RPI and GDP, but leads to a fall in house prices and household credit relative to the baseline projection due to substitution effects. A positive AS shock behaves like a textbook aggregate productivity shock that is persistent; it raises output, consumption, asset (house) prices and credit but lowers the general price level.

We check for the robustness of reported results on the basis of estimating the model with 4 lags instead of 2 and using annual growth rates rather than levels. The results are largely unchanged and are available upon request. Estimation in growth rates leads to significantly wider credible bands.

### 4.2 Forecast error variance decomposition

Which shocks are important in explaining the fluctuations in the unexpected component of the endogenous variables? Figure 5 shows the forecast error variance decomposition for the five structural shocks which we identify, based on the median draw. The domestic housing demand shock plays an important role in explaining the dynamics of consumption, household credit and house prices, both in the short and long run, which we limit to a 10-year horizon. It explains a substantial share, around 50% and 25% of the variation in house prices and household credit respectively, in the first few periods following the shock, and about a third of the variation in consumption by the first year. This highlights a potentially strong role for the collateral channel in Malta. The contribution of this shock to house price variation falls to about 30% in the medium to long term, but rises to about 50% for household credit. On the other hand, the shock contributes to the variation in inflation and GDP only in the medium term, as inflationary pressures gradually build up and affect the competitiveness of Maltese exports as a small and open economy.

The foreign housing demand shock plays a smaller yet significant role in house price movements across all horizons; about 33% on impact and slightly lower in the medium to long term. On the other hand, the shock plays a bigger role in driving fluctuations in GDP, averaging about 20% of its forecast error variance at all horizons. However, it explains a very small share of the unexplained component of consumption.

Loan supply shocks explain around 20% of fluctuations in household credit in the short run but this falls at higher horizons. Similarly, they drive about 26% of movements in GDP in the first year but have a much weaker role for consumption and prices at all



horizons. These findings suggest that most of the observed variation in credit in the Maltese economy is explained by demand factors, with banks historically largely accommodating demand. On the other hand, aggregate demand shocks explain a significant share of movements in the RPI, house prices, consumption and credit at all horizons. Aggregate supply shocks however explain the bulk of the unexplained component of GDP and the RPI both in the short and long term, and are also non-trivial in their contribution to the dynamics of consumption, house prices and credit.

Our findings are close to those discussed in [Nocera and Roma \(2017\)](#), in particular for Ireland and Spain. In both these countries housing demand shocks explain slightly more than 40% of the movements in house prices and about 15% of movements in consumption at a 20-quarter horizon. Moreover, close to 40% of the unexplained component of credit is explained by the housing demand shock in their study, a result which is largely homogeneous across the seven euro area countries they consider.

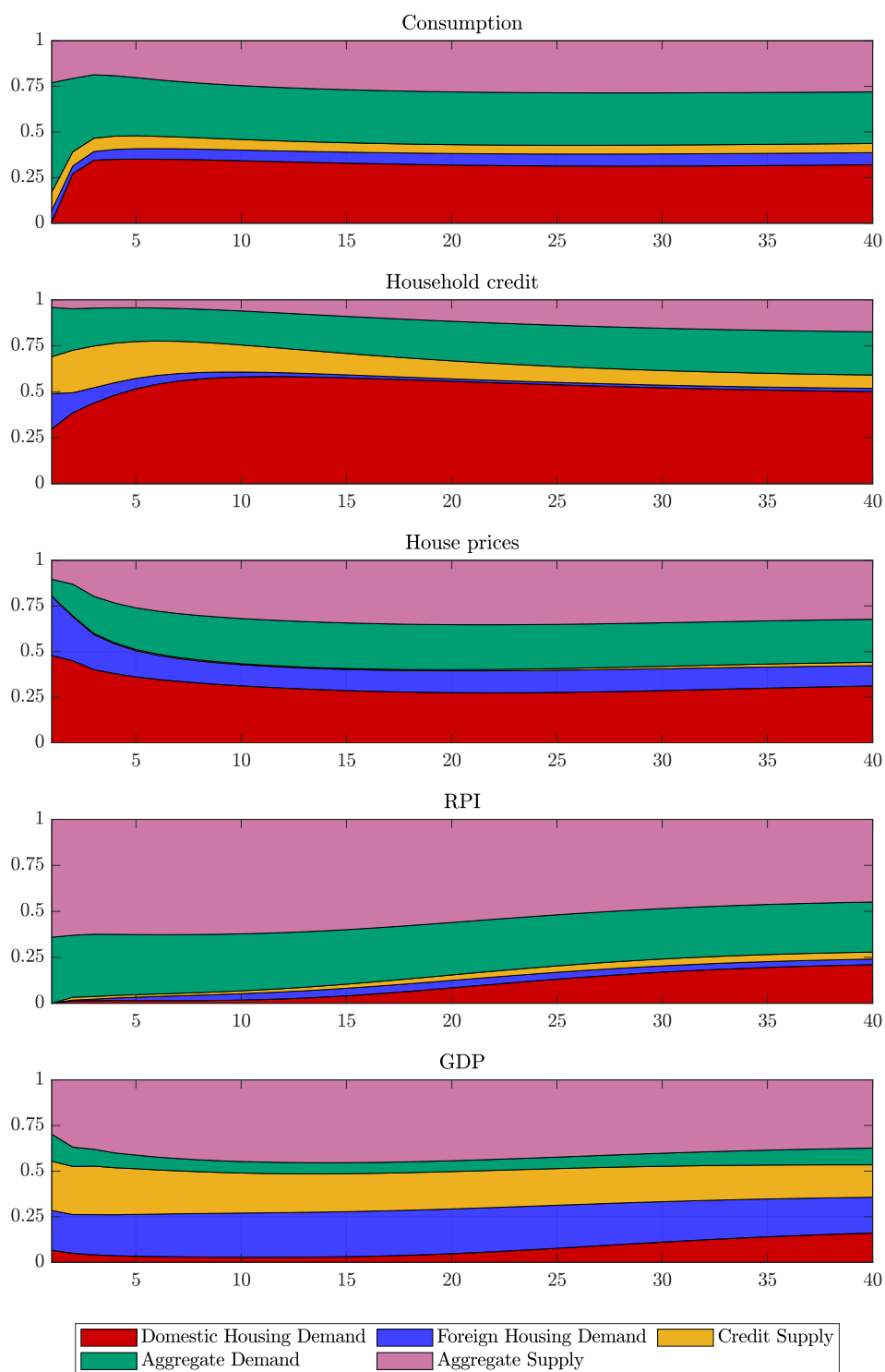


Figure 5: Forecast error variance decomposition at each horizon

Notes: The figure is based on the median draw. Values on the horizontal axis are quarters following the shock.

### 4.3 Disentangling the collateral and housing wealth channels

The impulse response functions and the forecast error variance decomposition imply a significant role for domestic housing demand shocks in driving consumption. To illustrate the importance of the housing wealth and collateral channels, we build the counterfactual response of consumption to a domestic housing demand shock. In particular, we try to disentangle the two channels by first building the counterfactual consumption response in the absence of a rise in credit. Then, we build the counterfactual response in the absence of both credit and house price movements.<sup>22</sup> In Figure 6 we plot these two counterfactuals, in each case superimposed on the benchmark response, for the two housing demand shocks.

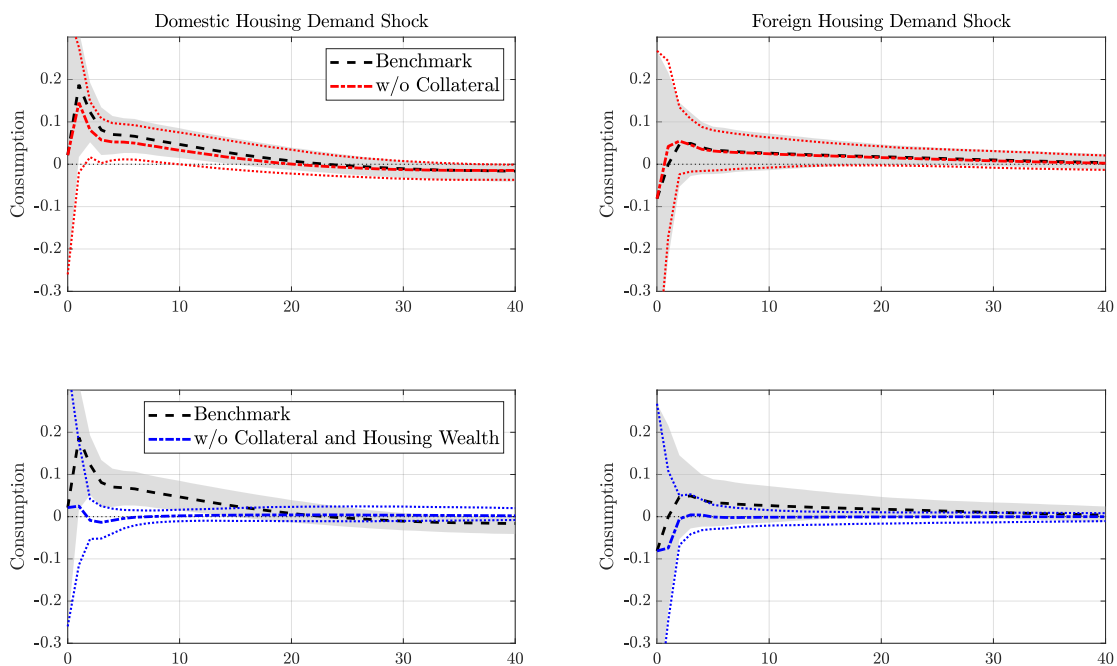


Figure 6: Counterfactual IRFs to housing demand shocks

Notes: The figure shows the median responses across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in real house prices on impact in both scenarios.

In the case of a domestic housing demand shock, we observe that both the collateral and housing wealth channels are operative. In the absence of credit rising, consumption still rises but is always lower compared to the benchmark. In the second scenario, the consumption response is virtually flat. With this exercise we illustrate the importance of the two main theoretical channels we are after. To quantify the relative strengths of these two channels, we compute the effect on the long run cumulative response of

<sup>22</sup>This amounts to setting to zero all the coefficients associated with credit in the first scenario, and credit and house prices in the second scenario, in the consumption equation. This exercise is after a purely mechanical decomposition of the responses, although we are aware that this might be subject to the Lucas critique. See Carrillo et al. (2020) for a methodologically similar counterfactual exercise.

consumption in the absence of each of these channels, and report them in Table 2.<sup>23</sup> The collateral and housing wealth channels each contribute about 0.4% to the cumulated response of consumption at a 10-year horizon, and jointly explain about 87% of the total consumption response to the domestic housing demand shock. Therefore, not only are the two channels about equally important but also capture the main driving forces behind the consumption response.

Table 2: Long run cumulative impact on consumption

	D.H.D	F.H.D
Total	0.89%	0.64%
Collateral channel	0.36%	0.02%
Housing wealth channel	0.41%	0.79%

Notes: The table shows the cumulative rise in consumption following a domestic (D.H.D) and foreign (F.H.D) housing demand shock respectively at a 10-year horizon.

On the other hand, in the case of a foreign housing demand shock the consumption response is purely driven by the housing wealth channel. Indeed, the top right panel in Figure 6 shows a very similar consumption response in the absence of credit movements, but the bottom right panel shows a very muted consumption response in the absence of both credit and house prices. In Table 2 we quantify the relative sizes and find that the housing wealth channel dominates the entire response, and the cumulative impact due to this channel is stronger than in the benchmark response, since consumption in the latter falls in the first few periods.

## 5 Validating the identified shocks

In this section we test the information content of the identified housing demand shocks by studying their historical impact on key observables. Armed with a set of specific events which likely contributed to these shocks, we observe whether the timing of these events and the contribution of the shocks overlap. We find that most events line up very well with the shocks we disentangle. This gives us further confidence in the strength of the identification strategy discussed in 3.2 and how it is able to provide plausible results without resorting to additional identifying assumptions, such as narrative sign restrictions as in [Antolin-Diaz and Rubio-Ramirez \(2018\)](#). Figure 7 shows the contribution of the two housing demand shocks to growth in house prices, household credit and

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<sup>23</sup>We obtain the contribution from the collateral channel by cumulating the difference between the median benchmark response and that when credit is switched off (dashed black less dashed red lines). The contribution from the housing wealth channel is the cumulated difference between the response when credit is switched off and the that when both credit and house prices are switched off (dashed red less dashed blue lines).

consumption, where the latter two are both expressed in per capita terms.<sup>24</sup> When the shaded area is below the actual data, this implies that the shock contributed positively to the variable in question, and vice versa. For example, in the beginning of 2011, house price growth would have been around 0% instead of -5% in the absence of both housing demand shocks.

The earliest specific event of interest in our sample is the referendum on Malta's membership of the European Union (EU), which was held in March 2003, labelled 'EU ref.'. We view the outcome, which was in favour of EU membership, as contributing to optimism about the economic outlook and development which boosted asset prices, credit and consumption.<sup>25</sup> In fact, the contribution of domestic housing demand shocks to house prices – and to a lesser extent consumption – turned positive in the wake of this event, and the negative contributions to credit started to subside.<sup>26</sup> Malta then joined the EU on 1 May 2004, marked 'EU accession' in Figure 7. The contribution of domestic housing demand shocks was the highest in this period, also explaining the rise in credit and consumption per capita.

The next event related to the housing market is a measure announced in the 2008 Budget Speech, effective as from 2007Q4, which offered an interest rate subsidy for first time buyers of up to 1% on the base rate if this was greater than 3.75% for 10 years, and the lower stamp duty of 3.5% on a personal residence worth up to €70,000 was extended to property valued at up to €116,498. We label this event as 'interest subsidy'. This measure was meant to stimulate the property sector, which was experiencing a heavy correction following several years of strong growth. We find that in this period low housing demand contributed negatively to house price growth, and the measure does not seem to have had any major influence on house prices, credit and consumption.<sup>27</sup>

Two other related events that we consider relevant for explaining shocks are the stamp duty exceptions for first-time buyers in 2014 and for second-time buyers in 2018 ('FTB st.duty' and 'STB st.duty' respectively). These two policies reduced the amount of stamp duty that a household incurs upon buying a house, and the former in particular was aimed at re-igniting the real estate market following years of subdued activity.<sup>28</sup>

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<sup>24</sup>The contributions of the identified shocks are calculated as the median of the distribution of all the historical decompositions, calculated as in [Burbidge and Harrison \(1985\)](#), across all the retained draws. We are aware of the critique outlined in [Fry and Pagan \(2011\)](#) and the ensuing possibility of using their solution, i.e., the Median Target Method. The latter is correct from a theoretical standpoint but is more difficult to implement from a practical perspective. This is so as the draw that generates the impulse responses that are the closest to the median will likely differ on the basis of many factors, such as, number of sampler draws, random generator seeds, and so on. As such, the results are likely to change from estimation to estimation making any meaningful inference difficult.

<sup>25</sup>See the discussion in [Gatt and Grech \(2016\)](#) and [Micallef \(2018\)](#).

<sup>26</sup>The referendum was held on 8 March. Given that the outcome was not clear ex-ante, and confirmed ex-post by a relatively slim margin, we mark the event as taking effect from 2003Q2.

<sup>27</sup>However, our analysis does not allow us to make statements on what would have happened had this measure not been implemented.

<sup>28</sup>The first-time buyer scheme waived all stamp duty payable on €150,000 from the value of the property to be purchased, while the second-time buyer scheme awarded a refund on stamp duty paid of up to €3,000.

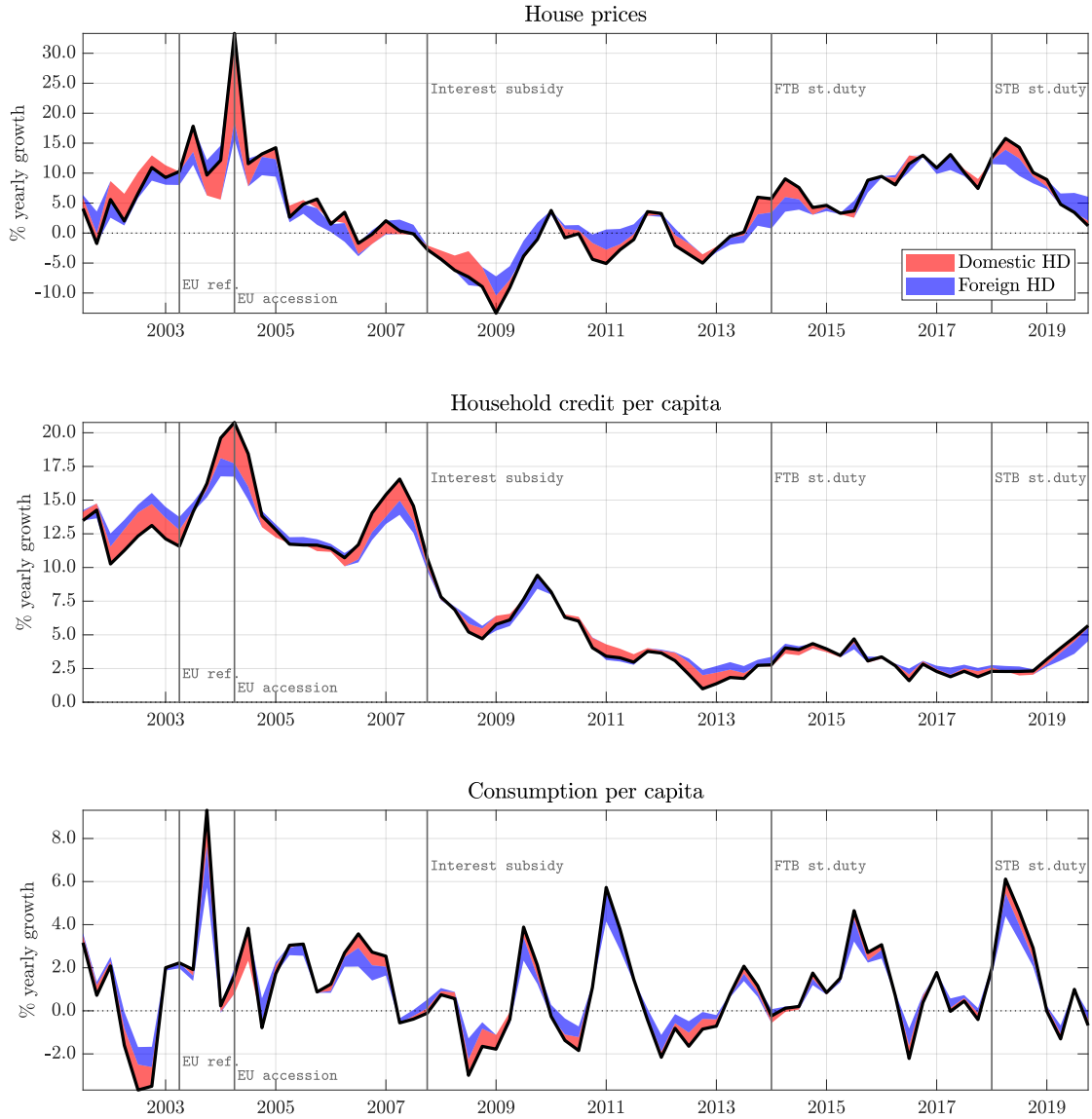


Figure 7: Contributions of the domestic and foreign housing demand shocks

Notes: In each panel the black line denotes the actual data and the shaded areas represent the contribution of the domestic (red) and foreign (red) housing demand shocks at each point in our sample. The horizontal axis denotes the first quarter in a given year, and the data shown spans the period 2001Q3-2019Q4. Shaded areas below the line indicate positive contributions while areas above the line indicate negative contributions. For instance, house price growth would have been zero in the beginning of 2007 in the absence of domestic housing demand shocks. The timing of the events as plotted are: ‘EU ref’ – 2003Q2, ‘EU accession’ – 2004Q2, ‘Interest subsidy’ – 2007Q4, ‘FTB st.duty’ – 2014Q1, and ‘STB st.duty’ – 2018Q1.

These two events coincide with sizeable, positive contributions of domestic housing demand shocks to house prices. The policy relating to first-time buyers was announced while domestic demand was already strong. However, since we use advertised house prices, we cannot rule out possible anticipation effects behind the rise in house prices prior to 2014. Although this policy was extended every year up to the end of our sample, we do not find strong contributions of housing demand shocks to house prices until the

stamp duty refund for second-time buyers was announced. The latter coincides with a reversal from negative to positive contributions to house prices, and we interpret at least part of the rebound in advertised prices at that point in time to this policy.<sup>29</sup>

Another noteworthy event in 2014 is the reduction in rental income tax from 35% to 15%. This likely contributed to the housing sector by boosting the supply of rental properties. Notwithstanding this, our decomposition attributes positive foreign housing demand shocks which pushed up house prices in this period. As we show in Figure 8, the number of foreign workers was rising at double digit rates in this period, with demand likely outstripping supply and putting further upward pressure on house prices.

We now turn our attention to foreign housing demand shocks. Figure 8 shows the contribution of these shocks to house prices and consumption and plots them on top of the dynamics of foreign workers in Malta.<sup>30</sup> Growth in the number of foreign workers correlates strongly with the contribution of our identified foreign demand shock on house prices and consumption, giving us confidence in our identification strategy. In particular, the house price contribution and foreign worker growth fit each other very well in the period 2004–2014, even though in our estimation we divide real variables by the total population, which followed largely different growth dynamics (see Figure 2 in the introduction).<sup>31</sup> In the bottom panel we lag the contribution to consumption by a year since the effect of the FHD shock takes about this much time to take full effect. This contribution also correlates reasonably well with the dynamics of foreign workers, albeit to a lesser extent than house prices. Our results for the contributions of foreign housing demand shocks on the variables in Figure 7 are therefore explained well by the movement in foreign workers over time.

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<sup>29</sup>The accuracy behind the Central Bank of Malta’s advertised house price index is likely to have fallen over the latter part of our sample. This is because the index is based on adverts listed in a leading Sunday newspaper, which have fallen in volume over the past years given the decline of print to online newspaper readership. Therefore, although both the implied trends in property price inflation and our estimated contributions of the shocks to this seem reasonable, we acknowledge that the actual growth rate is subject to a degree of uncertainty.

<sup>30</sup>We focus on foreign workers, rather than foreign population, as we believe the former offer a better mapping to housing demand, since a worker can live alone, or share accommodation with another worker, but a family is less likely to be composed entirely of workers.

<sup>31</sup>The correlation over the period 2002-2019 is 0.58. If we exclude 2019 on the basis of not having data on foreign workers for the full year, the correlation rises to 0.62. If, instead, we consider only the 2004-2019 period (post-EU accession) the correlation goes up to 0.74.



Figure 8: The foreign labour force and housing demand shocks

Notes: The figure shows the contribution of foreign housing demand shocks to house price growth on the right axis, averaged over a year. The last observation for foreign workers data is as at October 2019. The contribution of the shock to consumption is lagged by one year in the lower panel.

## 6 Conclusion

In this paper we look at the link between house prices and consumption, motivated by the collateral and housing wealth channels documented in the literature. We use a SVAR estimated on Maltese data to study the responses of a set of macroeconomic variables to housing demand shocks. We propose an identification strategy that allows us to disentangle the effects of two housing demand shocks, to capture the potentially different channels through which they might propagate, contributing to the literature.

We find a positive response of consumption to a domestic housing demand shock, driven equally by both the collateral and housing wealth channels. This is in line with theoretical predictions from DSGE models and empirical evidence from VAR models estimated for other economies. Therefore, the results in this paper also serve as an important cross-check on the same theoretical restrictions imposed in MEDSEA-FIN via the collateral constraint. Domestic housing demand shocks contributed significantly to the evolution of house prices, credit and consumption in Malta. Moreover, we also find an important role for foreign housing demand shocks, driven by strong inflows of foreign workers in the Maltese economy, on house prices and consumption.



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## Appendix A Data

### A.1 Retail Price Index

We use the Retail Price Index as our price series when the data does not have its corresponding deflator. We re-base it to 100 in the year 2000 and exclude the contribution of the component relating to rents from this index.<sup>32</sup> We use a seasonally adjusted series based on the Census X12 method. We source the raw data from the Central Bank of Malta.

### A.2 Population and Foreign workers

Population data are available in annual frequency from Eurostat. We interpolate the data within the year using a cubic spline, such that the end-of-year value is consistent with the official number. We build the 2019 figure based on EURPOP19 projections. The data for foreign workers is sourced from JobsPlus and are end-of-year values. Data for 2019 was only available up to October.

### A.3 House prices

House prices are measured using the Central Bank of Malta's house price index, which is based on advertised property prices. We re-base the index to 100 in 2000 and deflate it using the RPI index after we remove the housing component.

### A.4 Consumption and GDP

Real consumption and GDP are defined as the ESA 2010 chain-linked volumes. The vintage relates to NSO news release 091/2020 which reports data up to 2020Q1 and therefore the data for the period 2011–2019 are subject to revisions. We seasonally adjust using Census X12 both series and express them in per capita terms based on the population series we construct.

### A.5 Total household credit

Total credit to households for the period 2003Q4–2019Q4 is obtained from the Central Bank of Malta (OMFI loans to residents of Malta by economic activity) using end-of-period values. Data prior to this is constructed by obtaining corresponding series from the STREAM database, which is the Central Bank of Malta's macroeconomic model, and splicing the missing values for OMFI loans back to 2000Q1 based on quarterly growth rates. We divide total credit by population and deflate it using the RPI.

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<sup>32</sup>The contribution of this component was historically very small, at less than 0.1 percentage points throughout the period of interest, since the weight on the rents index is very small (varying between 0.72% in the early 2000s to 1.08% more recently)

## A.6 Lending interest rates

We build the lending interest rate series by splicing MIR lending rates to households and NPISH (new business), available from January 2008 onwards, with the OMFI lending rate to households and individuals for the earlier period, using the spread between these two series from 2008 on. All data is sourced from the Central Bank of Malta. We take quarterly average and express the lending rate in real terms by subtracting yearly RPI inflation.

## Appendix B Technical details

### B.1 Estimation procedure

This appendix aims at illustrating the technical details relative to the procedure to estimate the model in Section 3. The VAR described in (1) can be compactly written as:

$$\mathbf{Y} = \mathbf{X}\mathbf{B} + \mathbf{U} \quad (\text{B.1})$$

where  $\mathbf{Y} = [y_1, \dots, y_T]'$ ,  $\mathbf{B} = [A, B, C_1, \dots, C_L, D_1, \dots, D_L]'$ ,  $\mathbf{U} = [u_1, \dots, u_T]'$ , and

$$\mathbf{X} = \begin{bmatrix} 1 & 1 & y'_0 & \dots & y'_{-L} & z'_0 & \dots & z'_{-L} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 1 & T & y'_{T-1} & \dots & y'_{T-L} & z'_T & \dots & z'_{T-L} \end{bmatrix}.$$

For ease of estimation, the model in (B.1) can be written in vectorised form as

$$\mathbf{y} = (I_N \otimes \mathbf{X})\boldsymbol{\beta} + \mathbf{u} \quad (\text{B.2})$$

where  $\mathbf{y} = \text{vec}(\mathbf{Y})$ ,  $\boldsymbol{\beta} = \text{vec}(\mathbf{B})$  and  $\mathbf{u} = \text{vec}(\mathbf{U})$ . In equation (B.2),  $\text{vec}()$  is the columnwise vectorisation operator and  $\mathbf{u} \sim N(0, \Sigma \otimes I_T)$ . The likelihood function for  $\mathbf{B}$  and  $\Sigma$  implied by equation (B.2) is derived in [Kadiyala and Karlsson \(1998\)](#) and assumes the following form:

$$L(\mathbf{B}, \Sigma) \propto |\Sigma|^{-\frac{T}{2}} \exp\left(-\frac{1}{2}(\boldsymbol{\beta} - \hat{\boldsymbol{\beta}})'(\Sigma^{-1} \otimes \mathbf{X}'\mathbf{X})(\boldsymbol{\beta} - \hat{\boldsymbol{\beta}})\right) \exp\left(-\frac{1}{2}\text{tr}(\Sigma^{-1}\hat{S})\right) \quad (\text{B.3})$$

where  $\hat{S} = (\mathbf{Y} - \mathbf{X}\hat{\mathbf{B}})'(\mathbf{Y} - \mathbf{X}\hat{\mathbf{B}})$  and  $\hat{\boldsymbol{\beta}} = \text{vec}(\hat{\mathbf{B}})$  with  $\hat{\mathbf{B}} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y}$ .

We use a Normal-inverse Wishart prior for  $\boldsymbol{\beta}$  and  $\Sigma$  as follows:

$$p(\boldsymbol{\beta}, \Sigma) \sim N(\bar{\boldsymbol{\beta}}, \Sigma \otimes \bar{H}) \quad (\text{B.4})$$

$$p(\Sigma) \sim IW(\bar{S}, \bar{\alpha}). \quad (\text{B.5})$$

In (B.4), the prior mean  $\bar{\boldsymbol{\beta}}$  is set in such a way to incorporate the belief that each variable in  $y_t$  follows a random walk process like in a Minnesota prior ([Litterman, 1986](#)). As the variables in the estimation enter in logarithms, this reflects the belief that the latter are characterised by high persistence. As such, considering that  $l = 1, \dots, L$  denotes

the lag order while  $i, j = 1, \dots, n$  the equation number in the vector autoregression, the elements of  $\bar{\beta}$  in (B.4) are set in the following way:

- $\overline{b_{l,i,j}} = 1$  if  $l = 1$  and  $i = j$ , i.e., for the coefficient on first lagged value of the  $n^{\text{th}}$  endogenous variable in the  $n^{\text{th}}$  equation;
- $\overline{b_{l,i,j}} = 0$  otherwise.

Furthermore, following [Blake and Mumtaz \(2017\)](#),  $\bar{H}$  is a  $K \times K$  diagonal matrix with  $K = (NL + ML + 2)$  and diagonal elements set as follows:

- $\left(\frac{\lambda_0 \lambda_1}{l^{\lambda_3} \sigma_n}\right)$  for the coefficients on the lagged values of the  $n^{\text{th}}$  endogenous variable in the  $n^{\text{th}}$  equation;
- $(\lambda_0 \lambda_4)^2$  for all the other coefficients, i.e., intercept, time trend and lagged values of the exogenous variables.

The hyperparameters in the  $\bar{H}$  matrix in (B.4) are set in a quite standard way and have the following function:

- $\lambda_0$  controls the overall tightness of the prior and is set to 1;
- $\lambda_1$  controls the tightness on the coefficients associated with the first lagged values of the endogenous variables and is set to 0.5;
- $\lambda_3$  controls the degree of shrinkage on higher order lags of the endogenous variables and is set to 1;
- $\lambda_4$  controls the degree of shrinkage on all the other coefficients and is set to  $10^4$ , i.e., a flat prior on all the exogenous component.

In (B.5),  $\bar{\alpha} = N + 1$  while  $\bar{S}$  is an  $N \times N$  diagonal matrix with elements equal to  $\left(\frac{\sigma_n}{\lambda_0}\right)^2$ . The choice of  $\lambda_0 = 1$  implies that the prior scale  $\bar{S}$  of the variance-covariance matrix  $\Sigma$  is obtained through the AR(1) residual variances of the  $N$  endogenous variables.

We can then obtain the posterior, as the product of a Normal distribution for  $\beta$  conditional on  $\Sigma$  and an inverse Wishart distribution for  $\Sigma$ , through the following expression:

$$p(\mathbf{B}, \Sigma | \mathbf{Y}, \mathbf{X}) \propto |\Sigma|^{-\frac{K}{2}} \exp\left(-\frac{1}{2}(\beta - \tilde{\beta})'(\Sigma^{-1} \otimes \tilde{H})(\beta - \tilde{\beta})\right) |\Sigma|^{-\frac{T+\bar{\alpha}}{2}} \exp\left(-\frac{1}{2}\text{tr}(\Sigma^{-1}\tilde{S})\right) \quad (\text{B.6})$$

where  $\tilde{\alpha} = T + \bar{\alpha}$ ,  $\tilde{H} = (\mathbf{X}'\mathbf{X} + \bar{H}^{-1})^{-1}$ ,  $\tilde{\mathbf{B}} = \tilde{H}(\mathbf{X}'\mathbf{Y} + \bar{H}^{-1}\bar{\mathbf{B}})$  with  $\text{vec}(\tilde{\mathbf{B}}) = \tilde{\beta}$  and, finally,  $\tilde{S} = \mathbf{Y}'\mathbf{Y} + \bar{S} + \bar{\mathbf{B}}'\bar{H}^{-1}\bar{\mathbf{B}} - \tilde{\mathbf{B}}'\tilde{H}^{-1}\tilde{\mathbf{B}}$ . As such, our inference is carried out by drawing from the following posterior distributions:

$$p(\beta, |\Sigma, \mathbf{Y}, \mathbf{X}) \sim N(\tilde{\beta}, \Sigma \otimes \tilde{H}) \quad (\text{B.7})$$

$$p(\Sigma | \mathbf{Y}, \mathbf{X}) \sim IW(\tilde{S}, \tilde{\alpha}). \quad (\text{B.8})$$

Finally, as specified in Section 3, we implement the procedure described in [Arias et al. \(2018\)](#) to obtain the shock identification through a mix of zero and sign restrictions.

## B.2 Lag length selection

This appendix aims at justifying the choice of the lag length used to estimate the model in equation (1). We use two measures to gauge the goodness of fit. The first is the marginal likelihood as recommended in [Carriero et al. \(2012\)](#) or [Giannone et al. \(2015\)](#), while the second is the Deviance Information Criterion (DIC) suggested in [Spiegelhalter et al. \(2002\)](#). We calculate the two measures by estimating the model in (1) with one up to five lags, that is, from the minimum possible to a lag length covering one year of data plus one quarter. The criteria are shown below:

Table 3: Information criteria

Lags	Marginal likelihood	DIC
1	1022.5	-2249.1
2	1016.7	-2251.8
3	1003.6	-2231.9
4	988.9	-2214.8
5	979.6	-2189.3

Note: DIC – Deviance Information Criterion

The second column of Table 3 shows how the model with only one lag should be preferred as it is associated with the highest value of the marginal likelihood. On the other hand, the third column shows how a model with two lags should be preferred as it is associated with the lowest value of the Deviance Information Criterion. We prefer to estimate the model by employing two lags as suggested by the DIC, since this criterion penalizes for the effective number of parameters to be estimated. As both the marginal likelihood and the DIC do not change remarkably when moving from one model to the other, we prefer to use an information set that covers six months of data with the belief that this helps better capture the dynamics of the data used.

## B.3 Convergence Diagnostics

This appendix shows the convergence diagnostics relative to the model presented in section 3. As suggested in ([Primiceri, 2005](#)), in order to assess the satisfactory performance of the algorithm, the 20th-order autocorrelation of the retained draws is employed. The red vertical lines separate the autocorrelations of the intercept, time trend and slope coefficients, i.e.,  $A$ ,  $B$ ,  $C$  and  $D$  in (1), from those of the variance-covariance matrix  $\Sigma$ .

Figure B.1 shows how all the autocorrelations of the retained draws lie within the  $[-0.2, 0.2]$  interval. Independently of the high dimensionality of the model, the algorithm performs in a satisfactory way and the draws are nearly independent. As such, the latter can be used to conduct a meaningful inference.



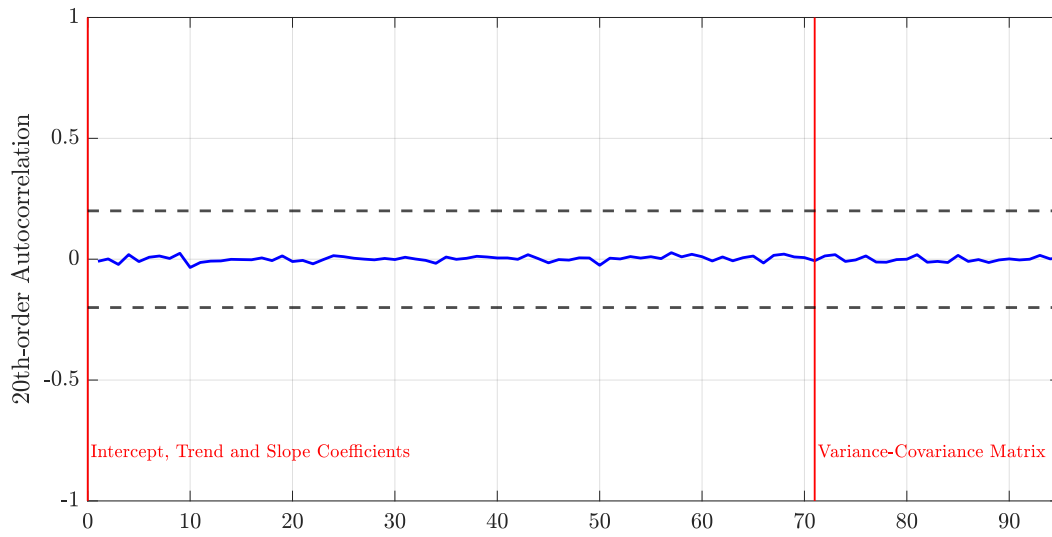


Figure B.1: 20<sup>th</sup>-order autocorrelation of the retained draws of the VAR parameters

## Appendix C Other figures

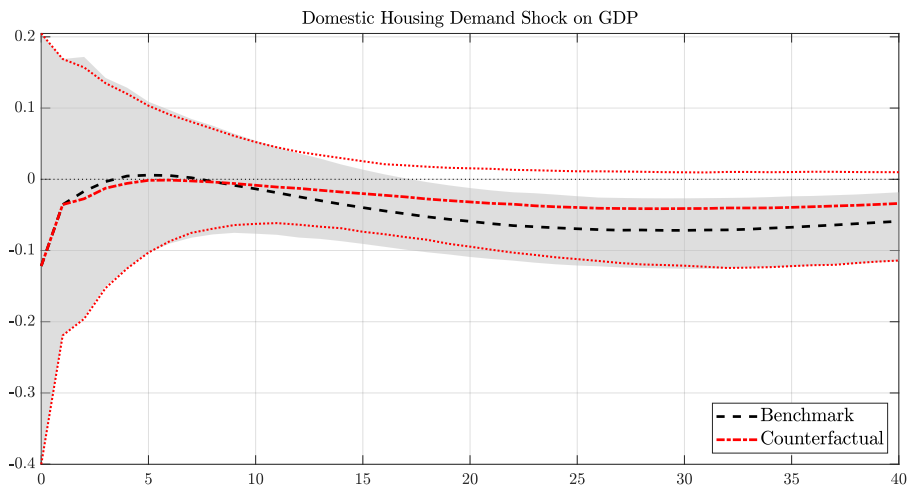


Figure C.1: Counterfactual IRF of GDP for DHD shock without RPI feedback

Notes: The figure shows the median responses across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in house prices on impact in both scenarios.

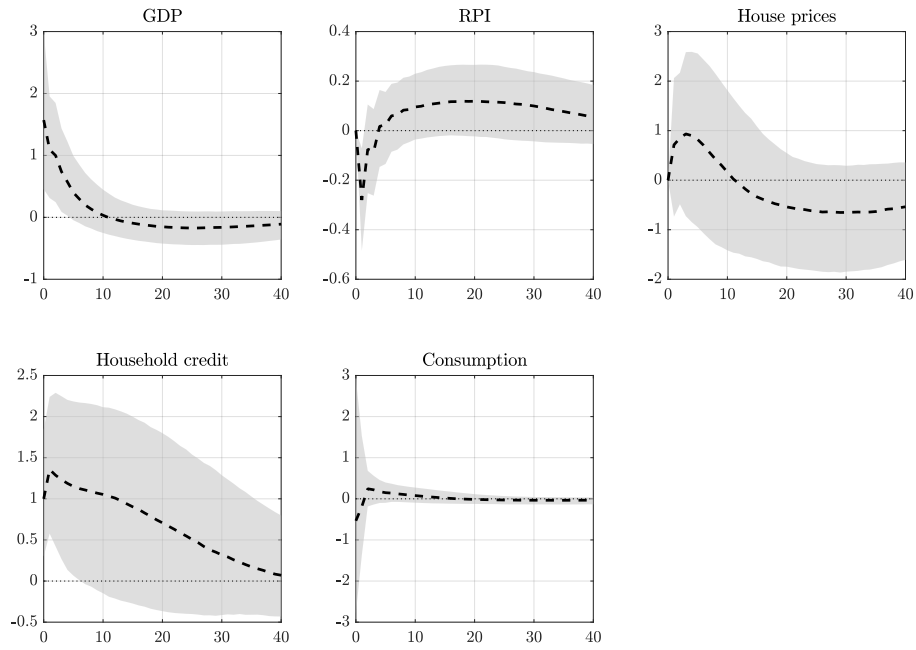


Figure C.2: IRFs to loan supply shock

Notes: The figure shows the median response across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in household credit per capita on impact.

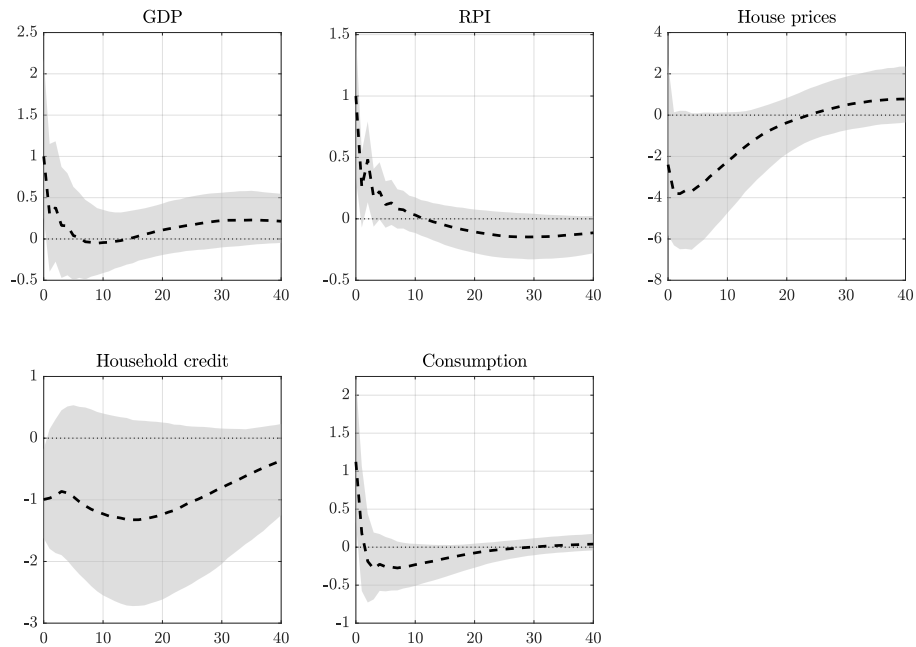


Figure C.3: IRFs to aggregate demand shock

Notes: The figure shows the median response across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in real GDP per capita on impact.

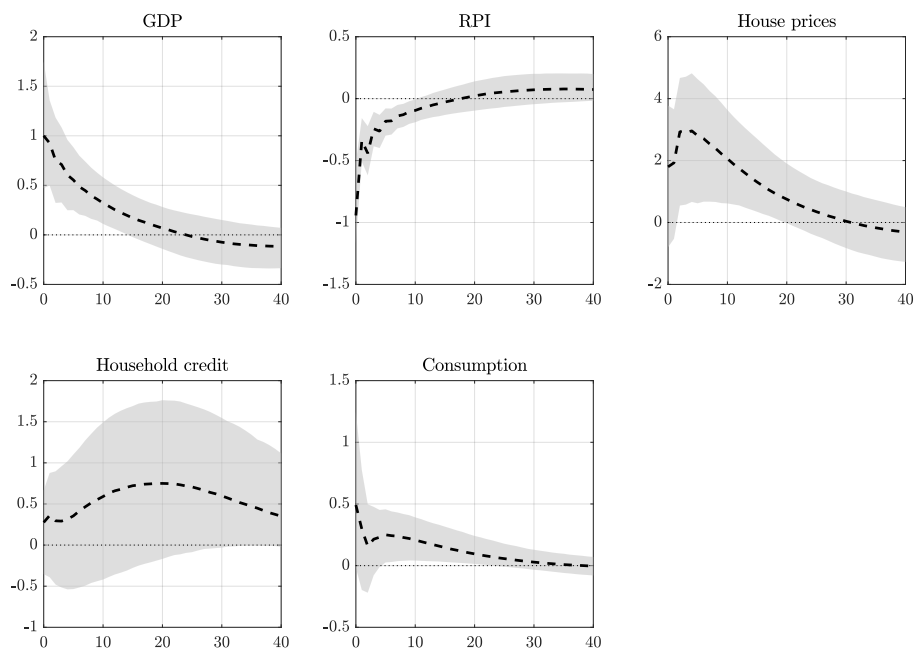


Figure C.4: IRFs to aggregate supply shock

Notes: The figure shows the median response across the identified sets and the 68% credible bands, in percentage deviation from the baseline projection. Values on the horizontal axis are quarters following the shock. We normalize the shock to produce a 1% rise in real GDP per capita on impact.