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DOMESTIC AND GLOBAL DETERMINANTS OF INFLATION: EVIDENCE FROM EXPECTILE REGRESSION

by Fabio Busetti*, Michele Caivano* and Davide Delle Monache*

Abstract

The paper investigates the role of domestic and global determinants of euro area core inflation. We analyse the entire conditional distribution of inflation by estimating a Phillips curve type relationship using an expectile regression approach, extended to capture time-varying effects. The main findings are as follows. First, both the domestic and foreign output gap are significant drivers of euro area core inflation, once external demand pressures are properly orthogonalized in a modified measure of domestic gap. However, the inflationary impact of the domestic component is relatively stronger. Second, the domestic output gap has a bigger influence in the right tail of the conditional distribution of inflation. Third, adding international price pressures in the regression weakens the link between inflation and the foreign output gap. Fourth, in a time- varying perspective, there is an increase in the response of inflation to the domestic gap in the last decade but only at the lower quantiles. Overall, the evidence on the so-called "globalization hypothesis" is mixed: while the pass-through to inflation of foreign prices and the exchange rate increased over time at all quantiles, the impact of global slack remained broadly stable, particularly in the central part of the distribution.

JEL Classification: C53, E17.
Keywords: asymmetric least squares, globalization, inflation quantiles, Phillips curve, time varying parameters.

Contents

* Bank of Italy, Directorate General for Economics, Statistics and Research.

1 Introduction*

Inflation rates tend to move together in advanced economies as a result of common trends in commodity prices and a certain degree of synchronization of business cycles and monetary policies. For example, Ciccarelli and Mojon (2010) found that a global factor accounts for nearly 70% of the variance of inflation in 22 OECD countries.[1]

Some authors have further argued that globalization has made inflation react relatively more to global economic conditions, with some additional impact on top of the standard channel of import prices. The reason is that increased trade integration may "*have made markets much more contestable, eroding the pricing power of both labour and firms*"; see, among else, Borio and Filardo (2007), Auer et al. (2017), Borio (2017, p. 4). Forbes (2018) provides considerable empirical evidence to support this claim and she illustrates the various channels through which globalization may affect firms pricing decision. Other empirical studies nevertheless find no or only negligible effects of global economic slack on domestic inflation.[2]

The Phillips curve is the standard framework to describe the relationship between inflation and demand pressures, labour market conditions and firms'pricing policies in a closed economy; in empirical investigations it is usually augmented to capture inflation expectations and the pass-through of import and commodity prices. In the 2000's several policymakers flashed a 'flattening' of the Phillips curve, i.e. a lower response of inflation to measures of economic slack. In contrast to the view on globalization, the flattening was mainly linked to the change of paradigm in monetary policy, switched to explicit inflation targeting, that has proved successful for stabilizing actual and expected inflation; see, among else, Roberts (2006), Williams (2006), Mishkin (2007), Gaiotti (2010). During the last decade, the possibility of changes in the sensitivity of inflation to economic slack has been related to nonlinearities and mismeasurements in output and unemployment gaps.[3]

This paper investigates the role of domestic and global determinants of euro area core inflation. The focus is on the entire conditional distribution of inflation. We estimate a Phillips curve type relationship through the method of expectile

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* *The view expressed here are those of the authors and do not necessarily reflect those of the Bank of Italy.*

[1] Further evidence of a large global component of inflation is given in Monacelli and Sala (2009), Neely and Rapach (2011), Delle Monache, Petrella and Venditti (2016), Carriero, Corsello and Marcellino (2018). The weight of the global factor is lower when inflation is measured net of the energy and food components.

[2] See, among else, Ball (2006), Calza (2009), Milani (2010), Ihrig et al. (2010), Mikolajun and Lodge (2016), ECB (2017), Bereau et al. (2018). Bianchi and Civelli (2015) nd that global slack affects the dynamics of inflation in many countries, but its influence has not become stronger over time.

[3] See, for instance, Ball and Mazumder (2011), Riggi and Venditti (2015).

regression (or asymmetric least squares), that is here extended in a novel way to capture time-varying effects. Expectiles describe the whole distribution of a stochastic variable and can be easily mapped into quantiles if wished so; see Newey and Powell (1987), Efron (1991). Hence expectile methods can be used also to estimate specific quantiles. Compared with quantiles, conditional expectiles are simpler to characterize, which facilitates the extension to a time-varying framework proposed here.

The main findings of our study are as follows. First, as expected, domestic and foreign output gaps tend to be highly correlated making it generally difficult to disentangle their effect on inflation. However we find that both of them are significant drivers of euro area core inflation, once external and domestic demand pressures are properly orthogonalized. The inflationary impact of the domestic component is however relatively stronger. The orthogonalization of domestic and foreign demand pressures has been achieved by simulating, through a VARX model, a counterfactual path for the euro area GDP based on a foreign demand variable net of its cyclical component. This model-based orthogonalization has not been considered in other works, in which empirical results might be obscured by collinearity of regressors. Second, domestic output gap has a stronger impact in the right tail of the conditional distribution of inflation. Third, adding international price pressures in the regression (imported prices and the exchange rate) weakens the link between inflation and foreign output gap. Fourth, in a time-varying perspective, there is an increase of the response of inflation to domestic gap in the latest decade but only at the lower quantiles. The pass-through to inflation of import prices and the exchange rate tends to become stronger over time at all quantiles. Finally, the underlying model-based measure of core inflation shows a tendency to fall in recent periods.

Other papers have analyzed the conditional distribution of inflation in a quantile regression framework, but without explicitly allowing for time-varying effects. Manzan and Zerom (2013) argue that macroeconomic indicators are useful for predicting the distribution of US inflation, while Wolters and Tillman (2015) find a decrease in persistence at all quantiles since the early Eighties. The distribution of euro area inflation is analyzed in Busetti, Caivano, Rodano (2015), Busetti (2017), Bereau, Faubert, Schmidt (2018) and Tagliabracci (2019) with findings that are broadly comparable to what presented here for the case of fixed coefficients.

In general, several studies have shown that the (augmented) Phillips curve is not stable over relatively long time spans; see e.g. IMF (2006), Stock and Watson (2009), Musso, Stracca, VanDijk (2009). Looking at the recent evidence on possible structural changes and time-varying parameters, our empirical results confirm the claim of Forbes (2018) of an increase of the role of global factors in the last decade in terms of the response to import prices and the exchange rate, but not with respect to foreign demand pressures; this latter result is in line with Bianchi and Civelli (2015). Then, if we restrict to the lower quantiles of the distribution, our results share some similarity with Riggi and Venditti (2015) where the possibility of an increased response of euro area inflation to cyclical conditions is investigated.

The paper proceeds as follows. Section 2 presents the methodological framework of expectile regression, that is here extended to allow for time-varying coefficients. Section 3 introduces a model-based measure of domestic output gap, net of foreign demand pressures. Preliminary OLS evidence on a Phillips curve relationship with domestic and global drivers is presented in section 4. In section 5 the regression model is estimated for several conditional quantiles/expectiles of euro area core inflation and empirical evidence on time-variation of the regression coefficients is provided. Section 6 concludes.

2 Quantile and expectile regression

Let $q(\alpha)$ be the quantile of order $\alpha \in (0,1)$ of a random variable with a continuous distribution function $F(.)$, i.e. $F(q(\alpha)) = \alpha$. The empirical quantile from a sample of n observations $y_1,\ y_2,\ ...,\ y_n$ can be computed by ordering them in ascending order or, equivalently, by minimizing

$$S_\alpha = \sum_{t=1}^{n} \xi_\alpha \left(y_t - q\right)$$

where $\xi_\alpha(e) = e\ \left(\alpha - I(e<0)\right)$ is the so-called 'check function' and $I(.)$ denotes the indicator function.

Expectiles are measures of location similar to quantiles, but they are determined by tail expectations rather than tail probabilities. For a random variable with a finite mean, the expectile of order $\omega \in (0,1)$, denoted as $\mu(\omega)$, is defined by the following equation[4]

$$(1-\omega)\int_{-\infty}^{\mu(\omega)} (y-\mu(\omega))\, dF(y) + \omega \int_{\mu(\omega)}^{\infty} (y-\mu(\omega))\, dF(y) = 0.$$

The sample expectile is obtained by minimizing

$$L_\omega = \sum_{t=1}^{n} \rho_\omega \left(y_t - \mu\right) \tag{1}$$

where $\rho_\omega(e) = e^2\ |\omega - I(e<0)|$; see Newey and Powell (1987), Efron (1991). This is also called 'asymmetric least squares' since the estimate minimizes the squared

[4]For quantiles the corresponding equation is given by $(1-\alpha)\int_{-\infty}^{q(\alpha)} dF(y) - \alpha \int_{q(\alpha)}^{\infty} dF(y) = 0$.

residuals giving them different weight according to whether they are positive or negative. Note that $\omega = 0.5$ corresponds to Ordinary Least Squares and hence the estimate is the sample mean. Busetti and Harvey (2010) construct tests of stability of a distribution function based on partial sums of the first derivative of $\rho_\omega \left(y_t - \widehat{\mu}(\omega)\right)$, where $\widehat{\mu}(\omega)$ is the sample expectile; similar tests are obtained for quantiles.[5]

Quantiles and expectiles can be easily mapped into each other. For a given quantile $q(\alpha)$ there is a corresponding expectile of order $\omega(\alpha)$ given by

$$\omega\left(\alpha\right) = \frac{\alpha\ q(\alpha) + \int_{q(\alpha)}^{\infty} ydF(y)}{2\int_{q(\alpha)}^{\infty} ydF\left(y\right) - \left(1-2\alpha\right)\ q(\alpha)}.$$

The formula is obtained by equating the definitions of $q(\alpha)$ and $\mu(\omega)$ and then solving for ω; see also Yao and Tong (1996). As an example, for a Gaussian distribution $\mu(.25) = q(.33)$. In practice, given an estimate of an expectile the corresponding quantile order can be obtained by counting the numbers of observations below that value (Efron, 1991).[6]

Expectiles may depend on covariates. Assuming a linear relation with a vector of covariates x, $\mu(\omega|\,x) = \beta' x$, the parameter β can be estimated by expectile regression,

$$\widehat{\beta}(\omega) = \arg\min \sum_{t=1}^{n} \rho_\omega\left(y_t - x_t'\beta\right),$$

which is the obvious extension of (1). This boils down to OLS when $\omega = 0.5$. As shown in Newey and Powell (1987), $\widehat{\beta}(\omega)$ can be expressed as 'iterated weighted least square estimator', i.e. the solution of the equation

$$\widehat{\beta}(\omega) = \left[\sum_{t=1}^{n} w_t\left(\widehat{\beta}(\omega)\right) x_t x_t'\right]^{-1} \sum_{t=1}^{n} w_t\left(\widehat{\beta}(\omega)\right) x_t y_t \tag{2}$$

where the weights are

$$w_t\left(\widehat{\beta}(\omega)\right) = \left|\omega - 1\left(y_t - x_t'\widehat{\beta}(\omega) < 0\right)\right|.$$

Newey and Powell (1987) show that, under regularity conditions, the asymmetric least square estimator (2) is asymptotically Gaussian. The estimator of the limiting variance can be easily computed.

[5] De Rossi and Harvey (2009) extend a standard unobserved component framework to track time variation in quantiles and expectiles.

[6] As showed in Taylor (2008), expectiles are also closely related to *Expected Shortfall* $(ES(\alpha))$, a risk measure defined as the average value in the left tail of the distribution where the tail is delimited by $q(\alpha)$, $\alpha < 0.5$. Let $\omega(\alpha)$ be the expectile order corresponding to the α-quantile, then, for a random variable with zero mean, $ES(\alpha) = \mu(\omega(\alpha))\left(1 + \frac{\alpha}{(1-2\alpha)\omega(\alpha)}\right)$.

The simple expression for the estimator (2) facilitates an extension to a time-varying parameter framework. Here we propose a modification of the Kernel estimation of Giraitis et al. (2014), which is itself a generalization of the rolling window estimator. The time-varying expectile regression coefficient is hence given by

$$\widehat{\beta}_t(\omega) = \left[\sum_{s=1}^{n} K\left(\frac{t-s}{H}\right) w_s\left(\widehat{\beta}_s(\omega)\right) x_s x_s' \right]^{-1} \sum_{s=1}^{n} K\left(\frac{t-s}{H}\right) w_s\left(\widehat{\beta}_s(\omega)\right) x_s y_s \tag{3}$$

where $K(x) \geq 0$ is a usual kernel function, e.g. $K(x) = \frac{3}{4}(1-x^2)1(|x| \leq 1)$ or $K(x) = (2\pi)^{-0.5}\exp(-0.5x^2)$, and H is the bandwidth. Giraitis et al. (2014) derive the limiting properties of this type of estimator for a standard regression model with stochastic coefficients. A generalization of those asymptotic results to the case of expectile regression is beyond the scope of this paper.

3 Disentangling domestic and global determinants of inflation: preliminary OLS evidence

The output gap is generally measured through statistical filtering of the data, aimed at extracting the fluctuations (at business cycle frequencies) around an underlying trend. The so-called HP filter is a simple example. Filtering may be applied either to GDP or to each of its supply components (labour, capital and total factor productivity) assuming an aggregate production function for the economy. Although different filtering methods produce alternative results, the estimates typically share broadly similar characteristics and they are highly correlated. For example, the estimates of the euro area output gap produced by the IMF, OECD and European Commission are shown in the left-hand panel of Figure 1, together with the outcome of a standard HP filter. As it often happens, differences tend to be larger towards the end of the sample, when revisions due to new data are important.

Several authors have argued that global demand pressures may be an important driver of domestic inflation since trade integration "*have made markets much more contestable, eroding the pricing power of both labour and firms*"; see, among else, Borio and Filardo (2007), Auer et al. (2017), Forbes (2018). Borio and Filardo (2007) suggest to measure global economic slack by taking a weighted average of countries output gaps, where the weights reflect the commercial links with those countries (i.e. trade-weighted foreign output gap). The right-hand side panel of Figure 1 shows a proxy of foreign output gap for the euro area constructed precisely in that way, using the weights for the main trade partners with the euro area. The red line is constructed as a weighted average of the IMF estimates of countries annual output gap; the pink dotted line is similar except that each country output gaps is computed by a standard HP filter applied to quarterly GDP. By comparison, we also show two (equally weighted) measures of output gap for advanced economies, obtained by the IMF and OECD data respectively. Overall they are all broadly similar, as expected.

As business cycles and monetary policies show a certain degree of synchronization internationally, particularly among advanced economies, it is no surprise that the euro area output gap in the left panel of the figure shows a similar pattern to the proxy of global slack reported in the right panel. Hence, due to collinearity, it may be difficult to disentangle their effects in a regression model for inflation. As an alternative strategy one could think of constructing a proxy of domestic output gap that reflect business cycle developments net of the impact of foreign demand pressures. This would break most of the correlation between domestic and foreign output gap, making it easier to include both of them in a model for inflation. This is done in the next subsection using counterfactual simulations of a simple econometric model.

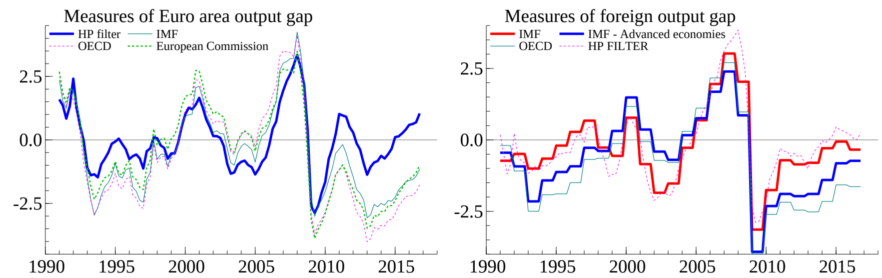

Figure 1: Output gap in the euro area and in the world economy

3.1 Removing global demand in a measure of domestic output gap

We start from a simple VARX model with 3 endogenous variables (real GDP, consumption deflator, long term interest rates), 2 lags and 3 exogenous variables (foreign demand, oil prices in euro, short term interest rates), estimated over the period 1980-2016; all variables, except for the interest rates, are in logs. Foreign demand is computed on the basis of real imports of goods and services of the main trading partners of the euro area. The data are taken from the Area Wide Model dataset, available online at https://eabcn.org/page/area-wide-model. In order to construct counterfactual simulations of euro area GDP net of foreign demand pressures, we are mostly interested in the dynamic responses of our VARX model with respect to a shock in foreign demand. These are shown in Figure 2 and compared with two benchmarks (that help validating our estimates): the ECB euro area wide model and the euro area aggregation of countries' results of the econometric models of the Eurosystem's national central banks; the figures are taken from Fagan and Morgan (2005, p.41). According to these results, a 1% increase of foreign demand rises the level of euro area GDP between 0.1 and 0.2 percentage points on average on a three-year horizon; the impact is somewhat more front-loaded in our simple VARX compared to macroeconometric models of the ECB and the national central banks.

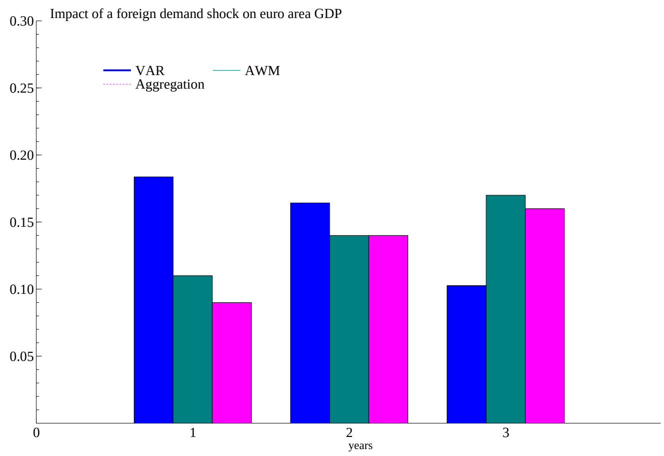

Figure 2: Elasticities of the euro area GDP to a permanent 1% increase in foreign demand

A measure of euro area domestic output gap, net of foreign demand pressures is computed as follows. First, a counterfactual path for the exogenous variable of foreign demand is assumed, imposing that it grows at a constant rate throughout the simulation period (the average growth rate over 1980-2016); hence, by assumption, global cyclical fluctuations are removed.[7] Then the VARX model is simulated under this alternative assumption of foreign demand to generate a counterfactual path of euro area GDP that, by construction, will be net of the global demand pressures. A 'domestic output gap' measure for the euro area is finally obtained by applying the HP filter to the counterfactual GDP series.

[7]This is arguably a crude approximation of a counterfactual scenario since, for instance, it ignores implications for commodity prices and the possibility of changes in the underlying trend of global output. Nevertheless, since we are not interested in the path of euro area GDP per se but only in its deviation from a trend, our approximation is less crude than could seem at a first sight.

The left-hand panel of Figure 3 shows the foreign output gap, the standard measure of euro area output gap (HP filter) and our proxy for the domestic component of the gap computed through the counterfactual simulation just described. While the standard euro area output gap (in red) and the foreign output gap (in black) look broadly similar, different patterns are clearly visible between the foreign gap and our measure of (counterfactual) domestic gap. For example, in 2009 the domestic component of output gap is not particularly negative, consistently with the evidence that the recession was mostly of imported nature; conversely, from 2011 to 2016, during the sovereign debt crisis and the following recovery the slack in the euro area appears to be mainly driven by its domestic component.

The scatter plot of the standard euro area output gap (red crosses) and the counterfactual measure of domestic demand pressures (blue squares) against the foreign gap is shown in the right-hand panel of Figure 3. The implied regression lines confirm a low correlation of the domestic and foreign gaps (R-square equal to 0.04), which supports the use of these two proxies as separate drivers in a model for inflation.

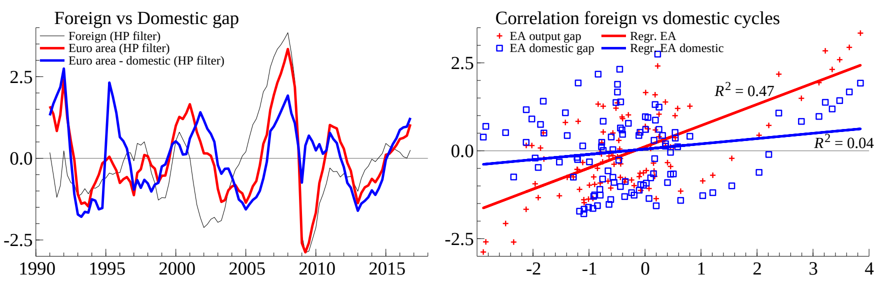

Figure 3: Domestic component of the euro area GDP

4 Evidence from OLS regressions

As a preliminary evidence, we estimate by OLS a standard Phillips curve type relationship for the euro area (with quarterly data over the period 1989-2016),

$$\pi_t = \beta_0 + \beta_1 \pi_{t-1} + \beta_2' x_{t-1} + \varepsilon_t, \tag{4}$$

where $\pi_t = 100\,(p_t/p_{t-4} - 1)$ is the year-on-year inflation rate which depends on its lagged values and on a set of covariates x_{t-1}, including (foreign and/or domestic) output gap and external price pressures (measured by the percentage change of either the import deflator or the effective exchange rate of the euro); $\beta = (\beta_0, \beta_1, \beta_2')'$ is the vector of slope parameters and ε_t is a stochastic disturbance.

Inflation is defined in terms of the Harmonized Index of Consumer Prices net of the more volatile components (food and energy) in order to insulate from the often large fluctuations due to commodity prices. The data for inflation, GDP, import prices and nominal effective exchange rate are taken from the area wide model database, while the measures of domestic and foreign output gap are those described in the previous section.

Table 1 in the appendix shows the regression results for several specifications[8], labelled (a) to (g); the coefficients highlighted in bold are statistically significant at least at the 5% level using HAC standard errors.

In all models the lagged dependent variable, domestic output gap and external price pressures are significant drivers of euro area core inflation, in line with the Phillips curve arguments and the empirical evidence of large degree of persistence in the inflation process.

Models (a) through (d) consider a standard measure of domestic gap, based on a HP filter of euro area GDP but the results would be similar for other cases. The slope coefficient is between 0.07 and 0.09, meaning that a one percent rise of output gap yields an immediate increase of inflation of nearly 0.1 percent and then gradually keeps feeding prices through the autoregressive component. In these regressions foreign output gap (measured by the weighted average of gaps of euro area trading partners) is not significant. This could be partly due to its correlation with the standard measure of output gap (as showed in Figure 3) yielding an issue of collinearity among regressors.

If our model-based orthogonalized measure of output gap is used (which basically removes the impact of external demand pressures) then both components of domestic and foreign output gap contribute to explaining the dynamics of core inflation; cf. columns (e), (f), (g). Their coefficients basically sum up to the one attached to the standard measure of gap in (a)-(d). Note that adding the import deflator to the equation weakens the link between inflation and foreign gap, showing that some of external demand pressures are already accounted in foreign prices developments.

Overall this preliminary OLS evidence suggests that our strategy of orthogonalizing domestic and foreign demand pressures is successful for modelling the conditional mean of core inflation. In the next sections we look if both measures of output gaps remain significant in explaining the lower and upper quantiles of the distribution of inflation using the method of expectile regression. We then explore the presence of time-varying effects.

[8] The results are similar results if the covariates x_t enter the regression without lag.

5 Using expectile regressions to assess the impact on the conditional distribution of inflation

Expectile regressions allow to track the properties of the distribution of euro area inflation (e.g. in terms of dispersion, asymmetry and tail behavior) as a function of the state of the economy. Both demand and supply determinants of inflation are considered and they are allowed to have different impact in different regions of the distribution and over time. in particular, a Phillips curve relationship (4) is estimated using the method of expectile regression, as described in Section 2. The vector of regression parameters now depends on the expectile order ω. We show results for $\omega = .05, .10, .25, .75, .90, .95$ and compute the corresponding quantiles orders; note that $\omega = .50$ boils down to the OLS regression showed previously.

Table 2 in the appendix reports the results for the simpler model where inflation depends only on its past values and on output gap, which is however disentangled into domestic and foreign components. Hence it generalizes regression (e) of Table 1; the constant term is not displayed.

A clear finding is that domestic demand pressures have stronger effects on the upper right tail of the distribution of core inflation; the slope coefficient is about three times larger and the statistical significance is also higher. The impact of foreign gap appears on the other hand rather similar across quantiles, although it is somewhat stronger in the lower part of the distribution. Note that the implicit quantile orders, reported in the last row of the Table, are not strikingly different from what implied by a Gaussian distribution, where e.g. $\omega = .05$ (.25) corresponds to $\alpha = .13$ (.33).

Overall, the upper side of the distribution of core inflation appears relatively more influenced by positive developments in the domestic economy than those at a global level, while the converse seems true for the left tail of the distribution. The results hence suggest that economic policies that stimulate the domestic economy may have a relatively smaller impact on inflation if global conditions remain weak.

Table 3 then displays results where a measure of foreign price pressure, either the import deflator or the nominal effective exchange rate, is added in the regression. As for the case of the conditional mean, it is found that the import deflator appears to partly capture also the impact of foreign gap, which becomes no longer statistical significant. Foreign gap remains however statistically significant if the exchange rate replaces the import deflator in the regression. A further interesting finding is that foreign price pressures have similar (and statistically significant) effects across all quantiles of core inflation.

5.1 Time-varying effects for conditional expectiles and the globalization hypothesis

The time-varying expectile regression framework introduced in section 2 is used to investigate whether the relationship at different quantiles between core inflation and its main drivers has changed over time. In particular, we are interested in the so-called 'globalization hypothesis' which would show up in a stronger influence of foreign variables in driving the dynamics of domestic inflation.

The left panel of Figure 4 shows the time-varying coefficients of domestic output gap for expectile orders $\omega = 0.10, 0.50, 0.90$ in an expectile regression model which contains both domestic and foreign variables, as in case (e) of Table 1. The coefficients of foreign output gap are instead displayed in the right panel of the figure.

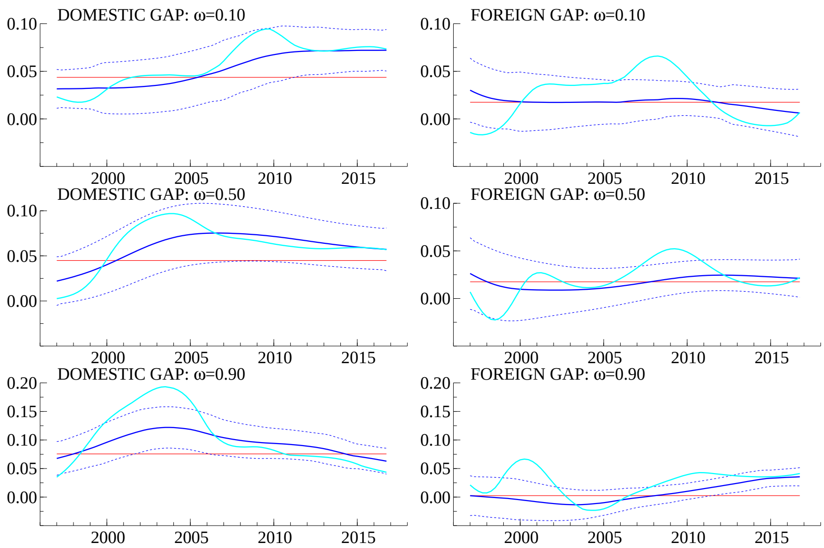

Figure 4: Coefficient estimates on the domestic and foreign gap

The time varying parameters are computed using formula (3) for two different values of the bandwidth parameter (that controls the degree of smoothing of the time-varying coefficients), with the dark (light) blue line indicating the case of more (less) smoothing; the first 8 years of observations are used to initialize the estimators. The values of the bandwidth parameter are chosen ad-hoc just to illustrate the sensitivity to the estimates to more local observations. For comparison, the fixed expectile regression coefficient is also showed in red (which for

$\omega = 0.5$ corresponds to the OLS coefficient). The confidence bands, displayed for the case of more smoothing, represent 2 times the time-varying standard deviation of the coefficient.[9]

Looking at the coefficients of domestic output gap the figure provides evidence of some increase in the slope of the Phillips curve in the latest decade but only for the lower quantiles; the response of foreign gap appears on the other hand more stable throughout time, with only some tendency to increase (from zero or slightly negative values) for $\omega = 0.90$.

The inflation response to foreign prices is showed in Figure 5. The left panel of the graph contains the time varying coefficients of the import deflator for the expectile regression corresponding to model (e) of Table 1. The right panel considers instead model (f) of Table 1, where the import deflator is replaced by the nominal effective exchange rate.

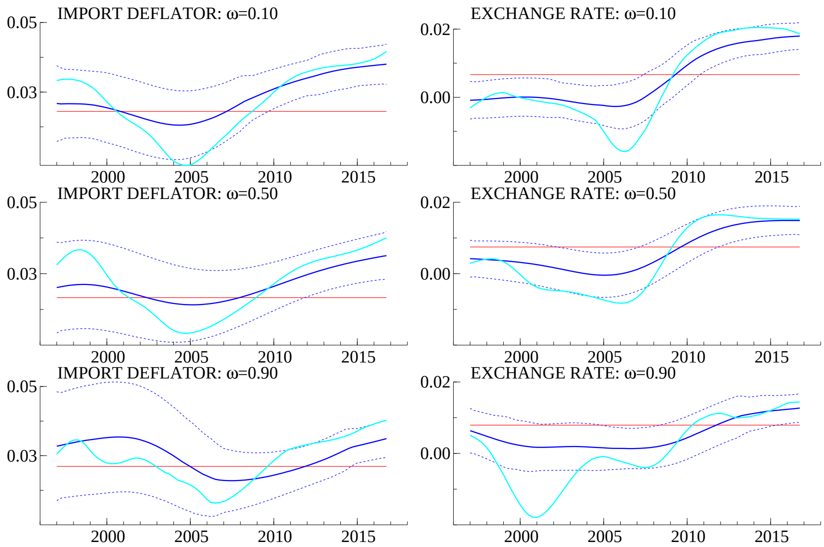

Figure 5: Coefficient estimates on the import deflator and the exchange rate

It is interesting to note that: (i) the coefficients are strikingly similar for all

[9] The variance matrix of the time-varying expectile regression coefficient, $\widehat{V}_t\left(\widehat{\beta}_t(\omega)\right)$, is computed following Giraitis et al. (2014). Using the notation of Section 2, $\widehat{V}_t\left(\widehat{\beta}_t(\omega)\right) = \left(\sum_{s=1}^{n} K_{ts} w_{ts}(\omega)\, x_s x_s'\right)^{-1} \left(\sum_{s=1}^{n} K_{ts}^2 w_{ts}^2(\omega)\, u_s^2 x_s x_s'\right) \left(\sum_{s=1}^{n} K_{ts} w_{ts}(\omega)\, x_s x_s'\right)^{-1}$, where $K_{ts} = K\left(\frac{t-s}{H}\right)$, $w_{ts}(\omega) = w_s\left(\widehat{\beta}_t(\omega)\right)$, $u_s = y_s - x_s'\widehat{\beta}_t(\omega)$.

expectile orders $\omega = 0.10, 0.50, 0.90$; (ii) the pass-through of foreign prices and exchange rate fluctuations to core inflation gets stronger in the last decade.

Taking the evidence of Figure 4 and 5 together, our analysis provides only partial support for the globalization hypothesis, since the contribution of foreign slack appears mostly stable over time.

Finally, Figure 6 shows the time-varying behavior of the long run centering parameter, i.e. $\beta_0/(1-\beta_1)$ in the formula (4), for $\omega = 0.25, 0.50, 0.75$.Since the output gap and the import deflator regressors have been demeaned, the case of $\omega = 0.50$ corresponds to the long-run mean of the inflation process, i.e. a measure of underlying inflation, which in the figure is plotted with the 2% threshold. It is interesting to see that underlying core inflation was close to 2% in the early 2000's but it has then decreased to just below 1.5% in more recent periods. The dispersion around the long-run mean of core inflation has also become smaller in the last decade.

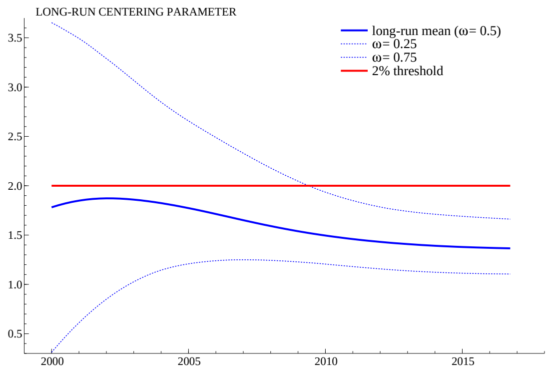

Figure 6: Long run centering parameter

6 Concluding remarks

The paper has analyzed the role of domestic and global drivers on the conditional distribution of euro area inflation through an expectile regression approach. Two methodological novelties have been introduced. First, expectile regression has been extended to capture the possibility of time-varying coefficients. Second, a model-based measure of domestic slack of the euro area economy net of the fluctuations of the global business cycle has been proposed, which allows a better identification of the impact of foreign and domestic demand pressures on inflation. On the empirical side, it is found that both foreign and domestic output gap are significant drivers of the euro area inflation, with the effect of the domestic output gap being relatively stronger. The response of inflation to internal demand pressures is overall stronger in the upper quantiles of the distribution, although the sensitivity in the lower quantiles has increased in more recent years. In terms of the implications for the 'globalization hypothesis', our findings show that the pass-through of import prices and the exchange rate has become higher in most recent periods, while the impact of foreign demand pressures on inflation appears to be broadly stable over time, particularly in the central part of the distribution.

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A Tables

Table 1: OLS regressions over the period 1989Q1-2016Q4; t-statistics in brackets.

Dependent variable: core inflation	(a)	(b)	(c)	(d)	(e)	(f)	(g)
Constant	0.08	0.08	0.06	0.06	0.06	0.05	0.04
	(1.57)	(1.43)	(1.34)	(1.18)	(1.16)	(1.17)	(0.91)
Lagged dependent variable	**0.95**	**0.95**	**0.95**	**0.97**	**0.96**	**0.96**	**0.97**
	(41.4)	(38.4)	(45.4)	(38.2)	(45.1)	(51.5)	(48.9)
Standard measure of output gap	**0.09**	**0.08**	**0.07**	**0.07**			
	(4.40)	(2.24)	(2.38)	(2.31)			
Counterfactual domestic gap					**0.04**	**0.04**	**0.03**
					(1.92)	(2.38)	(1.96)
Foreign output gap		0.01	−0.01	0.01	**0.04**	0.02	**0.04**
		(0.30)	(0.40)	(0.24)	(3.27)	(1.40)	(3.34)
Import deflator			**0.02**			**0.02**	
			(4.83)			(4.93)	
Effective exchange rate				**0.01**			**0.01**
				(2.02)			(2.24)
Regression standard error (%)	*19.9*	*20.0*	*19.2*	*19.7*	*20.7*	*19.6*	*20.3*

Note: the bold-face coefficients are significant at least at the 5% level for a one-sided test with asymptotic critical values

Table 2: Expectile regressions over the period 1989Q1-2016Q4; t-statistics in brackets. Model without foreign price regressors.

	Expectile order					
	0.05	*0.10*	*0.25*	*0.75*	*0.90*	*0.95*
Lagged dependent variable	**0.94**	**0.94**	**0.96**	**0.96**	**0.96**	**0.97**
	(45.9)	(46.9)	(46.1)	(46.7)	(50.1)	(47.3)
Counterfactual domestic gap	0.03	**0.03**	**0.03**	**0.05**	**0.07**	**0.09**
	(1.61)	(1.71)	(1.80)	(2.74)	(3.97)	(4.76)
Foreign output gap	**0.05**	**0.05**	**0.05**	**0.04**	**0.03**	**0.03**
	(3.96)	(4.30)	(3.71)	(2.47)	(2.11)	(1.64)
Implicit quantile order	*0.11*	*0.21*	*0.35*	*0.69*	*0.78*	*0.88*

Note: the coefficients for the constant term are not reported. The bold-face coefficients are statistically significant at least at the 5% level for a one-sided test with asymptotic critical values.

Table 3: Expectile regressions over the period 1989Q1-2016Q4; t-statistics in brackets. Model with a foreign price regressor.

	Expectile order				*Expectile order*			
	0.10	*0.25*	*0.75*	*0.90*	*0.10*	*0.25*	*0.75*	*0.90*
Lagged dependent variable	**0.93**	**0.95**	**0.96**	**0.97**	**0.95**	**0.97**	**0.98**	**0.98**
	(47.1)	(46.1)	(49.6)	(50.3)	(43.4)	(44.5)	(44.3)	(47.3)
Counterfactual domestic gap	**0.04**	**0.04**	**0.06**	**0.08**	0.03	**0.03**	**0.05**	**0.06**
	(2.73)	(2.36)	(2.98)	(4.11)	(1.64)	(1.68)	(2.28)	(3.57)
Foreign output gap	0.02	0.02	0.01	0.00	**0.05**	**0.05**	**0.03**	0.02
	(1.18)	(1.27)	(0.84)	(0.18)	(4.33)	(3.34)	(1.98)	(1.19)
Import deflator	**0.02**	**0.02**	**0.02**	**0.03**				
	(4.08)	(3.71)	(3.87)	(4.21)				
NEER					**0.01**	**0.01**	**0.01**	**0.01**
					(1.75)	(1.90)	(2.47)	(2.49)
Implicit quantile order	*0.22*	*0.33*	*0.70*	*0.80*	*0.20*	*0.29*	*0.68*	*0.77*

Note: the coefficients for the constant term are not reported. The bold-face coefficients are statistically significant at the 5% level for a one-sided test with asymptotic critical values.

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