BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

The non-linear effects of the Fed's asset purchases

by Alessio Anzuini

June 2020

Number 1280

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

The non-linear effects of the Fed's asset purchases

by Alessio Anzuini

Number 1280 - June 2020

The papers published in the Temi di discussione *series describe preliminary results and are made available to the public to encourage discussion and elicit comments.*

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

THE NON-LINEAR EFFECTS OF THE FED’S ASSET PURCHASES

by Alessio Anzuini*

Abstract

The Federal Reserve responded to the global financial crisis of 2008 with the deployment of new monetary policy tools, the most notable of them being the expansion of its balance sheet. In a recent paper, Weale and Wiladeck (2016) show that the asset purchases were effective in stimulating economic activity, inflation and asset prices. In this paper, we show that the results of asset purchases are state-dependent: large scale purchases are effective only when financial markets are impaired. Using an estimated threshold vector autoregressive model conditional on the volatility regime, we show that an increase in the balance sheet has expansionary effects on GPD and inflation when volatility is high, but not when it is low (in which case its effects become mostly insignificant). We argue that high volatility can be interpreted as a proxy of market dysfunction, and therefore only when this transmission channel is active is unconventional monetary policy particularly effective. This suggest that models of transmission mechanisms of unconventional policies that are based on asset purchases should focus more on the market functioning channel and not only on the portfolio rebalance channel.

JEL Classification: C32, E52.
Keywords: threshold vector autoregression, unconventional monetary policy.
DOI: 10.32057/0.TD.2020.1280

Contents

* Bank of Italy, DG for Economics, Statistics and Research, International Relations and Economics.

1 Introduction[1]

After the Global financial crisis (GFC), with interest rates at the zero lower bound (ZLB), major central banks embarked in large-scale asset purchases (LSAPs) to provide monetary stimulus to the economy. Weale and Wieladeck (2016; WW hereafter) have shown that LSAPs in the United States were effective in stimulating economic activity and inflation, via a number of channels: a decrease in the term premium component of longer maturities bonds (portfolio balance-effect); an enhancement of market functioning, due to the presence a large buyer playing the role of market maker and liquidity provider in a period of significant market stress; a boost to risky asset price prompting a positive wealth effect.[2] Indeed, the most visible impact of LSAP is a decrease in long term interest rates and an increase of risky asset prices (we also document a decline of asset price volatility). All these effects are at work in WW, who estimate VAR models identified, in the baseline version, with a Cholesky decomposition, and find that a one-percent of GDP-equivalent increase in asset purchases induces a decline of long term interest rates, an increase of asset prices and in both economic activity and inflation. We show that the effects recovered in WW using a linear model, disappear conditioning on some states of the economy. Our conjecture is that LSAP expansionary effects on the economy are strongly dependent on the existence of stress in financial markets so that market functioning channel is at work. We identify this channel through volatility: market dis-functioning (normal functioning) are associated with high (low) level of implied volatility in the stock market (VIX). Conditioning on differentvolatility level, we do find differences in the responses of economic variables: when volatility is high, a balance sheet expansion effectively boosts economic activity and prices through the channels described above. However, when volatility is low, none of those effects materializes, i.e. balance sheet expansion is ineffective as a way to steer the economy. The economic intuition is straightforward (and not new) once we interpret exceptionally high volatility as a sign of market distress: non-conventional policies are effective when markets impaired channel is at work (see Gagnon et al. (2001) and Curdia and Woodford (2011). Moreover, we show that our results are robust to different proxies of market dis-functioning.

In order to recover these non-linear effects, we estimate a threshold vector autoregressive (TVAR) model using the same variables as in WW. The VIX is our threshold variable, and we test for the presence of non-linearities conditional on the volatility regime; we are then able to recover standard linear impulse response functions, conditioning on the volatility regime and using bayesian techniques to mitigate the small

[1]I would like to thank Piergiorgio Alessandri, Giuseppe Ferrero, Marcello Pericoli and two anonymous referees for their suggestions. All errors are solely mine. The opinions expressed herein are of the author and do not necessarily reflect those of Banca d'Italia.

[2]See Boeckx et al (2017) and Gambacorta et al. (2014) for similar results within the euro area and Lewis and Roth (2017) for a discussion of medium run effects of balance sheet policies on financial stability.

sample bias. We show that the effects of balance sheet policies are significant, and have the expected sign, only in the high volatility regime: following an increase in the asset purchase equivalent to a 1 per cent of GDP, long term rates decline and asset prices, GDP and inflation all increase. None of those effects survive in the low volatility regime.

The uncovered non-linearity has far reaching implications. On the one hand since all past recessions have been accompanied by a shift to a high volatility regime our estimates suggest that unconventional policies will regain effectiveness exactly when they are needed. On the other hand, if volatility remain low and, most importantly, the market dis-function channel is not at work, it is unclear how effective the LSAP could be.

In the next section we first describe the baseline results of WW and then we introduce the TVAR methodology. In section 3 we apply the TVAR methodology the Fed unconventional monetary policy. Section 4 describes the main results and section 5 provides robustness analysis. Section 6 concludes.

2 Linear VAR vs TVAR

In their contribution WW estimate a set of vector autoregressive (VAR) models identified with a Cholesky decomposition. They use monthly data from March 2009 to May 2014, a sample encompassing only a period when asset purchases were an active policy tool. The variables included in the VAR , ordered in the Cholesky decomposition as follows, are: real GDP, CPI, asset purchases as a percentage of GDP,[3] the ten year government bond yield, and real equity prices (deflated using the CPI); all variables are in log levels (except those expressed in percentage point). Asset purchases are measured as the whole amount of planned purchases[4], for each program or change to a previous program, at the date when they were announced by the Fed; the maturity extension program (Operation Twist, OT) is an additional data point, as the asset purchase announcements of government bonds financed with the issuance of central bank reserves.[5]

In WW, averaging across the various identification schemes, GDP peaks at 0.58% and CPI at 0.62%, similarly to the results in Baumeister and Benati (2013) and Kapetanios

[3] Normalized by the first quarter of 2009.

[4] Hesse et al (2017) argue that subsequent round of QE were less effective in the US because they were partly anticipated.

[5] The WW model implicitly assumes that macroeconomic variables tend to respond to announcements, rather than actual asset purchases. However, they find that results are robust to using an alternative specification where the actual amount of assets purchased in each period is used instead. Also the treatment of the Operation Twist as if it were an announcement of purchases is debatable. For example in September 2011 the FOMC announced that: "The Committee intends to purchase, by the end of June 2012, $400 billion of Treasury securities with remaining maturities of 6 years to 30 years and to sell an equal amount of Treasury securities with remaining maturities of 3 years or less." This announcement translated directly into an increase of $400 billion in the series used in our estimates. While this may overestimate the series of asset purchase, WW show nonetheless that by rescaling by a half all the OT their results did not change. Please refer to the original paper for an in-depth explanation of the construction of the variables.

et al. (2012).[6]

The use of a linear model in WW implies a sort of symmetry in the response to a shock: what occurs in the balance sheet expansion phase should be the mirror image of what happens in the unwinding phase, however slowly it is implemented. Surprisingly, though, while balance sheet normalization was announced in early 2017 and actually started in October, it produced no perceptible impact on financial markets. We surmise (and want to test the hypothesis) that the absence of contractionary effects during this phase is not due to a simple asymmetry in the effects of expansion and contraction in balance sheet but rather to a non-linearity stemming from the state of the financial markets: if markets are calm and volatility is low, then balance sheet increases (decreases) have no expansionary (contractionary) effects; when, instead, financial markets are under pressure and volatility is high, those effects are significant and in line with what found in WW.

This intuition is not completely new. As already argued by Gagnon et al. (2011), the LSAPs may affect market interest rates mostly through a combination of portfolio balance and market functioning effects. The lack of significant movements of interest rates around the times each component of the LSAP programs was wound down suggests that market functioning was no longer impaired, and that the Fed's presence in the market had little additional effect beyond that through its portfolio holdings.

In line with Curdia and Woodford (2011), we find a much greater role for financial market stress (proxied by high or low volatility) in explaining the impact of unconventional policy than in Gagnon et al. (2011). To the best of our knowledge, in this paper we provide the first VAR analysis of the effects of unconventional monetary policy conditional on changing regimes.

2.1 The TVAR methodology

Using a threshold VAR we show that WW results can be interpreted as an across-regime estimates and that, since they do not explicitly deal with non-linearity, they may be strongly biased. We use the very same variables as in WW, except that we add the S&P500 implied volatility index (VIX) to our threshold vector autoregressive model (TVAR).

TVAR models have been applied in economics to examine the relationship between savings, openness and growth (Hoogstrate and Osang, 2005), between carry trade and foreign exchange rate volatility (Anzuini and Brusa, 2016), and in finance, for instance in the study of index futures arbitrage (Tsay, 1998). In this paper, a TVAR model is adopted to examine the relationship between balance sheet policies and market functioning. Our idea is that the impact of unconventional policies on financial markets and economic activity is asymmetric: much stronger in a distressed market, almost ininfluent in tranquil times when volatility is low. In our analysis the degree of market distress is proxied by the VIX, although we acknowledge that also other variables may be used

[6]In WW results obtained using sign restriction are bigger than those obtained with the Cholesky, however, due to the large uncertainty surrounding point estimates, these results are not statistically different from one another.

to gauge the level of market malfunctioning; we will show, however, that using other variables do not change the main results.

The empirical strategy follows Tsay (1998), who addresses both testing and model building issues concerning implementation of the TVAR technique. The TVAR specification he proposes is a multivariate version of the Self-Exciting Threshold Models outlined by Tong (1990). The peculiarity of the Threshold models in general is the use of a threshold variable to capture non-linearities. Within this group, TVAR models and Self-Exciting Threshold Models have two distinctive features: (i) they are linear autoregressive processes within each regime and (ii) they employ a delayed threshold variable to govern regime switching. Indeed, in a TVAR model the regime in place at any time t depends on the observable past history of the threshold variable itself.

A s-regime TVAR model, also called a Multivariate Threshold Model, satisfies (Tsay, 1998):

$$\mathbf{y}_t = \mathbf{c}_j + \sum_{i=1}^{p} \boldsymbol{\Phi}_i^{(j)} \mathbf{y}_{t-i} + \sum_{i=1}^{q} \boldsymbol{\beta}_i^{(j)} \mathbf{x}_{t-i} + \boldsymbol{\epsilon}_t^{(j)} \quad \text{if} \quad \gamma_{j-1} < b_{t-d} \leq \gamma_j \tag{1}$$

where $\mathbf{y}_t$ is a vector of endogenous variables, j = *1,..., s* indicates the regime/s, $\mathbf{c}_j$ are the constant vectors for the different regimes, $\Phi^{(j)}$ denotes the coefficient matrix of the respective lags and regime, γ_{j-1} and γ_j are threshold values and p is the number of lags included. The delayed threshold variable, b_{t-d}, determines which regime the system is in at any time. Asymmetries arise, as the coefficients of the linear VAR model can vary across the regimes defined by b_{t-d} , where d denotes the delay integer. Crucially, the model in (1) allows for an endogenous threshold variable, which can be defined as one of the endogenous variables in the model (as in our case) or alternatively can be computed as a function of one of them. Since the VIX is used as threshold variable, the threshold level of volatility that induces parameter shifts is endogenous to the econometric procedure (derived via grid searches, details below) rather than exogenously imposed. Furthermore, since shocks to any element in $\mathbf{y}_t$ are potentially able to induce a regime-shift via the threshold variable itself, regime switches are themselves endogenous in the model. Concerning the statistical properties, the threshold variable b_t is required to be stationary and to have a continuous distribution. The model in (1) is specified in the general form: it allows for s regimes, such that $-\infty = \gamma_0 < \gamma_1 < ... < \gamma_s < +\infty$ and is defined for a given vector of the exogenous variables, $\mathbf{x}_t$ with lag order q. Since the benchmark (linear) WW model does not include any exogenous variable, $\mathbf{x}_t$ is a vector of zeros in this study. Finally, the $\epsilon^{(j)}$ are sequences of white noises and are mutually independent.

Before modeling the TVAR specification, the presence of threshold non-linearity is formally assessed (using the *Tsay test*).

Testing the validity of a TVAR model (i.e. a linear VAR model under the null hypothesis and TVAR model under the alternative) involves non-standard inference due to the so called "nuisance parameter" problem: when threshold values are unknown, the parameters $\gamma_{j=1,\ldots,s}$ in (1) are identified under the alternative, but not under the null. In this study, the ad hoc test statistic designed by Tsay (1998) is employed to conduct inference.[7] Tsay (1998) transforms the problem of testing for a threshold into a problem of testing for a change-point. The model in (1) is re-arranged according to the increasing order of the threshold variable b_{t-d}; predictive residuals are then obtained in the new setup via recursive least squares and are used to construct a test statistic that does not involve undefined parameters.[8] The Tsay test statistic has an asymptotic Chi-squared distribution and can be also specified to allow for conditional heteroscedasticity. To assess the stability of the results, the Tsay test is generally performed for different starting values of the recursive estimation, m_0.[9] The test is designed to jointly detect the appropriate delay parameter d and the presence of non-linearity and assumes that both the threshold variable b_t and the lag parameter p are known. A standard procedure is to select the order p in the linear framework using an Information Criterion (i.e. AIC, HQ or SIB).[10]

Modelling a TVAR model includes selecting the threshold variable b_t, determining the number of regimes s, and choosing the order p for each regime (Tsay, 1998). A TVAR model is estimated by using the conditional least square method, while the selection of the best TVAR specification is based on some information criteria (i.e. commonly the minimum Akaike Information Criterion or the sum of squares residuals). The threshold values $\gamma_{j=1,...,s}$ are determined according to a grid search over a range of potential values of the threshold variable. Given s, p and the threshold variable b_t and conditional on each of these potential values, the TVAR model is estimated by ordinary least squares. The best TVAR specification is then selected using the aforementioned method. To ensure that each regime contains a minimum number of observations, the grid is usually restricted. It is common practice in the literature to allow for at least 10 percent of the total number of observations in each regime (Tsay, 1998; Hansen, 2000; Clements and Galvao, 2004). In our case, however, due to the very small sample size, we decide to leave at least 25 percent of observations in each regime and the number of possible regime is restricted to two. Once the best TVAR model has been selected, the specification is refined choosing the appropriate number of lags p in each regime; again, due to lack of available observation we use only one lag in each regime.

Finally, we estimate a set of conditional linear impulse responses to assess whether the dynamics of macro variables differ across the volatility regimes defined by the estimated TVAR model. Since conditional linear impulse responses are regime-dependent, they describe the dynamics of the system *within* each of the regimes identified by the estimated threshold values. There is indeed a limiting assumption underlying this approach: the regime prevailing at the time of the shock is supposed to be preserved throughout the horizon of the responses (Balke, 2000). It follows that conditional impulse responses are

[7] See Hansen (1996, 2000), Galbraith (1996) and Balke (2000) for other approaches to conduct non-standard inference in this framework.)

[8] Refer to Tsay (2008) for a formal and detailed description of the Test.

[9] Tsay (1998) studies the finite-sample performance of this test by simulation and recommends choosing $m_0 \sim 5\sqrt{n}$ when $\mathbf{y}_t$ is a unit root series, and $m_0 \sim 3\sqrt{n}$ under stationarity, where n is the sample size. The choice is a compromise between stable starting estimation and good power in testing.

[10] The choice of an appropriate threshold variable requires a careful investigation and remains one of the major problems in empirical applications of the method (Tsay, 1998).

an appropriate tool for examining the responses to an analogous shock in the presence of alternative volatility states, but are not designed to capture regime switching during the propagation of the shock.[11]

2.2 Data

We estimate our TVAR model with monthly data from 2009m3 to 2017m5: in March 2009 asset purchases began to be an active policy and May 2017 is the last month before the Federal reserve announced it was start removing the balance sheet stimulus. At the June 2017 FOMC meeting the Fed published an Addendum to the Policy Normalization Principles and Plans, stating that: "The Committee intends to gradually reduce the Federal Reserve's securities holdings by decreasing its reinvestment of the principal payments it receives from securities held in the System Open Market Account." It also specified the pace at which the removal was about to take place, but not the end-point at which balance sheet reduction would stop. This made it impossible for markets to telescope into the present the value of the overall balance sheet contraction, and very hard for an econometrician to incorporate this information into the construction of the series of the asset purchases for the estimates. However, FOMC members suggested, in public speeches, that balance sheet reduction was bound to halt somewhere in between the current level and the one prevailing before asset purchases began (1tn$).[12]

Monthly real GDP data for the US are taken from Macroeconomic Advisers. Consumer prices are the official measures published by the Bureau of Labour Statistics. Real equity prices are calculated by obtaining monthly averages of daily data for the S&P500 obtained from Thomson Datastream and deflating with the CPI. The asset purchases series is constructed following WW.[13]

3 The TVAR Model of LSAP

The relationship between LSAP and the volatility level, to the best of our knowledge, has never been directly investigated before. There is, however, widespread consensus that LSAP effectiveness tends to be more pronounced when implemented in times of market distress (see among other Gagnon et al. (2011) and Curdia and Woodford (2011)). We use volatility as a threshold variable and, while we do acknowledge the possibility that other proxies for market dysfunctions may work as well, we choose VIX for at least two reasons: 1) it is possibly the best known index of market sentiment, 2) it is correlated with a lot of other series that might be used as a threshold variable.[14] In the

[11] Notice that this caveat is well known in the literature and no clear solution has emerged.

[12] On November 28 2018 the Fed Chair Designate Powell said, during his confirmation hearing before the Senate Committee on Banking, Housing, and Urban Affairs, that he sees the balance sheet ending up around $2.5 trillion to $3 trillion.

[13] The series is expressed in percentage of annualised 2009Q1 nominal GDP in order to avoid the endogeneity issues which might arise from scaling by current nominal GDP.

[14] For example, the correlation between the convenience yield (i.e. the yield spread between a completely illiquid and a comparable fully liquid security) and the VIX is almost 0.9. For the convenience

robustness section we test the presence of non-linearities and estimate the parameters in the different states using three other possible threshold that usually indicate dysfunctions in the markets liable to affect the monetary policy transmission mechanism.

In order to argue that we should expect a stronger impact of LSAP in presence of market dysfunctions, it is worth mentioning the channels through which this policy affects the broad economy. For an in depth analysis of channels through which LSAP affects the economy see Krishnamurthy et al. (2011), in what follows we draw heavily on Gagnon et al. (2011).

The primary channel through which LSAPs appear to work is by affecting the risk premium on the asset being purchased. By purchasing a particular asset, a central bank reduces the amount of the security that the private sector holds, displacing some investors and reducing the holdings of others, while simultaneously increasing the amount of short-term, risk-free bank reserves held by the private sector. In order for investors to be willing to make those adjustments, the expected return on the purchased security has to fall. Put differently, the purchases bid up the price of the asset and hence lower its yield. This pattern was described by Tobin (1958, 1969) and is commonly known as the "portfolio balance" effect. Note that the portfolio balance effect has nothing to do with the expected path of short-term interest rates. Longer-term yields can be parsed into two components: the average level of short-term risk free interest rates expected to prevail over the term to maturity of the asset and a risk premium (the term premium). The former represents the expected return that investors could earn by rolling over short-term risk-free investments, and the latter is the expected additional return that investors demand for holding the risk associated with the longer-term asset. In theory, the effects of the LSAPs on longer-term interest rates could arise by influencing either of these two components. However, the Federal Reserve did not use LSAPs as an explicit signal that the future path of short-term risk-free interest rates would remain low.

These portfolio balance effects should not only reduce longer term yields on the assets being purchased but should also spill over into the yields on other assets. The reason is that investors view different assets as substitutes and, in response to changes in the relative rates of return, will attempt to buy more of the assets with higher relative returns. In this case, lower prospective returns on agency debt, agency MBS, and Treasury securities should cause investors to seek to shift some of their portfolios into other assets such as corporate bonds and equities and thus should bid up their prices. It is through the broad array of all asset prices that the LSAPs would be expected to provide stimulus to economic activity.

The LSAP programs began at a point of significant market strains, and the poor liquidity of some assets weighed on their prices. By providing an ongoing source of demand for longer-term assets, the LSAPs may have allowed dealers and other investors to take larger positions in these securities or to act as market-makers in them, knowing that, if needed, they could always sell the assets to the Federal Reserve.

Such improved trading opportunities could also reduce the liquidity risk premiums

---

yield we used the series constructed in Del Negro et al. (2017); data are available only to the end of 2014.

embedded in asset prices, thereby lowering their yields. This liquidity, or market functioning, channel, which is distinct from the portfolio balance channel, appears to have been important in the early stages of the LSAP programs for certain types of assets.

For example, the LSAP programs began at a point when the spreads between yields on agency-related securities and on Treasury securities were well above historical norms, even after adjusting for the convexity risk in MBS associated with the high interest rate volatility at the time. These spreads reflected in part poor liquidity and elevated liquidity risk premia on these securities. The flow of Federal Reserve purchases may have helped to restore liquidity in these markets and reduced the liquidity risk of holding those securities, thereby narrowing their spreads.

Overall, LSAPs may affect market interest rates through a combination of portfolio balance and market functioning effects.

As documented in Gagnon et al. (2011), the lack of significant movements in interest rates around the times that each component of the LSAP programs was wound down suggests that market functioning was no longer impaired and that the Federal Reserve's presence in the market had little additional effect beyond that through its portfolio holdings. More explicitly, our estimates will show that once the market functioning channel is shut down, the impact of LSAP is greatly reduced, up to a point where its impact on the broad economy becomes difficult to disentangle. In order to interpret the different response in the two regimes as due to the switching of the market functioning channel, one more implicit identifying assumption is needed: once the VIX is below a certain threshold, the market functioning channel is shut down. While the choice of the VIX as a threshold is based on our prior information, the actual value of the threshold used in our TVAR model is obtained through econometric tests. One thing is worth stressing: our analysis (and the one from WW) is constrained by the lack a observations. Obviously, we would have preferred to leave unconstrained the number of regimes but the lack of available observation forced us to impose the existence of only two regimes.[15]

3.1 Testing a TVAR model: Tsay test

Testing for threshold effects (i.e. with the Tsay test) entails selecting the lag parameter p and choosing a threshold variable b_t.

To select p, the number of lags, we employ the Multivariate Akaike Information Criterion (MAIC)[16]

[15]The possibility of more than two regimes would have allowed us to relax the, rather stringent, identifying assumption that market functioning channel is on (off) simply when volatility is above (below) the threshold. Three regimes for example would have allowed to assume the market functioning channel to be completely switched off (on) only in the very low (high) volatility regime leaving the middle regime unconstrained.

[16]$MAIC = nlog|\hat{\Sigma}|+2(k^2p+k)$ where $\hat{\Sigma}$ is the variance-covariance matrix of residuals, n is the number of observations, p is the number of lags and k is the number of endogenous variables. Once the threshold value is determined and we proceed with the estimates in the different regimes, due to the lack of degrees of freedom we are forced to reduce the number of lags to one.

The choice of the threshold variable requires careful evaluation: a misspecification may invalidate the selection of the regimes, thus affecting the ultimate conclusions of the analysis. As anticipated, in our baseline estimates, we capture non-linearities using the VIX, which is both endogenous and stationary, as required by Tsay (1998).[17] The threshold values are then derived endogenously via grid searches.

We run the Tsay test to assess the presence of threshold effects in the VAR model. Rejecting the null hypothesis (i.e H_0: $\mathbf{y}_t$ is linear) implies concluding in favour of a TVAR specification. Four values of the threshold delay parameter d are considered, so that *d=(0, 1,2,3)*. A delay integer equal to zero implies a contemporaneous (within a month) relationship between the VIX (b_t) and the other variables in the system, while a delay integer equal to three can be interpreted as a delay of a quarter. Since financial markets tend to react almost immediately to a rise in perceived risk, testing for longer delays does not seem appropriate. The stability of the results is assessed performing the test for different starting values of the recursive estimation, that is m_0 = *(20, 30, 40)*, where the choice of the values follows Tsay (1998)[18]. Conditional on m_0, the value of d associated with the maximum of the test statistic *C(d)* indicates the appropriate threshold delay integer.

The linearity assumption is rejected at the one percent significance level for any given value of d and m_0 and results are stable across alternative choices of the latter. Concerning the delay integer d, the test selects $d = 0$ as the appropriate choice, regardless of the starting value m_0.

3.2 Modeling a TVAR: threshold values

Due to the limited number of observations, we consider only a two-regime TVAR model ($s = 2$). That is, we allow for only two volatility states of the economy.[19]

Under $s = 2$, the threshold variable splits the sample endogenously into two parts: a "low volatility regime", which collects all the observations associated with values of VIX lower than the estimated threshold value $\hat{\gamma}_1$ and a "high volatility regime", which collects the remaining observations.

We use the grid search method with 300 grid points to select the threshold value. Under $s = 2$, we limit the search between the 25^{th} percentile and the 75^{th} percentile of the empirical distribution of our threshold variable b_t. This choice ensures that each regime contains a minimum number of observations without imposing strong restrictions on the location of the estimated threshold value.

The estimated threshold value $\hat{\gamma}_1 = 0.18$ meaning that each time the VIX is below (above) the threshold of 18% the corresponding observation is assigned to the low volatility regime (high volatility regime); 0.18 corresponds to the 58^{th} percentile of the empirical distribution of the VIX in our sample.

[17] Stationarity is assessed via the Augmented Dickey Fueller (ADF) Test.

[18] Refer to Footnote 10: $m_0 = 3\sqrt{96} \sim 30$, where n=96 denotes the total number of available observations.

[19] Under $s > 2$, potential issues in estimation may arise due to the presence of limited data in each regime.

This result is consistent with economic intuition: the upper regime includes a lower number of observations than the downside counterpart, as it collects periods of tensions in the markets. This sub-sample is large enough to include not only rare events, like the recent financial crisis, but also periods where tensions have been considerably higher than in normal circumstances.

4 Results

The final aim of our exercise is to obtain impulse responses conditional on different regimes. To that end, we use both classical and bayesian techniques. First, we use the Tsay test to detect non-linearities and recover the value of the threshold to split the sample in two regimes. Then, in order to mitigate the problems stemming from the small samples available, we use bayesian methods. In particular, we use a non-informative prior (Jeffreys prior) distribution on parameter space and an inverse Wishart distribution as the conjugate prior for the covariance matrix. Antithetic acceleration is then used to improve convergence of the Monte Carlo draws. In all estimated VARs identification is reached through a simple Cholesky decomposition. In figure 1 we report the results of our estimates in both regimes to an increase in asset purchases equivalent to 1 per cent of GDP. The differences in the two regimes are striking. When markets are under pressure, the asset purchase shock has a significant impact on economic activity, inflation and all other variables in the system. All signs are as expected: the 10 year yield decreases reaching a trough after five quarters; asset prices have a stronger and more front loaded response, increasing by more than 3% after 6 months; the VIX decreases by 3 percentage points in four months; GDP increases by 0.3% after 16 months, while the CPI increases by 0.4% after 7 months.[20]

The Board of Governors of the Federal Reserve System has estimated a cumulative effect of the Federal Reserves Securities Holdings (roughly $4.5 trillion) on Longer-term Interest Rates of about 100bp.[21] Back of the envelope calculations using our estimates suggest a not dissimilar result: the response (at peak) to a total 1.6 trillion expansion is slightly more than 30 basis points. Moreover, considering the uncertainty surrounding our estimates the two results would be not statistically different.

None of the above effects are detectable in the low volatility environment: the effects on all variables are barely different from zero, except for GDP and CPI, which move in a counterintuitive fashion. This confirms the importance of accounting for non-linearities.[22] While in the next session we will show that the counterintuitive effects will

[20] The lagged response of GDP is consistent with what found in Peersman (2011) for the euro area.

[21] https://www.federalreserve.gov/econres/notes/feds-notes/effect-of-the-federal-reserves-securities-holdings-on-longer-term-interest-rates-20170420.htm

[22] As an alternative informal test of the presence of non-linearities due to different volatility regimes, we update the estimates of the linear WW model to include most recent data, and find that impulse response functions consistent with a marginally significant fall of real GDP and a mitigated response (although still positive and significant) of the CPI. Considering that - according to our own estimates - the added three years of data belong almost entirely to the low volatility regime, the change in WW's results, which may be considered an across regime estimates, have a clear cut interpretation: when more

vanish when some alternative proxies of market distress are used, it is nonetheless worth mentioning two arguments that might explain the negative impact on GDP. First, it might be the case that the actual balance sheet expansion is consistently greater than the expected expansion exactly during high volatility episode. This would mean that balance sheet expansion would translate into an expansionary shock only in the high volatility regime. Second, a balance sheet expansion engineered during a low volatility (no market distress) period, if interpreted by the market as the central bank having private information about some negative upcoming economic development, might negatively impact growth expectation.

5 Robustness

To gauge the robustness of previous results we concentrate on possible alternative variables to be used as threshold. As threshold variables are meant to proxy the degree of market distress we look at three other alternatives already explored in the literature.[23] First, the Chicago Fed's National Financial Condition Index (NCFI) which provides a comprehensive update on U.S. financial conditions in money markets, debt and equity markets, and the traditional and shadow banking systems.[24] Positive values of the NFCI indicate financial conditions that are tighter than average, while negative values indicate financial conditions that are looser than average. The three subindexes of the NFCI (risk, credit and leverage) allow for a more detailed examination of the movements in the NFCI. Like the NFCI, each is constructed to have an average value of zero and a standard deviation of one over a sample period extending back to 1971. As second threshold we use the risk subindex (NCFIRISK) which captures volatility and funding risk in the financial sector; again a positive value for an individual subindex indicates that the corresponding aspect of financial conditions is tighter than on average, while negative values indicate the opposite.[25] As a third option we use the excess bond premium (EBP) of Gilchrist and Zakrajek (2012) where an increase in the excess bond premium reflect a reduction in the risk-bearing capacity of the financial sector. In figure 2 we report results for the NCFI. The similarity between the IRF obtained with VIX and those obtained with a different threshold are striking. Again, while in the regime where financial markets are under stress, the GDP moves significantly in the expected direction after an LSAP shock, it does not move in the low NCFI regime where market are not under pressure. Also the responses of equity prices and the long term rates move in the expected direction only in the high NCFI regime.[26] In figure 3 we report the estimates obtained with the subcomponent of the NCFI meant to capture volatility and funding

observations in the low volatility regime are added to the full sample estimation, impulses tend to be tilted to the one obtained in this latter regime. In the 36 months from May 2014 to May 2017, the VIX was above the theshold only 4 times.

[23]The three alternatives were suggested by an anonymous referee to whom we are indebted for this.

[24]Source: http://www.chicagofed.org/webpages/publications/nfci/index.cfm.

[25]Source: http://www.chicagofed.org/webpages/research/data/nfci/background.cfm.

[26]Admittedly, using NCFI we recover a significant effect on the CPI which is unclear trough which channel is taking place.

risk in the financial sector. Using this subcomponent we obtain impulse responses that are in line with our baseline results. In figure 4 we report results obtained using the EBP. In this case, the results are even more consistent with our economic argument: LSAP is effective when the market dysfunction channel is on, when this is not the case economic variables barely move conditional on an LSAP shock.

Conclusions

Our results are in line with and actually contribute to explain a simple evidence: the shrinking of the Fed balance sheet did not produce a significant increase in long term interest rates and in stock market volatility, nor a negative impact on asset prices because market were not distressed during that period; the VIX was low (below 13%) for most of the time since the beginning of 2017.[27]

Admittedly, our result could be influenced by the fact that we focus on a period where the ZLB was binding most of the time, and that a binding ZLB could in fact represent another condition (together with a high volatility regime) for asset purchase policy to be effective. While we cannot discard such possibility, it is worth remembering that during the past six US recessions the average reduction of the federal funds rate target was about 4 percentage points on average (figure 4), which means that the ZLB is likely to be binding also in future recessions, as argued in Kiley and Roberts (2017).

In this paper, to the best of our knowledge, we provide the first empirical evidence on the presence of non linearities in the transmission mechanism of the unconventional monetary policy deployed through the balance sheet. While at this stage we acknowledge that important caveats remain, we believe this is a promising avenue of research which may prove useful in reconciling different results recovered in the empirical literature on the effects of unconventional monetary policy.

[27] In early 2018, though, the VIX did increase above the threshold; to the extent that part the unwinding in the balance sheet takes place in this new environment some drag on the economic activity may be expected.

References

[1] Anzuini, A., Brusa, F., 2016. Carry trades and exchange rate volatility: a TVAR approach. Temi di discussione (Economic working papers) 1046, Bank of Italy, Economic Research and International Relations Area.

[2] Balke, N. S. 2000. Credit and economic activity: credit regimes and non-linear propagation of shocks. *The Review of Economics and Statistics*, 82.

[3] Baumeister, C., Benati, L. , 2013. Unconventional monetary policy and the great recession: estimating the macroeconomic effects of a spread compression at the zero lower bound. *International Journal of Central Banking.* Vol. 9,165–212 June.

[4] Boeckx, J., Dossche, M., and G. Peersman (2017). Effectiveness and Transmission of the ECBs Balance Sheet Policies, *International Journal of Central Banking*, vol. 13(1): pp. 297-333.

[5] Ciccarelli, M., A. Maddaloni, and J.-L. Peydro. (2013). Heterogeneous Transmission Mechanism: Monetary Policy and Financial Fragility in the Eurozone. *Economic Policy*, vol. 28 (75): pp. 459-512.

[6] Clements, M. P. and Galvao, A. C. 2004. A comparison of tests of non-linear cointegration with an application to the predictability of the us term structure of interest rates. *International Journal of Forecasting*, 20:219-236.

[7] Curdia, V., Woodford, M., 2011. The central-bank balance sheet as an instrument of monetary policy. *Journal of Monetary Economics*, Volume 58, Issue 1, January 2011, Pages 80-82

[8] Del Negro, M, G. Eggertsson, A. Ferrero, N., Kiyotaki. 2017. The Great Escape? A Quantitative Evaluation of the Fed's Liquidity Facilities," *American Economic Review*, American Economic Association, vol. 107(3), pages 824-857, March.

[9] Gagnon, J., Raskin, M., Remache, J. , Sack, B., 2011. The financial market effects of the Federal Reserve's large-scale asset purchases. *International Journal of Central Banking* Vol. 7, 3–43.

[10] Galbraith, J. W. 1996. Credit rationing and threshold e ects in the relation between money and output. *Journal of applied econometric*, 11 (4).

[11] Gambacorta, L., Hofmann, B., and G. Peersman (2014). The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-Country Analysis, *Journal of Money, Credit and Banking*, vol. 46(4): pp. 615-642.

[12] Gilchrist, S., and E. Zakrajek. (2012). Credit Spreads and Business Cycle Fluctuations. *American Economic Review*, vol. 102 (4): pp. 1692-1720.

[13] Hansen, B. 1996. Inference when a nuisance parameter is not identi ed under the null hypothesis. *Econometrica*, 64(2):413-430.

[14] ———. 2000. Sample splitting and threshold estimation. *Econometrica*, 68(3):575-603.

[15] Hesse, H., B. Hofmann and J. Weber, (2017). The macroeconomic effects of asset purchases revisited, BIS Working Papers 680, Bank for International Settlements.

[16] Hoogstrate, A. and Osang, T., 2005. Focus on Economic Growth and Productivity, chapter Saving, openness and growth: A panel data VAR approach, pages 115-142. Nova Science.

[17] Kapetanios, G., Mumtaz, H., Stevens, I., Theodoridis, K., 2012. Assessing the economy-wide effects of quantitative easing. Econ. J. 122, F316–F347.

[18] Kiley, M. T., Roberts, John M. 2017. Monetary Policy in a Low Interest Rate World, *Brookings Papers on Economic Activity*, Spring 2017, 317-396

[19] Krishnamurthy, A. and Vissing-Jorgensen A., 2011. The Effects of Quantitative Easing on Interest Rates: Channels and Implications for Policy, *Brookings Papers on Economic Activity*, Fall 2011.

[20] Lewis, V., and M. Roth (2017). The financial market effects of the ECB's asset purchase programs, Discussion Papers 23/2017, Deutsche Bundesbank.

[21] Peersman, G. (2011). Macroeconomic Effects of Unconventional Monetary Policy in the Euro Area. ECB Working Paper No. 1397.

[22] Tobin, J. 1958. "Liquidity Preference as Behavior Towards Risk. *Review of Economic Studies* 25 (2): 124–31.

[23] ———. 1969. A General Equilibrium Approach to Monetary Theory. *Journal of Money, Credit, and Banking* 1 (1): 15–29.

[24] Tong, H. 1990. Nonlinear time series: a dynamical system approach. Oxford, UK, : Oxford University Press.

[25] Tsay, R. S., 1998. Testing and modeling multivariate threshold models. *Journal of the American Statistical Association*, 93 No 443:1188-1202.

[26] Weale, M., Wieladek, T. 2016. 2What are the macroeconomic effects of asset purchases?. *Journal of Monetary Economics*, Elsevier, vol. 79(C), pages 81-93.

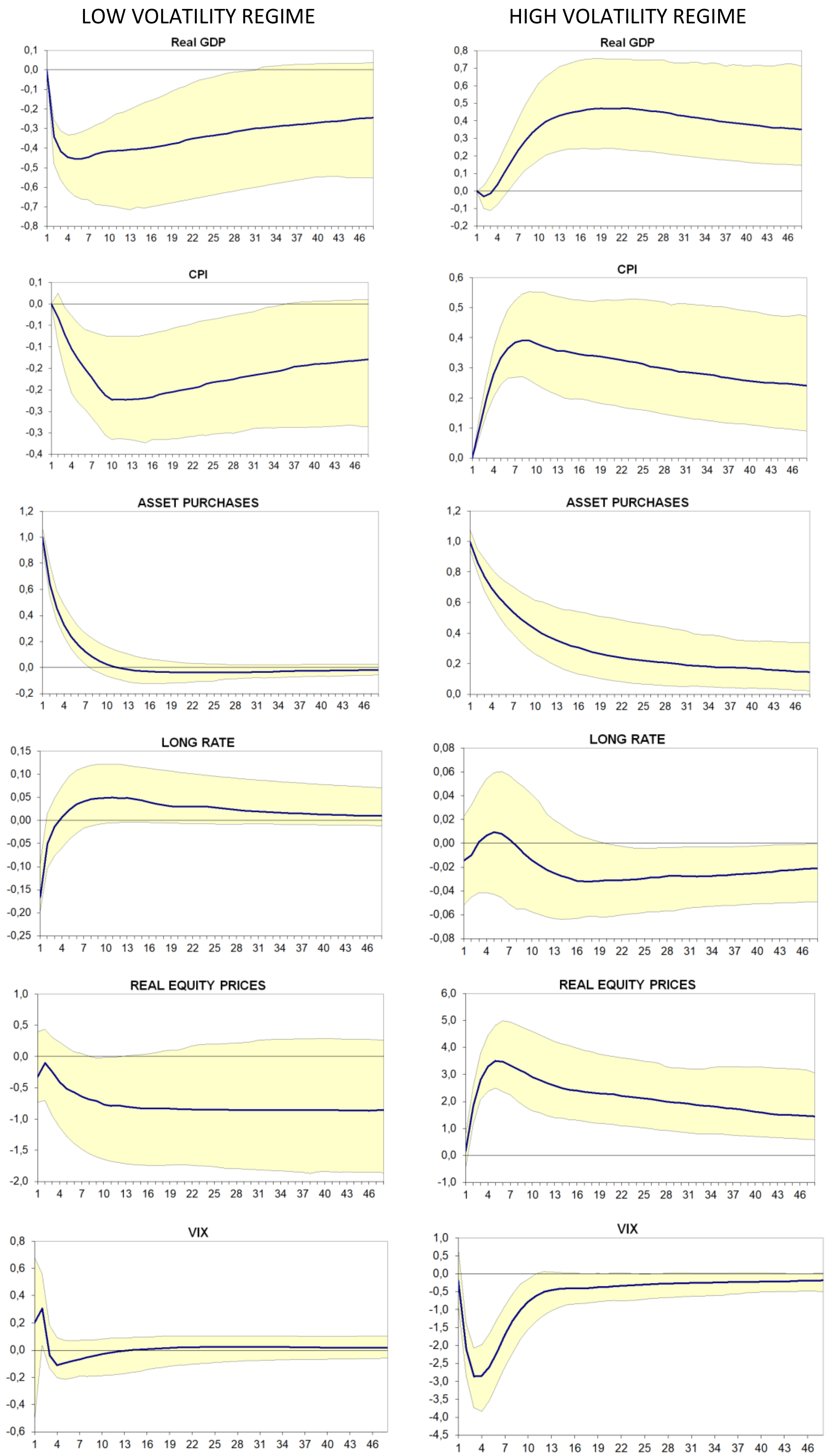

Figure 1: Response functions in the high volatility regime (VIX $\geq$ 18%) and in the low volatility regime (VIX $<$ 18%) to a 1 percentage point increase (in GDP terms) in the asset purchases. On the vertical axes the percentage deviation of the levels of the variables.

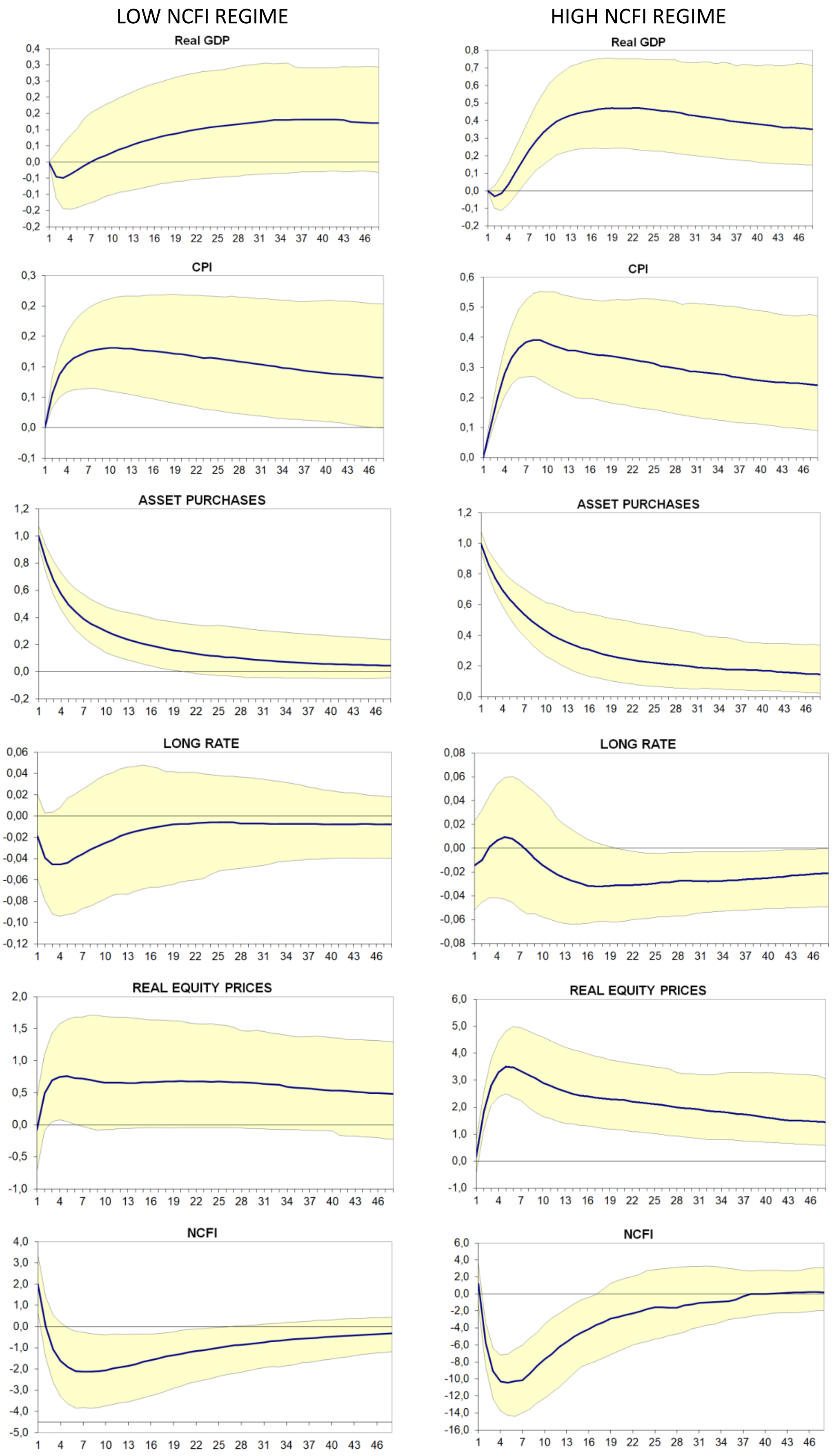

Figure 2: Response functions in the high NCFI regime (NCFI $\geq$ -0.54) and in the low NCFI regime (NCFI <-0.54) to a 1 percentage point increase (in GDP terms) in the asset purchases. On the vertical axes the percentage deviation of the levels of the variables.

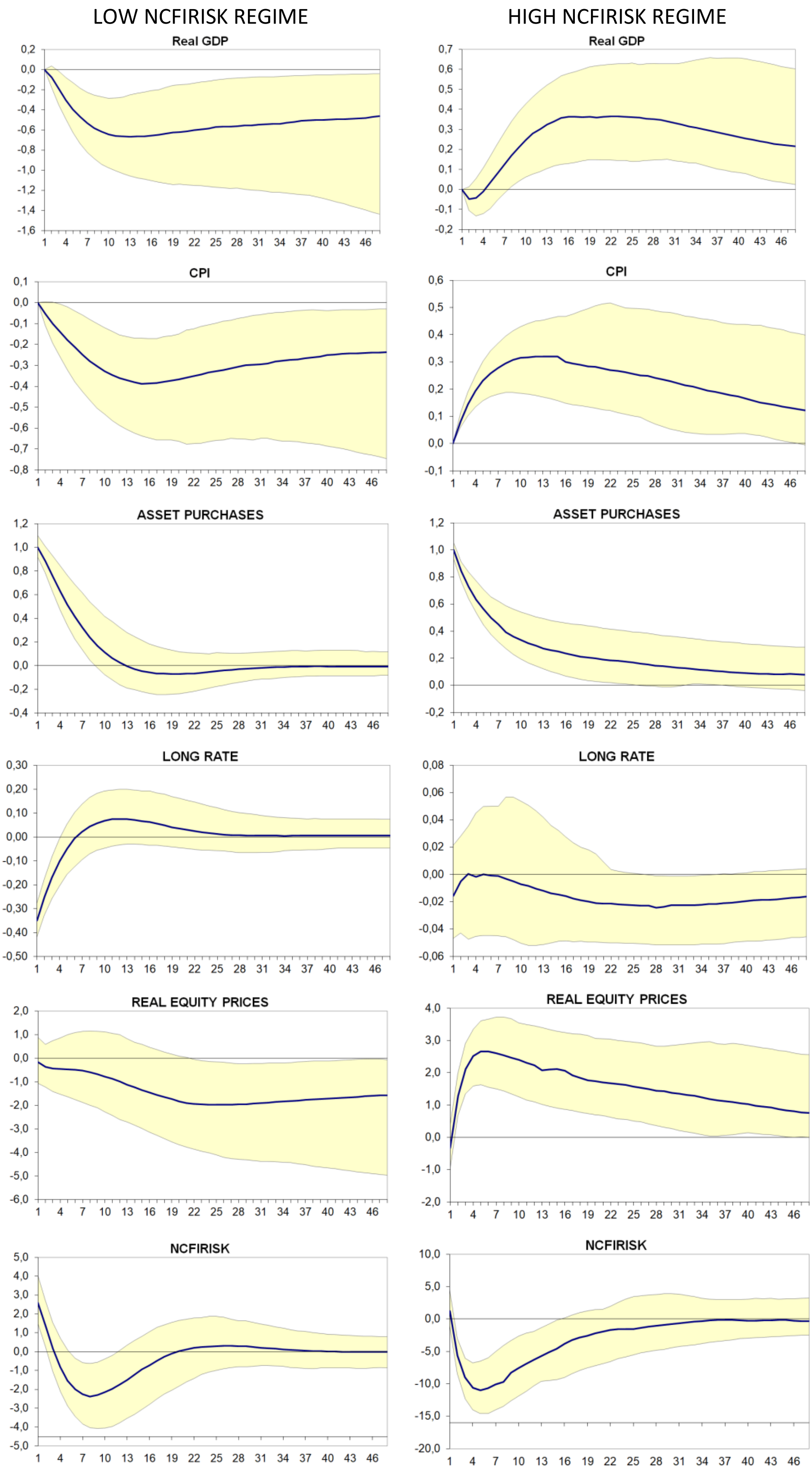

Figure 3: Response functions in the high NCFIRISK regime (NCFIRISK $\geq$ -0.41) and in the low NCFIRISK regime (NCFIRISK <-0.41) to a 1 percentage point increase (in GDP terms) in the asset purchases. On the vertical axes the percentage deviation of the levels of the variables.

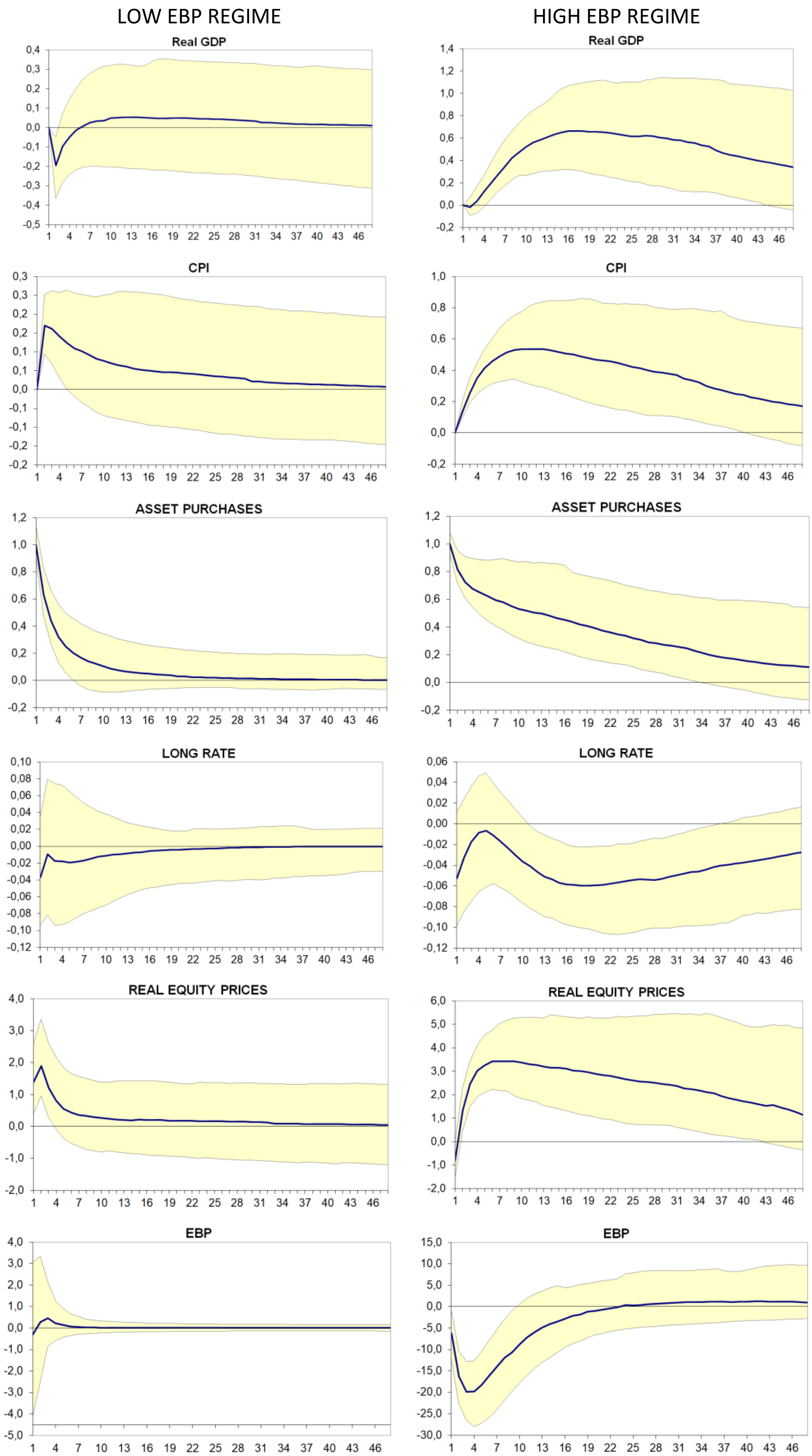

Figure 4: Response functions in the high EBP regime (EBP $\geq$ -0.2) and in the low EBP regime (EBP $<$-0.2) to a 1 percentage point increase (in GDP terms) in the asset purchases. On the vertical axes the percentage deviation of the levels of the variables.

RECENTLY PUBLISHED "TEMI" (*)

N. 1257 – *Labour productivity and the wageless recovery*, by Antonio M. Conti, Elisa Guglielminetti and Marianna Riggi (December 2019).

N. 1258 – *Corporate leverage and monetary policy effectiveness in the Euro area*, by Simone Auer, Marco Bernardini and Martina Cecioni (December 2019).

N. 1259 – *Energy costs and competitiveness in Europe*, by Ivan Faiella and Alessandro Mistretta (February 2020).

N. 1260 – *Demand for safety, risky loans: a model of securitization*, by Anatoli Segura and Alonso Villacorta (February 2020).

N. 1261 – *The real effects of land use regulation: quasi-experimental evidence from a discontinuous policy variation*, by Marco Fregoni, Marco Leonardi and Sauro Mocetti (February 2020).

N. 1262 – *Capital inflows to emerging countries and their sensitivity to the global financial cycle*, by Ines Buono, Flavia Corneli and Enrica Di Stefano (February 2020).

N. 1263 – *Rising protectionism and global value chains: quantifying the general equilibrium effects*, by Rita Cappariello, Sebastián Franco-Bedoya, Vanessa Gunnella and Gianmarco Ottaviano (February 2020).

N. 1264 – *The impact of TLTRO2 on the Italian credit market: some econometric evidence*, by Lucia Esposito, Davide Fantino and Yeji Sung (February 2020).

N. 1265 – *Public credit guarantee and financial additionalities across SME risk classes*, by Emanuele Ciani, Marco Gallo and Zeno Rotondi (February 2020).

N. 1266 – *Determinants of the credit cycle: a flow analysis of the extensive margin*, by Vincenzo Cuciniello and Nicola di Iasio (March 2020).

N. 1267 – *Housing supply elasticity and growth: evidence from Italian cities*, by Antonio Accetturo, Andrea Lamorgese, Sauro Mocetti and Dario Pellegrino (March 2020).

N. 1268 – *Public debt expansions and the dynamics of the household borrowing constraint*, by António Antunes and Valerio Ercolani (March 2020).

N. 1269 – *Expansionary yet different: credit supply and real effects of negative interest rate policy*, by Margherita Bottero and Enrico Sette (March 2020).

N. 1270 – *Asymmetry in the conditional distribution of euro-area inflation*, by Alex Tagliabracci (March 2020).

N. 1271 – *An analysis of sovereign credit risk premia in the euro area: are they explained by local or global factors?*, by Sara Cecchetti (March 2020).

N. 1272 – *Mutual funds' performance: the role of distribution networks and bank affiliation*, by Giorgio Albareto, Andrea Cardillo, Andrea Hamaui and Giuseppe Marinelli (April 2020).

N. 1273 – *Immigration and the fear of unemployment: evidence from individual perceptions in Italy*, by Eleonora Porreca and Alfonso Rosolia (April 2020).

N. 1274 – *Bridge Proxy-SVAR: estimating the macroeconomic effects of shocks identified at high-frequency*, by Andrea Gazzani and Alejandro Vicondoa (April 2020).

N. 1275 – *Monetary policy gradualism and the nonlinear effects of monetary shocks*, by Luca Metelli, Filippo Natoli and Luca Rossi (April 2020).

N. 1276 – *Spend today or spend tomorrow? The role of inflation expectations in consumer behaviour*, by Concetta Rondinelli and Roberta Zizza (April 2020).

(*) Requests for copies should be sent to:
Banca d'Italia – Servizio Studi di struttura economica e finanziaria – Divisione Biblioteca e Archivio storico – Via Nazionale, 91 – 00184 Rome – (fax 0039 06 47922059). They are available on the Internet www.bancaditalia.it.

2018

ACCETTURO A., V. DI GIACINTO, G. MICUCCI and M. PAGNINI, *Geography, productivity and trade: does selection explain why some locations are more productive than others?,* Journal of Regional Science, v. 58, 5, pp. 949-979, **WP 910 (April 2013).**

ADAMOPOULOU A. and E. KAYA, *Young adults living with their parents and the influence of peers,* Oxford Bulletin of Economics and Statistics,v. 80, pp. 689-713, **WP 1038 (November 2015).**

ANDINI M., E. CIANI, G. DE BLASIO, A. D'IGNAZIO and V. SILVESTRINI, *Targeting with machine learning: an application to a tax rebate program in Italy,* Journal of Economic Behavior & Organization, v. 156, pp. 86-102, **WP 1158 (December 2017).**

BARONE G., G. DE BLASIO and S. MOCETTI, *The real effects of credit crunch in the great recession: evidence from Italian provinces,* Regional Science and Urban Economics, v. 70, pp. 352-59, **WP 1057 (March 2016).**

BELOTTI F. and G. ILARDI *Consistent inference in fixed-effects stochastic frontier models,* Journal of Econometrics, v. 202, 2, pp. 161-177, **WP 1147 (October 2017).**

BERTON F., S. MOCETTI, A. PRESBITERO and M. RICHIARDI, *Banks, firms, and jobs,* Review of Financial Studies, v.31, 6, pp. 2113-2156, **WP 1097 (February 2017).**

BOFONDI M., L. CARPINELLI and E. SETTE, *Credit supply during a sovereign debt crisis,* Journal of the European Economic Association, v.16, 3, pp. 696-729, **WP 909 (April 2013).**

BOKAN N., A. GERALI, S. GOMES, P. JACQUINOT and M. PISANI, *EAGLE-FLI: a macroeconomic model of banking and financial interdependence in the euro area,* Economic Modelling, v. 69, C, pp. 249-280, **WP 1064 (April 2016).**

BRILLI Y. and M. TONELLO, *Does increasing compulsory education reduce or displace adolescent crime? New evidence from administrative and victimization data,* CESifo Economic Studies, v. 64, 1, pp. 15–4, **WP 1008 (April 2015).**

BUONO I. and S. FORMAI *The heterogeneous response of domestic sales and exports to bank credit shocks,* Journal of International Economics, v. 113, pp. 55-73, **WP 1066 (March 2018).**

BURLON L., A. GERALI, A. NOTARPIETRO and M. PISANI, *Non-standard monetary policy, asset prices and macroprudential policy in a monetary union,* Journal of International Money and Finance, v. 88, pp. 25-53, **WP 1089 (October 2016).**

CARTA F. and M. DE PHLIPPIS, *You've Come a long way, baby. Husbands' commuting time and family labour supply,* Regional Science and Urban Economics, v. 69, pp. 25-37, **WP 1003 (March 2015).**

CARTA F. and L. RIZZICA, *Early kindergarten, maternal labor supply and children's outcomes: evidence from Italy,* Journal of Public Economics, v. 158, pp. 79-102, **WP 1030 (October 2015).**

CASIRAGHI M., E. GAIOTTI, L. RODANO and A. SECCHI, *A "Reverse Robin Hood"? The distributional implications of non-standard monetary policy for Italian households,* Journal of International Money and Finance, v. 85, pp. 215-235, **WP 1077 (July 2016).**

CIANI E. and C. DEIANA, *No Free lunch, buddy: housing transfers and informal care later in life,* Review of Economics of the Household, v.16, 4, pp. 971-1001, **WP 1117 (June 2017).**

CIPRIANI M., A. GUARINO, G. GUAZZAROTTI, F. TAGLIATI and S. FISHER, *Informational contagion in the laboratory,* Review of Finance, v. 22, 3, pp. 877-904, **WP 1063 (April 2016).**

DE BLASIO G, S. DE MITRI, S. D'IGNAZIO, P. FINALDI RUSSO and L. STOPPANI, *Public guarantees to SME borrowing. A RDD evaluation,* Journal of Banking & Finance, v. 96, pp. 73-86, **WP 1111 (April 2017).**

GERALI A., A. LOCARNO, A. NOTARPIETRO and M. PISANI, *The sovereign crisis and Italy's potential output,* Journal of Policy Modeling, v. 40, 2, pp. 418-433, **WP 1010 (June 2015).**

LIBERATI D., *An estimated DSGE model with search and matching frictions in the credit market,* International Journal of Monetary Economics and Finance (IJMEF), v. 11, 6, pp. 567-617, **WP 986 (November 2014).**

LINARELLO A., *Direct and indirect effects of trade liberalization: evidence from Chile,* Journal of Development Economics, v. 134, pp. 160-175, **WP 994 (December 2014).**

NATOLI F. and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, v. 14, 1, pp. 35-71, **WP 1025 (July 2015).**

NUCCI F. and M. RIGGI, *Labor force participation, wage rigidities, and inflation,* Journal of Macroeconomics, v. 55, 3 pp. 274-292, **WP 1054 (March 2016).**

RIGON M. and F. ZANETTI, *Optimal monetary policy and fiscal policy interaction in a non_ricardian economy,* International Journal of Central Banking, v. 14 3, pp. 389-436, **WP 1155 (December 2017).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, v. 22, 2, pp. 661-697, **WP 1100 (February 2017).**

2019

ALBANESE G., M. CIOFFI and P. TOMMASINO, *Legislators' behaviour and electoral rules: evidence from an Italian reform,* European Journal of Political Economy, v. 59, pp. 423-444, **WP 1135 (September 2017).**

APRIGLIANO V., G. ARDIZZI and L. MONTEFORTE, *Using the payment system data to forecast the economic activity,* International Journal of Central Banking, v. 15, 4, pp. 55-80, **WP 1098 (February 2017).**

ARNAUDO D., G. MICUCCI, M. RIGON and P. ROSSI, *Should I stay or should I go? Firms' mobility across banks in the aftermath of the financial crisis,* Italian Economic Journal / Rivista italiana degli economisti, v. 5, 1, pp. 17-37, **WP 1086 (October 2016).**

BASSO G., F. D'AMURI and G. PERI, *Immigrants, labor market dynamics and adjustment to shocks in the euro area,* IMF Economic Review, v. 67, 3, pp. 528-572, **WP 1195 (November 2018).**

BATINI N., G. MELINA and S. VILLA, *Fiscal buffers, private debt, and recession: the good, the bad and the ugly,* Journal of Macroeconomics, v. 62, **WP 1186 (July 2018).**

BURLON L., A. NOTARPIETRO and M. PISANI, *Macroeconomic effects of an open-ended asset purchase programme,* Journal of Policy Modeling, v. 41, 6, pp. 1144-1159, **WP 1185 (July 2018).**

BUSETTI F. and M. CAIVANO, *Low frequency drivers of the real interest rate: empirical evidence for advanced economies,* International Finance, v. 22, 2, pp. 171-185, **WP 1132 (September 2017).**

CAPPELLETTI G., G. GUAZZAROTTI and P. TOMMASINO, *Tax deferral and mutual fund inflows: evidence from a quasi-natural experiment,* Fiscal Studies, v. 40, 2, pp. 211-237, **WP 938 (November 2013).**

CARDANI R., A. PACCAGNINI and S. VILLA, *Forecasting with instabilities: an application to DSGE models with financial frictions,* Journal of Macroeconomics, v. 61, **WP 1234 (September 2019).**

CHIADES P., L. GRECO, V. MENGOTTO, L. MORETTI and P. VALBONESI, *Fiscal consolidation by intergovernmental transfers cuts? The unpleasant effect on expenditure arrears,* Economic Modelling, v. 77, pp. 266-275, **WP 985 (July 2016).**

CIANI E., F. DAVID and G. DE BLASIO, *Local responses to labor demand shocks: a re-assessment of the case of Italy,* Regional Science and Urban Economics, v. 75, pp. 1-21, **WP 1112 (April 2017).**

CIANI E. and P. FISHER, *Dif-in-dif estimators of multiplicative treatment effects,* Journal of Econometric Methods, v. 8. 1, pp. 1-10, **WP 985 (November 2014).**

CIAPANNA E. and M. TABOGA, *Bayesian analysis of coefficient instability in dynamic regressions,* Econometrics, MDPI, Open Access Journal, v. 7, 3, pp.1-32, **WP 836 (November 2011).**

COLETTA M., R. DE BONIS and S. PIERMATTEI, *Household debt in OECD countries: the role of supply-side and demand-side factors,* Social Indicators Research, v. 143, 3, pp. 1185–1217, **WP 989 (November 2014).**

COVA P., P. PAGANO and M. PISANI, *Domestic and international effects of the Eurosystem Expanded Asset Purchase Programme,* IMF Economic Review, v. 67, 2, pp. 315-348, **WP 1036 (October 2015).**

ERCOLANI V. and J. VALLE E AZEVEDO, *How can the government spending multiplier be small at the zero lower bound?,* Macroeconomic Dynamics, v. 23, 8. pp. 3457-2482, **WP 1174 (April 2018).**

FERRERO G., M. GROSS and S. NERI, *On secular stagnation and low interest rates: demography matters,* International Finance, v. 22, 3, pp. 262-278, **WP 1137 (September 2017).**

FOA G., L. GAMBACORTA, L. GUISO and P. E. MISTRULLI, *The supply side of household finance,* Review of Financial Studies, v.32, 10, pp. 3762-3798, **WP 1044 (November 2015).**

GIORDANO C., M. MARINUCCI and A. SILVESTRINI, *The macro determinants of firms' and households' investment: evidence from Italy,* Economic Modelling, v. 78, pp. 118-133, **WP 1167 (March 2018).**

GOMELLINI M., D. PELLEGRINO and F. GIFFONI, *Human capital and urban growth in Italy,1981-2001,* Review of Urban & Regional Development Studies, v. 31, 2, pp. 77-101, **WP 1127 (July 2017).**

MAGRI S., *Are lenders using risk-based pricing in the Italian consumer loan market? The effect of the 2008 crisis,* Journal of Credit Risk, v. 15, 1, pp. 27-65, **WP 1164 (January 2018).**

MAKINEN T., A. MERCATANTI and A. SILVESTRINI, *The role of financial factors for european corporate investment,* Journal of International Money and Finance, v. 96, pp. 246-258, **WP 1148 (October 2017).**

MIGLIETTA A., C. PICILLO and M. PIETRUNTI, *The impact of margin policies on the Italian repo market,* The North American Journal of Economics and Finance, v. 50, **WP 1028 (October 2015).**

MONTEFORTE L. and V. RAPONI, *Short-term forecasts of economic activity: are fortnightly factors useful?,* Journal of Forecasting, v. 38, 3, pp. 207-221, **WP 1177 (June 2018).**

NERI S. and A. NOTARPIETRO, *Collateral constraints, the zero lower bound, and the debt–deflation mechanism,* Economics Letters, v. 174, pp. 144-148, **WP 1040 (November 2015).**

PEREDA FERNANDEZ S., *Teachers and cheaters. Just an anagram?*, Journal of Human Capital, v. 13, 4, pp. 635-669, **WP 1047 (January 2016).**

RIGGI M., *Capital destruction, jobless recoveries, and the discipline device role of unemployment,* Macroeconomic Dynamics, v. 23, 2, pp. 590-624, **WP 871 (July 2012).**

2020

BRIPI F., D. LOSCHIAVO and D. REVELLI, *Services trade and credit frictions: evidence with matched bank – firm data,* The World Economy, v. 43, 5, pp. 1216-1252, **WP 1110 (April 2017).**

COIBION O., Y. GORODNICHENKO and T. ROPELE, *Inflation expectations and firms' decisions: new causal evidence,* Quarterly Journal of Economics, v. 135, 1, pp. 165-219, **WP 1219 (April 2019).**

CORSELLO F. and V. NISPI LANDI, *Labor market and financial shocks: a time-varying analysis,* Journal of Money, Credit and Banking, v. 52, 4, pp. 777-801, **WP 1179 (June 2018).**

D'IGNAZIO A. and C. MENON, *The causal effect of credit Guarantees for SMEs: evidence from Italy,* The Scandinavian Journal of Economics, v. 122, 1, pp. 191-218, **WP 900 (February 2013).**

RAINONE E. and F. VACIRCA, *Estimating the money market microstructure with negative and zero interest rates,* Quantitative Finance, v. 20, 2, pp. 207-234, **WP 1059 (March 2016).**

RIZZICA L., *Raising aspirations and higher education. Evidence from the UK's widening participation policy,* Journal of Labor Economics, v. 38, 1, pp. 183-214, **WP 1188 (September 2018).**

FORTHCOMING

ARDUINI T., E. PATACCHINI and E. RAINONE, *Treatment effects with heterogeneous externalities,* Journal of Business & Economic Statistics, **WP 974 (October 2014).**

BALTRUNAITE A., C. GIORGIANTONIO, S. MOCETTI and T. ORLANDO, *Discretion and supplier selection in public procurement*, Journal of Law, Economics, and Organization, **WP 1178 (June 2018).**

BOLOGNA P., A. MIGLIETTA and A. SEGURA, *Contagion in the CoCos market? A case study of two stress events,* International Journal of Central Banking, **WP 1201 (November 2018).**

BOTTERO M., F. MEZZANOTTI and S. LENZU, *Sovereign debt exposure and the Bank Lending Channel: impact on credit supply and the real economy,* Journal of International Economics, **WP 1032 (October 2015).**

BRONZINI R., G. CARAMELLINO and S. MAGRI, *Venture capitalists at work: a Diff-in-Diff approach at late-stages of the screening process,* Journal of Business Venturing, **WP 1131 (September 2017).**

BRONZINI R., S. MOCETTI and M. MONGARDINI, *The economic effects of big events: evidence from the Great Jubilee 2000 in Rome,* Journal of Regional Science, **WP 1208 (February 2019).**

COVA P. and F. NATOLI, *The risk-taking channel of international financial flows,* Journal of International Money and Finance, **WP 1152 (December 2017).**

COVA P., P. PAGANO, A. NOTARPIETRO and M. PISANI, *Secular stagnation, R&D, public investment and monetary policy: a global-model perspective,* Macroeconomic Dynamics, **WP 1156 (December 2017).**

DEL PRETE S. and S. FEDERICO, *Do links between banks matter for bilateral trade? Evidence from financial crises,* Review of World Economics, **WP 1217 (April 2019).**

GERALI A. and S. NERI, *Natural rates across the Atlantic,* Journal of Macroeconomics, **WP 1140 (September 2017).**

LIBERATI D. and M. LOBERTO, *Taxation and housing markets with search frictions,* Journal of Housing Economics, **WP 1105 (March 2017).**

LOSCHIAVO D., *Household debt and income inequality: evidence from Italian survey data,* Review of Income and Wealth, **WP 1095 (January 2017).**

MOCETTI S., G. ROMA and E. RUBOLINO, *Knocking on parents' doors: regulation and intergenerational mobility,* Journal of Human Resources, **WP 1182 (July 2018).**

NISPI LANDI V. and A. SCHIAVONE, *The effectiveness of capital controls,* Open Economies Review, **WP 1200 (November 2018).**

PANCRAZI R. and M. PIETRUNTI, *Natural expectations and home equity extraction,* Journal of Housing Economics, **WP 984 (November 2014).**

PEREDA FERNANDEZ S., *Copula-based random effects models for clustered data,* Journal of Business & Economic Statistics, **WP 1092 (January 2017).**

RAINONE E., *The network nature of otc interest rates,* Journal of Financial Markets, **WP 1022 (July 2015).**

SANTIONI, R., F. SCHIANTARELLI and P. STRAHAN, *Internal capital markets in times of crisis: the benefit of group affiliation*, Review of Finance, **WP 1146 (October 2017).**

SCHIANTARELLI F., M. STACCHINI and P. STRAHAN, *Bank Quality, judicial efficiency and loan repayment delays in Italy,* Journal of Finance, **WP 1072 (July 2016).**