The Impact of Monetary Policy Instruments on the Euro Area Labor Market in the Context of COVID-19 Pandemic – Time-Varying Parameter VAR model approach

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Abstract. The paper examines simplified backward and forward transmission mechanism of monetary policy instrument to perturbation in un-employment rate. We apply three variables time-varying VAR model, with stochastic volatility, to determine the dynamic relationship among unemployment rate, interest rate and supply of money in the context of Euro Area. We concluded that, there is a possible stabilization potential through the increase in the money supply has dramatically risen before (and after) the COVID-19 pandemic; the reaction function of ECB to negative unemployment shock has been tied-up by the zero low bound and space for intense interest rate decrease has been empirically reduced in the pandemic times.

Keywords: monetary policy, pandemic, unemployment

JEL classification: *C32, E37, E52*

1 Introduction

The Euro Area labor market was severely hit by the SARS-COV2 pandemic and associated containment measures. Most academics would agree on the notion, that pandemic combines both supply and demand shock to European economy (for a short discussion see Baldwin (2021; 2020)). According to Brinca, Duarte, a Faria-e-Castro (2020) decomposition of hours worked in the US economy the labor market was severely hit by the supply shock due to mitigation measures, which consequently cause drop in the consumption rate due to job-losses. In Europe the total hours worked declined at the sharpest rates on the record. The labor force declined by about 5 million in the first half of 2020. The decomposition of worked hours and labor force decline in the Euro Area labor marked indicates the same similarities and differences from the financial crisis, as in the US context. During the financial crisis the demand shock accounted for two supply shock in labor force decline, current pandemic crisis indicate the direct opposite correlation (Anderton *et al.*, 2021). To minimize the short-term and long-term disturbances in the labor market and negative feedback loops to aggregate demand, the massive intervention of both labor market fiscal policies as well as massive monetary stimulus is needed. The pandemic however created a potential to long-term more productive re-allocation of labor, due to strong pressure of digitalization and automatization. These trends may have adverse effect on the deepening the skill mismatch, which could possibly lead to higher structural unemployment and further economic divergence among labor markets in Europe.

However, the European monetary policy is facing secular decline in the equilibrium real interest rate, which has limited the room for policy-rate reduction in the future recession (Coenen, Montes-Galdon and Schmidt, 2021). The unconventional monetary policy instruments were introduced, mainly captured by the rise of highly liquid money supply and a negative a policy-rate. Due to necessary transformation of monetary policy instruments, the relationship among them and unemployment may have changed.

In this paper we will examine to what extend the structural change among main monetary instruments and unemployment is observed in the data, and we will determine the rate (potential) of aggressiveness of ECB reaction to current pandemic crisis in terms of expansionary measures.

2 Materials and Methods

The bilateral effect of monetary policy instruments to unemployment rate in the level of Euro Area was estimated using three variables; seasonally adjusted unemployment rate, interest rate (EONIA-monthly average) and money aggregate M3; in the period of January 2010 to Jun 2021, on a monthly basis.

Based on the assumption, that the variables has unit root and are not cointegrated, we can estimate the time varying parameter VAR (TVP-VAR) model, which has a different structure from the standard VAR model, in the respect of changing estimated parameter over time (Primiceri, 2005). Nakajima (2011) extends Primiceri's approach with comprehensive and robust estimation algorithm including stochastic volatility for the TVP-VAR model. Stochastic volatility combined with TVP-VAR, allows us to capture possible structural changes of the economy.

The structural VAR representation of multivariate time series can be defined as follows (Primiceri, 2005; Nakajima, 2011):

$$A\boldsymbol{y}_t = F_1\boldsymbol{y}_{t-1} + \cdots + F_s\boldsymbol{y}_{t-s} + u_t \tag{1}$$

Where $\boldsymbol{y}_t$ is a $k\times 1$ vector of three endogenous variables (unemployment rate, short-term interest rate, money aggregate M3); $A, F_1, \ldots, F_s$ are a $k\times k$ matrices of coefficients.

The disturbance u_t is a $k\times 1$ structural shock with $u_t \sim N(0, \sum\sum)$ distribution, where $\sum_t = diag(\sigma_{1t}, \dots, \sigma_{3t})$.

The structural shock can be assumed by lower-triangular A matrix (Nakajima, 2011),

$$A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{pmatrix}$$

The VAR model in equation (1) can be rewritten in a reduced form:

$$\boldsymbol{y}_t = B_1 \boldsymbol{y}_{t-1} + \cdots + B_s \boldsymbol{y}_{t-s} + A^{-1} \sum \varepsilon_t \qquad \varepsilon_t \sim (0, \mathrm{I}_k)$$

where $B_i = A^{-1} F_i$, for $i = 1, \dots, s$. Stacking the elements in the rows of B_i to the $k^2 s \times 1$ vector β, and defining $X_t = I_s \otimes (\boldsymbol{y}'_{t-1}, \dots, \boldsymbol{y}'_{t-s})$, the model with all invariant parameters can be rewritten as:

$$y_t = X_t \beta + A^{-1} \sum \varepsilon_t \tag{2}$$

The model with time-varying parameters with stochastic volatility and time-varying parameters can be specified in the following form:

$$y_t = X_t \beta_t + A_t^{-1} \sum_t \varepsilon_t \tag{3}$$

with the time-varying coefficients vector β_t, created as stacked row vector of $B_{1t}, \dots, B_{st}$; $a_t = (a_{1t}, \dots, a_{qt})'$ is stacked row vector of the lower-triangular elements of A_t; $h_t = (h_{1t}, \dots, h_{qt})$, where $h_{it} = \log \sigma_{it}^2$. All time-varying parameters $A_t \; and \sum_t$ follow the random walk process (Nakajima, 2011):

$$\begin{matrix} \beta_{t+1} = \beta_t + u_{\beta t}, \\ a_{t+1} = a_t + u_{at}, \\ h_{t+1} = h_t + u_{ht}, \end{matrix} \begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N \left(0, \begin{pmatrix} \mathrm{I} & 0 & 0 & 0 \\ 0 & \sum_\beta & 0 & 0 \\ 0 & 0 & \sum_a & 0 \\ 0 & 0 & 0 & \sum_h \end{pmatrix} \right) \tag{4}$$

for $t = s + 1, \dots, n$, with $e_t = A^{-1} \sum_t \varepsilon_t$, where $\sum_a \; and \sum_h$ are diagonal matrices, $\beta_{s+1} \sim N(u_{\beta 0} \sum_{\beta 0})$, $a_{s+1} \sim N(u_{a0} \sum_{a0})$, and $h_{s+1} \sim N(u_{h0} \sum_{h0})$. The random walk specification allows to model sudden breaks in the evolution of the parameters and captures gradual changes in the relationship among variables.

The estimation procedure was based on functions and algorithm developed by Nakajima (2011). Suitability of our dataset was tested with Augmented Dickey-Fuller (for unit root tests) and Johansen test for cointegration. *Matlab* and *Stata* software was used for this purpose respectively. Noteworthy here is optimal lag selection, according to HQIC and SBIC the first-order lag can best fit our data.

3 Results

The unit root tests indicates that all our time series data are non-stationary at their level data but become stationary when first differencing them, suggesting that they are all integrated at order one at 5% significance level. Johansen test for cointegration indicates, that none of our time series is cointegrated. These results allow us to use TVP-VAR model to model data in their first difference form.
To begin with our estimation, we plot the time-series with their Nakajima's indicator of stochastic volatility in specific periods (see Figure 1). We observe rather static and slowly increasing trend of stochastic volatility in unemployment rate and M3 aggregate. In the case of interest rate, we observe some abrupt changes of their stochastic volatility due some unobserved major factor, in the periods of 2010 till the beginning of the 2015, and as the interest rate are below the zero low bound, the stochastic volatility decreased significantly.

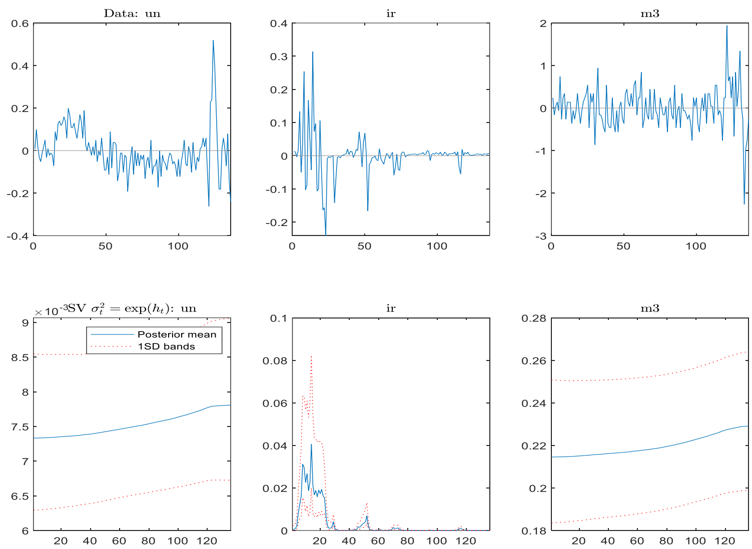

Figure 15. Time-series of unemployment rate, short-term interest rate (EONIA-monthly average), money aggregate M3 (all in first difference form). Stochastic volatility indicator for 2010-2021 periods.

Table 1 shows the estimates of TVP-VAR model with the MCMC algorithm with 15,000 iterations. It can be seen, that the Geweke statistics is greater than 10%, indicating that parameters converged to is posterior distribution. The ineffective factor is less than 100 (expect the parameters *h*), which meets the MCMC sampling with 15,000 sampling frequency. These results are supported by the autocorrelation functions (not displayed here). The estimates of mean value all parameters lie in the 95% confidence interval, which indicates effective and robust results of our estimation.

Table 14. Time-varying parameters VAR estimates

Parameter	Mean	Standard deviation	Confidence interval (95%)	Geweke statistics	Ineffective
$(\sum_\beta)_1$	0.0023	0.0003	[0.0018; 0.0029]	0. 177	7.13
$(\sum_\beta)_2$	0.0023	0.000	[0.0018; 0.0028]	0. 352	7.56
$(\sum_\alpha)_1$	0.0049	0.0012	[0.0033; 0.0078]	0. 330	22.02
$(\sum_h)_1$	0.0061	0.0032	[0.0034; 0.0134]	0. 208	115.18
$(\sum_h)_2$	1.0359	0.1856	[0.7039; 1.4345]	0. 726	41.06

Next, we will analyze the impulse response function of constant version of our model. The impulse response function is a basic tool to see the macroeconomic dynamics captured by the estimated VAR system. For a standard VAR model whose parameters are all time-invariant, the impulse responses are drawn for each subset of two variables in a model.

We firstly estimate the constant VAR model, and the impulse responses are displayed on the Figure 2.

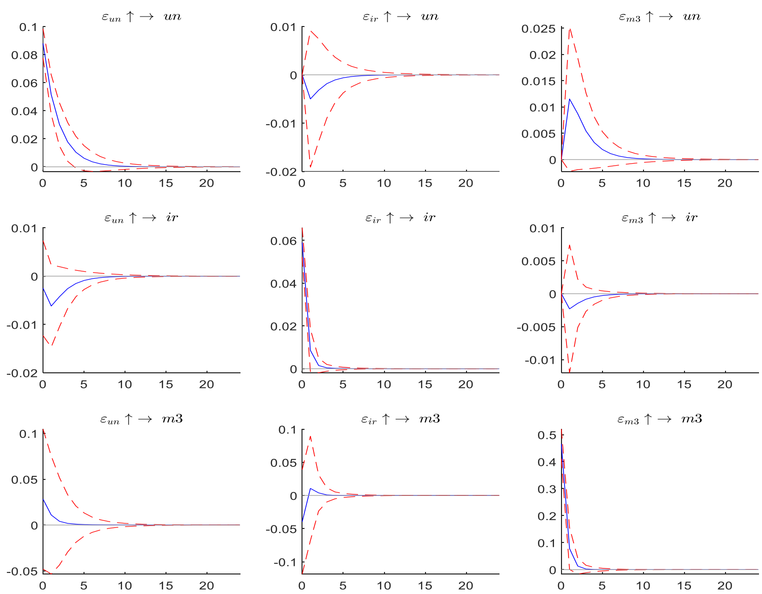

Figure 2 Impulse responses of constant VAR model, with 95% confidence intervals.

The constant VAR model indicates rather insignificant (inconclusive) relationship of negative shock in unemployment to both monetary instruments in the whole simulated period of two years. The effect of shock in unemployment is constantly zero after approximately one year lapsed. The opposite relationship of negative shock in interest rate indicates the expected slightly negative response of unemployment rate, but also not in a conclusive matter. The response on the money aggregate shock indicates expected negative relationship with the unemployment rate, but not significantly different from zero in simulated period. The reverse relationship indicates the same conclusions.

Since the key parameters of mutual relationship among unemployment and monetary instruments (may) have changed during the period of eleven years, we can discuss the impulse responses of time-varying parameters VAR model (see Figure 3). The responses of pairwise combinations are computed at all points in time using the estimated time-varying parameters (Nakajima, 2011).

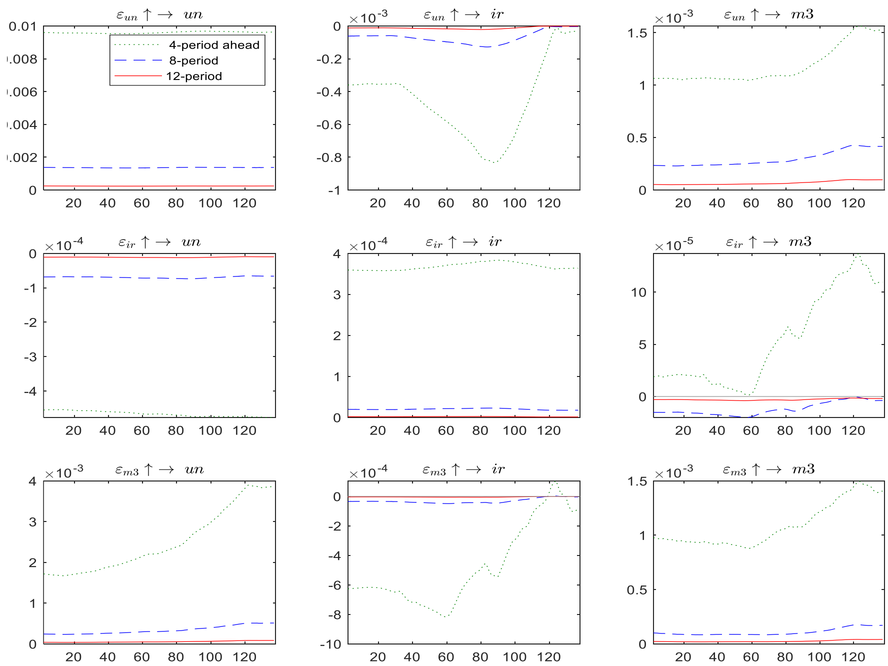

Figure 3 Impulse responses of TVP-VAR model (Feb 2010-May 2022) - posterior mean for one-quarter (green, dotted), two-quarters (blue, dashed), one-year (red, solid) ahead.

The impulse response function of negative shock in interest rate (due to expansionary measures) to unemployment ($\varepsilon_{ir} \uparrow \rightarrow un$) shows a similar behavior as described in the constant VAR model, and we do not observe some abrupt changes in mentioned direct transmissional channel during the past decade, in estimated periods of four to twelve months.

Similar (but opposite, due nature of indicator) and expected behavior is observed between the ‘tightening’ of the money aggregate and unemployment ($\varepsilon_{m3} \uparrow \rightarrow un$). The TVP-VAR model indicates the changing sensitivity of unemployment to money aggregate tightening. It can be ascribed to the possible (and effective) change in the composition of money aggregate to more liquid assets, which can be more linked to the variation in unemployment rate. But its beyond the scope of our paper and we are referring to further research of mentioned hypothesis.
TVP-VAR model indicates that the opposite relationship; or backward transmission mechanism; of shock in unemployment to selected monetary instruments is gradually changing during the business cycle, especially on the short-term periods. The interest rate was mostly responsive to negative shock in unemployment shortly after the expansion in 2016 till 2018. After the European economy starts expanding, the monetary policy is becoming less sensitive to (simulated) rise in unemployment. In the period of observed dramatic turnover of interest rate response (July 2016) to unemployment, the policy-rate hits the zero low bound and in could be the symptoms of necessary, not a deliberate strategy. The simulated period after the pandemic hit suggests slightly more sensitive response of short-term interest rate to unemployment, however we must consider the persisting zero-low bound in all simulated periods. The one-quarter impulse response function, during the periods after the pandemic hit response function displays very mild decreasing sensitivity, with indication of slight (but correct) response of the monetary authority to current labor market worsening. The money aggregate to unemployment shock shows the counter-cyclical response in the all-projected periods. The simulated short-run posterior mean indicates the loosing monetary aggregate after the rise in unemployment, with a little decrease in a sensitivity after the pandemic hit. But the high effort of monetary authority in terms of expansionary reaction to unemployment perturbation are continuously and significantly seen in the data in recent months.
The TVP-VAR model impulse response functions can be drawn in an additional dimension - time, we have plotted the time-varying response functions on Figure 4 and 5. In the connection with the Figure 3 the time-varying nature of model could be fully appreciated.

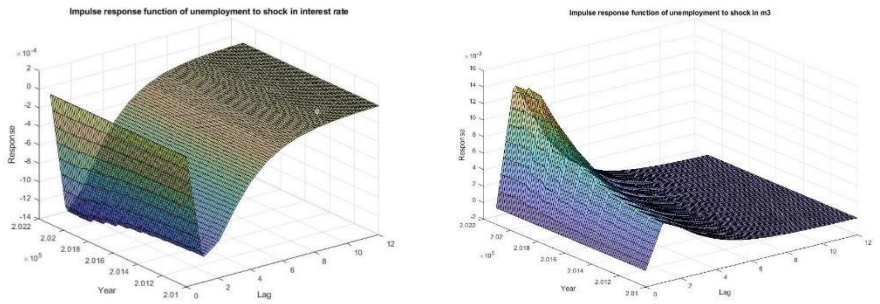

Figure 4 Three-dimensional impulse response function of negative monetary instruments shock to unemployment rate. The X-axis (Year) represents each point of time at the data period, the Y-axis (LAG) represent the time elapsed from the shock in respective monetary instrument. The Z-axis represents the response size in the unemployment rate.

As we have mentioned the data indicates that unemployment rate is becoming a little more responsive to positive shock in interest rate in the current crisis, the degree of sensitivity to the money aggregate tightening (loosing) is substantially higher. We are observing potential effective (and short) stabilization of unemployment rate due to following marginal rise of M3 aggregate.

Lastly, we simulate the impulse response of monetary instruments functions to the shock in unemployment rate. The response of money aggregate seems intuitive classical response function of central bank, and timely invariant in its nature.

The left upper and bottom boxes of Figure 5 simulate the impulse response function of short-term interest rate to shock in unemployment rate. We can easily identify the interest rate sensitivity to unemployment fluctuation in the past. With the very loosen and responsive policy rate, with its culmination in the 2018 when the interest rate hits the zero-lower bound. In the environment of low inflationary expectations, secularly decreasing equilibrium real interest rate and slow growth environment discourage the central bank from rising the policy rate above zero, despite the labor marked overheating. Empirical data suggest that the central bank is constantly tightening its reaction function. The ECB starts to slightly tighten the policy rate sensitivity in the expansion and would have intention to more prudently reacts to shock in unemployment in the environment of labor market overheating.

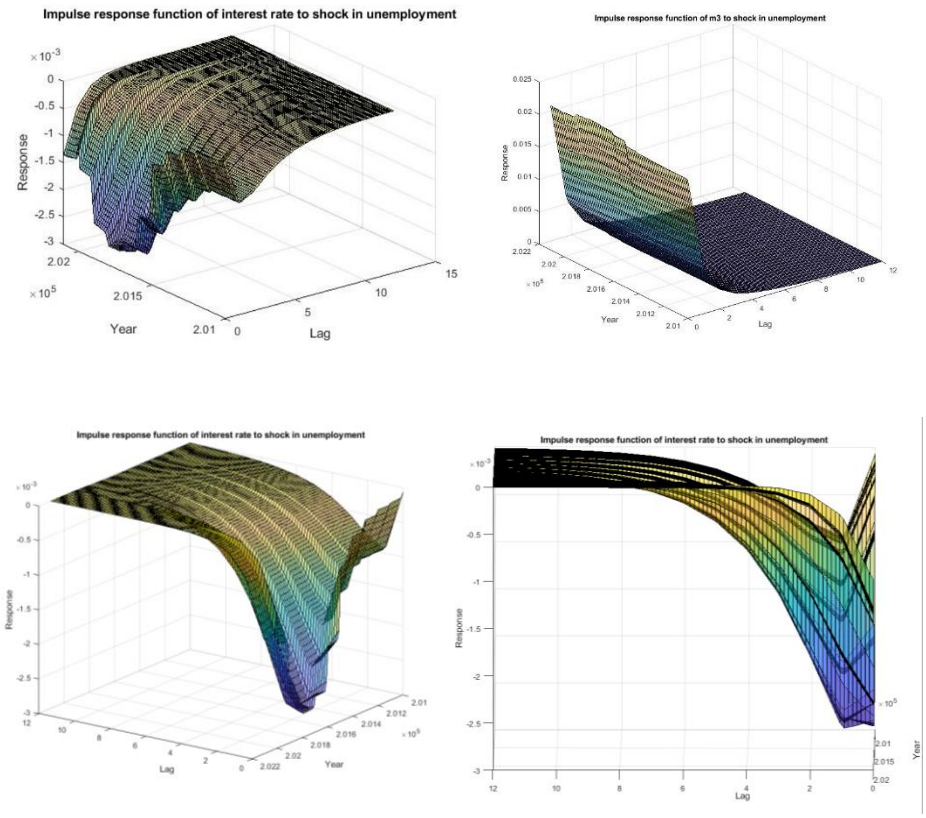

Figure 5 Three-dimensional impulse response function of positive unemployment shock to monetary policy instruments. The X-axis (Year) represents each point of time at the data period, the Y-axis (LAG) represent the time elapsed from the shock in unemployment. The Z-axis represent the response size in the respective instrument.

The current period simulated on the bottom box of Figure 5, indicates a slightly aggressive reaction of ECB policy-rate to shock in unemployment comparing to recession in 2013. Despite she is tied-up by the zero low bound. The last shock to unemployment is simulated in the May of 2021, the model indicates the possible sharp decline of interest rate after five months, policy rate change will return to zero in the July of 2022.

Despite the very limited monetary instrument intervention, the behavior of interest rate indicates the loosen frame of current monetary policy making, which could be effective in such enormous labor market shock in relation to rising backward link among policy-rate and unemployment (left graph Figure 4). It must be added that the persistence of loosen monetary policy (and possible chances to stabilization) has dramatically shorten since the 2018, which is the major secular trend the monetary authority face in the context of current pandemic identified in our paper.

4 Conclusions

Central banks' *Gordian knot* of effective stabilization in the low equilibrium real interest rate, empirically does not render monetary stabilization *per se* ineffective (Coenen, Montes-Galdon and Schmidt, 2021). In our paper we have examined the simplified relationship among interest rate, monetary aggregate, and unemployment rate. Applying the time-varying VAR model we are concluding the relationship among these variables has changed, during the last decade but not completely paralyzed the ECB from some *quasi-causal* control of unemployment rate. Last asset purchased on the financial market somehow changed the sensitivity of unemployment to changes in in money supply. Even thought the transmission mechanism of interest rate to unemployment indicates a time-invariant relationship, the backward relationship of unemployment to interest rate shows the shortening influence of interest rate on the real economy.

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