
The Macroeconomic Performance of Monetary Policies. A Stochastic Simulation Based on the Taylor's Rule

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In this paper we try to check if and how the macroeconomic performances induced by a Taylor's rule based kind of monetary policy are (or not) more efficient than those effectively induced by the most important central bank's monetary policies. In this kind of respect, we use a simple three equations model: a Phillips equation, an aggregate demand equation and a fixing rule for the main interest rate. Based on historical simulation as well as on stochastic simulation, it turns out that macroeconomic performances, in terms of inflation and productivity gap, would be more stable and efficient if the Taylor's rule would be used by a certain central bank in fixing its main interest rate.

Keywords: *Stochastic Simulation, Monetary Policy, Taylor's Rule, Central Banks, Macroeconomic Performance*

Introduction

The main purpose of this paper is to make some assessments concerning the transmission of the monetary policy in four countries: the United States of America (USA), Germany, France and Italy. In fact, we'll try to find out if a Taylor's rule-based mechanism in fixing the interest rates would (or not) fulfill some certain efficiency criteria. In this kind of respect, we will make a comparison, on historical basis, between the real

macroeconomic effects under already done monetary policy and the macroeconomic effects induced by a monetary policy based on the Taylor's rule.

In order to make assessments on the monetary policies in those four countries, we used, firstly, the estimated model from [1], then, we added to this model a monetary policy rule of Taylor kind. This model, initially designed to be applied in US economy, can also be assimilated by the EMU members. Unlike the USA, the EMU members are forced to adopt a monetary policy that is very close to the monetary policy adopted by Bundesbank, before 1999, inside the European Monetary System and, after, inside the Eurozone – Germany being considered the main stabilizing EU member, in economic and monetary terms, as well. Besides, in [2], in order to put in evidence the main monetary policy regimes inside the European Monetary System, three representative groups of countries are identified. Due to the importance of the Deutsche Mark inside the former European Monetary System, Germany is considered as a group by itself. The second group contains Austria, Belgium and Netherlands. These countries are strongly dominated by Germany, in monetary terms. The former local currencies of these countries had, actually, no fluctuations versus Deutsche Mark and their monetary policies were pretty much the same like those of Bundesbank. The third group includes countries like France, Italy, Spain, Finland and Greece. Their former currencies suffered a lot of devaluations as well as quite long periods of free floating outside the European Monetary System. In our research we choose Germany, France and Italy. We have considered that these countries are good examples in offering an accurate image on the monetary policies inside the former European Monetary System and on the actual ECB monetary policy. The robustness of the Taylor rule was also previously tested in [3].

Empirical Estimations on the Monetary Policies Transmission Mechanisms in USA, Germany, France and Italy

The model we have chosen is a simple linear one and it allows an easy analysis providing transparent results. A similar model was also tested in [4] and in [5]. Obviously, the model lacks some essential characteristics of the monetary policies implementation. Still, we strongly believe that the model is complex enough in terms of dynamics. Furthermore, the model catches a lot of characteristics of the macroeconomic policies. In [6] it's shown that, while an academic consensus concerning the structure of a

certain economy hasn't been reached, a model has to catch an as large as possible variety of macroeconomic parameters. The model is using a short-term interest rate as instrument of monetary policy. The model also includes an autoregressive expectations Phillips curve. The two equations of the model are [1]:

$$\pi_{t+1} = \alpha_{\pi 1} \pi_t + \alpha_{\pi 2} \pi_{t-1} + \alpha_{\pi 3} \pi_{t-2} + \alpha_{\pi 4} \pi + \alpha_y y_t + \varepsilon_{t+1} \quad (1)$$

$$y_{t+1} = \beta_{y1} y_t + \beta_{y2} y_{t-1} - \beta_r (\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \quad (2)$$

where π_t is the quarterly inflation that takes account of the GDP deflator (p_t), measured in basis points ($400(\ln p - \ln p_{t-1})$). The GDP deflator is used only in case of the US economy and in case of Germany, France and Italy, the Consumer Price Index (CPI) is used; $\bar{\pi}_t$ is the four quarters average inflation ($\frac{1}{4} \sum_{j=0}^3 \pi_{t-j}$); i_t is the interest rate during one quarter period of time measured in basis points; \bar{i}_t is the four quarters average interest rate ($\frac{1}{4} \sum_{j=0}^3 i_{t-j}$); y_t is the difference between the real GDP (q_t) and the potential GDP (q_t^*) ($100(q_t - q_t^*)/q_t^*$), and ε_{t+1} and η_{t+1} can be interpreted as being economic shocks.

The first equation establishes a relation between the future inflation and the difference between the real and potential GDP in the actual quarter and the inflation in previous quarters, as well. The link between the inflation in the next quarter and the inflation in previous quarters is an autoregressive representation of the expectations on inflation. During the analysis, we will not reject the hypothesis accepting that the inflation coefficients from the past might be equal to the unity. The second equation establishes a relation between the output gap in the next quarter and the output gap in the previous quarter and the difference between the average interest rate and the average inflation in the last four quarters. The third term of equation is a simple representation of the monetary policy transmission mechanism and, according to many central banks, could imply nominal interest rates, exchange rates or some other monetary aggregates. In fact, the second equation approximates all those variations during the entire process of monetary policy implementation. Data series concerning GDP, interest rate

and CPI were obtained from the statistics section of the central banks and from IMF International Financial Statistics. Data series concerning the potential GDP of Germany, France and Italy were obtained using the Hodrick-Prescott filter.

The goal of any (every) central bank is to keep the inflation under control and at as low as possible value (target) and to keep the output gap in a close proximity of a fixed low value (usually, the target value for the output gap is zero).

The Obtained Results

The Results concerning the United States of America, estimated by using the method of least squares and the 1961-2010 data, are presented¹. The Phillips equation, after estimations, has led to the following results:

Table 1: The output estimation for the Phillips equation
 United States of America

Dependent Variable: PI				
Method: Least Squares				
Date: 10/11/10 Time: 13:09				
Sample: 1961:1 2010:1				
Included observations: 197				
$PI = MPILO + C(1) * (PI(-1) - MPIL1) + C(2) * (PI(-2) - MPIL2) + C(3) * (PI(-3) - MPIL3) + (1 - C(1) - C(2) - C(3)) * (PI(-4) - MPIL4) + C(5) * (GAP(-1) - MGAPL1) + U_AS$				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.444875	0.071364	6.233872	0.0000
C(2)	0.075019	0.075387	0.995125	0.3209
C(3)	0.290272	0.075561	3.841558	0.0002
C(5)	0.155965	0.035046	4.450279	0.0000
R-squared	0.783163	Mean dependent var		3.682557
Adjusted R-squared	0.779721	S.D. dependent var		2.392191

¹ The results were obtained using EViews software.

S.E. of regression	1.122748	Akaike info criterion	3.089942
Sum squared resid	238.2462	Schwarz criterion	3.157563
Log likelihood	-294.1794	Durbin-Watson stat	1.985078

$$\pi_{t+1} = 0.44\pi_t + 0.075\pi_{t-1} + 0.29\pi_{t-2} + 0.195\pi_{t-3} + 0.155y_t + \varepsilon_{t+1} \quad (3)$$

The estimation of the aggregate demand equation made by the method of least squares has led to the following results:

Table 2: The output estimation for the aggregate demand equation
 United States of America

Dependent Variable: GAP				
Method: Least Squares				
Date: 10/11/10 Time: 13:09				
Sample: 1961:1 2010:1				
Included observations: 197				
GAP=MGAPLo+C(1)*(GAP(-1)-MGAPL1)+C(2)*(GAP(-2)-MGAPL2)+C(3)*(R(-1)-MRL1) +U_IS				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.242516	0.068611	18.10946	0.0000
C(2)	-0.316347	0.068657	-4.607647	0.0000
C(3)	-0.047767	0.025662	-1.861397	0.0642
R-squared	0.902507	Mean dependent var		-0.357786
Adjusted R-squared	0.901481	S.D. dependent var		2.486296
S.E. of regression	0.780393	Akaike info criterion		2.357385
Sum squared resid	115.7126	Schwarz criterion		2.408100
Log likelihood	-224.4876	Durbin-Watson stat		2.075819

$$y_{t+1} = 1.24y_t - 0.31y_{t-1} - 0.05(\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \quad (4)$$

The model catches quite exactly the evolution of the aggregate supply and demand equation. The explanatory power of the aggregate supply equation (R^2) is 78.3%, which means that that price evolution dynamics is 78.3% influenced by the factors we have taken into

consideration in the equation. The inflation is influenced only 15.5% by the output gap. Furthermore, the explanatory power (R^2) is 90.2%, which means that production is 90.2% influenced by the factors we have been considered in the equation. The real interest rate (meaning the difference between the existing interest rate and the existing inflation rate) does influence only by 5% the production. The value of these coefficients shows that Federal Reserve (Fed) has had a monetary policy strategy that had targeted a long term inflationary stabilization as well as a sort of „general stabilization” concerning the output gap.

Concerning Germany, the equation results, also estimated by using the method of least squares and using 1971- 2010 data, are also presented. The Phillips equation, after estimation, has led to the following results:

Table 3: The output estimation for the Phillips equation – Germany

Dependent Variable: PI				
Method: Least Squares				
Date: 10/11/10 Time: 18:16				
Sample(adjusted): 1971:2 2010:3				
Included observations: 158 after adjusting endpoints				
$PI = MPI_{L0} + C(1) * (PI(-1) - MPIL1) + C(2) * (PI(-2) - MPIL2) + C(3) * (PI(-3) - MPIL3) + (1 - C(1) - C(2) - C(3)) * (PI(-4) - MPIL4) + C(5) * (GAP(-1) - MGAPL1) + U_AS$				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.382111	0.080079	4.771689	0.0000
C(2)	0.171796	0.081687	2.103108	0.0371
C(3)	0.346225	0.081221	4.262777	0.0000
C(5)	0.086790	0.079655	1.089580	0.2776
R-squared	0.590628	Mean dependent var		2.805675
Adjusted R-squared	0.582440	S.D. dependent var		2.146209
S.E. of regression	1.386855	Akaike info criterion		3.517586
Sum squared resid	288.5052	Schwarz criterion		3.596467
Log likelihood	-266.8541	Durbin-Watson stat		2.016963

$$\pi_{t+1} = 0.38\pi_t + 0.17\pi_{t-1} + 0.35\pi_{t-2} + 0.10\pi_{t-3} + 0.08y_t + \varepsilon_{t+1} \quad (5)$$

For Germany, the explanatory power of the aggregate supply equation is smaller, being only of 59%. This fact could be explained by the after World War II price stability in this country. When the inflation is kind of inert, we may assume it could be influenced only by external shocks. Concerning the aggregate demand equation, its explanatory power is quiet stronger: 65,6%. The estimation of the aggregate demand equation, using the method of the least squares, furnished the following results:

Table 4: The output estimation for the aggregate demand equation – Germany

Dependent Variable: GAP				
Method: Least Squares				
Date: 10/11/10 Time: 18:16				
Sample(adjusted): 1971:2 2010:3				
Included observations: 158 after adjusting endpoints				
GAP=MGAPLo+C(1)*(GAP(-1)-MGAPL1)+C(2)*(GAP(-2)-MGAPL2)+C(3)*(R(-1)-MRL1) +U_IS				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.874834	0.078512	11.14264	0.0000
C(2)	-0.067330	0.082294	-0.818165	0.4146
C(3)	-0.072396	0.043493	-1.664532	0.0981
R-squared	0.656357	Mean dependent var		-0.000424
Adjusted R-squared	0.651805	S.D. dependent var		1.459149
S.E. of regression	0.861015	Akaike info criterion		2.557879
Sum squared resid	111.9434	Schwarz criterion		2.617040
Log likelihood	-193.9567	Durbin-Watson stat		1.934182

$$y_{t+1} = 0.87 y_t - 0.06 y_{t-1} - 0.07(\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \tag{6}$$

Concerning France, the results of the equations, also estimated using the method of the least squares and using 1979-2010 data, are also presented. The Phillips equation, after estimation, has led to the following results:

Table 5: The output estimation for the Phillips equation – France

Dependent Variable: PI				
Method: Least Squares				
Date: 11/11/10 Time: 18:21				
Sample(adjusted): 1979:2 2010:3				
Included observations: 126 after adjusting endpoints				
$PI = MPI_{Lo} + C(1) * (PI(-1) - MPIL_1) + C(2) * (PI(-2) - MPIL_2) + C(3) * (PI(-3) - MPIL_3) + (1 - C(1) - C(2) - C(3)) * (PI(-4) - MPIL_4) + C(5) * (GAP(-1) - MGAPL_1) + U_AS$				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.382508	0.088507	4.321768	0.0000
C(2)	0.145914	0.094015	1.552035	0.1233
C(3)	0.175281	0.094041	1.863877	0.0648
C(5)	0.111414	0.162967	0.683659	0.4955
R-squared	0.794605	Mean dependent var		3.615041
Adjusted R-squared	0.789427	S.D. dependent var		3.769584
S.E. of regression	1.729795	Akaike info criterion		3.965863
Sum squared resid	356.0707	Schwarz criterion		4.057316
Log likelihood	-239.9006	Durbin-Watson stat		1.999322

$$\pi_{t+1} = 0.38\pi_t + 0.14\pi_{t-1} + 0.17\pi_{t-2} + 0.31\pi_{t-3} + 0.111y_t + \varepsilon_{t+1} \quad (7)$$

The estimation, using the method of the least squares, of the aggregate demand equation has led to the following results:

Table 6: The output estimation for the aggregate demand equation – France

Dependent Variable: GAP				
Method: Least Squares				
Date: 11/11/10 Time: 18:21				
Sample(adjusted): 1979:2 2010:3				
Included observations: 126 after adjusting endpoints				
$GAP = MGAPL_0 + C(1) * (GAP(-1) - MGAPL_1) + C(2) * (GAP(-2) - MGAPL_2) + C(3) * (R(-1) - MRL_1) + U_IS$				

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.183268	0.086649	13.65592	0.0000
C(2)	-0.317093	0.087954	-3.605212	0.0005
C(3)	-0.011795	0.015110	-0.780577	0.4366
R-squared	0.827144	Mean dependent var		0.008957
Adjusted R-squared	0.824263	S.D. dependent var		0.982543
S.E. of regression	0.411892	Akaike info criterion		1.087975
Sum squared resid	20.35856	Schwarz criterion		1.156565
Log likelihood	-63.91046	Durbin-Watson stat		2.175625

$$y_{t+1} = 1.18y_t - 0.31y_{t-1} - 0.01(\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \quad (8)$$

The model catches the evolution of both aggregate supply and demand in France. The inflation dynamics is 79.4% influenced by the factors included in the equation. The GDP dynamics is 82,7% explained by those factors.

For Italy, the results of the equations, estimated using the method of the least squares and using 1984-2010 data, are also presented. The Phillips equation, after estimation, has led to the following results:

Table 7: The output estimation for the Phillips equation – Italy

Dependent Variable: PI				
Method: Least Squares				
Date: 12/11/10 Time: 15:46				
Sample(adjusted): 1984:2 2010:3				
Included observations: 106 after adjusting endpoints				
PI=MPIL0+C(1)*(PI(-1)-MPIL1)+C(2)*(PI(-2)-MPIL2)+C(3)*(PI(-3)-MPIL3)+(1-C(1)-C(2)-C(3))*(PI(-4)-MPIL4)+C(5)*(GAP(-1)-MGAPL1)+U_AS				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.539354	0.093925	5.742365	0.0000
C(2)	-0.136191	0.105014	-1.296890	0.1977

C(3)	0.240628	0.104372	2.305493	0.0232
C(5)	0.073276	0.166433	0.440272	0.6607
R-squared	0.846829	Mean dependent var		5.145962
Adjusted R-squared	0.842187	S.D. dependent var		3.992447
S.E. of regression	1.586027	Akaike info criterion		3.798402
Sum squared resid	249.0326	Schwarz criterion		3.900721
Log likelihood	-191.6177	Durbin-Watson stat		1.856168

$$\pi_{t+1} = 0.53\pi_t - 0.14\pi_{t-1} + 0.24\pi_{t-2} + 0.36\pi_{t-3} + 0.07y_t + \varepsilon_{t+1} \quad (9)$$

The estimation of the aggregate demand equation, using the method of the least squares, has led to the following results:

Table 8: The output estimation for the aggregate demand equation – Italy

Dependent Variable: GAP Method: Least Squares Date: 12/11/10 Time: 15:46 Sample(adjusted): 1984:2 2010:3 Included observations: 106 after adjusting endpoints GAP=MGAPL0+C(1)*(GAP(-1)-MGAPL1)+C(2)*(GAP(-2)-MGAPL2)+C(3)*(R(-1)-MRL1) +U_IS				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	1.128117	0.096210	11.72560	0.0000
C(2)	-0.326227	0.094663	-3.446201	0.0008
C(3)	-0.023928	0.016474	-1.452436	0.1495
R-squared	0.754855	Mean dependent var		-0.073652
Adjusted R-squared	0.749903	S.D. dependent var		0.939312
S.E. of regression	0.469747	Akaike info criterion		1.355727
Sum squared resid	21.84559	Schwarz criterion		1.432932
Log likelihood	-66.14208	Durbin-Watson stat		2.027925

$$y_{t+1} = 1.12y_t - 0.32y_{t-1} - 0.02(\bar{i}_t - \bar{\pi}_t) + \eta_{t+1} \quad (10)$$

Like in the France case, in the case of Italy the model catches quite accurately the evolution of both aggregate demand and supply equations. The inflation dynamics is 84.6% influenced by the factors included in the equation and the GDP dynamics is 75.4% influenced by those elements. The real interest rate influences only 2% the evolution of production.

A Possible Alternative to the Existing Monetary Policy Promoted by Major Central Banks

Since Taylor presented a very simple rule of monetary policy conducting, two issues were, actually, discussed, both theoretically and empirically: the robustness and the efficiency of this rule. In this kind of respect, the main purpose of this study is to put together and compare the monetary policies of US Federal Reserve, Bundesbank, Banque Nationale de France and Bank of Italy and, through the last three, the European Central Bank, with an ideal monetary policy induced by the Taylor rule.

In order to assess the economic performance of these economies, the economic evolution was simulated by the Taylor's rule, in terms of GDP and inflation [3]. The analysis was made by using both historical and stochastic simulations. At the historical simulation, a change in the monetary policy strategy (a new rule in fixing the interest rate) is confronted with shocks that occurred in a certain period. We are in a position to find out, considering the model as accurate, if the alternative to the existing monetary policy could have better results.

The only problem that could occur concerns the robustness of the simulation. The historical results could depend on eventual shocks that may be not be representative for the future of the monetary policy even they are strong. The stochastic simulation tries to solve the robustness issue. A new series of shocks are generated, using new hypothesis on shock distribution. So, the performance of the new rule could be estimated on many different economies. Doing things this way we could compare the real „universe” of historical data on inflation and GDP with a Taylor's rule-based „alternative universe” built on simulated values of inflation and GDP.

In order to compare the real economic performance with the simulated one, we estimated once again the evolution of the US economy between 1961 and 2010, of the German economy between 1971 and 2010, of

the France's economy between 1979 and 2010 and of the Italy's economy between 1984 and 2010 and we have measured the economic performance through a function defined by the variations of inflation and output gap. There is no consensus if the monetary policy based on rules is more efficient, in terms of economic performance (inflation and output gap values and stability), than the discretionary one.

The inflation volatility is associated with poor performances of growth due to the uncertainty the inflation induces in the consumers and the investors behaviour [7]. We will present the results of the economic re-evaluation, based on Taylor's rule.

Using the estimated model given by the equations 1 and 2, we have evaluated once again the economic evolution by adopting the Taylor's rule in fixing the interest rate. We took into account, during each and every period the estimated inflation and output gap shocks given by the equations 3 and 4 for the US economy, by the equations 5 and 6 for Germany's, by the equations 7 and 8 for France's and by equations 9 and 10 for Italy's. The Taylor's rule form used for this simulation is:

$$i_t = i_t^* + \pi_t + 0.5 * (\pi_t - \pi_t^*) + 0.5 * (y_t - y_t^*) \quad (11)$$

where i_t is the interest rate level, i_t^* is the long term equilibrium interest rate (usually based on historical observations), π_t is the inflation level, π_t^* is the inflation target, y_t is the level of GDP and y_t^* is the potential level of GDP.

Comparison between the Real Trajectories with the Simulated Trajectories

The main conclusion is that the Taylor's rule would had better results than the real FED monetary policy (table 9). In case that the Taylor's rule would had been used, both the variations of output gap and inflation would had been smaller (the average output gap would had been -0,44, while the average inflation would had been 2,68 versus 3,68; the output standard deviation would had been 2,45%, and the inflation standard

deviation would had been only 1,39%). Similar results can be obtained in case of historical simulation.

Table 9: A macroeconomic simulation based on Taylor's rule (USA)

	Average			Standard deviation		
	Output gap	Inflation	Interest rate	Output gap	Inflation	Interest rate
Actual results	-0.36	3.68	6.01	2.48	2.22	3.30
Historical simulation	-0.44	2.68	5.13	2.45	1.39	2.81
Stochastic simulation	-0.28	1.22	3.05	2.32	1.93	4.71

In order to confirm these results and to avoid basing only on the historical simulation, the stochastic simulation was used by resembling inflation and output gap standard deviation data. All data were resembled 1000 times.

The simulation results in case of Germany (table 10) are kind of surprising. Historical simulation leads to similar results both for average and standard deviation. We may conclude that Bundesbank followed a rule that was very close to the Taylor's. The economic performance of the Germany's economy after the World War II is outstanding: low inflation volatility (1.85%) and low output gap volatility (1.47%). Also, the inflation level is very low (2.80%) as well as the deviation of the output gap from the natural level (0.01).

Table 10: A macroeconomic simulation based on Taylor's rule (Germany)

	Average			Standard deviation		
	Output gap	Inflation	Interest rate	Output gap	Inflation	Interest rate
Actual results	0.01	2.80	5.50	1.47	1.85	2.79
Historical	-0.07	2.45	5.32	1.47	1.81	3.31
Stochastic	-0.20	2.81	5.81	1.46	2.88	4.52

Also for France the study's results are pretty much the same (table 11).

Table 11: A macroeconomic simulation based on Taylor's rule (France)

	Average			Standard deviation		
	Output gap	Inflation	Interest rate	Output gap	Inflation	Interest rate
Actual results	-0.01	3.55	6.81	0.98	3.44	4.00
Historical	-0.05	3.43	7.13	0.98	3.42	5.38
Stochastic	-0.29	3.22	6.79	0.96	3.18	5.21

In case of Italy, the results are quite the same (table 12). The robustness of the Taylor's rule is well sustained by the satisfying results of the stochastic simulation. In case of Italy as well as in case of France, we have to notice the high values of the standard deviation both for inflation and output gap.

Table 12: A macroeconomic simulation based on Taylor's rule (Italy)

	Average			Standard deviation		
	Output gap	Inflation	Interest rate	Output gap	Inflation	Interest rate
Actual results	-0.08	5.17	9.43	0.93	3.72	5.50
Historical simulation	-0.21	5.06	10.48	0.95	3.75	5.71
Stochastic simulation	-0.60	4.39	9.00	0.93	2.87	4.87

Conclusions

Our results are in line with all debates existing in modern economic literature concerning monetary policy decisions. Furthermore, despite the fact that monetary policy has multiple purposes (stabilizing the inflation and the output gap, but, also, the financial markets stability), we have at our

disposal a simple and comprehensive rule based only on two purposes. More else, looking at the existing financial situation, a monetary policy designed to stabilize a certain economic situation seems to be desirable.

Both in cases of historical and stochastic simulations, the resulting macroeconomic performances, in terms of inflation and output gap, have more efficiency and stability in case of using the Taylor's rule. Our study put, also, in evidence the robustness and efficiency of this rule.

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