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by

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Making a Weak Instrument Set Stronger: Factor-Based Estimation of the Taylor Rule*

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Abstract

The problem of weak identification has recently attracted attention in the analysis of structural macroeconomic models. Using robust methods can result in large confidence sets making inference difficult. We overcome this problem in the analysis of a forward-looking Taylor rule by seeking stronger instruments. We suggest exploiting information from a large macroeconomic data set by generating factors and using them as additional instruments. This approach results in a stronger instrument set and hence smaller weak-identification robust confidence sets. It allows us to conclude that there has been a shift in monetary policy from the pre-Volcker regime to the Volcker-Greenspan tenure.

Keywords: Taylor Rule, Weak Instruments, Factor Models
JEL-Codes: E31, E52, C22

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This paper combines the insights from the literature on factor models and from studies on the weak-identification problem in the estimation of Taylor rules. In a recent paper, Mavroeidis (2010) reassesses the seminal work by Clarida, Galí and Gertler (2000). Given that their analysis of monetary policy rules in the US might suffer from weak instrumental variables (IV),[1] which can lead to biased estimators and inference, he evaluates their model using methods that are robust against weak IVs. In constructing joint confidence sets for the parameters on expected future inflation and the output gap, he empirically confirms the conclusion that pre-Volcker monetary policy was accommodative to inflation. In contrast to Clarida et al. (2000) though, he claims that with the use of robust methods it cannot be shown whether monetary policy during the Volcker-Greenspan tenure was adherent to the Taylor principle or not due to inconclusive confidence sets.

We follow a different route in this paper. Rather than relying solely on weak IV robust methods that can result in uninformatively large confidence sets, we construct additional instruments by estimating factors from a comprehensive macroeconomic data set (Stock and Watson, 2008). We employ these factors in the first stage of the estimation, an approach first applied to point estimates of Taylor rules by Bernanke and Boivin (2003) and Favero, Marcellino and Neglia (2005). In contrast to these studies, we consider the joint distribution of parameter estimates in order to derive conclusions with respect to the Taylor principle. In addition, we rely on the weak-identification robust statistic suggested by Kleibergen (2005), as this guarantees comparability with the results by Mavroeidis (2010) and does not constitute a serious power loss in case instruments are strong.

The literature on factor analysis has shown that dimension-reduction techniques can be successful in summarizing a vast amount of information in few variables (e.g. Stock and Watson, 2002, 2008). These variables, i.e. the

[1]Note that for simplicity we refer to the case of weak identification also as a problem of weak instruments.

factors, can perform well as additional instruments in IV and GMM estimation as has been shown in formal evaluations by Bai and Ng (2010) and Kapetanios and Marcellino (2010), respectively. Kapetanios, Khalaf and Marcellino (2011) analyze factor-based weak-identification robust statistics.

Our empirical results illustrate that the use of factors substantially reduces the size of the two-dimensional weak IV robust confidence sets, as the factor-augmented instrument set is stronger in the estimation procedure. This allows us to conclude that in the Volker-Greenspan period, monetary policy satisfied the Taylor principle.

The structure of the paper is as follows. In Section 1, we introduce the assumed Taylor rule and model. Section 2 presents our approach and Section 3 corresponding results. Section 4 concludes.

1 A Model of Monetary Policy

1.1 A Forward-Looking Taylor Rule

The conduct of monetary policy we assume is the Clarida et al. (2000) version of a forward-looking Taylor rule with a certain degree of interest rate smoothing, which is also used in Mavroeidis (2010):

$$r_t = \alpha + \rho(L)\, r_{t-1} + (1-\rho)(\psi_\pi\, \mathbb{E}_t \pi_{t+1} + \psi_x\, \mathbb{E}_t x_t) + \varepsilon_t, \tag{1}$$

where the variables r_t, π_{t+1} and x_t are the policy interest rate, the one-period-ahead inflation rate and the output gap, respectively, and $\mathbb{E}_t$ is the expectations operator with respect to current information.[2] The monetary policy shock is an i.i.d. innovation such that $\mathbb{E}_{t-1}\, \varepsilon_t = 0$. The intercept α is a linear combination of the inflation and the resulting interest rate target and (ψ_π, ψ_x) are the feedback coefficients of the policy rule. $\rho(L) =$

[2] As the output gap x_t is not known at the time the interest rate is set in period t, we use its expected value.

$\rho_1 + \rho_2 L + \ldots + \rho_n L^{n-1}$ displays the degree of policy smoothing, where L is the lag operator, and $\rho = \rho_1 + \rho_2 + \ldots + \rho_n$.

The estimation equation is obtained by replacing the expected values by their realizations:

$$r_t = \alpha + \rho(L)\, r_{t-1} + (1-\rho)(\psi_\pi \pi_{t+1} + \psi_x x_t) + e_t, \tag{2}$$

where the resulting error $e_t = \varepsilon_t - (1-\rho)[\psi_\pi(\pi_{t+1} - \mathbb{E}_t\pi_{t+1}) + \psi_x(x_t - \mathbb{E}_t x_t)]$ is serially uncorrelated.

1.2 Transmission Mechanism

The transmission mechanism used to interpret the results is fully characterized by two equilibrium conditions which are derived from a standard New Keynesian sticky-price model by log-linearization around the steady state (see e.g. Clarida et al., 2000; Lubik and Schorfheide, 2004). Together with equation (1) these two conditions, namely an Euler equation for output and the following version of the New Keynesian Phillips Curve, $\pi_t = \beta\,\mathbb{E}_t[\pi_{t+1}] + \lambda(y_t - z_t)$, capture the dynamics of the model. The output elasticity of inflation $\lambda > 0$ reflects the degree of nominal rigidities, $0 < \beta < 1$ is the discount factor, y_t stands for output and $z_t = y_t - x_t$ captures variation in the marginal cost of production.

As highlighted in Woodford (2003, ch. 4), determinacy in this model requires:

$$\psi_\pi + \frac{1-\beta}{\lambda}\,\psi_x - 1 \geq 0. \tag{3}$$

Further, the interest rate response should not be too strong – a condition that is not binding for the empirical results in this paper.[3]

[3] Recent studies show that other factors might also be important in guaranteeing determinacy (see e.g. Davig and Leeper, 2007; Coibion and Gorodnichenko, 2011). Cochrane (2011) argues that the existence of a unique equilibrium in a New Keynesian model with

Equation (3) is a generalized version of Taylor's principle that the policy rate should be raised more than one for one with inflation to guarantee macroeconomic stability and can be seen as a benchmark to evaluate monetary policy (see Taylor (1999) for a qualitative and Clarida et al. (2000) for a more quantitative perspective on this principle).

2 Factor-GMM Methodology

As the realizations of future inflation and the output gap are unknown at time t, we estimate the model with the Generalized Method of Moments (GMM) assuming rational expectations, where the moment conditions are $\mathbb{E}Z_t e_t = 0$ for any predetermined instrument set Z_t. The benchmark instrument set comprises four lags of the Federal Funds rate, inflation and the output gap. Data is quarterly and the pre-Volcker and Volcker-Greenspan periods run from 1961:I to 1979:II and 1979:III to 1997:IV, respectively (see the data appendix for details). Mavroeidis (2010) considers the same instrument set and time periods and in order to guarantee comparability of our results, we stick with the additional assumption that $n = 2$ for the first and $n = 1$ for the second time period, i.e. $\rho(L) = \rho_1 + \rho_2 L$ and $\rho(L) = \rho_1$, respectively.[4]

Clarida et al. (2000) find evidence that in the pre-Volcker period monetary policy was accommodative to inflation and therefore might have allowed for sunspot fluctuations in inflation, while in the second era it satisfied the Taylor principle, as depicted by inequality (3).

It has been pointed out, however, that estimation of DSGE models may be subject to the weak-identification problem (see e.g. Lubik and Schorfheide,

a Taylor rule requires imposing strong assumptions. Further, he shows analytically that the forward-looking version we analyze in this paper can be identified.

[4]Clarida et al. (2000) use four lags of commodity price inflation, M2 growth and the spread between the long-term bond rate and the three-month Treasury bill rate as additional instruments and consider slightly different time periods, where the first period spans 1960:I to 1979:II and the second 1979:III to 1996:IV.

2004; Canova and Sala, 2009). Further, conventional GMM methods can be biased in the single-equation context, when the expected Jacobian of the moment equation is not of full rank as the instruments are insufficiently correlated with the relevant first-order conditions (see Stock and Wright, 2000; Mavroeidis, 2004, among others). Therefore, Mavroeidis (2010) reconsiders the empirical evidence of Clarida et al. (2000) by testing different joint parameter specifications for the feedback coefficients of the Taylor rule using the K-LM test that is weak-instrument robust and for a high degree of overidentification more powerful than a test based on Stock and Wright's S statistic (see Kleibergen, 2005).[5]

For the pre-Volcker period Mavroeidis' results support the previous finding that monetary policy did not satisfy the Taylor principle. For the second subsample, on the other hand, he shows that there is inconclusive evidence whether a determinate equilibrium exists or not due to uninformative confidence sets.

2.1 A Factor Model

The size of the weak IV robust confidence sets by Mavroeidis (2010) suggests that instruments are indeed weak and therefore stronger instruments are called for. Thus, we follow the approach of generating factors from a large macroeconomic data set and using them in the first stage of the estimation as discussed for Taylor rules in Bernanke and Boivin (2003) and Favero et al. (2005). In contrast to these authors, who consider only point estimates, we also analyze the joint distribution of parameters estimates to be able to make inference with respect to the Taylor principle. The rationale underlying the use of Factor GMM is that a central banker relies on a large information set in his forecasts of important macroeconomic variables. While each individual

[5]The K-LM test employed by Mavroeidis (2010) and also in this paper is actually a combination of a 9 percent level K test and a 1 percent level J test, which improves the power of the former test against irrelevant alternatives.

variable in this data set is only weakly correlated with future inflation or the output gap and therefore contains only little information, the factors serve as a summary of that information and are thus better predictors for our variables of interest (Bernanke and Boivin, 2003).

The results by Stock and Watson (2002, 2008) indicate that the factors derived from their data sets contain important information with respect to inflation and output. Consequently, they have the potential to make the benchmark instrument set stronger. In order for the factors to be appropriate instruments, we need to make sure that they are uncorrelated with the error term in equation (2). Therefore, the validity of the overidentifying restrictions is discussed in Section 3.

The properties of Factor-IV and Factor-GMM estimation were analyzed with Monte-Carlo simulations by Bai and Ng (2010) and Kapetanios and Marcellino (2010), respectively. Kapetanios et al. (2011) evaluate factor-based weak IV robust statistics. Favero et al. (2005) compare two different ways to construct factors in a dynamic factor model: dynamic and static principal components (for the two approaches see Forni, Hallin, Lippi and Reichlin, 2000 and Stock and Watson, 2002, respectively). The authors report that the results for the two methods are comparable. Overall the static factors perform slightly better in their applications, while the dynamic factors seem to provide a better summary of information as fewer factors explain as much variation in the variables from the data set. For simplicity we rely on static principle components, given that the performance of both methods seems comparable.

Principal component analysis relies on the assumption that the set of variables is driven by a small set of factors and some idiosyncratic shocks. We assume the data-generating process underlying the variables to admit a factor representation:

$$X_t = \Lambda F_t + \nu_t, \tag{4}$$

where X_t is an $N \times 1$ vector of zero-mean, $I(0)$ variables, Λ is an $N \times k$ matrix of factor loadings, F_t is an $k \times 1$ vector of the factors and ν_t is an $N \times 1$ vector of idiosyncratic shocks, where N, the number of variables, is much larger than the number of factors k. Static factors can be estimated by minimizing the following objective function:

$$V_{N,T}(F, \Lambda) = \frac{1}{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} (X_{it} - \Lambda_i' F_t)^2, \tag{5}$$

where $F = (F_1, F_2, \ldots, F_T)'$, Λ_i' is the i-th row of Λ, X_{it} is the i-th component of X_t and T is the number of time periods.

2.2 Factor Data

To construct the factors we employ the data set by Stock and Watson (2008), which is an updated version of the data they use for former papers, e.g. Stock and Watson (2002). The subset of this data set relevant for the estimation of factors includes 109 quarterly time series that have strong information content with respect to inflation and output, consisting of disaggregated price and production data, as well as indices, among others. The time series span 1959:III to 2006:IV with $T = 190$ observations. We use principal component analysis to extract the factors from the transformed data series, where we carried out the same transformations as indicated in Stock and Watson (2008) to guarantee stationarity of both the time series and the resulting factors (see the data appendix for details).

Stock and Watson (2008) use the factors for forecasting and provide evidence that if potential changes in the factor model are sufficiently small there is a particular benefit in calculating the factors for the whole data set by principal components, even if there exists a structural break in the forecasting equation.[6] Moreover, in the construction of the factors having more observations increases the signal-to-noise ratio.

So far there is no general consensus on how to determine the number of factors k. We rely on the criteria that are recommended by Bai and Ng (2002) in this context (PC_1, PC_2, IC_1, IC_2) and are frequently used in the literature on factor models as they seem to perform well for large N. The PC criteria, which are shown to rather overestimate the true number of factors, are consistent with five or six factors, whereas the IC criteria are consistent with two or four factors for the whole data set. Based on these results and the canonical correlations between subsample and full-sample estimates of the factors, Stock and Watson (2008) make a case for using four factors, and we follow their suggestion. Using more factors does not improve our estimation results significantly, while it introduces even more instruments, and with fewer factors the results are somewhat less accurate; in either case the main conclusions would persist.[7]

3 Results

We estimate equation (2) using the same time periods and methods as Mavroeidis (2010), i.e. GMM with Newey-West weight matrix.[8] However, in

[6]If one interprets the factor model as a set of policy functions, where the factors can be seen as states, a structural break in the Taylor rule has the potential to cause a break in the factor model. However, as Stock and Watson (2008) show, the factor model is relatively stable such that any potential regime change in monetary policy conduct would have only affected the dynamics of the benchmark instruments while the factor model implied policy functions are relatively unchanged.

[7]More recently proposed criteria like those by Onatski (2009) or Ahn and Horenstein (2009) are in line with our choice. The criterion by Onatski as well as the two criteria by Ahn and Horenstein predict two factors. Simulations by the respective authors have shown that these criteria tend to rather underestimate the true number of factors. As underestimation of the number of factors is more severe than overestimation in this context, the use of four factors seems a reasonable choice.

[8]Note that there are papers stressing the importance of using real-time rather than final revised data, e.g. Orphanides (2001). This is not a concern for our study, as we are interested in the actual feedback coefficients rather than the intended ones.

Table 1: Point estimates for the parameters of the Taylor rule

	Time period (in quarters)					
	1961:I-1979:II		1979:III-1997:IV		1987:III-2006:I	
	BM	Factor GMM	BM	Factor GMM	BM	Factor GMM
α	0.54***	0.76***	0.16	0.36***	−0.18	−0.07
	(0.18)	(0.08)	(0.19)	(0.13)	(0.18)	(0.12)
ψ_π	0.86***	0.83***	2.24***	1.91***	2.80***	2.80***
	(0.07)	(0.03)	(0.32)	(0.18)	(0.65)	(0.68)
ψ_x	0.29***	0.19***	0.82*	0.84***	1.43***	1.54***
	(0.10)	(0.04)	(0.43)	(0.20)	(0.28)	(0.26)
ρ	0.68***	0.57***	0.83***	0.83***	0.89***	0.92***
	(0.10)	(0.04)	(0.05)	(0.03)	(0.02)	(0.01)

***, **, and * denote significance at the 1, 5 and 10 percent level, respectively. Standard errors are in brackets. Estimation of the Taylor rule, equation (2), is conducted by GMM using Newey-West weight matrix. BM refers to the results based on the benchmark instrument set, which comprises four lags of π_t, x_t and r_t. The Factor-GMM results are generated extending the instrument set by lags one to four of the factors derived before.

order to have more information with respect to the two endogenous variables and thus more precise estimation results, we expand the benchmark instrument set by the four factors we generated from the Stock and Watson (2008) data set. As the contemporaneous values of the factors may be correlated with the error term e_t, we use only their first four lags as instruments. To investigate whether the over-identifying restrictions are satisfied, we calculate the weak-identification robust S sets for both periods and instrument sets considered. These confidence sets are based on the S statistic that equals the estimate of the GMM objective function at the parameter values of the null hypothesis. They contain all parameter values, where one cannot jointly reject the null hypothesis and the validity of the overidentifying restrictions. The fact that the S sets are indeed not empty provides evidence that our identifying assumptions are reasonable (see Stock and Wright, 2000).

For illustrative purposes point estimates for our specification are presented in Table 1. Note, that the Factor-GMM results closely resemble the evidence by Favero et al. (2005).[9] The results based on the benchmark in-

[9]Favero et al. (2005) estimate a forward-looking Taylor Rule for the US from 1979:I to

strument set are similar in spirit to Clarida et al. (2000).[10] The confidence sets based on the K-LM statistic discussed below provide evidence that the new instrument set is stronger and hence factor-based point estimates are more likely to be reliable. One should keep in mind, though, that in the presence of weak instruments point estimates are inconsistent and standard errors are not reliable. What stands out from the results is the significant reduction in standard errors by roughly 50 percent for the first and second period and all coefficients. Consequently, in our specification all estimated coefficients (but α) are significant at the 1 percent level. The point estimates indicate that there is a shift in the conduct of monetary policy from the first period to the second. While the feedback coefficients (ψ_π, ψ_x) in the pre-Volcker regime are estimated to be $(0.83, 0.19)$, their estimates increase to $(1.91, 0.84)$ in the Volcker-Greenspan regime. These results already point to a more aggressive response of monetary policy to inflation and the output gap in the second period. To get information about the more recent stance of monetary policy, we also include a third period, which coincides with the Greenspan regime, 1987:III to 2006:I. Monetary policy under Greenspan seems to be characterized by a high degree of smoothing ($\rho = 0.92$), as also noted by Mavroeidis (2010), and an even stronger response to inflation and the output gap. The standard errors of the feedback coefficients are larger for this period, which is probably a result of the increased persistence of the policy rate (see Mavroeidis, 2010).

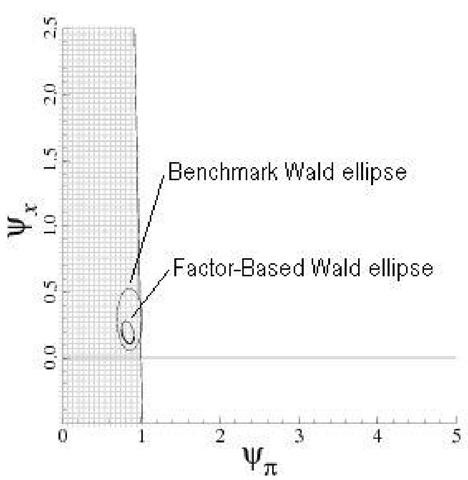
In order to be able to make inference with respect to the Taylor principle, however, we consider the joint distribution of the estimates for the feedback coefficients. Figure 1 shows the Wald ellipses for the two parameters of

1998:IV. In contrast to them, however, we use a different benchmark instrument set, a different data set for generating the factors and also consider the pre-Volcker and Greenspan period.

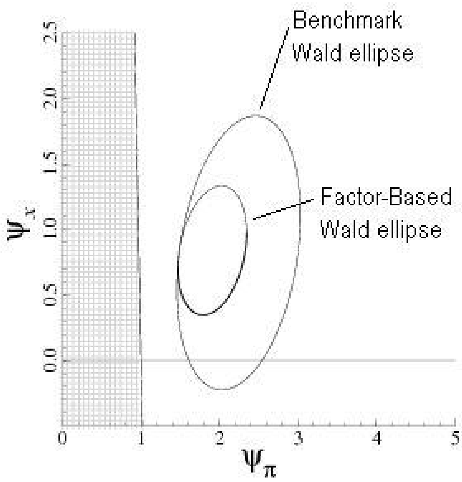
[10] In contrast to Clarida et al. (2000), though, we leave out the three additional instruments commodity price inflation, M2 growth and the spread between the long-term bond rate and the three-month Treasury Bill rate, as Mavroeidis (2010) does in his analysis. We verify that this does not influence the main results significantly.

Figure 1: 95 percent Wald ellipses for the feedback coefficients of the Taylor rule

(a) Pre-Volcker



(b) Volcker-Greenspan



Note: The Wald ellipses for the feedback coefficients (ψ_π, ψ_x) of the Taylor rule, as specified in equation (2), are constructed using GMM with four lags of the instruments and Newey-West weight matrix. The benchmark Wald ellipses are based on the point estimates similar to those by Clarida et al. (2000), where the instrument set comprises four lags of π_t, x_t and r_t. The factor-based results are generated extending the instrument set by lags one to four of the factors derived before. The almost vertical line represents equation (3), i.e. the Taylor principle with $\lambda = 0.3$ and $\beta = 0.99$, being the boundary between indeterminacy (to the left) and determinacy (to the right).

interest, i.e. ψ_x and ψ_π, based on the point estimates presented before.[11] Interpreting their results Clarida et al. (2000) and Mavroeidis (2010) assume that the degree of nominal rigidities λ and the discount factor β are equal to 0.3 and 0.99, respectively. They argue that these assumptions are in line with empirical evidence and we stick to them for comparability, verifying that they do not influence our main conclusions. The almost vertical line represents equation (3), i.e. the Taylor principle, under these assumptions, and is thus the boundary between indeterminacy (to the left) and

[11]Figures 1 and 2 are constructed using the programming language Ox, see Doornik (2007), and the code by Mavroeidis (2010). The factors are added as additional instruments.

determinacy (to the right).

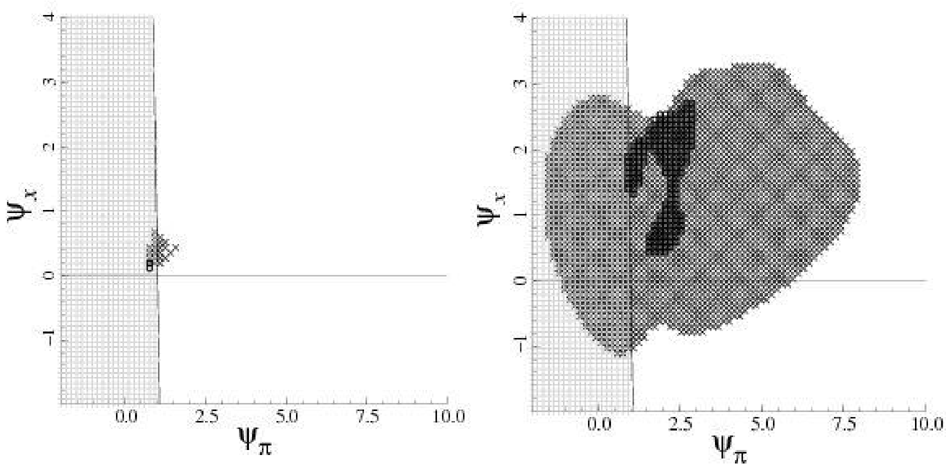
For both periods discussed the factor-based Wald ellipse lies firmly within the ellipse based on the original instrument set. As presented in Figure 1(a), the pre-Volcker regime Wald ellipses are both located in the indeterminacy region. In contrast to that, the ellipses for the Volcker-Greenspan period have shifted to the determinacy region, as shown in Figure 1(b). These results provide evidence that the Taylor principle is satisfied under Volcker-Greenspan, while it has been violated before.

However, in the presence of weak instruments point estimates are inconsistent resulting in unreliable Wald ellipses. Further, it needs to be taken into account that using conventional two-step procedures after pretesting for identification is not recommended, as the size of such methods cannot be controlled (see e.g. Andrews, Moreira and Stock, 2006). Therefore, we rely on the weak IV robust K-LM test, which does not seem to display a serious power loss in the case of strong instruments (Kleibergen, 2005) and guarantees comparability with the results of Mavroeidis (2010). Figure 2 shows the factor-based joint confidence sets at 95 percent significance for both subsamples (dark grey areas). For comparison we include the results from Mavroeidis (2010), namely the weak IV robust confidence sets, constructed with the benchmark instrument set (light grey areas). Theses sets contain all values of (ψ_π, ψ_x) that cannot be rejected by the K-LM test. The shape of the K-LM sets for the second period may seem unconventional. However, note that confidence sets can be nonconvex and unbounded if based on the K statistic as explained by Kleibergen (2005).

Figure 2(a) provides further evidence that pre-Volcker monetary policy was not adherent to the Taylor principle, as the Factor-GMM confidence set also lies within the indeterminacy region. The large reduction in the size of the confidence set for the second period corroborates our finding that the factors contain relevant information for the estimation. Most importantly, our

Figure 2: 95 percent weak-identification robust confidence sets
for the feedback coefficients of the Taylor rule

(a) Pre-Volcker (b) Volcker-Greenspan



Note: The figure shows weak identification robust confidence sets for the feedback coefficients (ψ_π, ψ_x) of the Taylor rule, as specified in equation (2). The light grey areas (crosses) represent the K-LM sets as estimated by Mavroeidis (2010) using the benchmark instrument set, namely four lags of π_t, x_t and r_t. The dark grey areas (circles) are the K-LM sets with lags one to four of the factors as additional instruments. The almost vertical line represents equation (3), i.e. the Taylor principle with $\lambda = 0.3$ and $\beta = 0.99$, being the boundary between indeterminacy (to the left) and determinacy (to the right).

confidence set clearly lies outside the indeterminacy region, while in contrast to that, Mavroeidis' confidence set for this time period has a considerable part in this very area and his results are even consistent with negative values for both parameters. A significant part of our confidence set is located around the point estimate of $(\psi_\pi, \psi_x) = (1.91, 0.84)$, whereas another part lies above it, showing that there is some remaining uncertainty with respect to the feedback coefficients of the Taylor rule. Our findings highlight that with the inclusion of additional important information it can be empirically shown that monetary policy conduct under Volcker and Greenspan was more aggressive towards fighting inflation than pre-Volcker and thus satisfied the

Taylor principle.[12]

The results with fewer factors or lags are less precise, but go in the same direction, i.e. a shift outwards from the indeterminacy region, while with more factors the results are comparable. Results using the weak IV robust conditional likelihood ratio (CLR) statistic rather than the K-LM statistic are very similar providing evidence for the robustness of our findings. With the use of more recent data, i.e. until 2006:I, the confidence sets shift more towards the indeterminacy region, suggesting that there might have been some time variation in the conduct of monetary policy under Alan Greenspan.[13]

Our results corroborate the empirical evidence by Lubik and Schorfheide (2004), Coibion and Gorodnichenko (2011), Boivin and Giannoni (2006) or Inoue and Rossi (2011), among others. Using Bayesian methods, Lubik and Schorfheide (2004) estimate the parameters of the whole model that underlies our single-equation estimation, whereas Coibion and Gorodnichenko (2011) analyze a similar model under the assumption of a positive and time-varying inflation trend. Boivin and Giannoni (2006) examine the monetary transmission mechanism using a vector autoregressive framework. Albeit the different approaches, these studies find a move of the US economy from indeterminacy to determinacy as a result of a more aggressive monetary policy regime. Inoue and Rossi (2011) use both DSGE models and vector autoregressions allowing for structural breaks in all parameters and show that changes in monetary policy parameters have, among other factors, let to the Great Moderation.

[12]A decrease in λ or β would rotate the boundary of the indeterminacy region counterclockwise around the intersection with the horizontal axis as explained by Mavroeidis (2010). For all admissible values a change in either parameter would not alter our conclusion of determinacy for the second period as our confidence sets are already to the right of the boundary. Similarly, given our estimation results, for the first period λ would have to be smaller than 0.01 to change our finding of indeterminacy.

[13]The results for these alternative specifications are available from the authors upon request.

4 Conclusion

In this paper we reassess the study by Mavroeidis (2010), who analyzes a forward-looking version of a Taylor Rule using weak-identification robust methods. Given that his results with respect to monetary policy conduct under Volcker and Greenspan are inconclusive due to large confidence sets, we propose to employ factors generated from a large macroeconomic data set as additional instruments. The inclusion of these factors in the estimation procedure reduces weak-identification robust confidence sets substantially in a way that allows us to conclude that monetary policy in the after-1979 period satisfied the Taylor principle and thus contributed to containing inflation dynamics from there on. Our paper highlights that Factor GMM can be a useful tool to overcome the weak-identification problem common to many macroeconomic applications.

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Appendices

A Data

A.1 Benchmark Data

As a benchmark we use the exact same data set as Mavroeidis (2010). It consists of the federal funds rate, the annualized quarter-on-quarter inflation rate based on the seasonally adjusted GDP deflator and the CBO output gap for the US. Data is of quarterly frequency from 1960:I to 2006:II.

Website:
http://www.aeaweb.org/aer/data/mar2010/20071447_data.zip

A.2 Factor Data

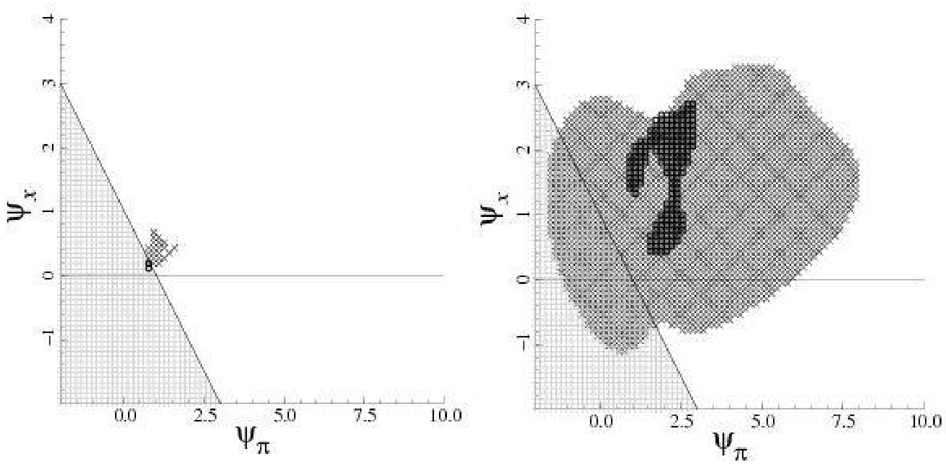
For generating the factors we use quarterly data for the US from 1959:III to 2006:IV by Stock and Watson (2008), which is an updated version of the data they use for former papers, e.g. Stock and Watson (2002). Details for the 109 quarterly time series that have strong information content with respect to inflation and output, as well as the transformations needed to guarantee stationarity are provided by Stock and Watson (2008) in the data appendix of their paper.

Website:
http://www.princeton.edu/ mwatson/papers/hendryfestschrift_stockwatson_April282008.pdf

B Additional Figures

Figure 3: 95 percent weak-identification robust confidence sets
for the feedback coefficients of the Taylor rule
for $\lambda = 0.01$ instead of $\lambda = 0.3$

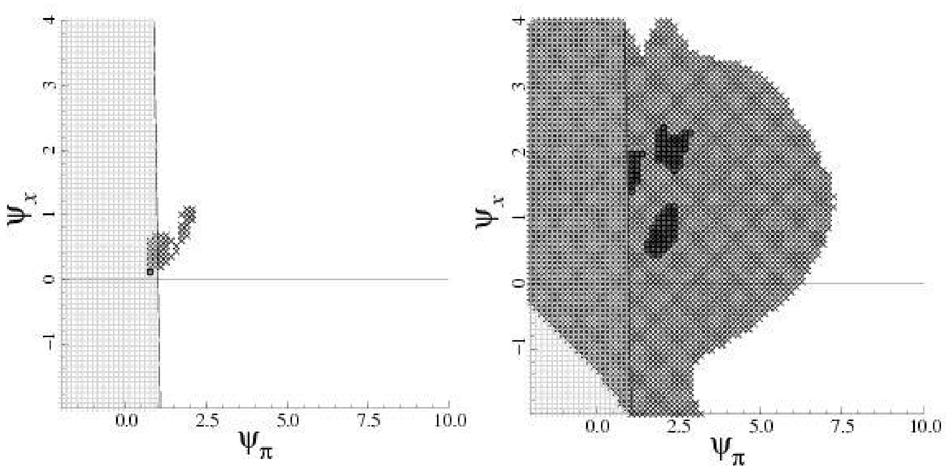
(a) Pre-Volcker (b) Volcker-Greenspan



Note: The figure shows weak identification robust confidence sets for the feedback coefficients (ψ_π, ψ_x) of the Taylor rule, as specified in equation (2). The light grey areas (crosses) represent the K-LM sets as estimated by Mavroeidis (2010) using the benchmark instrument set, namely four lags of π_t, x_t and r_t. The dark grey areas (circles) are the K-LM sets with lags one to four of the factors as additional instruments. The almost vertical line represents equation (3), i.e. the Taylor principle with $\lambda = 0.01$ and $\beta = 0.99$, being the boundary between indeterminacy (to the left) and determinacy (to the right).

Figure 4: 95 percent weak-identification robust confidence sets
for the feedback coefficients of the Taylor rule
using the CLR statistic instead of the K-LM statistic

(a) Pre-Volcker (b) Volcker-Greenspan



Note: The figure shows weak identification robust confidence sets for the feedback coefficients (ψ_π, ψ_x) of the Taylor rule, as specified in equation (2). The light grey areas (crosses) represent the CLR sets using the benchmark instrument set, namely four lags of π_t, x_t and r_t. The dark grey areas (circles) are the CLR sets with lags one to four of the factors as additional instruments. The almost vertical line represents equation (3), i.e. the Taylor principle with $\lambda = 0.3$ and $\beta = 0.99$, being the boundary between indeterminacy (to the left) and determinacy (to the right).