Replication Paper: "Cross-Country Variation in the Anchoring of Inflation Expectation"

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Ⅰ. Introduction

There is a famous theorem in sociology called Thomas Theorem, formulated as "If men define situations as real, they are real in their consequences." It is a perfect sentence to describe the inflation expectation. If a firm expect a higher price of inputs in the future, than it will set a higher price of outputs now because the price has to stay fixed for years. If a worker expects a higher price of consumption in the future, he will sign a contract that has higher wage now because the contract will last for years. This positive feedback loop causes the fact that expectation of higher prices in the future actually leads to higher prices in current period. Therefore, the function of central bank to control inflation expectation plays such an important role in controlling actual inflation. However, the anchoring of inflation expectation does not perform very well the whole time, many temporary shock in US and in the world history has led to long-term inflation.

Thus, it is imperative to evaluate the inflation expectation anchoring as an indicator of credibility of the central bank. And it is also beneficial to make comparisons cross-time and cross-countries to get some deep insights. These are the study questions that the Davis and Mack paper (2013) wants to tackle with. First, the authors use both long-run inflation expectation regression and Phillips curve regression to gauge the US inflation expectation anchoring overtime and they find out the US inflation expectation is not well anchored in the 80s, but it is better anchored now. Then the authors applied this method on 64 countries and calculate their estimated anchoring. They found the results are consistent with the intuition that the high credibility central bank countries are well anchored, and low credibility central bank countries are not well anchored, and the results hold for both headline inflation and core inflation. Finally, the authors use moving-window regression to show the changes in the inflation expectation anchoring overtime for US, Canada, Mexico, UK and twelve first euro-zone countries. They find out that the oil crises in the 1970s has made most the of the countries unanchored, but after a series of inflation targeting and independence of central bank, most countries' central bank regained their credibility and re-anchored the inflation expectation again.

In this paper, I am going to replicate and extend this paper. The next section is the literature review. The third section discusses the empirical strategy of estimation. Section Ⅳ describes the data source. Section Ⅴ presents the results of my estimation and extension. This paper concludes with briefly summary and some policy implications.

Ⅱ. Literature review

Davis and Mack paper is consistent with many former researches which study the inflation expectation anchoring cross-time and cross-country.

Clark and Davig paper (2011) study the volatility and responsiveness of US inflation expectation over time. It estimates a VAR model with stochastic volatility and decomposing the decline in expectations volatility. The authors find out that the volatility in inflation expectation is decreasing over time, and the factors that drive the volatility has changed from shocks in inflation expectations itself to the actual inflation. This means that the inflation expectation is better anchored than before. They suggest that this is due to a shift in monetary policy towards more systematic behavior.

Beechey, Johannsen, and Levin paper (2011) compares the long-run inflation expectation anchoring between US and euro area. They use the regression of inflation compensation, which is derived from inflation swaps, with regards to some surprise components of macroeconomic data. Their results are that both long-run inflation expectation of US and euro countries are well anchored in recent years, but the one in euro area is anchored more firmly than in US. The authors ascribe the difference to the difference in communication practices between European Central Bank and Federal Reserve. So they suggest that announcing a quantitative inflation target can help US have a firmer inflation expectation anchoring.

Gürkaynak, Levin, and Swanson paper (2006) compares long-run inflation expectation anchoring between inflation targeters UK and Sweden and non-inflation-targeter US. They examine how much the inflation compensation, which is defined as the difference between far-ahead forward rates on nominal and inflation-indexed bonds, moves in response to macroeconomic data releases and monetary policy announcements. They find that the inflation compensation in Sweden is not sensitive to the news the whole time; in UK it is not sensitive after the independence of Bank of England, while the in the US it is quite sensitive the whole time. This paper reaffirms the importance of inflation targeting and central bank credibility in inflation expectation anchoring.

These paper get the same result as the Davis and Mack paper, in both time and geographic dimensions. These prove that the results Davis and Mack get are valid.

Ⅲ. Empirical Strategy

1.Using long-run inflation expectations

The anchoring of inflation expectation can be formulated as the response of the change in long-run inflation expectation to an unexpected change in current period inflation shock. So Davis and Mack use the following regression at first:

$$E_t(\pi_{t+5,t+10})- E_{t-1}(\pi_{t+5,t+10})= \delta + \theta\ [\pi_{t-1,t}-E_{t-1}(\pi_{t-1,t})] + \varepsilon_{t-1,t}$$

where $\pi_{t,t+i}$ is the rate of change in consumer prices between period t and period t+i, which is the inflation. $E_t(\pi_{t+5,t+10})$ measures the expected change in consumer prices between five years from today and ten years from today, thus $E_t(\pi_{t+5,t+10})- E_{t-1}(\pi_{t+5,t+10})$ measures the change in long-term inflation expectations over the past year. Similarly, $\pi_{t-1,t}-E_{t-1}(\pi_{t-1,t})$ measures the difference between the observed inflation rate over the past year and the expected inflation rate over that same period, the unexpected component of inflation. Thus, the anchoring of inflation expectation is measured by θ.

Using this regression, the authors calculate the anchoring of U.S. inflation expectation from 1983-2007, and 83-89, 90-99, 00-07 respectively. In this paper I will extend the data period to 2016, and estimate the additional anchoring estimate of 08-16.

2. Using Phillips regression and cross-country comparisons

In the former identification strategy, the 5-year-5-year-forward inflation expectation is necessary to compute a measure of anchoring, while this index is not available in most countries around the world. Thus the authors turn to a Phillips curve regression to measure the anchoring. This regression comes from a Phillips curve, with a few steps of derivation in the original paper, the final regression the authors use is:

$$\pi_{t-1,t}= \alpha +\sum_{n=1}^{N} \gamma(1-\gamma)^{n-1}\, \pi_{t-n-1,t-n}+\frac{\lambda}{1-\gamma} y_t+\varepsilon_{t-1,t}$$

where y_t is a measure of slack in the economy, and for this analysis they use the growth rate in industrial production, and γ is the measure of inflation expectation anchoring.

Here there are two problems that the paper is not doing well. First is that the $\pi_{t-1,t}$ in the previous formula means inflation from year ago, but in this formula it cannot be the case because we do not have so early data to support the substantial lag terms. So I suppose in this regression $\pi_{t-1,t}$ means inflation from month ago, while the authors have not specified it. The second problem is that the authors have not mentioned how many lags does their regression use for the U.S. data. I have tried 24, 48 and 400 lags and find out the result is robust after 48 lags, so I use 48 lags in this paper.

This regression is a non-linear regression, by which different estimation strategy will yield different results. Unfortunately, the authors did not specify which estimation strategy they use. In addition, non-linear estimation involves choice of initial value, which is also not reported in the original paper. In this paper, I use Non-linear Least Square to estimate the parameters, and set initial value at 0 because we

expect to see a well anchored inflation expectation, the global minimum should be close to 0.

Utilizing this strategy, the authors recalculate the anchoring of U.S. inflation expectation and compare the results to the previous part. If they are similar, then this method is meant to be valid. In addition, the authors calculate the anchoring of 64 different countries from 1996-2013 using this method, with 24 lags of inflation. Due to lack of data from some of the developing countries, I only calculate the results for 41 different countries and groups, but I also extend the data period to 2016.

Because the New Keynesian Phillips curve is derived with regards to core inflation, while in previous results we are calculating the results with headline inflation, we recalculate the results using core inflation. Due to unavailability of data, the authors only calculate 34 countries in the original paper, while I get results from 38 countries and groups.

Finally, the authors use moving-window techniques to visualize the change in the anchoring of inflation expectation over time for U.S., Mexico, Canada, U.K. and first twelve euro-zone members.

Ⅳ. Data description

Davis and Mack obtain long-run inflation expectation $E_t(\pi_{t+5,t+10})$ and short-run inflation expectation $E_{t-1}(\pi_{t-1,t})$ data from Federal Reserve Bank of Cleveland, while they do not state where they get the data of the rest of variables. I get inflation $\pi_{t-1,t}$ and growth rate in industrial production y_t for U.S. from FRED, and from OECD database for rest of the countries. It is noteworthy that the inflation and industrial production data for U.S. are not the same in Fred and in OECD database, no matter seasonally adjusted or not. So there is big concern that if I do not use the same data source from the original paper, my result will not be the same with that from the original paper.

The data are all in monthly frequency. For the first regression, $\pi_{t-1,t}$ represents the inflation from year ago for every month, while for the second regression, it represents the inflation from month ago for every month. Both headline and core (headline minus food and energy) inflations are collected. All the growth rate data have been annualized through continuously compounded method. The data period for the first regression and U.S. part of the second regression is from 1959-2016. For the cross-country comparison, the data is from 1994-2016. For moving-window estimates, the data period depends case by case.

For cross-country comparison part, I cannot get the data of many Asian and Africa developing countries, so I only use data from all OECD and European Union countries. But which I will extend in the paper is that I use the data of the average of OECD, OECD-European, European Union, Euro-zone and G7 countries respectively, and want to have a peep at how well anchored of inflation expectation for those organizations members on average.

Ⅴ. Results and extension

The results of inflation expectation anchoring using the long-run inflation expectation regression is presented in Table 1. Comparing to the original paper, my results for 83-07 and 83-89 differ from the paper after two decimal points, and after three decimal points for 90-99 and 00-07 period. This might due to the different data source of inflation we use.

These results indicate that the inflation expectation of U.S is not well anchored for the last 24 years. On average, one percent point higher in the unexpected shock in inflation today will lead to 0.20 percent point higher in the long-run inflation expectation. However, the inflation expectation is becoming better anchored over time. In the 1980s, the estimate value of θ is 0.29, way higher than the average of last 25 years. In the 1990s and 2000s, the estimate value of θ drops down rapidly to 0.08, indicates that U.S. has a well anchored inflation expectation recently.

One concern is that after 2008 recession, people have less confidence in the Federal Reserve, which will lead to a worse anchoring of inflation expectation than ever. The original paper did not explore this

time period, so I extend the results to the post-recession period. The 33-year average of θ is 0.13, way smaller than 24-year average, which indicate a better anchored inflation expectation in the last 9 years. The estimate value of θ for 07-16 is 0.021 and statistically insignificant, which means after the recession the inflation expectation is almost exactly anchored. This might be due to all the effort the Federal Reserve to cut down the Fed Funds rate, discount rate and depreciate the dollar. These strong monetary policies make people believe that the inflation will still be well or even better controlled by the Federal Reserve, so the shock in temporary inflation during the recession will hardly affect people's long-run inflation expectation. This indicates the Federal Reserve has done a good job after the recession.

The results of inflation expectation anchoring using the Phillips curve regression is presented in Table 2. As stated in the empirical strategy part, due to lack of information about what estimation method and what data source Davis and Mack use, my result is not so similar with the original paper. For 83-89, the results differ after one decimal point, and two decimal points for 90-99 and 00-07. Even though, my results are still consistent with the original paper in magnitude, and can get the same conclusion that, the inflation expectation is anchored better over time for U.S. This prove that the Philips curve regression is a valid way to measure the anchoring of inflation expectation, even when the inflation expectation data is not available.

Also, I extend the data period using the Phillips curve regression to the post-recession time. As the Table 2 shows, the response of inflation expectation to a shock in inflation is -0.004 and not statistically significant. This result is consistent with my extension in the first part that the inflation expectation is almost exactly anchored post-recession.

The results of cross-country inflation expectation anchoring comparison with headline inflation is presented in Table 3A. Although the results are not the same as the original paper, the ranking of each country is almost the same. The results are quite consistent with our intuition about the credibility of central bank in different countries. Latin America countries like Columbia, Brazil and Chile do not have strong and credible central bank, so the inflation expectation anchoring is the worst in those countries. And for inflation targeting countries like Norway and Canada, their inflation expectation anchoring is among the best of those countries.

My extension for this part is I calculate the average anchoring of many organizations. We can see that OECD European are better anchored than OECD in all, because European countries all have well behaved central bank systems. Also 19 Euro-zone countries are better anchored than 28 European Union countries, because those EU countries who do not use euro are Southern and Eastern European countries, whose central banks are also not strong enough. The best anchored organization is the G7 countries. They have strong central bank, and most of countries are also inflation targeters. This results put more emphasis that the credibility of central bank is the most important instrument in inflation expectation anchoring.

Also I extend the data period to 2016. This is more like a robustness check, and we can see in Table 3B that the results are almost the same as the results in Table 3A.

The result with core inflation are presented in Table 4A. It is still not exactly the same as the original paper, but the ranking is still the same. And it is largely the same as the Table 3A. The best anchored core inflation countries are inflation targeters, and the worst are the Latin American countries. The ranking of the organizations is also exactly the same as headline inflation, and the extension result in Table 4B is robust with in Table 4A.

Figure 1 presents the graph of moving-window estimates over time for U.S., Mexico, Canada and U.K. Figure 2 and 3 presents the graph for first 12 Euro-Area countries. My graphs are almost the same with the original paper, especially the position of the spikes.

The graph of U.S. clearly shows that the inflation expectation was well anchored in the late 60s and early 70s. However, after 1973 oil crisis, due to lack of actions by the Federal Reserve, the anchoring estimate increased rapidly through next decade. After 1990s, the anchoring estimate became small again, and maintained a relatively low level. This graph is consistent with the results in the Table 1 and 2.

The remaining graphs in Figure1 are highly consistent with some important events of the central banks of these countries. In early 2000s, the Banco de México became independent, so we can see the anchoring estimate fell from almost 1 to only 0.2 in 2005, and never went back to 1. In 1991 the central bank of Canada adopted inflation targeting, so we can see a huge downward spike of anchoring estimate in the early 90s. In 1997 the Bank of England became independent, so we can see the estimate started to decrease after 2000s.

The graphs of first 12 Euro-area members shown in Figure 2 and 3 shares many common elements. Most of the countries are influenced by the oil crisis, so there are upward spikes in most of the graphs in early 1970s. Some of the countries adopt the European exchange rate mechanism(ERM) in the early 1980s, which cause a series of devaluations, we can also see upward spikes in the early 1980s in countries like Belgium and Luxembourg. However, after the movement of the "hard European monetary system" (hard-EMS) in 1996, the inflation expectation becomes well anchored again. And after 2000s the foundation of economic and monetary union(EMU), many Euro-zone country adopted the monetary policy of the German Bundesbank, inflation expectations are now perfectly anchored in these countries. These findings once again emphasis the importance of the role of central bank and monetary policy in anchoring the inflation expectation.

I extend all these moving-window estimates to 2016, instead of 2007 in the original paper. We can see that most countries have almost 0 anchoring estimates in current 10 years, way better than in decades ago. Two exceptions are Mexico and Ireland. Although Mexico has a lower average of anchoring estimate than before, the value is still fluctuating between 0 and 0.5. Also for Ireland, the anchoring estimate becomes larger in recent years than last century. These all indicates that their central bank is not credible enough to keep well anchored inflation expectations.

VI. Conclusion

The most important function of this paper is it reveals the close connection between inflation expectation anchoring and the credibility of central bank. From cross-country comparison we can see that all the countries with well anchored inflation expectations are inflation targeters, and those with worst anchored inflation expectations are developing countries with not so well functioned central banks. From moving-window estimates we can see that most developed countries have better anchored inflation expectations than before, due the adoption of inflation targeting or the independence of the central bank. Especially for Euro-area countries, the European monetary integration lead to a convergence in the anchoring of inflation expectations for most of Euro-area countries, as they adopt the monetary policy of the German Bundesbank.

The results in my paper is almost the same as the original paper, which makes me have more confidence in the results of Davis and Mack. The discrepancy between my results and the original results may be due to the choice of data source and the non-linear regression method, as I stated in the previous parts. My extension to the original paper focus on the data period, which shows a consistent better inflation expectation anchoring in recent years in each part.

Policy implication of this paper is straight forward, as I have emphasis so much on the role of the central bank. Central bank must act strongly and actively to adopt policies that will make people think the long-run inflation will stay at a constant level, thus the inflation expectation will be well anchored. As Beechey, Johannsen, and Levin (2011) suggest, if Federal Reserve can adopt inflation targeting policies in the future, the inflation of U.S. will be even better anchored.

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Table 1: Estimated Anchoring of U.S. Inflation Expectations Using the Cleveland Fed Inflation Expectations Data

	1983-2007	1983-2016	1983-1989	1990-1999	2000-2007	2008-2016
θ	0.196	0.127	0.293	0.171	0.082	0.021
	(0.018)	(0.013)	(0.029)	(0.037)	(0.032)	(0.013)
R^2	0.293	0.190	0.547	0.154	0.066	0.025
obs.	300	402	84	120	96	102

Table 2: Estimated Anchoring of U.S. Inflation Expectations Using a Phillips Curve Regression

	1983-1989	1990-1999	2000-2007	2008-2016
γ	0.160	0.118	0.017	-0.004
	(0.043)	(0.046)	(0.014)	(0.012)

Table 3A: Estimated Anchoring of Inflation Expectations, Found Using the Coefficients from a Phillips Curve Regression with Headline Inflation, 1996-2013

	γ Coeff.	Std. Error		γ Coeff.	Std. Error
Columbia	1.067	(0.069)	U.K.	0.018	(0.022)
Brazil	0.773	(0.067)	Finland	0.014	(0.016)
Mexico	0.769	(0.066)	Korea	0.014	(0.019)
Turkey	0.318	(0.050)	EA19	0.013	(0.027)
Chile	0.277	(0.047)	Portugal	0.011	(0.020)
Latvia	0.228	(0.046)	Japan	0.007	(0.020)
Estonia	0.226	(0.046)	Greece	0.006	(0.027)
Italy	0.174	(0.039)	Netherland	0.004	(0.027)
Russia	0.173	(0.039)	Sweden	0.003	(0.018)
Iceland	0.132	(0.034)	Spain	0.001	(0.021)
Ireland	0.112	(0.032)	Austria	0.000	(0.017)
OECDE	0.065	(0.018)	Denmark	-0.002	(0.030)
Hungary	0.060	(0.016)	Luxembourg	-0.003	(0.030)
Poland	0.057	(0.013)	France	-0.003	(0.018)
Slovenia	0.047	(0.019)	G-7	-0.004	(0.016)
Israel	0.047	(0.017)	U.S.	-0.005	(0.016)
Czech Republic	0.046	(0.020)	Norway	-0.006	(0.020)
OECD	0.043	(0.018)	Germany	-0.009	(0.019)
Slovakia	0.033	(0.019)	Canada	-0.009	(0.017)
EU28	0.025	(0.019)	Belgium	-0.016	(0.010)
India	0.025	(0.018)			

Table 3B: Estimated Anchoring of Inflation Expectations, Found Using the Coefficients from a Phillips Curve Regression with Headline Inflation, 1996-2016

	γ Coeff.	Std. Error		γ Coeff.	Std. Error
Columbia	1.069	(0.064)	U.K.	0.022	(0.020)
Brazil	0.783	(0.063)	Finland	0.021	(0.017)
Mexico	0.782	(0.062)	EU28	0.019	(0.015)
Turkey	0.273	(0.044)	Spain	0.016	(0.020)
Latvia	0.228	(0.046)	Portugal	0.015	(0.018)
Estonia	0.226	(0.046)	Greece	0.013	(0.022)
Chile	0.216	(0.039)	Denmark	0.010	(0.022)
Russia	0.173	(0.036)	Sweden	0.007	(0.017)
Iceland	0.135	(0.034)	France	0.007	(0.019)
Italy	0.090	(0.026)	Japan	0.006	(0.016)
Ireland	0.074	(0.024)	EA19	0.006	(0.022)
OECDE	0.068	(0.018)	Netherland	0.005	(0.024)
Hungary	0.062	(0.014)	G-7	0.003	(0.016)
Poland	0.060	(0.012)	Luxembourg	0.001	(0.028)
Israel	0.053	(0.017)	U.S.	0.001	(0.015)
Slovenia	0.049	(0.017)	Austria	0.000	(0.017)
Czech Republic	0.048	(0.019)	Germany	-0.002	(0.020)
OECD	0.047	(0.017)	Belgium	-0.003	(0.011)
Slovakia	0.043	(0.019)	Norway	-0.006	(0.020)
Korea	0.025	(0.018)	Canada	-0.015	(0.014)
India	0.023	(0.017)			

Table 4A: Estimated Anchoring of Inflation Expectations, Found Using the Coefficients from a Phillips Curve Regression with Core Inflation, 1996-2013

	γ Coeff.	Std. Error		γ Coeff.	Std. Error
Columbia	0.688	(0.065)	Portugal	0.013	(0.023)
Mexico	0.630	(0.062)	G-7	0.012	(0.020)
Turkey	0.117	(0.023)	Japan	0.011	(0.021)
Hungary	0.066	(0.015)	U.K.	0.010	(0.024)
OECDE	0.061	(0.016)	Finland	0.008	(0.018)
Poland	0.057	(0.010)	Greece	0.007	(0.027)
OECD	0.057	(0.015)	France	0.005	(0.023)
Slovakia	0.054	(0.021)	Netherland	0.004	(0.031)
Ireland	0.054	(0.022)	Spain	0.003	(0.030)
Iceland	0.052	(0.020)	Canada	0.002	(0.024)
Latvia	0.050	(0.016)	Denmark	0.001	(0.043)
Estonia	0.044	(0.020)	EU28	0.001	(0.050)
Israel	0.043	(0.016)	EA19	0.000	(0.054)
Czech Republic	0.042	(0.018)	Austria	0.000	(0.025)

Chile	0.033	(0.020)	Norway	-0.001	(0.021)
Korea	0.025	(0.015)	Sweden	-0.002	(0.021)
Slovenia	0.021	(0.019)	Luxembourg	-0.003	(0.052)
Italy	0.020	(0.013)	Germany	-0.004	(0.035)
U.S.	0.015	(0.021)	Belgium	-0.011	(0.019)

Table 4B: Estimated Anchoring of Inflation Expectations, Found Using the Coefficients from a Phillips Curve Regression with Core Inflation, 1996-2016

	γ Coeff.	Std. Error		γ Coeff.	Std. Error
Columbia	0.688	(0.062)	Japan	0.014	(0.019)
Mexico	0.614	(0.058)	U.S.	0.014	(0.019)
Turkey	0.111	(0.019)	Greece	0.010	(0.024)
Hungary	0.068	(0.014)	G-7	0.009	(0.019)
OECDE	0.058	(0.015)	U.K.	0.008	(0.024)
Poland	0.058	(0.009)	Finland	0.007	(0.017)
Slovakia	0.056	(0.021)	Spain	0.006	(0.026)
Iceland	0.053	(0.021)	France	0.004	(0.024)
OECD	0.053	(0.014)	Denmark	0.004	(0.034)
Latvia	0.050	(0.016)	Norway	0.003	(0.021)
Ireland	0.045	(0.019)	Netherland	0.003	(0.030)
Israel	0.045	(0.015)	Canada	0.002	(0.022)
Estonia	0.044	(0.020)	EU28	-0.001	(0.045)
Czech Republic	0.041	(0.017)	Sweden	-0.001	(0.021)
Chile	0.033	(0.020)	EA19	-0.001	(0.051)
Italy	0.026	(0.013)	Austria	-0.002	(0.026)
Korea	0.024	(0.014)	Luxembourg	-0.002	(0.052)
Slovenia	0.021	(0.019)	Germany	-0.004	(0.035)
Portugal	0.014	(0.021)	Belgium	-0.009	(0.018)

Figure 1: The Parameter from the Phillips Curve Regression, as Estimated in Ten-Year Moving-Window Regressions

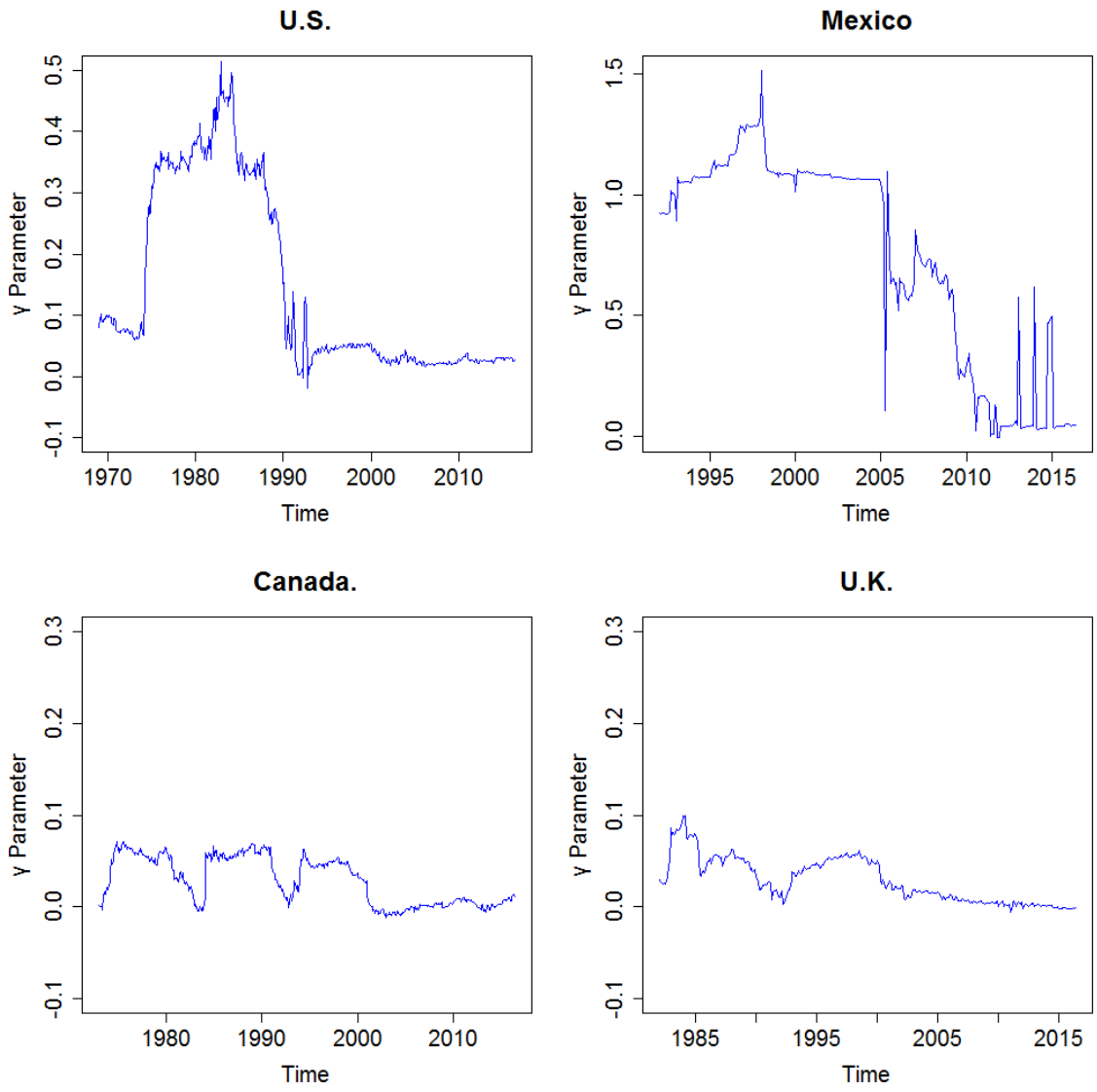

Figure 2: The Parameter from the Phillips Curve Regression, as Estimated in Ten-Year Moving-Window Regressions in Euro-Area Core Countries

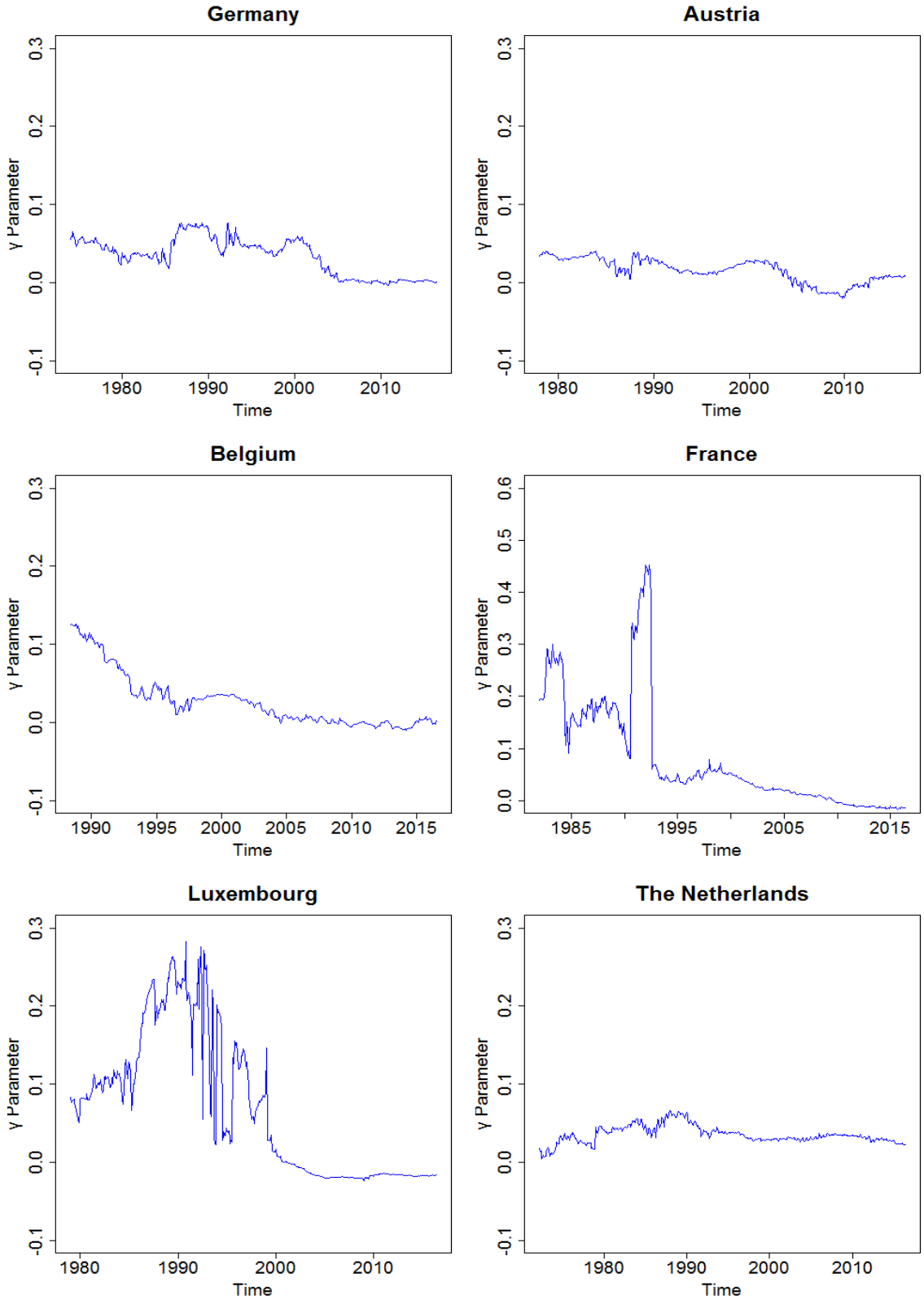

Figure 3: The Parameter from the Phillips Curve Regression, as Estimated in Ten-Year Moving-Window Regressions in Euro-Area Periphery Countries