Nominal GDP targeting for a speedier economic recovery

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Abstract:

For U.S. recessions since 1948, we study paneled time series of (i) ExUR, the excess of the unemployment rate over the prerecession rate, and (ii) NGAP, the percent deviation of nominal GDP from its prerecession trend. Excluding the 1969-70 and 1973-75 recessions, a regression of ExUR on current and past values of NGAP has an R^2 of 75%. Simulations indicate that NGDP targeting could have eliminated 84% of the average ExUR during the period from 1.5 years and 4 years after the recessions began. The maximum effect of NGAP on unemployment occurs with a lag of 2 to 3 quarters.

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# Nominal GDP Targeting for a Speedier Economic Recovery

By David Eagle

"Major institution change occurs only at times of crisis. … I hope no crises will occur that will necessitate a drastic change in domestic monetary institutions. … Yet, it would be burying one's head in the sand to fail to recognize that such a development is a real possibility. … If it does, the best way to cut it short, to minimize the harm it would do, is to be ready not with Band-Aids but with a real cure for the basic illness." Milton Friedman, 1984

Figure 1. Excess Unemployment Rate Comparison
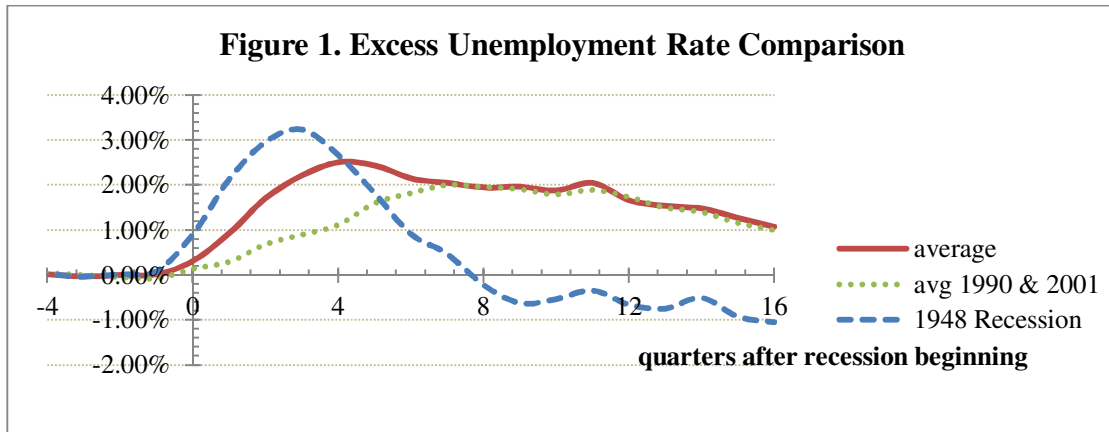
Recessions usually lead to high unemployment, and this high unemployment usually persists well after the recessions end. For U.S. recessions since 1947, the unemployment rate has on average taken well over four years (16 quarters) to return to its prerecession level as shown in Figure 1, where the excess unemployment rate (ExUR) is defined as the unemployment rate less the prerecession rate. However, following the Recession of 1949, the ExUR returned to zero within two years (8 quarters). As shown in Figure 2, this short duration of ExUR coincides with another economic variable called NGAP that also returned to zero within two years of the Recession of 1949's beginning.

NGAP is the percent deviation that nominal GDP (NGDP) is from its prerecession trend. The Recession of 1949 experience indicates that a way to try to keep unemployment low is to try to keep NGAP close to zero. A central bank (CB) trying to do so would in essence be pursuing NGDP targeting (which we nickname "NT") where its NGDP target increases at the constant rate

Figure 2. Recession of 1949 - Relationship Between Excess Unempl. Rate and NGAP
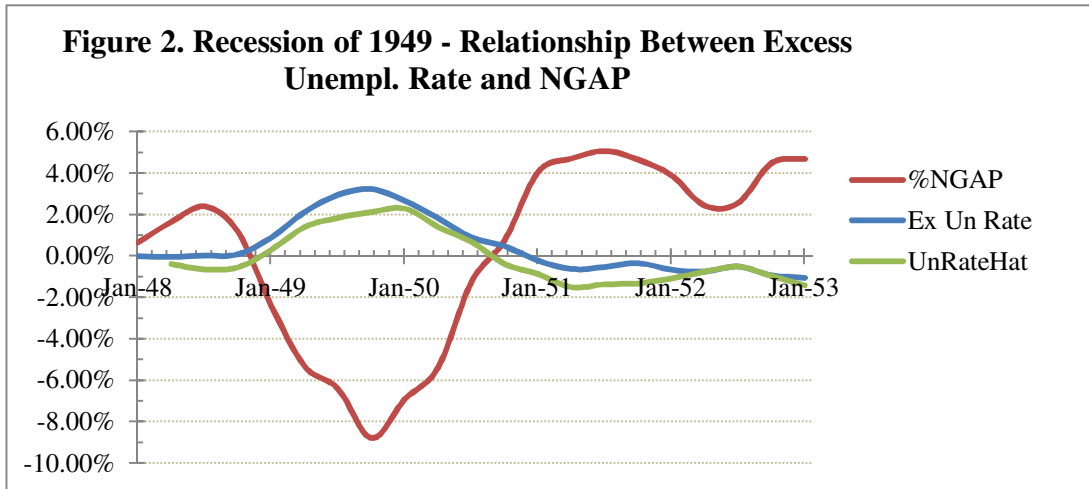
of $k\%$ per year. Given the unpredictability of velocity in the U.S. since 1980, NT is the natural modern-day extension of Friedman's $k\%$ money-growth-rate rule.[1,2]

This paper reports our empirical investigation into the relationship between ExUR and NGAP using a paneled-time-series methodology. For most recessions, we find the primary cause of high unemployment during and after a recession is negative NGAP. We also find that the reason high unemployment persists after a recession is because of a phenomenon we call negative "NGDP base drift," which occurs when NGDP drifts below its trend and remains below that trend well after the recession ends. [3]

Many economists[4] have previously noted the existence of base drift with respect to inflation targeting. In particular, they cite this drift as the primary difference between price-level targeting (PLT) and inflation targeting (IT). However, rather than discussing this base drift with

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[1] Another term for "nominal GDP targeting" is "nominal income targeting."

[2] To see that NT is a natural extension of Friedman's k% rule, realize that if income velocity is constant, the Friedman's k% rule is the same as NT. If velocity is variable and unpredictable, then NT can be viewed as an attempt to get the same effect as Friedman's k% rule would have achieved had velocity been constant.

[3] Technically speaking, NGAP base drift also should apply to positive NGAP, leading to the central banks changing to a NGDP projector that is above and parallel to the previous NGDP trend. However, our empirical analysis has little to say about the existence of the NGAP base drift associated with positive NGAP since our analysis focused on U.S. recessions, which were associated with negative NGAPs.

[4] Svensson, 1996, called this effect "basis drift" whereas Amber, 2009, and Coletti, 2008, called this "price-level drift". Taylor, 2006, referred to this as letting "bygones be bygones."

respect to NGDP, these economists focused on the base drift with respect to the price level.[5]

This paper extends the price-level base drift of IT to NGDP base drift and empirically documents its statistical and economic significance with respect to the Early 1990s and Early 2000s Recessions in the U.S. The prolonged high unemployment associated with NGDP base drift is a problem not only with IT, but also with NGDP growth-rate targeting (which we will nickname "ΔNT").

The next section discusses our empirical methodology and results. Section III extends the concept of price-level base drift to NGDP base drift in the context of delineating between the different targeting regimes of IT, PLT, NT, and ΔNT. Section IV empirically establishes the statistical significance of NGDP base drift with respect to the Early 1990s and Early 2000s Recessions in the U.S.. Section V summarizes this paper's findings and reflects upon the implications of those findings both for policy and economic thinking.

II. Empirical Relationship between NGAP and High Unemployment.

This section reports on our empirical analysis into the relationship between ExUR and NGAP. In order to determine NGAP, we first need to determine the prerecession trend for NGDP, which can be expressed as $N_t = N_0(1+k)^{4t}$ where time 0 is the official beginning of the recession, k is the annual trend growth rate, and time is measured in quarters. Quarter t is t quarters after the beginning quarter, and quarter $–t$ means t quarters before the beginning quarter (e.g., quarter -4 is the quarter four quarters before the beginning quarter). Taking the natural logarithm of both sides gives a linear relationship: $\ln(N_t) = \ln(N_0) + \ln(1+k) \cdot (4t)$. To

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[5] Meh et al. (2008) state, "Under IT, the central bank does not bring the price level back and therefore the price level will remain at its new path after the shock. …An important difference between IT and PT is that the central bank commits to bringing the price level back to its initial path after the shock."

determine the prerecession trend, we regressed $\ln(N_t)$ on $\ln(N_0)$ and the negative values of t that represented the quarters in the prerecession time period identified in Table 1. Where the resulting linear estimate is $\ln(N_t) = \hat{a} + \hat{b}t$, the trend's estimate for NGDP at time 0 is $e^{\hat{a}}$ and the estimate for the trend's annual growth rate for NGDP is $e^{\hat{b}/4} - 1$.

Because our focus is on NGAP, our determination of quarter 0 for some recessions differs from the official beginning of some recessions. Table 1 summarizes our analysis that led to the determination of what quarter to treat as quarter 0. For the Recession of 1949 and the 1973-1975 Recession, the significant negative NGAPs showed up the quarter following the official recession beginning; therefore, we designated that following quarter as quarter 0. For the early 2000s recession, NGAP became negative two quarters prior to the official beginning of the recession. For the Great Recession (2007-2008), NGAP first became significantly negative three quarters after the official beginning of the recession.

We also considered there to be two sets of "double-dip" recessions: (i) the Recession of 1958 and of 1960-61, and (ii) the 1980 and Early 1980s recessions. For the second dip of each of these "double-dip" recessions, we based NGAP on the NGDP trend established prior to the first dip. Hence the "quarter 0" designation for the second dip has no consequence.

Having established the "quarter 0" designation for each recession, we then set the prerecession unemployment rate for each recession as the average of the unemployment rates for quarters -4, -3, and -2. For the "double-dip" recessions, the second dip used the prerecession unemployment rate for the first dip. We then computed the excess unemployment rate (ExUR) as the difference between the unemployment rate and this prerecession unemployment rate. In order to accommodate both the autoregressive lags and the lags involving NGAP, we computed

Recession	Official Beg	NGDP Trend		NGDP$_0$	growth	%NGAP by quarter relative to official recession beginning							Quarter 0
		Begin	End			-2	-1	0	1	2	3	4	
... of 1949	1948-IV	1942[A] & 1943[A]	1947[A]	271.91	6.93%	1.7%	2.4%	1.2%	-2.4%	-5.3%	-6.4%	-8.8%	**1949-I**
... of 1953	1953-III	1951-I	1953-II	387.31	6.62%	0.9%	0.2%	-1.6%	-4.5%	-6.2%	-7.5%	-7.8%	**1953-III**
... of 1958	1957-III	1955-I	1957-III	467.18	5.85%	-0.3%	-0.2%	-2.6%	-5.6%	-6.1%	-4.6%	-3.3%	**1957-III**
... of 1960-61	1960-II	1955-I	1957-III	546.30	5.85%	-3.3%	-2.2%	-3.7%	-4.5%	-6.8%	-7.4%	-6.8%	**1960-II**
... of 1969-70	1969-IV	1968-II	1969-III	1,016.05	8.23%	-0.1%	0.0%	-1.1%	-1.9%	-2.3%	-2.6%	-4.3%	**1969-IV**
1973-1975 ...	1973-IV	1971-I	1973-III	1,426.45	10.48%	1.1%	0.0%	0.4%	-1.1%	-1.0%	-1.5%	-1.5%	**1974-I**
1980 ...	1980-I	1978-III	1980-I	2,727.68	10.64%	0.0%	-0.1%	-2.5%	-2.9%	-0.9%	1.1%	-0.3%	**1980-I**
Early 1980s ...	1981-III	1978-III	1980-I	3,174.30	10.64%	1.1%	-0.3%	0.1%	-1.9%	-4.6%	-5.4%	-6.8%	**1981-IV**
Early 1990s ...	1990-III	1985-IV	1990-II	5,817.17	6.57%	1.3%	0.6%	-1.1%	-2.1%	-2.3%	-2.7%	-3.3%	**1990-III**
Early 2000s ...	2001-I	1996-III	2001-IV	10,257.49	5.95%	-0.9%	-1.0%	-2.4%	-3.2%	-3.4%	-3.8%	-4.3%	**2000-III**
Great ...	2007-IV	2006-I	2008-III	14,146.63	3.95%	0.7%	0.8%	0.8%	-0.1%	-0.1%	-1.2%	-4.2%	**2008-III**

Table 1: %NGAP Around Recession Beginning and Determination of Quarter 0
Notes: [A] means based on annual instead of quarterly data

the ExUR and NGAP for quarters -14 through +16 for each recession.[6] We then paneled this data together for periods for quarters -3 through +16, eliminating any duplicated quarters.[7] Normally panel data sets have two dimensions – a cross-sectional dimension and a time-series dimension. In our analysis, we replaced the cross-sectional dimension with a second time-related dimension representing the different recessions. Our two basic regression variables are EXUR$_{i,t}$ and NGAP$_{i,t}$ where i represents the particular recession and t represents the number of quarters since the beginning of that recession.

For our primary regression, we did not include the Recession of 1969-70 and the 1973-1975 Recession as these two recessions behaved very differently from the other recessions. Reasons for this different behavior may be related to a demographic shift due to an influx of young members into the labor force from the baby-boom generation and because the role oil prices played in the 1973-1975 Recession.

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[6] For the Recession of 1949, we computed NGAP for quarters -5 through +16 because quarterly data only became available in 1947 and 1948. We based on the trend of NGDP for the Recession of 1949 on the average of the geometric average growth rate using annual NGDP between 1942-1947 and 1943-1947.

[7] For duplicated quarters, we kept the data for the first recession and eliminated the data for the second recession for quarters preceding the beginning of the second recession, and we eliminated the data for the first recession and kept the day for the second recession once the second recession began. The duplicated issue became much less pronounced when we treated the 1957 and 1960 recessions and the 1980 and early 1980s recessions as double-dip recessions. What we kept and what we eliminated is important because both ExUR and NGAP are based on pre-recession rates or trends, so that the values of these variables for the same quarter do differ depending which recession we base the computation on.

Our basic regression model is as shown below:

$$\text{ExUR}_{i,t}=\alpha+a\cdot\max(0,t)+b\cdot f(t)+\widetilde{\widetilde{c}}\cdot\max(0,\text{NGAP}_{i,t})+\widetilde{c}\cdot\min(0,\text{NGAP}_{i,t})+\sum_{s=1}^{L}d_s\cdot NGAP_{i,t-s}+\varepsilon_{i,t} \quad (1)$$

where α, a, b, are coefficients, $\widetilde{\widetilde{c}}$ is the coefficient on current NGAP when NGAP is positive, $\widetilde{c}$ is the coefficient on current NGAP when NGAP is negative, d_s is the coefficient on NGAP lagged one period, and $\varepsilon_{i,t}$ is the regression error term. One of the reasons for this regression is to see if it would imply that the central bank following NGDP targeting (i.e., targeting NGAP equal to zero) would return EXUR to zero. If we had left off the intercept term and the two terms involving time t, then our regression equations would have forced that conclusion to hold. Therefore, in addition to including the intercept term α, we also included the two terms involving time. The second term in the regression equation is just a linear function of time except that it is zero for periods before the recession began. The third term in the regression equation involves the nonlinear time function $f(t)$ which equals 0 if t≤0; $t^2/40.5$ if 0<t≤ 4.5; and $1-\left(\max(0,9-t)\right)^2/40.5$ if t>4.5. Figure 3 shows a plot of $f(t)$.

We settled on nine lags as we will explain later. We regressed (1) using data for all the U.S. recessions since 1947 except for the recessions of 1969-70 and 1973-75 and for t=-3, -2, …, 16. The results of that regression are shown in Table 3. While the intercept and time coefficients are statistically significant, of greater immediate interest are the coefficients and cumulative coefficients involving NGAP. Our regression breaks down current NGAP into its positive and negative components. The negative NGAP coefficient is very significant whereas the positive NGAP coefficient is not. Also, the positive NGAP coefficient of -0.0726 is much

Figure 3. The function $f(t)$
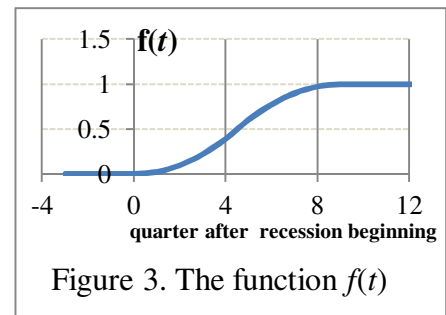
smaller than the negative NGAP coefficient of -0.3018. The signs of both coefficients are consistent with our expectation that NGAP and ExUR are inversely related.

We can make sense of the different current NGDP coefficients by associating negative and positive NGAP with aggregate nominal spending (as measured by NGDP) pushing the economy to be below or above capacity respectively. If NGDP falls below trend (negative NGAP), then the reduction of aggregate spending will lead to below-capacity production and higher unemployment. On

	Coefficient	Pvalue	−NGAP Cumulative
intercept	0.30%	3.06%	
NGAP+	-0.0726	45.31%	
NGAP-	-0.3018	0.00%	-0.3018
NGAP,L1	-0.1111	32.37%	-0.4129
NGAP,L2	-0.0319	77.69%	-0.4448
NGAP,L3	0.0167	88.27%	-0.4281
NGAP,L4	0.0921	40.17%	-0.3360
NGAP,L5	0.0444	67.33%	-0.2915
NGAP,L6	0.0042	96.79%	-0.2873
NGAP,L7	-0.0315	75.92%	-0.3188
NGAP,L8	-0.0137	89.38%	-0.3325
NGAP,L9	0.1675	1.42%	-0.1650
time1	-0.14%	0.01%	
time2	1.91%	0.00%	

Statistics:

# observations =	144
degrees of freedom =	129
R^2 =	74.79%
adjusted R^2 =	72.06%
F(,)=	29.44
Pvalue=	0.00%

Table 3: Basic Regression Results with

the other hand, the above-trend increase in aggregate spending represented with positive NGAP will push the economy beyond full capacity, resulting with the positive NGAP having a greater inflationary impact and a lower unemployment impact than with negative NGAP. While this does make a good story, we do realize that this study focuses on recessions where NGAP tends to be negative. Hence, our analysis has relatively few positive NGAP observations, which partly explains the high pvalue of the positive current NGAP coefficient.
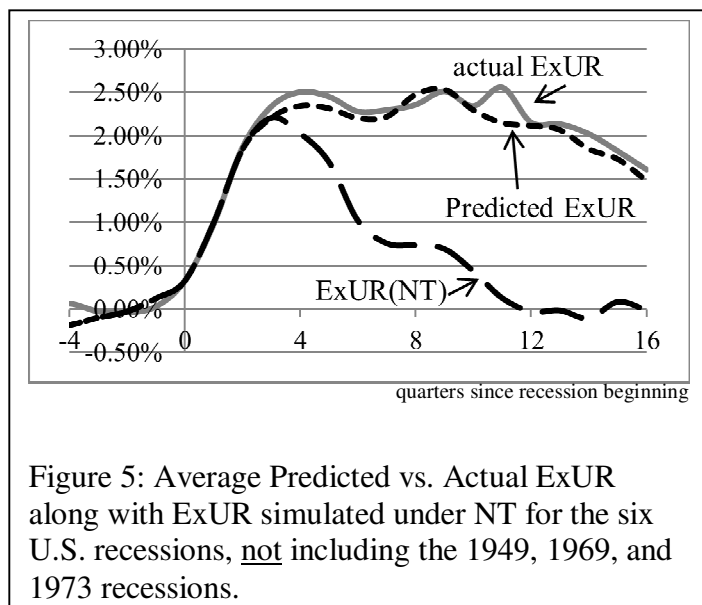
To further make sense of the information in Table 3, suppose NGDP decreases to 1% below its prerecession trend and then stays that percentage below trend (in other words, NGAP falls to and remains at -1%) which is consistent with a central bank following ΔNT. We can use the cumulative column in Table 3 to predict will happen to the unemployment rate for this -1% NGDP base drift. Immediately when NGAP becomes -1%, the unemployment rate will increase

.3018%. The next quarter, the unemployment rate will increase an additional .1111% to .4129% above its initial level. Two quarters after the drop of NGAP, the unemployment rate will increase an additional .0319% to .4448% above its initial level. Three quarters after the drop of NGDP, the unemployment

Figure 4: Model Simulation of NT and ΔNT Scenarios

rate will decrease slightly and continue to slowly decrease thereafter.
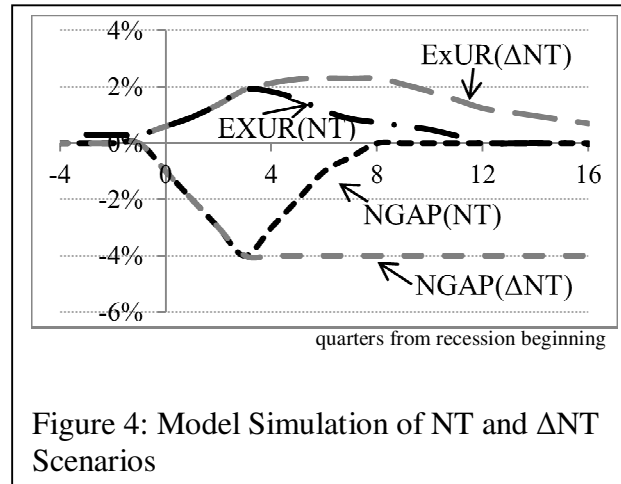
The constant and the time variables also have an impact on ExUR during and after a recession. To more clearly see how the model says the unemployment rate reacts to a recessionary drop in NGAP, Figure 4 shows model simulations of two scenarios: (i) a 1% quarterly drop in NGAP for four quarters and then NGAP returning to zero over the next four quarters, and (ii) the same decrease in NGAP for the first four quarters and then NGAP remaining at 4% thereafter. The first scenario represents NGDP targeting (NT) whereas the second scenario represents the NGDP base drift that would occur with NGDP growth rate

targeting (ΔNT). The 4% NGAP is near the average NGAP experienced in a recession (See Figure 7). The simulations show the excess unemployment peaking under NT at 1.9% after three quarters, then falling to 0.77% after two years and then to 0% after three years. On the other hand,

Figure 5: Average Predicted vs. Actual ExUR along with ExUR simulated under NT for the six U.S. recessions, not including the 1949, 1969, and 1973 recessions.

under ΔNT, the excess unemployment peaks at 2.32% after six quarters and is still 2.31% after two years, and then decreases to 1.24% after three years. Based on these simulations, the average EXUR over periods 6 through 16 would have been 0.37% under NT and 1.57% under ΔNT. Hence NT over this time period would reduce the excess unemployment rate by 76% relative to ΔNT (=(1.57%-0.37%)/1.57%). These simulations provide strong support for following NT instead of ΔNT in order to reduce recessionary unemployment quickly after a recession.

The R^2 for the regression results in Table 3 is almost 75% and the adjusted R^2 is 72%. This compares to an R^2 of 55% reported by Reichel (2004) for the short-run Phillips Curve in the U.S., except that Phillips Curve included an autoregressive component which usually increases the R^2 substantially compared to when no autoregressive component is included. Our model presented in Table 3 has no autoregressive component as we found the autoregressive components to be statistically insignificant.

The R^2 is a measure of goodness of fit of a model. We can also see this goodness of fit in graphs comparing the model's predictions to how the unemployment rate actually behaved. Figure 5 shows both the average actual and predicted ExUR for the six U.S. recessions not including the 1949, 1969-70, and 1973-75 recessions.[8] Note how close the model predicts well the average ExUR path.

Figure 6 displays the predicted and actual paths for ExUR for all the U.S. recessions except for the 1949 recession (which is displayed in Figure 2). Also included in Figure 6 are the NGAP paths. Again note how well the predicted paths for EXUR compare to the actual paths for

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[8] We exclude the 1969-70 and 1973-75 recessions because, as we said earlier, those recessions did behave differently than other recessions. We also exclude the Recession of 1949 because Figure 5 also includes the predicted ExUR for our model's simulation of the central bank pursuing NT modeled after the Recession of 1949, except that NGDP does a soft landing on its prerecession trend instead of overshooting that trend as it did after the Recession of 1949.

all recessions except the 1969-70 and 1973-75 recessions. Other than those two recessions, the latest recession (called the "Great Recession") had the widest margin of error with the predicted path of ExUR falling short of the actual
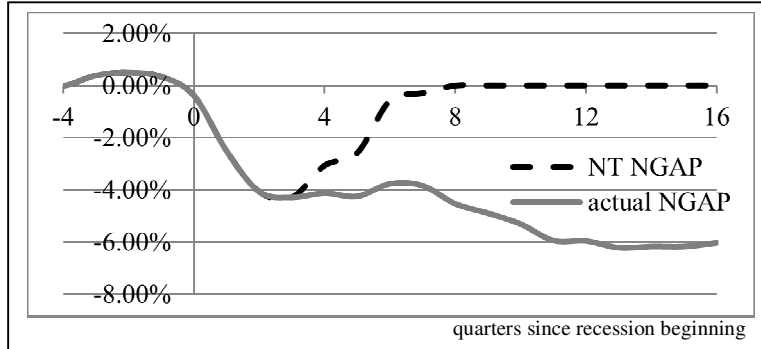

Figure 7: Actual vs. NT-Simulated NGAP for Figure 5

path. However, even here the model explains about 75% of the ExUR.

<< Insert Figure 6 >>

The second thing to note in Figure 6 is the behavior of NGAP. Other than the 1949, 1969-70, and 1973-75 recessions, the economy experienced NGDP base drift, meaning that the central bank settled on NGDP staying below its prerecession trend rather than trying to return NGDP to that trend.
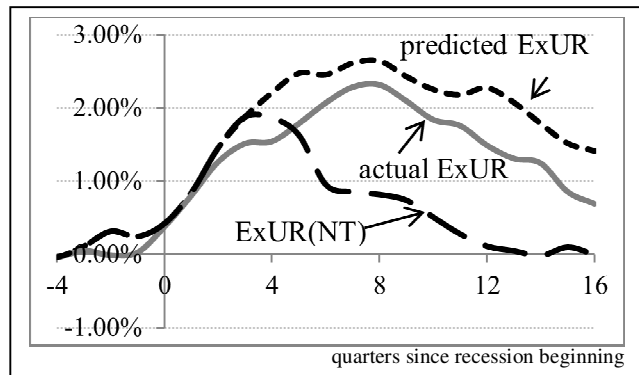

Figure 8: 1990 Recession ExUR – actual, predicted, NT simulated.

For the six recessions depicted in Figure 5, we simulated the central bank targeting NGDP by returning NGAP to zero as occurred in the Recession of 1949, except in the simulation the central bank makes a soft landing at a zero NGAP. Define $\Gamma_{i,t}$ and $\tilde{\Gamma}_{i,t}$ respectively as recession i's actual and simulated NGAP for time t. For this simulation we set $\tilde{\Gamma}_{i,t} = \Gamma_{it}$ for quarters t<4; $\tilde{\Gamma}_{i,t} = \left(\Gamma_{1948,t} / \Gamma_{1948,t-1}\right)\tilde{\Gamma}_{i,t-1}$ for quarters t=4, 5, and 6; $\tilde{\Gamma}_{i,t} = \tilde{\Gamma}_{i,t-1} / 2$ for t=7; and $\tilde{\Gamma}_{i,t} = 0$ for t>7. For the six recessions covered by Figure 5, Figure 7 shows the average actual

and simulated NGAP. Again note on average these recessions reflect substantial negative NGDP base drift.

Figure 9: 2001 Recession ExUR – actual, predicted, NT simulated.

As shown in Figure 5, when NGAP behaves as the NT-simulated NGAP in Figure 7, the ExUR is substantially reduced returning to zero in about 12 quarters or three years. The ExUR averaged over quarters 6, 7, …, 16 fell from the actual 2.19% to 0.34% for the NT-simulation, a drop of the ExUR by 84.86%.[9] This provides strong evidence that a central bank can substantially reduce the prolonged unemployment rate by following NT rather than the status quo which had led to the substantial negative NGDP base drift shown in Figure 7.

Figure 10: 2008 Recession ExUR – actual, predicted, NT simulated.

Figure 5 shows the NT simulation's reduction in ExUR on average over six recessions. Figures 8, 9, and 10 show those reductions individually for the 1990, 2001, and 2008 recessions. I will let the graphs speak for themselves. However, please note that with the 2008 recession, the model predicts NGDP targeting would have returned the unemployment rate to normal after 2.5 years, which would have preceded the writing of this paper.
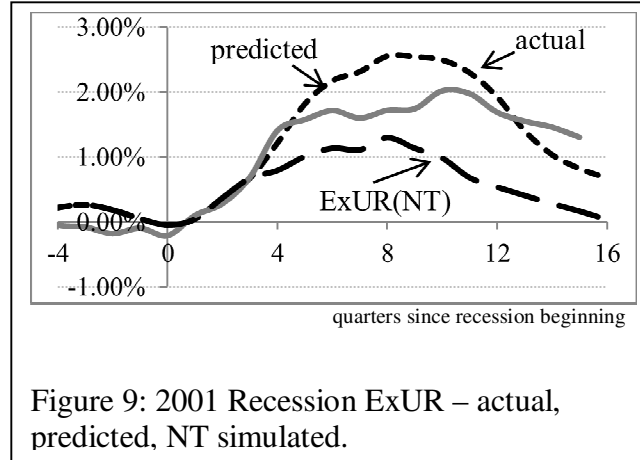
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[9] A more appropriate (but harder to communicate) measure of the reduction of ExUR by the NT simulation would be to compare the predicted ExUR to the simulated ExUR. Over the quarters 6, 7, …, 16; the average ExUR decreased from 2.10% for the predicted given the actual NGAP to 0.34% for the simulated NGAP, a drop of 83.97%.

While we reported no autoregressive lags and nine lags involving NGAP for the regression results we presented in Table 2, we considered other lag structures including autoregressive lags. The most number of lags of NGAP in any of our regressions was 11. For this lag structure of 11 NGAP lags, Table 4 summarizes the results from our

# lags	R^2	Adjusted R^2	Avg. Pvalue	Min. Pvalue
7	76.55%	73.37%	68.76%	37.57%
6	76.18%	73.56%	59.49%	32.37%
5	76.20%	73.03%	56.44%	38.03%
4	76.05%	72.88%	52.78%	37.56%
3	75.99%	72.84%	57.58%	46.68%
2	75.71%	72.52%	82.24%	74.87%
1	75.89%	72.77%	24.08%	24.08%
0	75.62%	72.69%	68.76%	37.57%

Table 4: Effect of autoregressive lags on R^2.

investigation into autoregressive lags. The Pvalues for the autoregressive coefficients never fell below 24%, and going from zero to seven autoregressive lags only increased R^2 from 75.62% to 76.55% and only increased adjusted R^2 from 72.69% to 73.37%. Therefore, we decided to leave off any autoregressive lags from our primary regression results.

Next, we investigated the different lag structures concerning NGAP with no autoregressive lags. Table 5 summarizes that investigation's findings. For zero NGAP lags, the R^2 was 64.7% and the adjusted R^2 was 63.4%. Increasing the number of lags of NGAP did increase R^2 and the adjusted R^2 especially going from two to three lags and from seven lags to

# lags	R2	Adjusted R2	%NGAP P-values												
			NGAP+	NGAP-	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11
0	64.7%	63.4%	11.1%	0.0%											
1	65.0%	63.4%	49.6%	0.0%	34.1%										
2	65.9%	64.1%	82.7%	0.2%	3.3%	5.3%									
3	68.3%	66.4%	80.5%	0.6%	10.6%	24.9%	0.2%								
4	69.8%	67.8%	51.1%	0.2%	27.3%	49.8%	89.2%	1.0%							
5	70.4%	68.1%	49.6%	0.1%	28.1%	74.2%	95.8%	74.1%	11.2%						
6	70.9%	68.5%	47.8%	0.0%	31.0%	75.0%	75.4%	65.0%	86.8%	12.7%					
7	71.9%	69.2%	58.7%	0.0%	22.3%	87.8%	77.4%	46.5%	93.9%	53.8%	4.0%				
8	73.4%	70.7%	63.0%	0.0%	21.2%	78.3%	70.6%	48.6%	65.1%	76.1%	51.5%	0.8%			
9	74.6%	71.8%	44.5%	0.0%	34.6%	78.2%	91.5%	41.0%	65.9%	97.1%	74.9%	91.5%	1.6%		
10	75.2%	72.2%	51.5%	0.0%	19.5%	96.2%	93.2%	55.6%	58.0%	98.2%	98.8%	91.6%	77.9%	9.1%	
11	75.6%	72.5%	52.5%	0.0%	22.6%	81.2%	73.6%	60.5%	69.5%	95.7%	99.1%	74.0%	65.2%	99.0%	13.8%

Table 5: Effect of NGAP lags on R^2

eight lags to nine lags. To include more lags means leaving off more valuable data in the Recession of 1949 recession since U.S. quarterly data started only in 1947 for NGDP and 1948 for the unemployment rate. On the other hand, we also were concerned about the goodness of fit, measured not only by R^2, but also by a graphical comparison of the models to actual, which was much closer for the nine-lag than for the three-lag model.. We therefore reported the nine-lag model as our primary regression results.

	VIF
NGAP+	2.7
NGAP-	11.8
NGAP, L1	40.6
NGAP, L2	40.2
NGAP, L3	40.0
NGAP, L4	36.4
NGAP, L5	31.6
NGAP, L6	29.3
NGAP, L7	25.7
NGAP, L8	23.5
NGAP, L9	9.2

Table 4. Variation Inflation Factors and Multicollinearity

Because of strong multicollinearity between the different lags of NGAP, the coefficients we reported in Table 3 are not as meaningful as they would be if we eliminate the multicollinearity. The multicollinearity caused the pvalues of these coefficients to be quite high expect for the that of the current NGAP and the last lag of NGAP. We tested the multicollinearity of among current and lagged NGAPs using a Variance Inflation Factors (VIFs), which are reported in Table 4. Since VIFs over 5 or 10 indicate strong multicollinearity, the VIFs of above 30 indicate extremely strong multicollinearity.

To obtain more meaningful coefficients, we then took a two-step approach. First, we regressed NGAP on lagged values of NGAP. We then used the resulting regression to define the "innovation" of NGAP to be the difference between the actual value of NGAP and its predicted value based on its lagged values. In other words where $\tilde{\Gamma}_{it}$ is defined as the innovation in NGAP and $\hat{\Gamma}_{it}$ is the predicted NGAP, $\tilde{\Gamma}_{it} \equiv \Gamma_{it} - \hat{\Gamma}_{it}$. The resulting innovations, therefore, were

virtually uncorrelated, eliminating the multicollinearity issue. We then regressed equation (1) using the current and lagged NGAP innovations instead of NGAP itself.

Table 5 shows the results for NGAP regressed on lagged NGAP. Where possible, we used the four-lag model to determine innovation of NGAP, but when our

	constant	NGAP, L1	NGAP, L2	NGAP, L3	NGAP, L4
Coef	-0.0036	1.4310	-0.3411	-0.3324	0.1773
pvalue	(0.22%)	(0.00%)	(1.79%)	(1.99%)	(3.55%)

	constant	NGAP, L1	NGAP, L2	NGAP, L3
Coef	-0.0041	1.4130	-0.4083	-0.0902
pvalue	(0.06%)	(0.00%)	(0.43%)	(28.49%)

	constant	NGAP, L1	NGAP, L2
Coef	-0.00387	1.4617	-0.5380
pvalue	(0.09%)	(0.00%)	(0.00%)

	constant	NGAP, L1
Coef	-0.00396	0.9599
pvalue	(0.36%)	(0.00%)

Table 5. NGAP regressed on lagged NGAP

data did not have sufficient lags, we used either the two-lag or the one-lag model. Because our results were so interpretable and the pvalues mostly significant, we extended equation (1) to more completely deal with whether NGAP was positive or negative. If $\Gamma_{it} > 0$, then we treated the NGAP innovation as "positive" whereas if $\Gamma_{it} < 0$ then we treated the NGAP innovation as "negative." Table 6 presents the resulting regression.

Without any multicollinearity between NGAP innovations and its lags, the pvalues for the negative NGAP innovations are significant for lags 0 through 8. The coefficients of the positive NGAP innovations are uniformly less than the coefficients of the negative coefficients; none of which are significant at the 5% level of significance, but lags 2, 3, and 4 are significant at the 10% level. For both the negative and positive NGAP innovations, almost all the coefficients are negative; negative coefficients are to be expected as a drop in NGAP should lead to an increase in the unemployment rate. The only positive coefficients are for the 11th lag of
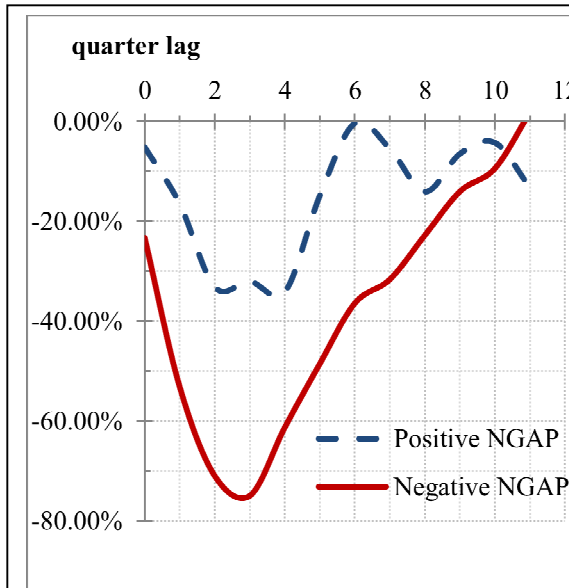
Figure 11. Coefficients on Positive and Negative NGAP Innovations Depending on Lag

	Negative NGAP		Positive NGAP	
lag	Coef.	pvalue	Coef.	pvalue
0	-23.25%	0.66%	-5.10%	77.51%
-1	-53.14%	0.00%	-16.48%	35.12%
-2	-71.00%	0.00%	-33.16%	6.65%
-3	-74.97%	0.00%	-32.02%	7.98%
-4	-61.25%	0.00%	-34.12%	5.33%
-5	-48.49%	0.00%	-14.80%	37.55%
-6	-36.37%	0.01%	-0.30%	98.56%
-7	-31.60%	0.05%	-5.46%	74.71%
-8	-22.74%	0.83%	-14.04%	39.37%
-9	-13.98%	9.23%	-6.43%	71.62%
-10	-9.35%	25.72%	-4.23%	81.04%
-11	1.92%	80.34%	-13.25%	45.45%
		time1	-0.0017	0.00%
		time2	0.0230	0.00%
		constant	0.0133	0.00%

Statistics:

# observations =	141
degrees of freedom =	114
R^2 =	74.77%
adjusted R^2 =	69.02%
F(26,114)=	13.00
Pvalue=	0.00%

Table 6: Regression of EXUR on Current and Past, Positive and Negative NGAP Innovations

both the positive and negative NGPA innovations, which are small and not statistically significant.

We found the best way to interpret these results of Table 6 is to plot the coefficients for both the positive and negative NGAP innovations against the lag they represent; the resulting graph is shown in Figure 11.

The negative NGAP innovations have the strongest effect on EXUR. While the effect is significant for the current negative NGAP innovation, the effect gets stronger as we increase the lag, reaching its strongest effect at 2 and 3 lags. Thus while a negative NGAP does have an immediate effect on unemployment, its strongest effect occurs 2 and 3 quarters later. The positive NGAP innovations have very little effect immediately, but greater effect 2, 3, and 4 quarters in the future. However, for lags 0, 1, …, 7; the effect of the positive NGAP innovations is less than half that of the corresponding negative NGAP innovation.

Altavilla and Ciccarelli (2009, p. 23) find that monetary shocks in the U.S. have the maximum effect on unemployment 5-6 quarters later while interest-rate shocks in the euro area have its maximum effect on unemployment 4-5 quarters later. Since nominal GDP is an intermediate variable between monetary shocks or interest rate shocks and unemployment, the result depicted in Figure 11 that the maximum effect of NGAP innovations on unemployment is 2-3 quarters is both consistent with Altavilla and Ciccarelli's results and provides additional insight. The delay of a monetary shock on NGDP should be the difference between Altavilla and Ciccarelli's 5-6 quarter delay between a money shock on unemployment and this paper's result of a 2 to 3 quarter delay on NGDP's maximum effect on unemployment. While it would be useful in future empirical research to verify, the indication is that the delay between a monetary shock in the U.S. and the effect on NGDP is also 2 or 3 quarters.

This is relevant to the issue of NGDP targeting vs. Inflation targeting. Batini and Nelson (2002) report a consensus among central banks is that there is about a two-year lag between monetary policy and inflation, and inflation-targeting central banks take this delay into account in their decision making. However, with NGDP targeting, this feedback loop can be reduced to between 2 or 3 quarters, which would provide a much faster feedback than under inflation targeting.

III. NGDP base drift and the Differences among IT, PLT, NT, and ΔNT.

The empirical results in the previous section showed how prolonged unemployment resulted from the negative NGDP base drift that the U.S. economy usually experienced during after recessions. The previous section also showed how this NGDP base drift can occur because of a central bank following ΔNT. However, most major central banks either explicitly follow

some form of IT, or as in the case of the Federal Reserve, it is presumed that the central bank

targets inflation. Nevertheless, the previous section shows evidence of negative NGDP base drift

in the U.S., and section IV documents the statistical significance of this negative NGDP base

drift. Previous literature has discussed how IT could theoretically lead to base drift in the price

level. This section of this paper extends that literature to how IT leads to NGDP base drift.

Because base drift is natural in a discussion of the differences between targeting regimes, this

section proceeds as if its objective is to explain these differences.

Previous literature such as Kahn(2009) has noted that the theoretical difference between

IT and PLT is that IT will lead to price-level drift, whereas PLT will not. We will now define

the four targeting regimes in the order of IT, PLT, NT, and ΔNT.

Inflation Targeting (IT): Define π^* to be the CB's inflation target. Under IT, the CB will

try to increase inflation when $\pi_t < \pi^*$ and decrease inflation when $\pi_t > \pi^*$ as long as output gap is

zero.[10]

Price-Level Targeting(PLT): Define P_t^* to be the CB's price-level target. Under PLT,

the CB will try to increase the price level if $P_t < P_t^*$ and decrease the price level if $P_t > P_t^*$. We

assume the CB's price level target will be consistent with the inflation target the CB would have

pursued under IT so that:

$$P_t^* = P_0 \, (1 + \pi^*)^t \tag{2}$$

---

[10] Current, most monetary economists recognize that central banks affect monetary policy by controlling interest rates. Often when modeling inflation targeting (in an economy with no output gap), economists will assume the following Taylor-like reaction function $i_t = \hat{i} + b(\pi_t - \pi^*)$ where i_t is the short-term nominal interest rate set by the central bank, $\hat{i}$ is the nominal interest consistent with the actual inflation rate equaling the targeted inflation rate.

Nominal GDP Targeting(NT): Define N_t^* to be the CB's NGDP target at time t. Under

NT, the CB will try to increase NGDP if $N_t < N_t^*$ and decrease NGDP when $N_t > N_t^*$. Let g

represent the long-run growth rate in real GDP (RGDP). We assume that, when RGDP increases

at its long-run growth rate, the CB's NGDP target will be consistent with the inflation target the

CB would have pursued under IT so that:

$$N_t^* = N_0 \left((1+\pi^*)(1+g)\right)^t \tag{3}$$

Here, $(1+k) = (1+\pi^*)(1+g)$ where k is the growth rate in the targeted level of nominal GDP.

NGDP Growth Rate Targeting (ΔNT): Define k^* to be the CB's target for the growth rate

in NGDP and let $\%\Delta$NGDP be the actual percent change in NGDP. Under ΔNT, the CB will try

to increase the $\%\Delta$NGDP when $\%\Delta$NGDP $< k^*$ and decrease $\%\Delta$NGDP when $\%\Delta$NGDP $> k^*$.

We assume that $k^* = (1+\pi^*)(1+g)$ so that the initial NGDP targeted path is the same under
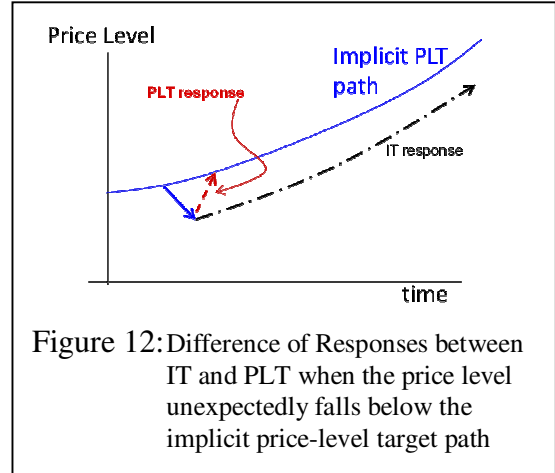
ΔNT as under NT.

The Difference between PLT and IT:

Under perfectly successful PLT, (2) implies that price level will equal:

$$P_t = P_0(1+\pi^*)^t \tag{4}$$

for t=1,…,T. On the other hand, if the CB followed IT and meets its inflation target for periods

s=1,2,…,t; then again the price level will equal (4). Hence, the initial price-level trajectory under

IT is the same as under PLT. The essential difference between IT and PLT occurs when the

central bank misses its target. Figure 12 shows the different responses under PLT and IT to the

actual price level being below the initial price-level trajectory. Under PLT, the CB takes action

to return the price level to the initial price-level trajectory. However, a CB following IT lets

"bygones be bygones" (Taylor, 2006) and tries only to return the inflation rate to its inflation target instead of trying to return the price level to the original implicit PLT path. Hence, the CB under IT shifts the price-level trajectory downward to be consistent with its inflation target from that time forward. For example, if $\pi^* = 2\%$, and $P_0 = 1.00$,

Figure 12: Difference of Responses between IT and PLT when the price level unexpectedly falls below the implicit price-level target path

then the initial price-level trajectory for both PLT and IT would be $P_t^* = 1.00(1.02)^t$. If at time 1, $P_1 = 1.01$ instead of 1.02, then the IT's new price-level trajectory would be $1.01(1.02)^{t-1} < 1.00(1.02)^t$. On the other hand, if $P_0 = 1.03$ instead of 1.02, then IT's new price-level trajectory would be $1.03(1.02)^{t-1} > 1.00(1.02)^t$, which means the CB shifts its price-level trajectory upward when the price level unexpectedly goes above the initial price-level trajectory. That IT shifts the price-level trajectory when the CB misses its target is what Ambler (2009) and Coletti, et al. (2008) call "price-level drift."

The Difference Between NT and PLT:

To understand the essential distinction between NT and PLT, let us revisit the equation of exchange (sometimes called the quantity equation): $M_tV_t = N_t = P_tY_t$. , which says that Money supply (M_t) times income velocity (V_t) equals nominal aggregate spending as measured by NGDP (N_t) which also equals the price level (P_t) times RGDP (Y_t). We concentrate on the *N=PY* part of this equation. Solving for P_t, we get:

$$P_t = \frac{N_t}{Y_t} \tag{5}$$

Assume perfectly successful NT (i.e., $N_t = N_t^*$). Also, assume RGDP is on its long-run growth path so that $Y_t = Y_0(1+g)^t$. Then, substituting (3) into (5) gives:

$$P_t = \frac{N_t}{Y_t} = \frac{N_0\big((1+\pi^*)(1+g)\big)^t}{Y_0(1+g)^t} = P_0\,(1+\pi^*)^t$$

This shows that perfectly successful NT and PLT result with the same price level as long as RGDP is on its long-run growth path. Thus the difference between NT and PLT occurs when RGDP deviates from its long-run growth path.

Assume RGDP falls. Under NT, the CB keeps to its NGDP target so (5) implies that the price level will increase. On the other hand, under PLT the CB tries to decrease NGDP to offset the effect of the fall in RGDP in order to keep the price level on target.

Now assume RGDP rises relative to its long-run growth path. Under NT, the CB lets the price level fall. Under PLT, the CB tries to increase NGDP to offset the unusual growth in RGDP in order to keep the price level on target.
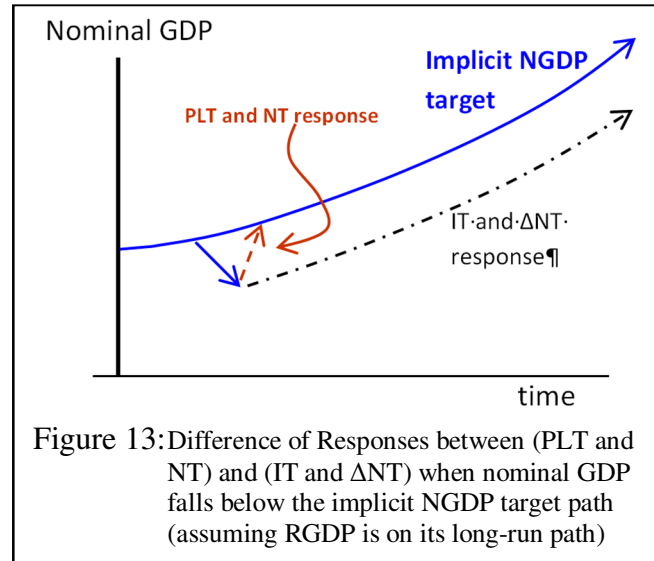
The Differences among IT, PLT, NT, ΔNT when real GDP is on track:

As long as real GDP is on its long-run growth path and as long as the CB perfectly meets its target, the result will be the same whether the CB follows IT, PLT, NT, or ΔNT. Therefore, to understand the differences among these targeting regimes, we must consider (i) RGDP exceeding or falling short of its long-run growth path, or (ii) the CB missing its target.

First, consider the RGDP straying from its long-run growth path, but the CB perfectly meets its target. Then under both NT and ΔNT, the CB will keep to the initial implicit NGDP target path. However, if RGDP falls below (rises above) its long-run growth path, then under IT

and PLT the CB will try to increase (decrease) NGDP in order that inflation (under IT) and the price level (under PLT) are as targeted.

Second, assume that RGDP does stay on its long-run growth path, but the CB misses its target. Then under both PLT and NT, the CB will try to return to the initial

Figure 13: Difference of Responses between (PLT and NT) and (IT and ΔNT) when nominal GDP falls below the implicit NGDP target path (assuming RGDP is on its long-run path)

NGDP trajectory. However, under IT and ΔNT, the CB will let "bygones be bygones" and try only to meet its future inflation or NGDP target. These reactions by both IT and ΔNT will lead to NGDP base drift.

For example, assume $\pi^* = 2\%$, $g = 3\%$, $P_0 = 1.0$, and $Y_0 = N_0 = N_0^* = 1000$. The initial NGDP trajectory under all four targeting regimes is $N_t^* = 1000\big((1.03)(1.02)\big)^t$. The ΔNT targeted NGDP growth rate is 5.06%, and the initial price-level trajectory equals $P_t^* = 1.0\big((1.02)\big)^t$ Assume at time 1, RGDP grows at its long-run growth rate so $Y_1=1030$, but $N_1=1040.30$ instead of its implicit NGDP target of 1050.60, which causes P_1 to be 1.01 instead of 1.02. Under NT and PLT, the CB will try to return NGDP to its initial NGDP trajectory. However, IT's new PLT trajectory would be $1.01(1.02)^{t-1}$. Multiplying this by $Y_t=1000(1.03)^t$ gives IT's new NGDP trajectory of $1000(1.03)^t1.01(1.02)^{t-1} < 1000\big((1.03)(1.02)\big)^t$. Also, since the CB under ΔNT lets "bygones be bygones," the ΔNT's new NGDP trajectory is also $1000(1.03)^t1.01(1.02)^{t-1}$. In other words, under both IT and ΔNT, the CB shifts its NGDP trajectory downward when it falls below that trajectory (when RGDP is on its long-run growth path).

Figure 13 illustrates this difference. Under the assumption that real GDP is on its long-run growth path, when nominal GDP falls below its initial NGDP trajectory, the CB's response

Figure 14. Actual NGDP vs. Trend after 1990 Recession
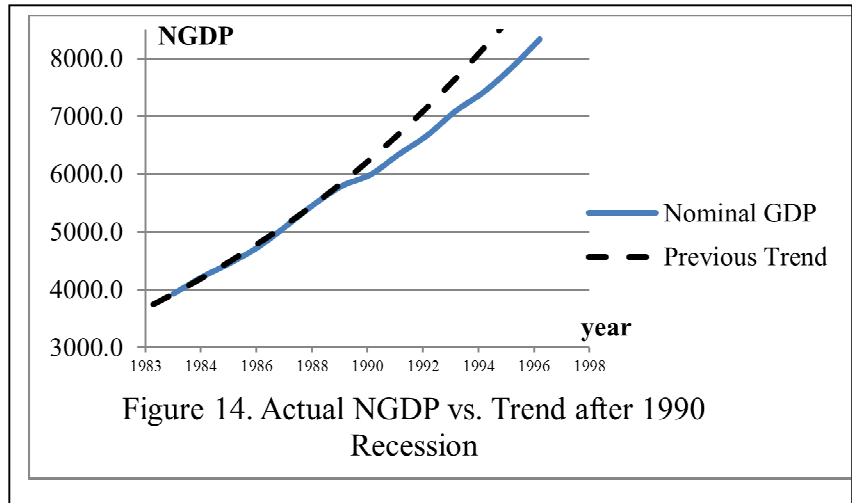
would be the same under both PLT and NT to increase NGDP back up to its initial NGDP trajectory. However, under IT and ΔNT, the CB lets "bygones be bygones" and shifts its new NGDP trajectory to be below and nearly parallel to the initial NGDP trajectory. Hence, both IT and ΔNT lead to NGDP base drift.

On the other hand, if NGDP rises above the initial NGDP trajectory, a CB targeting inflation or the NGDP growth rate would again try to meet its future targets, but not return to the initial NGDP trajectory. This results in an upward shift in the NGDP trajectory.

IV. Empirical Tests of NGDP base drift

The previous section argued that IT theoretically should lead to NGDP base drift because its focus is on the inflation rate, not the price level and not NGDP. Some economists may argue that IT

Figure 15. Actual NGDP vs. Trend after 2001 Recession
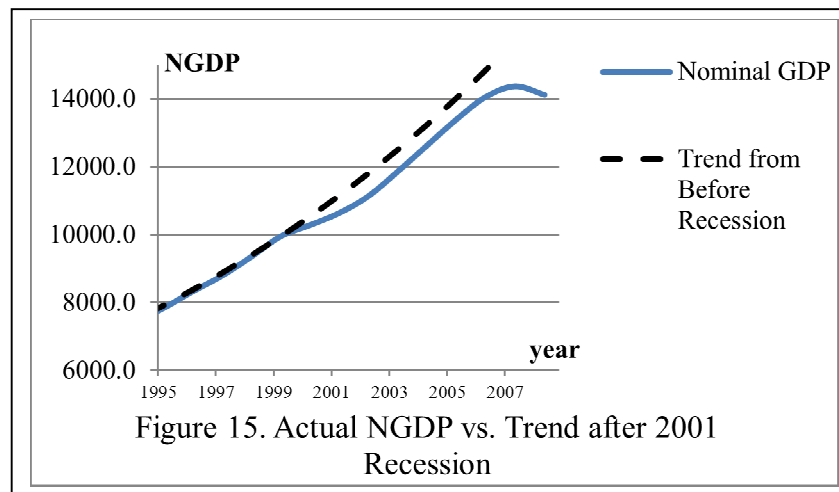
in practice does not exhibit NGDP base drift because a CB following IT in reality targets the

long-run inflation rate not the short-run inflation rate and because the CB usually also takes into

account output gap or unemployment as well as the inflation rate. Thus, this section empirically

investigates whether NGDP base drift occurred during the 1990 and 2001 U.S. recessions, when

the Federal Reserve was thought by many economists to be acting like they targeted inflation.

We begin this investigation by plotting the annual U.S. NGDP and its prerecession trend around

the 1990 recession in Figure 14 and around the 2001 recession in Figure 15.

 The similarity between these graphs and Figure 13 is quite close, especially for the 2001

recession. At the beginning of the 2001 recession, NGDP fell below its prerecession trend and

followed a path below and nearly parallel to the prerecession trend until the recession starting in

December 2007. The 1990 recession also depicted NGDP base drift, except NGDP increased at

a lower growth rate after the 1990 recession than before. Figures 13 and 14 visually indicate the

existence of negative NGDP base drift. Nevertheless, we should determine if this property is

statistically significant.

 Our methodology for assessing the statistical significance of NGDP base drift is shown

in Figure 16. If NGDP were to increase at k% per year, then $N_t = N_0(1+k)^{4t}$ where we measure

t in quarters. Taking natural
logarithms of both sides gives:

$$\ln(N_t) = \ln(N_0) + \left(\ln(1+k)\right)\cdot(b$$

We first define time 0 as the quarter
in the middle of the NGDP drop at
the beginning of the recession. We

Figure 16: Statistical Methodology to test for NGDP
base drift
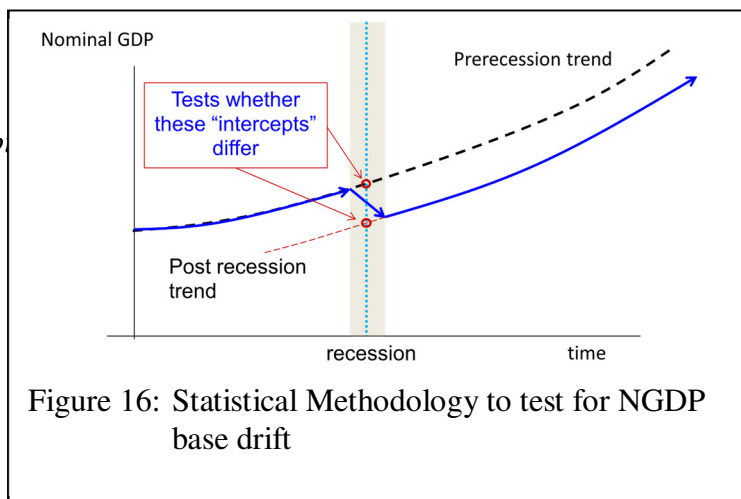
	1969 recession	1990 recession	2001 recession
Pre-recession period	1964-I thru. 1969-I	1984-I thru. 1990-I	1992-I thru. 2000-I
Intercept date	1969-III	1991-I	2000-I
Post-recession period	1970-I thru. 1975-I	1992-I thru. 2000-I	2002-I thru. 2008-I
NGDP intercept:			
Common	972.99	5,937.10	10,037.56
Pre-recession	992.36	6,066.98	10,191.15
Post-recession	954.03	5,848.83	9,819.74
% change	-3.86%	-3.60%	-3.64%
Common intercept test:	F-test(1,38)	F-test(1,54)	F-test(1,54)
F-statistic	32.47	96.91	89.36
P-value	0.00%	0.0000%	0.0000%
Test Conclusion	Sign. Drop	Sign. Drop	Sign. Drop
NGDP growth rate:			
Common	8.33%	5.81%	5.40%
Pre-recession	8.10%	6.80%	5.71%
Post-recession	9.70%	5.71%	5.81%
change	1.60%	-1.09%	0.10%
Common growth test:	F-test(1,39)	F-test(1,55)	F-test(1,55)
F-statistic	28.20	43.13	0.77
P-value	0.0005%	0.0000%	38.5370%
Test Conclusion	Sign. Growth Inc.	Sign. Growth Dec.	Growth Inc. Not Sign.

Table 7. Empirical Tests of "Let Bygones Be Bygones" with U.S. Nominal GDP Data

then estimated (6) first for the prerecession period, second for the post-recession period, and for the combination of the two periods. Since we determined the prerecession and post-recession periods by inspection, those are presented in Table 5; for the recessions reported in Table 7, the prerecession periods were relative long. We then did an F-test to see if the intercepts for the prerecession and post-recession periods are significantly different. We also test whether the growth of NGDP significantly differs between the prerecession and post-recession periods, which as we will soon discuss is relevant to whether NGDP base drift exists.

Table 7 presents the statistical results for the 1969, 1990, and 2001 recessions. All three of these recessions indicate that the intercepts of post-recession trend is lower than the

prerecession trend and that this difference is statistically significant for all three recessions. However, as we will later see, the NGDP for the 1969 recession actually does come back to the its prerecession trend because the growth rate in NGDP increases after the recession as compared to before the recession. As a result, not only should we check to see if the intercept drops significantly, but we should also check on the growth rate of NGDP. For the 1990 recession, the post-recession growth rate actually decreases statistically significantly, which causes NGDP to drift even further away from its prerecession trend. For the 2001 recession, the post-recession growth rate increases but only by .10%, which we deem to be insignificant both from a practical and a statistical standpoint. We therefore conclude that the NGDP base drifts following the 1990 and 2001 recessions are statistically significant.

V. Conclusions and Reflections

Since the Financial Crisis of 2008, a renewed interest in NGDP targeting has emerged (See for example Sumner, 2011a, and 2011b). Proposals of NGDP targeting go back to Meade (1978), Tobin (1980), and Brittan (1981). Hall (1984) and Hall and Mankiw (1994) continued to discuss the proposal of NGDP targeting. Bean (1981) discusses NGDP targeting in a theoretical model. Additional theoretical work done on NGDP targeting include McCallum (1997), and McCallum and Nelson (1999). The only primary empirical analysis concerning NGPD targeting that I found is Domac and Kandil (2002), which studies the experience of Germany as it was supposedly targeting NGDP. Domac and Kandill state, "A considerable amount has been written on the theory of nominal income targeting. Fewer studies have investigated the practical aspects of nominal income targeting by conducting historical counterfactual simulations to determine how economic performance might have differed if this policy had been adopted." The current

paper is attempt to fill this gap with a stronger empirical-based methodology than in previous studies. However, we do recognize that we used the regression model as though it were a structural relationship. By doing simulations with those regression results, we are subject to the Lucas critique. However, that the model works similar to how the economy actually behaved during the Recession of 1949 gives some validation to our results.

A major finding of this research is that the reason for prolonged high unemployment following a recession is NGDP base drift. McCallum (2011) also favors a target involving nominal GDP, but he actually prefers targeting the growth rate in nominal GDP rather than the level of nominal GDP. Since NGDP base drift would be as much a problem with nominal growth rate targeting as it is with inflation targeting, this finding suggests central banks should avoid targeting regimes like IT and ΔNT that lead to substantial NGDP base drift.

PLT would be better than IT since PLT does not have price-level base drift and hence should have less NGDP base drift. However, PLT could still have NGDP base drift because of prices being sticky and therefore prices do not immediately move when NGDP falls.

While this paper focused on the central bank following NGDP targeting, we should realize that one of the advantages of NGDP targeting is its transparence not only for the central bank but for fiscal policy as well. A major problem with fiscal policy has been that tax cuts are politically popular to "stimulate the economy," resulting with federal governments perpetually running fiscal deficits rather than balancing their budgets over time. With both the central bank and the federal government following NGDP targeting, when NGDP is at or above target, there is no need for fiscal stimuli so the federal government then should not use the economy as a Keynesian excuse for fiscal deficits.

In this paper's simulations, NT was able to reduce the excess unemployment rate by between 75% and 84% over the period from 1.5 years to 4 years after the recession's beginning. As such, NT should be looked at as a way to reduce the prolonged unemployment that has accompanied most recessions.

We do have theoretical reasons for urging the adoption of NGDP targeting over both PLT and IT. These reasons have to do with the distinction between aggregate-demand-caused inflation and aggregate-supply-caused inflation, distinctions that have been made in the Wage Indexation literature but that have not been fully synthesized into mainstream macroeconomic thinking. We will present these theoretical reasons in a different paper.

The empirical investigation in this paper differs from previous research in that it handled the analysis using panel data having two dimensions: (i) time from the beginning of the recession, and (ii) a dimension representing the different recessions. This methodology yielded a strong statistically significant relationship between unemployment and NGAP. However, this methodology should be looked at a start of a series of empirical studies that extends this methodology to more variables than just NGAP. We invite future researchers to so extend this work.

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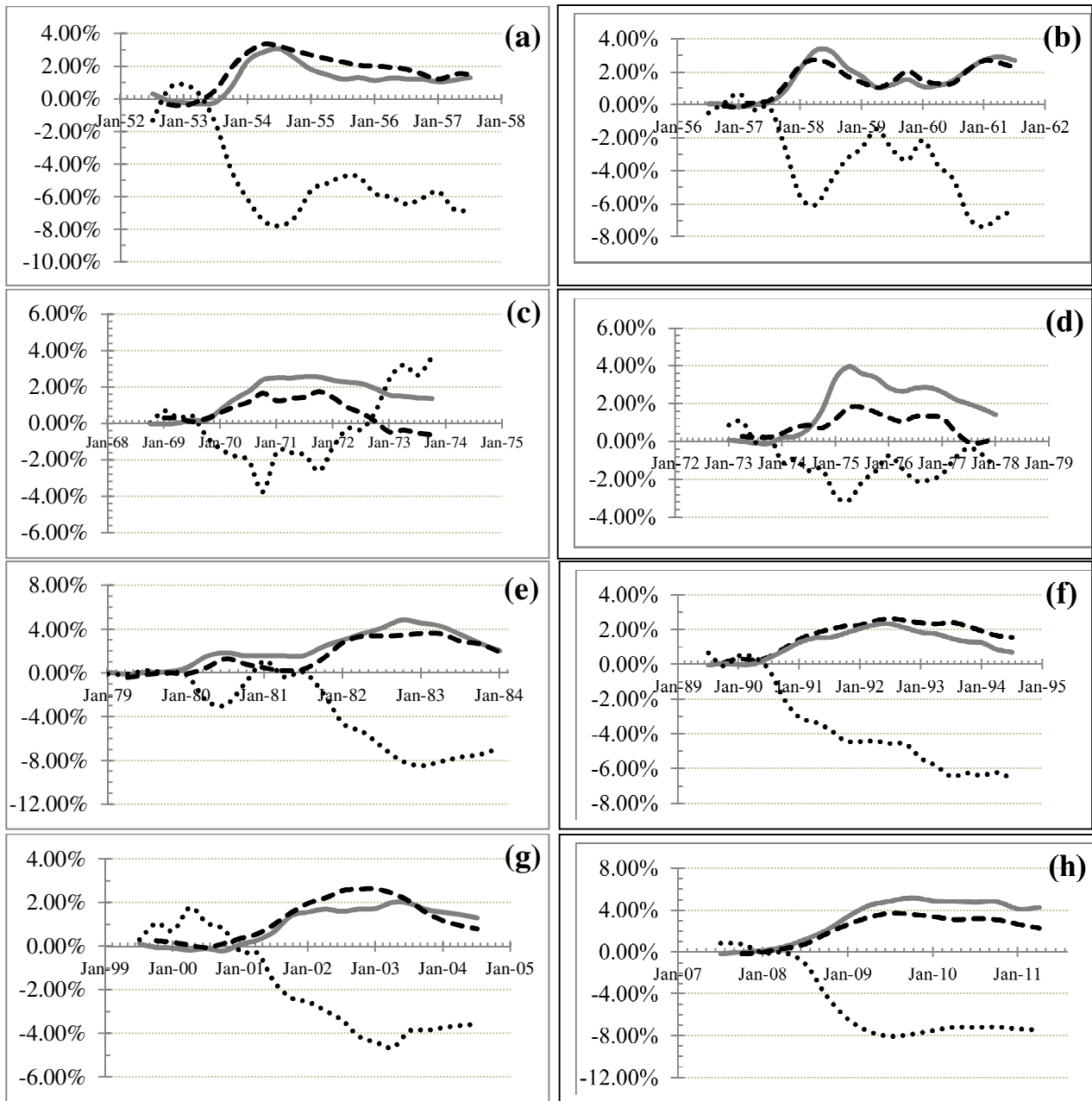
Figure 6: Comparisons of predicted ExUR to actual ExUR by Recession along with actual NGAP