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Beige Book**

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Evaluating the Eleventh District's Beige Book

Nathan S. Balke and Mine K. Yücel

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In this study Nathan Balke and Mine Yücel ask whether the Eleventh Federal Reserve District's Beige Book description contains timely information about economic activity within the District. They examine whether the Beige Book description tracks current Texas real gross state product (GSP) growth and current Texas employment growth. They also study whether the Beige Book has information about growth not present in other regional indicators that would have been available to analysts at the time of the Beige Book's release. They find that both the Beige Book summary and the average across sectors reflect Texas GSP and employment growth very well. These two measures of the Beige Book also have predictive content for one quarter ahead GSP growth. Balke and Yücel also find that the Eleventh District's Beige Book has information content for Texas economic activity over and above other state economic indicators such as Texas employment growth, personal income, or sectoral employment growth. Because the Beige Book is released at least one month earlier than employment data and at least two years before GSP data, its timeliness makes it a good tool for current regional economic analysis.

Is There a Persistence Problem? Part 2: Maybe Not

Evan F. Koenig

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In Part 1 of this two-part series, Evan Koenig explains why some economists are skeptical that staggered price adjustment can account for monetary policy's sustained effects on aggregate economic activity. In Part 2, Koenig looks at labor-market imperfections as a possible source of persistence. He concludes that persistence is much easier to obtain if either labor cannot move freely from firm to firm or wages are set in overlapping wage contracts.

Reliance, Composition, and Inflation

Joydeep Bhattacharya and
Joseph H. Haslag

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In this article Joydeep Bhattacharya and Joseph Haslag explore the effect of fiscal policy actions on long-run prices and the inflation rate. They study a model economy in which the central bank is not independent. Indeed, the government explicitly relies on the central bank for a predetermined amount of its revenue. Despite the absence of independence, the central bank does unilaterally control the composition of government paper. Bhattacharya and Haslag show that changes in reliance and composition have long-run impacts on prices and inflation. They conduct two separate policy experiments that suggest how a subservient central bank can retain substantial control over the inflation rate and still meet its revenue requirements set by the government.

Evaluating the Eleventh District's Beige Book

Nathan S. Balke and Mine K. Yücel

In this article, we examine how well the Beige Book corresponds to the growth rate of real Texas gross state product and employment.

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In formulating policy, the Federal Reserve's Federal Open Market Committee (FOMC) relies on information about not only national but also regional economic conditions. In fact, former Federal Reserve Governor George Mitchell once testified that the regional information "brings the committee qualitative judgments and insights that aggregative statistics will always lack." However, up-to-date regional statistics are not readily available at the time of the FOMC meeting. The most timely data—state and metropolitan employment statistics—are released with at least a month lag and provide direct information about only one dimension of the economy. Gross state product (GSP) data, which give a more comprehensive measure of economic activity, are released with at least a two-year lag. As a result, an important potential source of regional information is the Federal Reserve's Beige Book, an anecdotal report on economic conditions drawn mainly from surveys of businesses in the twelve Federal Reserve Districts and released approximately two weeks before each FOMC meeting.

Several recent papers have studied the information about aggregate economic activity contained in the Beige Book. Balke and Petersen (1998) give numerical scores to various dimensions of the Beige Book discussion and find that several Beige Book indexes have significant predictive content for current- and next-quarter real gross domestic product (GDP) growth. Furthermore, the Beige Book has information about current quarter real GDP growth not present in other indicators, such as the Blue Chip consensus forecast or time series models that use real-time data. Payne (1998) uses a different methodology to quantify the Beige Book but also finds it strongly correlates with aggregate economic activity. Fetting, Rolnick, and Runkle (1999), using not only the publicly available Beige Book but also its previously unreleased predecessor, the Red Book, find that the Beige Book predicts current-quarter real GDP growth and explains about 30 percent of the uncertainty in current-quarter real growth. However, Fetting, Rolnick, and Runkle conclude that the Beige Book provides little additional information about current-quarter real GDP growth once the private sector forecasts have been taken into account.¹

We examine whether the Eleventh District Beige Book description tracks current Texas real GSP growth and current Texas employment growth.² We also study whether the Beige Book contains information about growth not

Examples of Eleventh District Beige Book Summary

1. Eleventh District summary paragraph from January 18, 1995, Beige Book.

“The Eleventh District economy continued to grow at a solid pace in late November and December. Increasing strength was reported in the service sector, and manufacturing orders continued to rise at a steady rate. Strong commercial construction activity offset a further decline in the single-family sector. Retail sales growth slowed after the Thanksgiving holiday and Christmas sales were lower than expected. Growth in loan demand continued at a strong pace, but competition between banks for customers squeezed margins. District energy activity remained unchanged but was slightly below last year’s levels.”

The Balke and Petersen readers both scored the summary as 1.0. Note that while this Beige Book was released in mid-January, it really contains information about December’s economic activity.

2. Eleventh District summary paragraph from March 15, 1995, Beige Book.

“The Eleventh District economy continued to expand in late January and February but at a slightly slower pace. Manufacturing orders rose, and activity at business service firms remained very strong. Retail sales slowed, however, and some contacts said that Texas sales were among the weakest in the nation. Construction activity was steady as an increase in commercial construction offset a decline in homebuilding. Loan demand continued to rise. Energy activity declined seasonally and remained below last year’s levels. Agricultural production was better than expected. Despite growth in the district economy, respondents in several industries said expectations of a slowdown in the U.S. economy and uncertainty over the effects of the Mexican peso devaluation had reduced their optimism.”

One reader scored the summary as 0.5, while the other scored it as 1.0, for an overall score of 0.75.

present in other regional indicators available to analysts at the time of the Beige Book’s release. If the Beige Book is a good predictor of regional economic activity, it can provide timely information on employment and GSP growth and help us understand the state’s current economic climate.

ELEVENTH DISTRICT BEIGE BOOK SURVEY

Each of the twelve Federal Reserve Banks is responsible for reporting on economic conditions within its district. The district Banks are free to emphasize the sectors or aspects of economic activity they deem important for that particular Beige Book cycle. In the Dallas District, we contact about 100 businesses by telephone to obtain information on current conditions.³ To get a clear industry picture, we gather a minimum of three responses for each industry we cover. An analyst writes a summary for each sector surveyed. An economist reviews these sectoral reports, then writes a regional economic summary and a more detailed sectoral description.

In recent years, the Beige Books have also included descriptions of price and wage pressures in the districts, and very recently, e-commerce activity. In addition to the surveys,

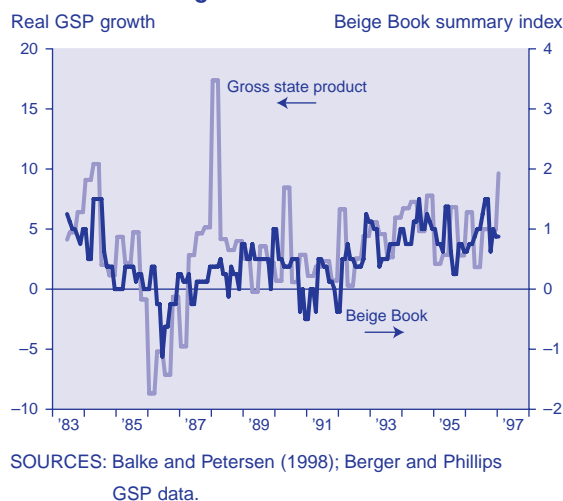
information from statistical releases and newspapers may be reported in the Beige Book.

NUMERICAL BEIGE BOOK INDEXES

To evaluate the Eleventh District Beige Book, we must assign numerical values to various aspects of the Beige Book description. We use the Beige Book scoring of Balke and Petersen (1998) for the Eleventh District. They read and scored each Beige Book from July 1983 through January 1997. Along with national and district summaries, Balke and Petersen graded the Eleventh District sectoral discussions for retail, manufacturing, finance or banking, construction, and mining sectors (which typically reflects the oil and gas industry).

Balke and Petersen gave the Beige Book descriptions numerical values ranging from –2 to 2. Typically, if the Beige Book description appeared to suggest “moderate” or “normal” economic growth, it was scored a 0.5, while a description implying “strong” economic growth was given a score of 1.0 or 1.5. Keywords could be helpful in scoring but were not relied on exclusively. (See the box above for examples of summary paragraphs from the Eleventh District Beige Book and how they were scored.) The

Figure 1
GSP Versus Beige Book Index



Beige Books were read in random order and with references to the calendar year removed to lessen the likelihood that hindsight would color scoring. Both readers scored all the Beige Books, and their grades were averaged to obtain the final score. Unlike traditional time series data—such as GDP, which refers to a specific quarter, or employment growth, which refers to a specific month—the Beige Book, compiled eight times a year, does not correspond exactly to a particular quarter or month. As a result, Balke and Petersen attempted to match the period for which the Beige Book was relevant with the period for the more traditional indicators of economic activity.⁴

TRACKING ELEVENTH DISTRICT ECONOMIC ACTIVITY

To evaluate how well the Beige Book tracks Eleventh District economic activity, we need some measure of District economic activity with which to compare the Beige Book. In this article, we examine how well the Beige Book corresponds to the growth rate of real Texas GSP and employment. The GSP data from the Bureau of Economic Analysis are available only on an annual basis and with at least a two-year delay. As of May 2000, the latest GSP data available are from 1997. Berger and Phillips (1995) estimate quarterly GSP for each standard industrial classification for the available GSP: "...industry-specific (real) GSP is measured so that the sum of GSP across all industries equals total real output. That is, each industry's GSP is a measure of value-added and is different from the total number of units produced or the total sales of the industry." We use Berger and

Phillips' quarterly GSP estimates, which are the sum of the sectoral GSP estimates.⁵

Texas employment growth data are released monthly. Preliminary estimates are available with a one-month delay, revisions come out the next month, and the final revision is released in March of the following year. For both employment and GSP growth, we use the final, revised estimates, which we take to be the best measure of economic activity during the period in question. Of course, these data are released many months or, in the case of GSP, many years after the fact.

Figure 1 plots the numerical scores for the Eleventh District Beige Book summary against quarterly GSP growth. The Beige Book index tracks the general cyclical movements in GSP growth well, capturing the Texas economy's boom in the early 1980s and the oil bust of the mid-1980s. It also reflects the relatively strong economic growth Texas experienced during the mid-1990s. Recall that the Beige Book is released nearly two years before the GSP numbers are finally released.

In Table 1, we examine the information in the Eleventh District Beige Book by regressing various Beige Book indexes against real GSP and against Texas employment growth. In addition to the District summary, we also examine an average of the Eleventh District's five sectoral Beige Book indexes.

The table shows that the Beige Book Eleventh District summary and the average-across-sectors scores (sectoral average) reflect the Texas economy quite well, with large and significant coefficients in both the real GSP and employment regressions.⁶ Although the Beige Book was not scored for its outlook, we find that it also has predictive content for next-quarter real GSP. Again, both the District summary and the sectoral average have large and significant coefficients. The sectoral average explains real GSP slightly better than the District summary does. This suggests that the individual sectoral discussions in the Beige Book contain information not entirely reflected in the Beige Book summary paragraph. Note also that the R^2 s of the next-quarter GSP regressions are about half those of the current GSP regressions, reflecting the difficulty of forecasting one quarter ahead.

We also examine whether the individual Beige Book sectoral summaries have any predictive power in explaining Texas real GSP and employment growth (*Table 1*). We find that the Beige Book descriptions of the manufacturing and mining sectors have predictive content for

Table 1

The Beige Book versus Texas Gross State Product and Texas Employment Growth

Independent variable	Dependent variable								
	Texas Gross State Product					Texas Employment Growth			
	Current quarter Texas real GSP growth			Next quarter Texas real GSP growth		Current month of Texas employment growth			
Model	1	2	3	4	5	6	7	8	9
Constant	1.39 (.84)	1.70 (.81)*	1.26 (.72)	1.86 (.98)	2.15 (.99)	1.98 (.68)**	.77 (.64)	1.00 (.58)	.74 (.56)
Beige Book Eleventh District summary	3.79 (1.01)**			3.16 (1.11)**			3.18 (.76)**		
Simple average of individual sectors		4.45 (1.29)**			3.65 (1.49)**			3.85 (.94)**	
Retail Beige Book Index			.41 (.64)			-.36 (.85)			.93 (.49)
Manufacturing Beige Book Index			3.07 (.91)**			2.69 (1.19)**			1.51 (.66)*
Finance Beige Book Index			.63 (.61)			.05 (.69)			.01 (.45)
Construction Beige Book Index			.14 (.55)			.23 (.74)			.79 (.47)
Mining Beige Book Index			.71 (.36)*			1.24 (.63)*			.69 (.38)*
Sum of individual sector coefficients			4.96 (1.05)**			3.85 (1.11)**			3.94 (.82)**
χ^2 statistic for jointly excluding individual sectors (p-value)			31.4 (.00)			17.7 (.00)			24.0 (.00)
Adjusted R ²	.26	.29	.36	.14	.15	.22	.25	.30	.30
SEE	3.21	3.13	2.97	3.83	3.81	3.67	2.76	2.67	2.67
Ljung–Box Q statistic	91.0 (.00)	108.6 (.00)	66.5 (.00)	113.7 (.00)	131.2 (.00)	65.8 (.00)	32.8 (.20)	34.65 (.15)	66.5 (.00)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

overall Texas economic activity but the Beige Book descriptions of retail, finance, and construction sectors generally do not. The manufacturing and mining indexes are also significant in explaining changes in next-quarter GSP. Nonetheless, the sum of the coefficients of the sectoral summaries is statistically significant, and the coefficients of the sectoral summaries are also jointly significant for both current and next-quarter Texas real GSP. We see a similar pattern for Texas employment growth. The Beige Book mining and manufacturing sectors closely track changes in total employment, but retail, construction, and finance do not. In the employment growth regressions, as with GSP, the sum of coefficients of the five sectoral summaries is statistically significant, and the hypothesis that all five coefficients are equal to zero is strongly rejected.

The fact that the mining and manufacturing sector descriptions generally have predictive content for Eleventh District economic activity may be a function of their coverage in our Beige Book survey. The manufacturing and mining sectors are surveyed heavily, while the retail and finance sectors are not covered as extensively. Moreover, retail, finance, and construction are relatively small sectors compared with mining and manufacturing. The share of manufacturing in GSP has been relatively constant at around 16 percent in the 1980s and 1990s. Although mining is only 7 percent of GSP today, it was 20 percent in the early 1980s. Currently, retail, construction, and finance are 7.2 percent, 4.4 percent, and 2.8 percent, respectively. Another reason some Beige Book sectors don't explain GSP growth could be that these sectors are not in sync with the state's economy in general. For

Table 2
**Texas GSP Regressions with Beige Book Indexes and the
Four Most Recent Months of Texas Employment Growth**

Independent variable	Dependent variable					
	Current quarter Texas real GSP growth			Next quarter Texas real GSP growth		
Model	1	2	3	4	5	6
Constant	1.76 (.61)**	1.86 (.69)**	1.48 (.53)**	2.22 (.94)*	2.43 (.96)**	2.39 (.60)**
Beige Book Eleventh District summary	2.69 (.67)**			1.96 (1.20)		
Simple average of individual sectors		3.58 (1.12)**			2.18 (1.73)	
Retail Beige Book Index			.32 (.63)			-.77 (.81)
Manufacturing Beige Book Index			2.64 (.80)**			2.22 (.88)**
Finance Beige Book Index			-.01 (.57)			-.65 (.66)
Construction Beige Book Index			.16 (.49)			.03 (.62)
Mining Beige Book Index			.77 (.34)*			1.14 (.58)
P-value for jointly excluding individual sectors			.000			.001
P-value for exclusion of the four most recent months of Texas employment growth data	.002	.007	.001	.010	.055	.023
Adjusted R ²	.33	.38	.44	.22	.23	.31
SEE	3.05	2.93	2.78	3.64	3.64	3.44
Ljung–Box Q statistic	90.8 (.00)	108.2 (.00)	58.1 (.00)	121.3 (.00)	139.3 (.00)	56.7 (.00)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

example, previous work by Petersen, Phillips, and Yücel (1994) shows that in the 1980s the construction sector peaked much later than the oil sector or the regional economy in general.

DOES BEIGE BOOK GO BEYOND OTHER ECONOMIC INDICATORS?

We now examine whether the Beige Book summaries contain information not in other real time economic indicators, such as state employment and personal income. To gather these series, we went back to the original statistical releases and compiled the employment growth and personal income data that analysts had available at the time they were reading the Beige Book.

Tables 2 through 4 summarize our findings. Table 2 compares the Beige Book's predictive content with that of the four most recent months of (real-time) Texas employment growth data. As before, we consider the Beige Book summary, the sectoral average, and the five disaggregated sectoral scores. Four lags of employment growth are included as regressors in each model. We find that the Beige Book has predictive content beyond that in the employment growth data. Both the summary and sectoral average variables continue to be highly significant and only slightly smaller in magnitude than in the model without the employment data (*Table 1*). Similarly, in the model with the disaggregated sectors, the Beige Book manufacturing and mining sectors continue to

Table 3
**Texas GSP Regressions with Beige Book Indexes and the
Four Most Recent Quarters of Real Texas Personal Income**

Independent variable	Dependent variable					
	Current quarter Texas real GSP growth			Next quarter Texas real GSP growth		
Model	1	2	3	4	5	6
Constant	1.53 (1.06)	1.85 (1.07)	1.15 (.89)	3.07 (.98)**	3.45 (.99)**	3.16 (.86)**
Beige Book Eleventh District summary	3.63 (.97)**			4.13 (1.04)**		
Simple average of individual sectors		4.30 (1.18)**			4.71 (1.28)	
Retail Beige Book Index			.30 (.63)			-.13 (.76)
Manufacturing Beige Book Index			3.09 (.93)**			2.38 (.91)**
Finance Beige Book Index			.47 (.61)			.84 (.77)
Construction Beige Book Index			.12 (.57)			.50 (.60)
Mining Beige Book Index			.63 (.32)*			1.15 (.58)*
P-value for jointly excluding individual sectors			.000			.002
P-value for exclusion of the four most recent quarters of real personal income growth	.166	.086	.073	.176	.205	.265
Adjusted R ²	.28	.29	.38	.27	.27	.29
SEE	3.16	3.08	2.92	3.57	3.53	3.50
Ljung-Box Q statistic	103.9 (.00)	121.9 (.00)	79.7 (.00)	63.9 (.00)	65.7 (.00)	45.0 (.02)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

be significant, and the sum of coefficients for individual Beige Book sectors is significant. For all three models, the sum of the coefficients of lagged Texas employment is also significant. The hypotheses that the coefficients are zero were rejected both for the lags of employment and for the Beige Book sectoral summaries.

When real-time, real personal income is included rather than total Texas employment, the Beige Book coefficients become larger as real personal income does not add much to the regression. As can be seen in Table 3, the lags of personal income are not significant at the 5 percent level in the Texas GSP equation.

We see a similar pattern in next-quarter GSP results. When the four most recent months of employment growth are added to the model,

both the Beige Book summary and sectoral averages continue to be significant, albeit with slightly smaller coefficients. Again, the Beige Book has predictive content for real GSP data that is not contained in the four most recent months of Texas employment growth data. For the Beige Book sectoral summaries, manufacturing and mining continue to be significant, and retail, finance, and construction remain insignificant.

In Table 4, we examine whether the Beige Book has predictive content for Texas employment growth after taking into account the information of other economic indicators. Again, we find that the Beige Book summaries continue to have predictive content above and beyond the information in past values of (real-time) Texas

Table 4

Texas Employment Growth Regressions with Beige Book Indexes and the Four Most Recent Months of Employment Growth Data

Independent variable	Dependent variable		
	Current month of Texas employment growth		
Model	1	2	3
Constant	1.03 (.53)*	1.12 (.51)*	.94 (.44)
Beige Book Eleventh District summary	2.37 (.61)**		
Simple average of individual sectors		3.15 (.83)**	
Retail Beige Book Index			.80 (.48)
Manufacturing Beige Book Index			1.21 (.59)*
Finance Beige Book Index			-.53 (.38)
Construction Beige Book Index			.79 (.44)
Mining Beige Book Index			.70 (.34)*
Sum of individual sector coefficients			2.96 (.66)**
χ^2 statistic for jointly excluding individual sectors (p-value)			26.7 (.00)
χ^2 statistic for jointly excluding four most recent months of employment growth from regression (p-value)	13.6 (.00)	16.4 (.00)	19.8 (.00)
Adjusted R ²	.28	.33	.35
SEE	2.70	2.60	2.57
Ljung–Box Q statistic	35.0 (.14)	32.46 (.22)	24.4 (.61)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

employment growth. However, past values of employment growth also have predictive content for employment growth. Nonetheless, it appears that the Beige Book has additional predictive content for final Texas employment growth above that in employment data available to analysts at the time of the Beige Book's release.

BEIGE BOOK SECTORAL INDEXES AND SECTORAL ECONOMIC ACTIVITY

Finally, we analyzed whether the sectoral summaries explained movements in sectoral Texas GSP or sectoral employment. We also included the four most recent months of sectoral employment growth data in both the real sectoral GSP and the sectoral employment growth regressions to determine whether the Beige Book sectoral summaries had predictive content over and above the sectoral employment growth data.

Table 5 shows that Beige Book sectoral summaries of the retail, construction, and mining sectors are significant at the 1 percent level, while finance and manufacturing are significant at the 5 percent level. Furthermore, the four most recent months of sectoral employment growth are significant in only the FIRE and mining value-added regressions. When sectoral employment is the dependent variable (*Table 6*), the mining and manufacturing Beige Book indexes continue to explain sectoral employment well, even when lags of sectoral employment are included in the regressions. The lags do not generally have much predictive power for sectoral employment itself; only in the construction and mining regressions are the lags significant. Thus, overall, the Beige Book contains information about Texas economic activity at the sectoral level not completely reflected by past values of employment growth in those sectors.

CONCLUSION

In this study, we analyze how well the Eleventh District Beige Book descriptions of regional economic activity track the Texas economy. We find that both the summary and the average across sectors reflect GSP and employment growth very well. These two measures of the Beige Book also have predictive content for GSP growth one quarter ahead. We also find that the Eleventh District's Beige Book has information for Texas economic activity over and above other state economic indicators, such as Texas employment growth, personal income, or sectoral employment growth. The Beige Book sectoral summaries also have predictive content for total GSP and employment growth. Furthermore, they typically contain information about economic activity in their own sectors not reflected in past values of sectoral employment growth.

We have shown that the Beige Book, although anecdotal in nature, tracks the regional economy well and has predictive content over and above other economic indicators. Because the Beige Book is released at least one month earlier than employment and two years before GSP data, its timeliness makes it a good tool for current regional economic analysis. Alan Blinder (1997) refers to the Fed's use of anecdotal evidence as the "ask your uncle" method of gathering information about the economy. However, this study suggests that the ask your uncle method can provide timely information about economic activity in the region. To paraphrase Nobel Prize-winning economist George Stigler, data are the plural of anecdote.

Table 5

Sectoral Value-Added Regressions with Sectoral Beige Book Indexes and the Four Most Recent Months of Sectoral Employment Growth

Independent variable	Dependent variable: Texas sectoral value-added growth				
	Wholesale and retail	Manu- facturing	FIRE	Construction	Mining
Model	1	2	3	4	5
Constant	1.06 (.77)	.80 (1.59)**	3.50 (1.84)	-.56 (1.42)	-2.50 (2.78)
Retail Beige Book Index	2.95 (1.03)**				
Manufacturing Beige Book Index		5.28 (2.10)*			
Finance Beige Book Index			4.99 (2.25)*		
Construction Beige Book Index				4.54 (1.22)**	
Mining Beige Book Index					9.98 (2.64)**
P-value for exclusion of the four most recent months of Texas sectoral employment growth data	.438	.069	.001	.053	.000
Adjusted R ²	.10	.27	.12	.29	.53
SEE	5.61	9.26	13.24	9.18	17.5
Ljung-Box Q statistic	64.5 (.00)	98.0 (.00)	32.4 (.22)	46.0 (.01)	129.8 (.00)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: FIRE is the acronym for finance, insurance, and real estate. Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

Table 6

Sectoral Employment Growth Regressions with Sectoral Beige Book Indexes and the Four Most Recent Months of Real-Time Sectoral Employment Growth

Independent variable	Dependent variable: Texas sectoral employment growth				
	Wholesale and retail	Manu- facturing	FIRE	Construction	Mining
Model	1	2	3	4	5
Constant	-.48 (.62)	-.40 (.64)	-.14 (.29)	-.45 (1.07)	-.62 (.63)
Retail Beige Book Index	.60 (.55)				
Manufacturing Beige Book Index		1.65 (.76)*			
Finance Beige Book Index			.22 (.31)		
Construction Beige Book Index				1.62 (1.07)	
Mining Beige Book Index					2.50 (.91)**
P-value for exclusion of the four most recent months of real-time Texas sectoral employment growth data	.071	.438	.058	.000	.000
Adjusted R ²	-.04	.04	.00	.15	.47
SEE	6.12	4.55	3.15	7.77	7.37
Ljung-Box Q statistic	6.3 (.99)	15.2 (.97)	28.4 (.39)	45.4 (.01)	27.2 (.45)

* Significant at the 5 percent level.

** Significant at the 1 percent level.

NOTES: FIRE is the acronym for finance, insurance, and real estate. Standard errors in parentheses for the coefficients. Standard errors derived from heteroskedastic, autocorrelation-consistent covariance matrix.

NOTES

- ¹ The apparently conflicting results of Balke and Petersen (1998) and Fetting, Rolnick, and Runkle (1999) are due to the timing difference of the private forecasts used. Fetting, Rolnick, and Runkle compare the quarterly American Statistical Association/National Bureau of Economic Research (ASA/NBER) consensus forecast, which is released at the end of the second month of the quarter, with the Beige Book released earlier in the quarter. Given that the ASA/NBER survey participants are likely to have had access to the Beige Book reports at the time of their survey, it is perhaps not surprising that the Beige Book has no additional explanatory power. When the ASA/NBER surveys are compared with Beige Books released later in the quarter, the Beige Book does contain additional predictive content.
- ² The Eleventh District consists of Texas and parts of Louisiana and New Mexico. However, because Texas accounts for 95 percent of economic activity in the District, the Eleventh District Beige Book only covers Texas.
- ³ Industries surveyed are retail sales; auto sales; agriculture; construction; real estate; legal, accounting, consulting, temporary, finance, and transportation services; petroleum refining; lumber and wood; chemicals; oil field machinery; apparel; electrical and electronic equipment; paper; primary metals; fabricated metals; stone, clay, and glass; food and kindred products; and telecommunications manufacturing.
- ⁴ See Balke and Petersen (1998) for a more detailed discussion of the issues associated with quantifying the Beige Book and with the timing of the quantified Beige Book series.
- ⁵ We deflate nominal sectoral GSP by the Consumer Price Index to correct for inflation. We believe that the overall price level rather than a sector-specific one is the relevant deflator for Beige Book respondents because their main concern is real profits, that is, the buying power of their nominal profits.
- ⁶ We used the “robust errors” option in RATS to compute a heteroskedastic, autocorrelation-consistent covariance matrix. The number of moving average terms was set to four.

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Is There a Persistence Problem?

Part 2: Maybe Not

Evan F. Koenig

Explaining persistence may not be that difficult after all.

If there are labor-market frictions, monetary policy can be expected to have long-lasting real effects even if final-goods prices are completely flexible.

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Empirical studies suggest that monetary policy shocks have real economic effects that continue for many quarters after a policy change is implemented.¹ These persistent real effects have sometimes been attributed to price contracts that are staggered across firms. In principle, staggered price setting can substantially delay the aggregate price level's response to policy shocks even if each individual price is fixed for only a short period. However, this result depends on the assumption that each firm seeks to keep its price close to the prices others charge. Recently, Chari, Kehoe, and McGrattan (2000)—hereafter CKM—have questioned the validity of this assumption. For a wide range of technology and taste specifications, CKM demonstrate that staggered price adjustment speeds up—rather than slows down—the economy's response to policy shocks.

Part 1 in this series of two articles develops the intuition underlying the CKM result (Koenig 1999). It runs as follows: The prices its competitors charge are relevant to the pricing decisions of a profit-maximizing firm only indirectly, through their impact on the firm's unit labor costs. If, say, the money stock has unexpectedly increased, unit labor costs will rise for two reasons. First, since most firms' prices are preset, the policy surprise will lead to an increase in real cash balances that stimulates aggregate sales and, hence, the demand for labor. Second, households, feeling wealthier, will be less inclined to work. For reasonable values of the wage and wealth elasticities of the labor supply, these two forces exert such a strong upward pressure on the market-clearing wage rate that any firm with the chance to adjust its price will increase it more than proportionately to the change in the money stock—not less than proportionately, as required to generate persistence.

This discussion suggests that what occurs in the labor market is critical for determining whether output prices adjust slowly toward long-run equilibrium following a monetary policy shock. If a labor-market friction were to short-circuit the wage increase that accompanies a monetary expansion in the CKM analysis, firms would feel less immediate pressure to raise their prices and monetary policy might have longer lasting effects on the real economy. This article uses a simple model to illustrate that labor-market frictions are, indeed, a potentially important part of the solution to the persistence problem.

The model economy developed here can be interpreted in two ways. Under one inter-

pretation, hours of labor supplied by different households (or groups of households) are imperfect substitutes in production. This imperfect substitutability gives workers a measure of monopoly power. Each worker (or worker group) acts as a wage setter, announcing a time path for the wage at which he is willing to supply labor.² This path is periodically revised to reflect new information on demand and supply conditions. The timing of the wage revisions is staggered across workers. Essentially, the staggered price setting of Part 1 is replaced by staggered wage setting.

An alternative interpretation of the model is that each household acts as an independent intermediate-goods producer. The intermediate goods different households produce are imperfect substitutes for one another. Price adjustment in the intermediate-goods market is staggered. Under this interpretation of the model, the key difference from the previous analysis is that intermediate-goods producers do not compete with one another for labor.³

Under either interpretation, the model captures important aspects of reality. Wage rates are commonly specified well in advance—by as much as three years in union labor contracts.⁴ At the same time, transportation costs, imperfect information, and workers' investments in firm-specific skills limit employee mobility.

The article's bottom line is that explaining persistence may not be that difficult after all. Indeed, if there are labor-market frictions, monetary policy can reasonably be expected to have long-lasting real effects even if final-goods prices are completely flexible.⁵ If final-goods prices are set in overlapping contracts, persistence is further enhanced.

THE MODEL ECONOMY

This section describes a simple, log-linear economy with labor-market frictions. I arbitrarily emphasize the sticky-wage interpretation of the model rather than the immobile-labor interpretation. As in Part 1 of this series, several simplifying assumptions are convenient. For example, I ignore capital investment. Labor contracts specify a path for the nominal wage rather than a fixed wage level.⁶ Also, most of the analysis is limited to the case in which output prices are completely flexible.⁷

Household Decisionmaking

As in my earlier analysis, I assume that a typical household—call it household i —has a utility function of the form

$$(1) \quad U(C_i, L_i) = (C_i^{1-\sigma} - 1)/(1 - \sigma) - L_i^{1+1/\xi}/(1 + 1/\xi)$$

each period, where C_i and L_i are the levels of output consumed and labor supplied, respectively, and where σ and ξ are positive constants. The first of these parameters is the inverse of the elasticity of intertemporal substitution, which measures households' willingness to shift consumption over time. The second parameter would be the wage elasticity of the labor supply if the labor market were competitive. Realistically, $\sigma \geq 1/2$ and $\xi < 1$.⁸

A wage-taking, utility-maximizing household would supply labor up to the point where the marginal rate of substitution between leisure and consumption equals the real wage: $-U_L/U_C = W/P$. However, I assume each household faces a downward-sloping demand curve for its labor:

$$(2) \quad I_i = I - (w_i - w)/(1 - E),$$

where I and w are the (logarithms of the) average aggregate employment level and money wage, respectively, w_i is the (logarithm of the) wage charged by household i , and $0 < E < 1$ is a parameter that is an inverse measure of the household's monopoly power.⁹ (Throughout this article, lowercase characters denote logarithms of the corresponding uppercase variables.) Confronting a labor demand schedule like that in Equation 2, household i will want to be paid a premium over the competitive wage. In particular, taking I and w as given, household i will want to charge a wage rate that satisfies the equation

$$(3) \quad W_i/P = -(U_L/U_C)/E.$$

Taking logarithms,

$$(3') \quad w_i - p = (1/\xi)I_i + \sigma c_i - \epsilon,$$

where $\epsilon \equiv \ln(E)$. The desired wage exceeds the competitive wage to the extent that E is less than 1.

My objective is to see whether staggered wage setting can help explain the persistent real effects of monetary policy. Accordingly, I assume each household must specify in advance a path for its wage rate. The length of time for which the wage path is preset is the same for every household, but the timing of their decisions differs. As a practical matter, to assume that households prespecify their wages means Equations 3 and 3' will not hold for every household at every instant. However, whenever it has a chance to reset its wage path, household i will choose a path that it *expects* will satisfy Equations 3 and 3' at each point in

the future. Firms decide how much of household i 's labor is hired at the specified wage. Households will be content to cede short-run control of hours to firms as long as the real wage continues to exceed the marginal rate of substitution between leisure and consumption.¹⁰

As in Part 1, I assume households' desired money balances are determined by their consumption expenditures:

$$(4) \quad m_i - p = c_i.$$

It greatly simplifies the analysis to assume households are able to fully insure consumption against idiosyncratic differences in the timing of wage decisions. In other words, it is convenient to assume all households end up with the same level of consumption and, hence, the same level of real money balances, regardless of when they are able to reset their wage paths. Accordingly, I henceforth drop the subscripts from c and m in Equations 3' and 4.

Firm Decisionmaking

Firms use the labor of a cross section of households to produce output, which is then sold back to households. I use the same, simple, linear production technology as in Part 1:

$$(5) \quad y_f = l_f,$$

where y_f is the amount of output firm f produces using l_f units of labor. It follows that the firm's marginal cost schedule is horizontal and that its height equals the prevailing average wage rate, w .

In general, the products of different firms are imperfect substitutes, so that each firm has some monopoly power in the output market. In particular, I assume the demand for firm f 's output is given by

$$(6) \quad y_f = y - (p_f - p)/(1 - \Theta),$$

where y and p are the average aggregate output level and price level, respectively, p_f is the price charged by firm f , and $0 < \Theta < 1$. Equation 6 says the higher firm f 's price is relative to the economywide average, the lower the firm's sales will be relative to economywide-average sales.¹¹ Perfect competition is obtained in the limit as $\Theta \rightarrow 1$. The firm is assumed to be small enough that it takes y and p as given. It follows that the firm's marginal revenue is $p_f + \theta$, where $\theta \equiv \ln(\Theta) < 0$.

Profit is maximized when marginal revenue equals marginal cost:

$$(7) \quad p_f = w - \theta.$$

In contrast to CKM (and my earlier article), out-

put prices are perfectly flexible, so that Equation 7 holds at every instant for every firm. (This assumption is relaxed in the box that accompanies this article.) If the price level responds sluggishly to monetary policy shocks, it is only because the average aggregate wage responds sluggishly to such shocks.

Short-Run and Long-Run Equilibrium Conditions

For notational convenience, I assume there is one household per firm. Then y denotes both the output each firm produces and average household income. The variable l denotes both the amount of labor each firm hires and the average amount of labor each household supplies. At every instant, $l = y = c = m - p$, where (recall) the variables c and m are the amounts of output consumed by and money held by each household, respectively. It follows that if we can determine how the price level moves over time in response to a monetary policy shock, we will also know how employment, output, and consumption move over time. Monetary policy shocks have persistent real effects only to the extent that the price level reacts sluggishly to changes in the money supply.

Once every household has adjusted its wage path in response to a policy shock, all households will charge the same wage and work the same number of hours. If we use an asterisk to denote the value each endogenous variable takes on in this long-run, market-clearing equilibrium,

$$(8) \quad y^* = c^* = l^* = (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

$$(9) \quad w^* = m + \theta - (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

and

$$(10) \quad p^* = m - (\theta + \epsilon)\xi/(1 + \sigma\xi).$$

Money is neutral in the long run. An increase in the money stock eventually drives up the nominal wage and the price level and leaves real variables unchanged.

SHORT-RUN WAGE AND PRICE ADJUSTMENT

Equation 7 implies that the average wage and the price level always move together. Thus, whether the price level reacts sluggishly to policy shocks is determined by how the average wage moves over time in response to unexpected changes in the stock of money. How the average wage moves over time is, in turn, determined by how aggressively households that are able to adjust their wages do so. Do these households have an incentive to keep their

Table 1
Overshooting Unlikely with Overlapping Wage Contracts

Possible values of the overshooting parameter in an economy with flexible prices and overlapping wage contracts (ω') and in an otherwise identical economy with flexible wages and overlapping price contracts (ω).

A. The case in which $\sigma = 1$.

	ω	ω'				
		$E = .99$	$E = .95$	$E = .90$	$E = .85$	$E = .80$
$\xi = 1/5$	6	.01	.06	.12	.17	.23
$\xi = 1/4$	5	.01	.06	.12	.18	.24
$\xi = 1/3$	4	.01	.07	.13	.19	.25
$\xi = 1/2$	3	.01	.07	.14	.21	.27

B. The case in which $\sigma = 2$.

	ω	ω'				
		$E = .99$	$E = .95$	$E = .90$	$E = .85$	$E = .80$
$\xi = 1/5$	7	.01	.07	.14	.20	.27
$\xi = 1/4$	6	.01	.07	.15	.22	.29
$\xi = 1/3$	5	.02	.08	.16	.24	.31
$\xi = 1/2$	4	.02	.10	.19	.28	.36

wages close to the average wage? If so, the average wage will move slowly toward its market-clearing level and policy shocks will have long-lasting real effects.

An Individual Household's Wage Demands

Consider a household (i) that is updating its wage demands in response to the latest economic data. Using Equation 2 to eliminate I_i from Equation 3', and using the fact that $I = c = m - p$:

$$(11) \quad w_i = w + \alpha[(1/\xi + \sigma)(m - p) - (\theta + \epsilon)],$$

where $\alpha \equiv \xi(1 - E)/[1 + \xi(1 - E)] < 1$. This equation becomes

$$(11') \quad 0 = \alpha[(1/\xi + \sigma)(m - p^*) - (\theta + \epsilon)]$$

in long-run, market-clearing equilibrium. By subtracting Equation 11' from Equation 11, we obtain

$$(12) \quad w_i = w + \alpha(1/\xi + \sigma)(p^* - p),$$

or (recalling that Equation 7 holds for every firm at every instant)

$$(12') \quad w_i = w + \alpha(1/\xi + \sigma)(w^* - w).$$

Equation 12' is the key formula relating the wage demands of household i to the current average wage and the market-clearing wage. If $\alpha(1/\xi + \sigma) < 1$, households with a chance to respond to a policy shock choose a wage part-way between the market-clearing wage and the average wage; they don't want their wages to move too far from the wages others charge. If, on the other hand, $\alpha(1/\xi + \sigma) > 1$, households with a chance to respond to a policy shock pick

a wage that *exceeds* the market-clearing wage rate. Below, I refer to $\omega' \equiv \alpha(1/\xi + \sigma)$ as the overshooting parameter for an economy with staggered wage contracts.

A Comparison with Price Adjustment in the CKM Model

In the simple version of the CKM model developed in Part 1 of this series, price adjustment is governed by an equation very similar to the wage-adjustment equation derived above. In particular,

$$(13) \quad p_t = p + (1/\xi + \sigma)(p^* - p),$$

where p_t is the price chosen by a firm able to respond to the policy shock, p^* is the market-clearing price level, and p is the average current price level. The key difference between Equations 12' and 13 is the α parameter, which appears in the former equation but is absent from the latter. This parameter acts unambiguously to make wage (and hence, price) adjustment in the staggered-wage-contract model slower than price adjustment in the CKM staggered-price-contract model. In the staggered-price economy, the overshooting parameter is $\omega \equiv 1/\xi + \sigma$. In the staggered-wage economy, the overshooting parameter is $\omega' = \alpha\omega < \omega$.

Is the contribution of staggered wage setting to persistence likely to be quantitatively significant? Table 1 compares the values of ω and ω' implied by a range of reasonable values for the inverse of the elasticity of intertemporal substitution (σ), the wage elasticity of the labor supply (ξ), and the ratio of the competitive to the monopolistically competitive wage (E).¹² The table suggests that ω can reasonably be expected to fall somewhere between 3 (when $\sigma = 1$ and $\xi = 1/2$) and 7 (when $\sigma = 2$ and $\xi = 1/5$). (Note that the competitiveness of the labor market is irrelevant for ω .) In any event, the overshooting parameter in an economy with flexible wages and overlapping price contracts is well above 1—a result consistent with CKM. In sharp contrast, the overshooting parameter in an economy with flexible prices and overlapping wage contracts ranges from a low of 0.01 (when the labor supply is highly inelastic and the labor market is nearly competitive) to a high of only about 1/3 (when $\xi = 1/2$ and $E = .8$). In other words, the overshooting parameter is at least an order of magnitude smaller in an economy with staggered wage setting than it is in an economy with staggered price setting. If workers don't have much bargaining leverage, it may well be several orders of magnitude smaller. The implication is that staggered wage

contracts are far more likely to generate persistence than are staggered price contracts of the same length.

Tracking the Economy Over Time

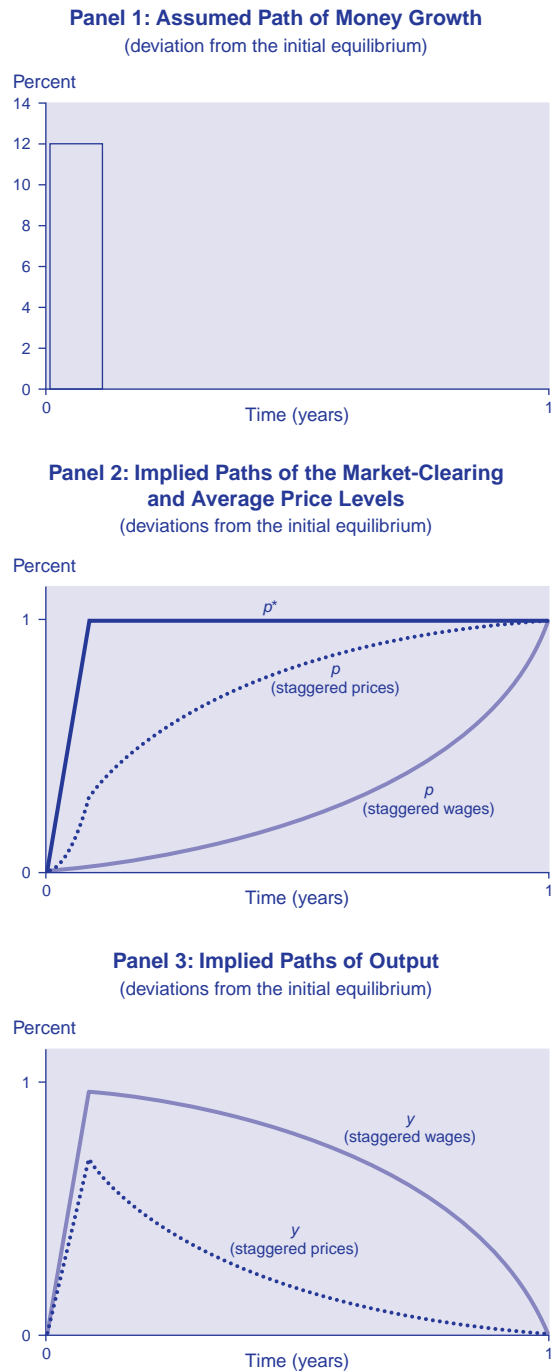
In this section, I use a series of figures to illustrate the impact labor-market imperfections can have on the economy's response to a monetary policy shock. (For a more general treatment, see the box entitled "The Short-Run Dynamics of an Economy with Labor-Market Frictions.") These figures assume that $\omega' = .25$ —an overshooting parameter that is toward the upper end of the range in Table 1 and that, accordingly, may understate persistence. For comparison, the figures also show the policy responses of an economy with flexible wages and overlapping price contracts. For this economy, I assume $\omega = 4.5$ —the same value my earlier article uses and near the middle of the range in Table 1.

The policy shock I consider is a surprise, temporary increase in the money growth rate that permanently raises the level of the money stock 1 percent above what the public had expected. I arbitrarily assume the money-growth surge lasts one-twelfth as long as contracts do. So if contracts specify the wage path for a year at a time, money growth remains elevated for only one month.¹³ (See Panel 1 of Figure 1.) The market-clearing price, p^* , rises with the money stock, reaching a new, permanently higher level in one month (Panel 2).

Panels 2 and 3 show the paths of the average price level and rate of production in the economy with overlapping wage contracts (assuming $\omega' = .25$) and the economy with overlapping price contracts (assuming $\omega = 4.5$). Clearly, price and output adjustment take substantially longer in the staggered-wage economy than in the staggered-price economy. (As the box discusses, price and output adjustment are even further delayed if staggered wage and staggered price setting are combined.) With staggered wages, it takes 9.6 months for the price level to move halfway to its long-run, market-clearing level, compared with 2.2 months with staggered prices.¹⁴ Similarly, the output response is larger and longer lasting in the staggered wage economy than in the staggered-price economy. These results are consistent with the view that persistent real monetary policy effects are much easier to obtain in an economy with labor-market imperfections than in an economy without such imperfections.

It is important to note that the differences between the staggered-price and staggered-

Figure 1
Response to a Monetary Policy Shock



wage economies seen in Figure 1 are not due to any difference in contract length between the two economies: in both, contract length is one year. Price adjustment and output adjustment are slower in the staggered-wage economy than in the staggered-price economy solely because households' incentive to keep their wages close to the average wage in the former economy is stronger than firms' incentive to keep their prices close to the average price in the latter

The Short-Run Dynamics of an Economy with Labor-Market Frictions

Consider an economy that is initially in long-run, market-clearing equilibrium, with (for notational convenience) a constant money stock. Suddenly, at $t = 0$, a change in the money stock's path is announced. The announcement is a complete surprise but fully credible. Without any loss of generality, we can define the unit time interval to equal the length of a labor contract. Then, by $t = 1$ every household will have had a chance to reset its wage path, and the economy will be back in market-clearing equilibrium. This box derives the formulas that govern the behavior of output, wages, and the price level over the interval from $t = 0$ to $t = 1$. I begin with the case in which final-goods prices are completely flexible, then briefly discuss how the analysis would differ in an economy with overlapping price contracts.

Flexible Final-Goods Prices. The basic building blocks for the analysis are the equations

$$(B.1) \quad w^*(t) = m(t) + \theta - (\theta + \epsilon)\xi/(1 + \sigma\xi),$$

$$(B.2) \quad w_i(t) = w(t) + \omega'[w^*(t) - w(t)],$$

and

$$(B.3) \quad w(t) = tw_i(t) + (1 - t)w(0).$$

Equation B.1 gives the market-clearing wage as a function of the current money stock. It restates Equation 9 from the main text. Similarly, Equation B.2 is a restatement of Equation 12'. It gives the wage rate that will be chosen at time t by any household that has had a chance to react to the new monetary policy. Finally, Equation B.3 is a formula for the average wage that follows from the assumption that wage adjustment is evenly staggered over the unit interval. At any given time t , $0 < t < 1$, the fraction t of households will have had a chance to reset their wage paths and will be charging $w_i(t)$. The fraction $1 - t$ of households will be charging the wage that prevailed in the initial market-clearing equilibrium, $w(0)$.¹

Together, Equations B.2 and B.3 imply that

$$(B.4) \quad w(t) = w(0) + \left[\frac{\omega't}{\omega't + (1-t)} \right] [w^*(t) - w(0)].$$

Since every firm sets its price as a markup over the average wage (compare Equation 7), we also have

$$(B.5) \quad p(t) = p(0) + \left[\frac{\omega't}{\omega't + (1-t)} \right] [p^*(t) - p(0)],$$

where the market-clearing price level is proportional to the current money stock (Equation 10). This equation is the same as that governing price adjustment in an economy with staggered price setting, except ω' has replaced ω . (Compare Equation B.5, above, with Equation B.4 in Part 1 of this series.) Price adjustment is one-half complete when $\omega't/[\omega't + (1-t)] = 1/2$, or $t = 1/(1 + \omega')$. So the smaller the overshooting parameter, ω' , the slower the aggregate price adjustment.

Recall that our units of measurement are chosen so that average employment and output both equal real money balances at every instant: $l(t) = y(t) = m(t) - p(t)$. Using Equations 10 and B.5, it follows that

$$(B.6) \quad l(t) = y(t) = m(t) - p(t) = [m(0) - p(0)] + \left[\frac{1-t}{\omega't + (1-t)} \right] [m(t) - m(0)].$$

Equations B.5 and B.6 are the basis for Panels 2 and 3 of Figure 1 in the main text.

Staggered Final-Goods Prices. Staggered price setting adds to persistence when present in an economy with labor-market frictions. It also causes the real wage to vary procyclically. I illustrate these facts in the special case where price contracts have the same length as wage contracts.

When there are staggered final-goods price contracts, Equation 7 applies only to firms that have had a chance to reset their price paths following the monetary shock. While Equation 12 remains valid, Equation 12', in general, does not. Hence, we must go back a step and replace Equation B.2 with

$$(B.7) \quad p_i(t) = w(t) - \theta$$

and

$$(B.8) \quad w_i(t) = w(t) + \omega'[p^*(t) - p(t)],$$

which are simply restatements of Equations 7 and 12, respectively, in the main text. While previously we had $p(t) = p_i(t)$, now

$$(B.9) \quad p(t) = tp_i(t) + (1 - t)p(0).$$

Equation B.9 governs the evolution of the average price level in much the same way that Equation B.3 governs the evolution of the average wage.²

Equations B.3 and B.7–B.9 can be solved for the paths of the wage rate and price level:

$$(B.10) \quad w(t) = w(0) + \left[\frac{\omega't}{\omega't^2 + (1-t)} \right] [w^*(t) - w(0)];$$

$$(B.11) \quad p(t) = p(0) + \left[\frac{\omega't^2}{\omega't^2 + (1-t)} \right] [p^*(t) - p(0)].$$

From Equations 9 and 10, $w(0) - p(0) = w^*(t) - p^*(t) = \theta$. Hence, subtracting B.11 from B.10,

$$(B.12) \quad w(t) - p(t) = \theta + \left[\frac{\omega't(1-t)}{\omega't^2 + (1-t)} \right] [m(t) - m(0)].$$

It follows that the real wage is procyclical to the extent that the business cycle is driven by monetary policy shocks.

Straightforward algebraic manipulations establish that

$$(B.13) \quad l(t) = y(t) = m(t) - p(t) = [m(0) - p(0)] + \left[\frac{1-t}{\omega't^2 + (1-t)} \right] [m(t) - m(0)].$$

Since $t^2 < t$ for $0 < t < 1$, output and employment are more sensitive to monetary shocks in this economy than they are in an economy with flexible final-goods prices. (Compare Equations B.6 and B.13.)

What of persistence? According to Equation B.11, price adjustment is half completed when $\omega't^2 = 1 - t$ in the economy examined here. With flexible final-goods prices, the corresponding condition is $\omega't = 1 - t$. The left-hand side of each of these equations is an increasing function of t , but since $t^2 < t$ for $0 < t < 1$, it takes a larger t to satisfy the first equation than the second. In other words, monetary shocks have more persistent real effects in an economy where both wages and prices are preset in overlapping contracts than in an otherwise identical economy in which only wages are preset.

NOTES

¹ Equation B.3 is an approximation of the exact formula, which can be found using the definition of W given in Note 9 to the main text:

$$w(t) = [(E - 1)/E] \ln\{t \exp[w_i(t)E/(E - 1)] + (1 - t) \exp[w(0)E/(E - 1)]\}.$$

The approximation will be good as long as $w_i(t)$ is not too different from $w(0)$.

² Like Equation B.3, Equation B.9 is a log-linear approximation.

economy. The staggered-wage economy would generate even more persistence than is displayed in Figure 1 if our analysis recognized that some real-world labor contracts are renegotiated only once every three years.¹⁵

SUMMARY AND CONCLUSION

If the labor market is frictionless—if wages are flexible and workers can move freely from one employer to another—it is difficult to understand how monetary policy changes can have long-lasting effects on output and employment. The problem is that any policy that stimulates real activity will also drive the wage rate sharply higher in such an economy. This higher wage rate gives firms that are free to adjust their prices a powerful incentive to raise them. Consequently, for realistic contract lengths the average price level moves quickly toward its market-clearing level, and the stimulus to aggregate output and employment is short-lived.

Staggered wage contracts are a possible solution to this persistence problem. Workers—fearful of pricing themselves out of the market—will not press their wage demands aggressively in response to stimulatory monetary policy. Consequently, the average wage level adjusts slowly. Since cost pressures are muted, firms feel little need to raise their prices and the stimulus to aggregate output and employment persists. This argument applies even if final-goods prices are completely flexible. (If they are sticky, persistence is further enhanced.)

Labor immobility across employers is another possible explanation for persistence. With immobile labor, the wage a firm must pay is tied as much to its own labor demand as to the economywide employment level.¹⁶ A firm that is able to raise its price relative to others' following monetary stimulus will find that its marginal labor costs tend to decline along with the demand for its output. Consequently, a smaller price increase is chosen than would be optimal in an otherwise identical economy with mobile labor. Since firms with an opportunity to adjust their prices choose to stay fairly close to the average price, the average price moves slowly and output and employment effects persist.

The results this article reports suggest that labor-market frictions are potentially significant quantitatively as well as qualitatively. A key parameter that measures the speed with which the price level moves toward its market-clearing level is likely between one and three orders of magnitude smaller in an economy with labor-

market frictions than in a similar economy with staggered price setting, flexible wages, and mobile labor. The effect is to increase the amount of time required for the price level to complete half its adjustment by a factor of four or more.

NOTES

- ¹ For example, see Leeper, Sims, and Zha (1996). The evidence is not definitive. There is always a danger that such studies attribute to monetary policy real fluctuations that are, in fact, caused by unobserved changes in tastes and technology to which policymakers are reacting—a point Sims (1992) emphasizes.
- ² Blanchard and Kiyotaki (1987) develop the basic framework. An alternative approach would be to model the bargaining that takes place between workers and their employers. For an example, see Benabou and Bismut (1988).
- ³ Gust (1997) and Ascari (2000) take this approach.
- ⁴ See Taylor (1983) for a detailed look at the length of union labor contracts and the timing of negotiations. Even in the nonunion sector, evidence suggests that wage rates are typically prespecified for a year or more. For a nice summary of the empirical evidence, see Taylor (1999).
- ⁵ See Koenig (1997) and Andersen (1998) for early developments of this argument. Ascari (2000) reaches a superficially different conclusion with regard to persistence. He is interested in whether labor-market imperfections similar to those examined here are able to generate a near-random walk in output in response to monetary policy shocks—a very high degree of persistence indeed. A near-random walk in response to money shocks is required only if one wants to claim that changes in the money stock are the *principal* source of output variation in the economy. These days, few economists would take so extreme a position.
- ⁶ Hence, the analysis presented here is more closely related to that of Fischer (1977) than to that of Taylor (1980).
- ⁷ If anything, relaxing these assumptions would make it easier to obtain persistent real monetary effects. For example, it is well known that when contracts specify a wage path, real monetary effects cannot last longer than the longest contract, whereas when contracts specify a fixed wage, policy shocks are propagated beyond the longest contract (Taylor 1980). Similarly, Erceg's (1997) analysis suggests that making investment endogenous contributes to persistence, provided the demand for money is linked to consumption rather than to income. That moving from a world of sticky wages and flexible prices to a world of sticky wages and prices tends to add to persistence is discussed in the box that accompanies this article.
- ⁸ Empirical estimates Pencavel (1986) reviews suggest $\xi \approx .25$. It is often assumed utility is logarithmic in

consumption ($\sigma = 1$)—an approximation consistent with estimates Beaudry and van Wincoop (1996) obtain. On the other hand, Attanasio and Weber (1994) and Ogaki and Reinhart (1998) report $\sigma \approx 2$.

⁹ A labor demand curve of this form is consistent with profit maximization by firms if the labor variable that enters firm f 's production function is a composite of the labor different households supply. In particular, if there is a continuum of households indexed by $i \in [0, 1]$, Equation 2 is obtained if

$$L_f = (\int L_{fi}^E di)^{1/E}$$

and

$$W \equiv (\int W_i^{E/(E-1)} di)^{(E-1)/E},$$

where L_{fi} is the amount of household i 's labor used by firm f (Blanchard and Kiyotaki 1987).

¹⁰ Erceg (1997) takes another approach. In his analysis, monetary policy is non-neutral because of staggered price contracts, as in CKM. Labor contracts preset wages—short-circuiting the rise in unit labor costs that is responsible for rapid price adjustment in CKM—but hours of employment vary as if wages were perfectly flexible.

¹¹ A demand curve of this form is consistent with household utility maximization if the output variable, C_i , that enters household i 's utility function is a composite of the goods different firms produce. In particular, if there is a continuum of firms indexed by $f \in [0, 1]$, Equation 6 is obtained if

$$C_i = (\int C_{fi}^\theta df)^{1/\theta}$$

and

$$P \equiv (\int P_f^{\theta/(\theta-1)} df)^{(\theta-1)/\theta},$$

where C_{fi} is the amount of firm f 's output consumed by household i .

¹² As Note 8 mentions, recent studies suggest $\sigma = 1$ or 2 and $\xi \approx .25$. Unfortunately, empirical evidence concerning E is almost nonexistent. Studies that examine the substitutability of one type of labor for another usually divide workers into only a few broad classes, such as skilled and unskilled. In the present context, however, the relevant elasticity of substitution [$1/(1 - E)$] is that between the labor supplied by different individual bargaining units. One would expect this elasticity to be much greater than that between skilled laborers as a group and unskilled laborers as a group. A high elasticity of substitution means a low monopoly wage premium (a value of E close to 1).

¹³ While three-year contracts are typical in unionized industries, currently only about 10 percent of workers are union members. Moreover, CKM examine one-year price contracts and it seems desirable to compare like with like. The reader is free to reinterpret the unit time interval.

¹⁴ When both wage adjustment and price adjustment are staggered, 9.9 months are required for the average

price level to adjust halfway toward its new market-clearing level.

¹⁵ To generate a realistically persistent economic response to monetary shocks, it is sufficient that only a small fraction of labor contracts be renegotiated infrequently (Koenig 1997).

¹⁶ Recall that I assume households are able to insure their consumption against idiosyncratic shocks. Consequently, a higher average level of economic activity raises everyone's standard of living and, through the resultant wealth effect, tends to lower everyone's willingness to work.

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Reliance, Composition, and Inflation

Joydeep Bhattacharya and Joseph H. Haslag

This article explores the effect of fiscal policy actions on long-run prices and the inflation rate.

To pay for their spending, governments use one or more of the following: taxes, sale of debt to the public, and money creation. Taxes and debt issuance are typically under the purview of the treasury (the government's fiscal side), and money creation is under the control of the central bank (the government's monetary side). This split seems natural since most central banks are required to maintain price stability and, hence, ought to have complete control over the money supply. In recent years, however, based on the work of Christ (1968) and Sargent and Wallace (1981), economists have noted that a single, forward-looking budget constraint unifies these two government branches. As a direct consequence of this constraint, every fiscal action potentially has a monetary component to it, and vice versa. As such, it becomes hard to pinpoint whether the central bank really has complete control over money creation or whether it is passively creating money at the treasury's beck and call. If the latter is true, the central bank is severely constrained in performing its task of maintaining price stability. Or is it? This article presents a model in which the central bank retains substantial control over the inflation rate despite being subservient to the treasury in a very precise sense.

We consider a situation in which the government explicitly relies on the central bank to meet a portion of the government's revenue needs. More precisely, our measure of this reliance captures the extent to which the central bank is required to raise revenue from money creation (seigniorage) to pay for the interest expenses on the debt floated by the treasury. Greater reliance implies that seigniorage accounts for a larger fraction of the treasury's revenue requirements brought on by its outstanding interest obligations. This notion of reliance stems from the idea of "economic independence" as described by Grilli, Masciandaro, and Tabellini (1991), Alesina and Summers (1993), and Capie et al. (1994). Capie et al., for instance, differentiate between goal independence and instrument independence. Goal independence exists when the central bank can choose *what* it wants monetary policy to accomplish without regard to the treasury's or other policymakers' desires.¹ Instrument independence is present when the central bank can choose *how* to use the instrument of monetary policy without regard to the treasury's wishes.²

In contrast, our measure of reliance has little connection with the idea of goal independence. Interestingly, as Grilli, Masciandaro, and Tabellini (1991) point out, goal independence and instrument independence are not always positively correlated.³

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In this article, the central bank is (possibly) goal independent although it is not instrument independent because it has to raise a certain amount of revenue for the government. As such, it is constrained in its choice of, say, the money growth rate. It does, however, have control over the composition of government liabilities, namely debt versus money. Our question, then, is: Does the control over the composition of government “paper” translate into control over the inflation rate even when the central bank is not instrument independent in the sense of Capie et al. (1994)?

To get a sense of some of the issues involved, consider the case of a government that floats some debt on the market to, partly, finance its expenditures. The government must credibly demonstrate the presence of enough funds to cover the principal and interest payments on all debt held by the public. Using the government’s long-run budget constraint, it is possible to show that having a current outstanding debt requires the government to run surpluses in the future. These surpluses may be generated by cutting expenditures, implementing taxes, or altering the revenue from money creation, or seigniorage.⁴

We are particularly interested in seigniorage. The central bank may print money to pay for the treasury’s interest expenses or exchange new money for existing government bonds. In the case of an open market purchase, in which the central bank buys government bonds and gives money to the public, the stock of money in the economy goes up but the interest expense of the debt goes down. Because money does not pay interest, future taxes may go down. This may reduce the government’s revenue needs, such that the central bank has more control over the inflation rate. Thus, the central bank, even though it is not independent, can, via open market operations, control the composition of government paper, thereby affecting the government’s *de facto* reliance on seigniorage (and indirectly the inflation rate).

This article illustrates some of these basic ideas within the context of a well-specified general equilibrium model in the tradition of Sidrauski (1967). In our model, a large number of infinitely lived households with 20/20 foresight derive utility from the consumption of a single nonproduced perishable good and from liquidity services (money). The government sells bonds and prints money to cover its interest obligations on these bonds. The central bank is not economically independent; in fact, the government explicitly relies on the central

bank to raise a fraction of its interest expenses on outstanding debt (henceforth the reliance parameter).

First, we analyze the long-run relationship between this reliance parameter and the price level, the inflation rate, and the nominal interest rate. In other words, we attempt to answer the question: Do countries that rely heavily on seigniorage endure higher long-run inflation rates in comparison with countries with less seigniorage? Second, we examine the relationship between the composition of government paper—bonds versus money—and the effects on the price level, the inflation rate, and the nominal interest rate. This inquiry may be of topical interest in that more and more governments are realizing primary surpluses and paying off some outstanding debt. Insofar as these surpluses translate into permanent changes in the composition of government paper, we ask how such a change would affect the long-run values of these economic variables.

The two main results are easily summarized. First, we show that the price level is positively related to the stock of government debt as long as the government relies on the central bank to raise some revenue. This reliance requires the central bank to monetize some of the outstanding debt. Consequently, the treasury’s debt decisions affect the price level. In short, the price level has a “fiscal” aspect. Viewed another way, the effective stock of money in the economy consists of the actual quantity of money and the fraction of bonds backed by money.

Second, we derive the impact of permanent changes in both the reliance and the composition parameters on the long-run inflation rate. We show that the inflation is positively related to the government’s reliance on seigniorage and is inversely related to the composition of government paper. When the latter shifts toward money, government debt falls, implying that the government’s expenses are smaller. Hence, less seigniorage is required.

The chief policy lesson is that an economically dependent central bank, via its ability to control the composition of government paper, may be quite successful in controlling the inflation rate.⁵

We begin by laying out the details of the model economy.

THE MODEL ECONOMY

The economy is populated by a large number of dynastic (infinitely lived) households. Time is discrete and is indexed by $t = 1$,

2, 3.... There is a single, perishable consumption good. At each date $t \geq 1$, a household receives a fixed endowment of y units of the single consumption good; it does not have to exert any effort to produce or receive this good.

Households may hold their wealth two ways: government bonds and fiat money. Both assets are nominally denominated (in, say, dollars). Government bonds mature one period after they are issued. If the household pays \$1 for a unit of government debt at date t , it receives $\$I$ at date $t + 1$. In contrast, no interest is paid on money. At date $t = 1$, each household is endowed with $\$B_0$ and $\$M_0$.

At the start of any period, a representative household's wealth comprises three entities: the proceeds from the sale of its endowment of y goods, its money holdings from the previous period (whose value, as we will see, may have gone up or down depending on inflation), and the interest (plus principal) payments on its bond holdings from the previous period. The household may use this wealth to provide for its consumption during that period, buy new bonds and money, and pay a lump-sum tax to the government.

The household's budget constraint, therefore, is

$$(1) \quad p_t y + M_{t-1} + I_{t-1} B_{t-1} = p_t c_t + M_t + B_t + p_t \tau_t,$$

where p is the price level measuring the number of dollars traded for one unit of the consumption good, M is the quantity of money, B is the quantity of government bonds, τ is the lump-sum tax, and c is consumption. Equation 1 stipulates that the dollar value of the household's after-tax resources must equal the dollar value of its expenditures, including savings.

It is possible, and instructive, to convert the household's budget constraint (written in dollar terms in Equation 1) to its goods value. To do this, let

$$\begin{aligned} 1 + \pi_t &= \frac{p_t}{p_{t-1}} \quad \text{and} \quad R_{t-1} = 1 + r_{t-1} \\ &= \frac{I_{t-1}}{1 + \pi_t} = \frac{1 + i_{t-1}}{1 + \pi_t}. \end{aligned}$$

Here, π stands for the rate of change in the price level over time, or the inflation rate; i is the net nominal interest rate; r is the net real interest rate; and R is the gross real interest rate (principal plus interest). Divide both sides of Equation 1 by p_t to obtain

$$(2) \quad y + (1 + r_{t-1})b_{t-1} + \frac{m_{t-1}}{1 + \pi_t} - \tau_t = c_t + m_t + b_t,$$

where m denotes the real value of money balances and b the real value of government bonds. Equation 2 states the household's budget constraint—both sources of income and expenditures—measured in units of the consumption good. Note that b can be either positive or negative. With $b > 0$, the government is borrowing from the household. With $b < 0$, the government is loaning resources to households.

The left side of Equation 2 represents the resources the household has available to spend at date t . Given these resources, how much consumption can this household afford at the market price? How much money and bonds *should* it hold? We now turn to a determination of the household's demand for consumption, money, and bonds. We study an equilibrium in which the demands for all three are positive. A problem we face in this environment is that money is dominated in rate of return by government bonds, and, hence, households will not hold money unless we build into the model some rationale for money to be demanded.

Possibly the simplest way to achieve our purpose is to assume the household has preferences defined over the consumption good *and* real money balances. In other words, households value liquidity directly and are willing to alter their consumption to get the desired amount of liquidity. We are not arguing that households derive happiness from holding intrinsically worthless pieces of paper. Rather, the fact that money facilitates market exchange makes it relatively more attractive than bonds and accounts for why the latter are not also in the utility function. We do not explicitly model how and why money is more liquid than bonds. Suffice it to say that money-in-the-utility-function is a general formulation that encompasses many deeper reasons why fiat money is valued in the real world despite being dominated in rate of return.⁶

For expositional convenience, the representative household's preferences at date t are represented as

$$(3) \quad U(c_t, m_t) = \ln c_t + \theta \ln m_t,$$

where θ is the rate at which a household will substitute money for consumption. Equation 3 specifies that the household's utility is characterized in a log-separable form. Three properties of the function $U(\cdot)$ are worth noting. First, the household's utility increases when either consumption or real money balances increase. In other words, marginal utility is positive with respect to each variable. Second, an increase in consumption results in declining marginal utility. Third, separa-

The Long-Run Government Budget Constraint

In this box we formally derive the government's long-run budget constraint. There are principal and interest expenses associated with outstanding government debt. These expenses are backed by the revenues from taxes and seigniorage.

We begin with the period-by-period expression of the government budget constraint; that is, at date t

$$(B.1) \quad (1 + r_{t-1})b_{t-1} = \tau_t + b_t + s_t.$$

At date $t + 1$, Equation B.1 is written as

$$(B.2) \quad (1 + r_t)b_t = \tau_{t+1} + b_{t+1} + s_{t+1}.$$

Thus, the date t level of government debt is

$$b_t = \frac{\tau_{t+1} + b_{t+1} + s_{t+1}}{(1 + r_t)}.$$

Substitute for b_t in Equation B.1, yielding

$$(B.3) \quad (1 + r_{t-1})b_{t-1} = \tau_t + \frac{\tau_{t+1} + b_{t+1} + s_{t+1}}{(1 + r_t)} + s_t.$$

Next, update Equation B.1 two periods, solving for b_{t+1} and substituting in Equation B.3, yielding

$$(1 + r_{t-1})b_{t-1} = \tau_t + \frac{\tau_{t+1} + b_{t+1} + s_{t+1}}{(1 + r_t)} + \frac{\tau_{t+2} + b_{t+2} + s_{t+2}}{(1 + r_{t+1})(1 + r_t)} + s_t.$$

By repeating this process, we get the following expression

$$(B.4) \quad (1 + r_{t-1})b_{t-1} = T_t + S_t + \lim_{j \rightarrow \infty} \frac{b_{t+j}}{(1 + r_{t+j-1}) \dots (1 + r_t)},$$

where

$$T_t = \tau_t + \frac{\tau_{t+1}}{(1 + r_t)} + \frac{\tau_{t+2}}{(1 + r_{t+1})(1 + r_t)} + K = \tau_t + \frac{1}{(1 + r_t)} \left[\tau_{t+1} + \frac{\tau_{t+2}}{(1 + r_{t+1})} + K \right],$$

$$S_t = s_t + \frac{s_{t+1}}{(1 + r_t)} + \frac{s_{t+2}}{(1 + r_{t+1})(1 + r_t)} + K = s_t + \frac{1}{(1 + r_t)} \left[s_{t+1} + \frac{s_{t+2}}{(1 + r_{t+1})} + K \right].$$

Equation B.4 states that the government's principal and interest expense is equal to the sum of the present value of its tax revenues, its seigniorage and its long-run debt position. We impose the condition that the treasury cannot roll over its debt (or loans) forever. The standard no-Ponzi condition is represented by the following expression:

$$(B.5) \quad \lim_{j \rightarrow \infty} \frac{b_{t+j}}{(1 + r_{t+j-1}) \dots (1 + r_t)} = 0.$$

Thus, the no-Ponzi condition implies that the government's date t principal and interest expenses are backed completely by tax revenues and seigniorage.

Now that we have defined our notion of backing, we can articulate our notion of reliance. Suppose the government decrees that a fraction ϕ of its date t debt obligations will be met by tax revenues. Thus,

$$(B.6) \quad T_t = \phi(1 + r_{t-1})b_{t-1}.$$

The government's long-run budget constraint, Equation B.4, together with Equations B.5 and B.6, implies that

$$(B.7) \quad S_t = (1 - \phi)(1 + r_{t-1})b_{t-1}.$$

How should current taxes be set, given Equations B.6 and B.7? Recall that

$$T_t = \tau_t + \frac{1}{(1 + r_t)} T_{t+1} = \tau_t + \frac{1}{(1 + r_t)} [\phi(1 + r_t)b_t] = \tau_t + \phi b_t.$$

Since $\tau_t = T_t - \phi b_t$, current taxes must satisfy

$$(B.8) \quad \tau_t = \phi(1 + r_{t-1})b_{t-1} - \phi b_t = \phi[(1 + r_{t-1})b_{t-1} - b_t].$$

bility means a household's marginal utility of consumption is invariant to changes in real money balances, and vice versa.

The government consists of two separate entities bound by a single budget constraint. The fiscal authority, or treasury, collects the lump-sum taxes and sells and redeems bonds. It has no other expenditures. Simultaneously, the monetary authority, or central bank, potentially controls the nominal quantity of money over time. It can alter the quantity of money by directly handing money over to each household; alternatively, it could trade money for an equal dollar value of government bonds—an open market operation. Changes in the nominal money stock allow the government to buy goods with the extra money printed. Each authority operates in such a way that the following budget constraint is satisfied period by period:

$$(4) \quad (1 + r_{t-1})b_{t-1} = \tau_t + b_t + s_t,$$

where s denotes the seigniorage raised by the central bank.

Conceivably, the treasury could keep issuing new debt to pay for the interest obligations on outstanding debt but never really retire the debt, thus rolling it over forever. Forward-looking agents will understand this and refuse to lend to the treasury. Hence, we must impose an additional long-run restriction on the treasury's debt issuance. Specifically, as we show in the box entitled "The Long-Run Government Budget Constraint," the present value of government revenues must be equal to the initial stock of the treasury's real bond payments. More concretely, the present value of the treasury's debt must equal the present value of government revenues (that is, future debt obligations must be fully backed by future revenues of the treasury and the central bank). Thus, the treasury is restricted to be neither a lender nor a borrower, at least in terms of the present value of its debt obligations. This policy is sometimes referred to as a no-Ponzi condition.

We now introduce the notion of reliance. Since each authority contributes to the present value of revenues, we can assign the contribution from each. Reliance, therefore, represents the portion of the present value of revenues that must come from each authority:

$$(5) \quad PV(\tau_t) = (1 - \phi)(1 + r_{t-1})b_{t-1},$$

and

$$(6) \quad PV(s_t) = \phi(1 + r_{t-1})b_{t-1},$$

where PV stands for the present value of the term in parentheses. In other words, the present

value of lump-sum taxes and seigniorage is equal to the principal and interest expenses of the initial stock of real government bonds. It is possible (see Equation B.8 in the box) to write

$$(7) \quad \tau_t = (1 - \phi)[(1 + r_{t-1})b_{t-1} - b_t].$$

Thus, another way to think of our notion of reliance is that *current* taxes are responsible for $(1 - \phi)$ percent of the *current* interest expenses on the outstanding debt or that the central bank is responsible for ϕ percent of the current interest expenses. Hereafter, we refer to ϕ as the seigniorage-reliance parameter.

A few remarks about measurement and realism are in order. First, reliance is difficult to measure because it is quite hard to isolate those changes in the stock of high-powered money that the central bank engineered exclusively to finance government deficits. This is because high-powered money could change for reasons other than to finance deficits. Second, we have taken a particular stand with respect to the institutional structure linking the fiscal authority and the central bank. It is difficult to find examples of countries that fit our environment perfectly. As discussed in the introduction, we like to think of ϕ as a continuous version of instrument independence as postulated by Capie et al. (1994). One could be agnostic about all this, simply follow Aiyagari and Gertler (1985), and refer to ϕ as the portion of government bonds eventually backed by money.

In the next section, we turn our attention to the equilibrium relationship between the reliance parameter and the price level in our economy.

A FISCAL THEORY OF PRICES

The household's utility maximization problem can be stated as

$$\max \sum_{t=0}^{\infty} \beta^t (\ln c_t + \theta \ln m_t)$$

subject to Equation 2. β is a positive fraction that measures the rate at which the household discounts future utility. In equilibrium, the household's maximization problem yields the following decision rule for real money balances and consumption:

$$(8) \quad m_t = \theta \left(\frac{1 + i_t}{i_t} \right) c_t$$

and

$$(8') \quad \frac{1}{c_t} = \frac{\beta(1 + r_t)}{c_{t+1}}.$$

In equilibrium, since the good is perishable, the household will consume all its endowment; that is, $c_t = y$ for all t .⁷ Substituting for c in Equation 8 and using Equation 7 to substitute for τ , the household's date t budget constraint (Equation 2) can be written as

$$(9) \quad y + \phi(1 + r_{t-1})b_{t-1} + \theta \left(\frac{1 + i_{t-1}}{i_{t-1}} \right) \frac{y}{1 + \pi_t} \\ = y + \theta \left(\frac{1 + i_t}{i_t} \right) y + \phi b_t.$$

Thus, the household's budget constraint is characterized by the size of the endowment, the path of government bonds, the real interest rate, the inflation rate, and the government's long-run reliance on taxes.

In this article, we focus only on steady-state, or long-run, equilibria, that is, equilibrium allocations—consumption, real money holdings, and real bond holdings—that are time invariant. With consumption constant across time, the price of date $t + 1$ consumption measured in units of date t consumption is constant (see Equation 8'). This price is the gross real interest rate, $(1 + r)$. In steady state, therefore, we know that

$$(1 + r) = \frac{1}{\beta}.$$

Using this, we can rewrite the household's budget constraint as

$$(10) \quad \phi r b = \frac{\theta y \pi (1 + r)}{i}.$$

Next, solve Equation 10 for real government bonds:

$$(11) \quad b = \theta \frac{(1 + r) \pi y}{i \phi r}.$$

Note that Equation 11 is the quantity of real government bonds that people will hold in equilibrium. Thus, Equations 8, 11, and $c = y$ completely describe the household's steady-state allocations.

We conduct the following experiment to demonstrate how fiscal policy directly affects the price level. Suppose the nominal stocks of money and government bonds are set at their initial levels. It is straightforward to derive the relationship between the equilibrium steady-state price level and seigniorage reliance.⁸ We substitute the steady-state expressions for bonds, money, and consumption into the household's budget constraint (Equation 9), and after some rearrangement, the steady-state price level is expressed as

$$(12) \quad p = \frac{r\beta}{\theta y} (M + \phi B).$$

$$m = \theta \left(\frac{i}{1+i} \right) y.$$

To understand the deeper implications of Equation 12, consider an increase in the central bank's revenue generation responsibility, ϕ . With the central bank raising more revenue, the treasury can reduce the household's taxes and retire some outstanding debt using the funds the central bank raised. Retiring debt means that B falls. It follows that households now have a smaller stock of assets available. In contrast, with lower lump-sum taxes, the household's disposable income rises. If $\phi < 1$, it can be shown that the former effect dominates. The bottom line is that an increase in the central bank's revenue generation responsibility raises the quantity of resources available for the household to spend. More resources chase the same amount of goods. The price level rises as a consequence.

Equation 12 says the long-run price level is proportional to the "monetized" portion of the government's liabilities. Note that ϕ represents the long-run fraction of government bonds backed by money. In the minds of forward-looking agents, then, the actual amount of money in the economy is not only the money stock M but also the fraction of bonds backed by money. When the latter goes up, agents see this as an increase in the amount of money in the economy; consequently, the price level rises. With $\phi > 0$, in addition to the central bank, the treasury plays a role in determining the price level through the quantity of government bonds outstanding.

Equation 12 captures an idea in contrast to the standard textbook version of the quantity theory of money, which postulates that only changes in the money stock affect the price level. Here, fiscal policy actions (such as a permanent increase in the treasury's stock of debt) can easily affect the price level as long as $\phi < 1$ holds, even though the stock of money is held constant. Thus, when considering correlations between the price level and money, the appropriate definition of money should include the stock of debt, a point long recognized by proponents of the real bills doctrine.⁹

To finance the government's interest expenses, the money stock will change over time. We turn our attention to the effect that changes in reliance and composition have on the steady-state inflation rate and the nominal interest rate. To that end, with $c = y$, the equilibrium expression for real money demand using Equation 8 is given by

Set this equal to real money supply M/p , where p is computed from Equation 12.¹⁰ After some rearrangement, it is possible to show that

$$(13) \quad i = \frac{(1-\beta)(M + \phi B)}{M - (1-\beta)(M + \phi B)},$$

and

$$(14) \quad \pi = \frac{(1-\beta)\phi B}{M - (1-\beta)(M + \phi B)}.$$

We now can answer our initial question: Does increased reliance on seigniorage increase the inflation rate? Recall that the seigniorage reliance parameter is denoted by ϕ . Then, an increase in this parameter raises the numerator of Equation 14 and reduces the denominator, thereby increasing π . Simply stated, an increase in the central bank's revenue-raising responsibility precipitates an increase in the inflation rate. Analogously, we can show (using Equation 13) that such an action increases the nominal interest rate.¹¹

Note that money demand is interest-inelastic (*Equation 8*). This point is important in deriving the relationship between reliance and both the inflation rate and the nominal interest rate. To illustrate, suppose money demand is interest-elastic. Money demand decreases, in percentage terms, more than nominal interest rises. In steady state, nominal interest rate movements reflect movements in the inflation rate; recall that the steady-state real interest rate is $1/\beta$, a constant. In the interest-elastic case, the economy could be on the wrong side of the Laffer curve. In other words, seigniorage would decrease because the tax base (money demand) falls by more than the tax rate. Interest-inelastic money demand assures that this does not occur.¹²

Evidence supports the conclusion that greater reliance is correlated with higher inflation. Grilli, Masciandaro, and Tabellini (1991) examine the period 1950–89. They construct an "economic independence indicator" for a group of European nations and for each of the four decades in their sample. (See Table 14 in their paper.) They estimate the correlation coefficient between each country's decade-average inflation rate and the economic independence measure, finding that countries with more economically dependent central banks (such as Greece, Portugal, and Spain) have consistently higher inflation rates and the highest levels of seigniorage.

What effect would a change in each type of government paper have on the long-run inflation rate? To answer this, rewrite Equation 14 as

$$(14') \quad \pi = \frac{1}{\left(\frac{\beta}{1-\beta} \cdot \frac{M}{B} \cdot \frac{1}{\phi}\right) - 1}.$$

Then an increase in M reduces the inflation rate, whereas an increase in B increases the inflation rate. The intuition is clear: money is a cheaper way to pay off the government's interest obligations because the government does not pay interest on money. On the other hand, an increase in the stock of bonds requires the central bank to eventually raise more revenue, for a given seigniorage reliance, to meet the increased interest obligations on this debt, thereby increasing the inflation rate.

COMPOSITION OF GOVERNMENT LIABILITIES

We can use our setup to answer yet another important question: Does the composition of government liabilities (interest-bearing debt, like bonds, versus non-interest-bearing debt, like money) matter? The answer seems particularly relevant as more and more countries, including the United States, realize budget surpluses and pay down their debt.

Define $\alpha = M/(M+B)$. Then it is possible to rewrite Equation 12 as

$$(15) \quad p = \frac{r\beta}{\theta y} \left\{ \left[1 - (1-\phi)(1-\alpha) \right] (M+B) \right\}.$$

Consider a one-for-one exchange in which government bonds are permanently traded for money. This changes the composition of the government's liabilities but not their total value, $M+B$. With $0 < \phi < 1$, an increase in α , for instance, results in a higher price level.

We next analyze how a change in the composition of government liabilities affects the inflation rate. An increase (decrease) in α may be thought of as representing a less restrictive (tight) monetary policy.¹³ Suppose the government initiates a permanent open market purchase of bonds in exchange for money. This open market operation results in more money and fewer bonds, that is, α increases. To see the effect of this on the inflation rate, rewrite Equation 14 as

$$(16) \quad \pi = \frac{(1-\beta)\phi}{\beta \left(\frac{\alpha}{1-\alpha} \right) - (1-\beta)\phi}.$$

Then, Equation 16 indicates that inflation is

inversely related to movements in α .¹⁴ So, the composition of government liabilities does matter. This result has an unpleasant monetarist arithmetic feel to it.¹⁵ An open market purchase lowers the eventual interest expenses associated with interest-bearing government bonds. Consequently, less inflation is needed to fund the smaller expenses. Hence, inflation declines as the composition shifts toward money and away from bonds.

CONCLUDING REMARKS

In this article, we investigate the effects of monetary policy decisions that are explicitly linked to fiscal policy decisions and vice versa. More important, the nature of the linkage—here, the government stipulates how much it will rely on seigniorage to back its long-run expenses—has direct consequences for the inflation rate. Our model economy produces the following prediction: controlling for other factors, if a country's reliance on seigniorage increases, the country's inflation rate will increase. We go on to show that a permanent open market purchase (one in which a country reduces its stock of government bonds and increases the quantity of money) results in a decline in the long-run inflation rate.

Our analysis has implications for a classic question in monetary economics: How much control can a central bank have over the value of its currency? (Sargent 1987, 139). We consider cases in which the central bank is not instrument independent. These central banks can—via open market operations—switch the composition of government liabilities toward non-interest-bearing money and away from debt. We show that the open market operation lowers debt expenses and reduces the government's effective reliance on seigniorage. This way, it can retain substantial control over the value of its currency.

In light of our results, we close with two important questions for future research. First and foremost, how should ϕ and α be measured? This is a difficult issue because ϕ represents the fraction of money created to meet the government's financing needs. Governments typically do not preannounce how much they will rely on the seigniorage. Consequently, one must infer how much money is created for financing needs and how much is created to meet other central bank activities. Second, what is the relationship between ϕ and α ? That is, is there a relationship between a country's reliance on seigniorage and its composition of government liabilities?

NOTES

Chapter 4 in Walsh (1998) stimulated many of the ideas presented here. Part of the work was done when Bhattacharya visited the Federal Reserve Bank of Dallas' Research Department in the summer of 1999. We gratefully acknowledge the department's hospitality and helpful comments from Mark Wynne, Mark Guzman, and Jim Dolmas.

¹ Though they adopt different terminology, Grilli, Masciandaro, and Tabellini (1991) focus on a similar concept. To borrow from their definition, goal independence "is the capacity to choose the *final goal* of monetary policy, such as inflation or the level of economic activity."

² Alesina and Summers (1993) use slightly different terminology. Specifically, they assert, "Economic independence is defined as the ability [of the central bank] to use instruments of monetary policy without restrictions. The most common constraint imposed upon the conduct of monetary policy is the extent to which the central bank is required to finance government deficits. This index of economic independence essentially measures how easy it is for the government to finance its deficits by direct access to credit from the central bank."

Grilli, Masciandaro, and Tabellini (1991) in Table 13 of their paper provide some evidence on the Alesina–Summers instrument-independence indicator. According to them, instrument independence of the central bank is high in West Germany, Switzerland, the United States, Austria, and Belgium. Conversely, central banks in Italy, New Zealand, Portugal, Greece, and Spain have very little instrument independence.

³ Take the example of India. The Reserve Bank of India (RBI) is definitely politically independent. Nonetheless, during 1998–99, the net lending by the RBI to the Indian government was about 10 percent of the gross fiscal deficit for that year, precipitating an 18 percent increase in M1.

⁴ Using data from a large group of countries over many years, Fischer (1982) shows that governments do generate revenue from money creation more often than not. Click (1998) documents that between 1971 and 1990, in a wide cross section of countries, currency seigniorage as percent of GDP ranged from 0.3 percent to 14 percent, and seigniorage as percent of government spending ranged from 1 percent to 148 percent.

⁵ One implication of our findings is that prohibition of deficit financing is redundant. For instance, in the membership requirements put forward by the European Union, there is an upper bound on the debt-to-GDP ratios. What really matters, and what the central

bank can achieve, is the mandate for price stability.

⁶ See Feenstra (1986) for a more formal description of the functional equivalence between models with explicit transaction costs and those with money-in-the-utility-function. It is important to mention here that functional equivalence does not mean that the intuition or interpretation of the results is model invariant.

⁷ One may wonder why people hold money here since they end up consuming only their endowment anyway. The answer lies in the notion of equilibrium. When agents solve their individual problems to determine how much money to hold, they perceive the possibility of trade in the good and do not know that, *in equilibrium*, they will all simply consume their endowment.

⁸ For the interested reader, the notion of a steady-state price level is more fully developed in Walsh (1998), 143–46.

⁹ Sargent and Wallace (1982) and Smith (1988) contain good discussions of the doctrine.

¹⁰ Alternatively, one could equate bond demand (see Equation 11) to real bond supply and arrive at the same expressions for i and π as in Equations 13 and 14.

¹¹ For the interested reader, the optimal policy (one that maximizes steady-state welfare of agents) would be to set $\phi = 0$. In words, the household's welfare is highest when the government relies solely on lump-sum taxes to pay for its interest expense. The general flavor of this result extends to several cases in which distorting taxes are present. See Chari, Christiano, and Kehoe (1996) and Correia and Teles (1999).

¹² See Lucas (2000) for an excellent discussion on the elasticity of money demand. He provides an overview of the empirical support for the position that money demand is interest inelastic.

¹³ Greenwood (1998), for instance, focuses on tight money policies. As the recent crisis in Japan unfolds, many commentators are suggesting that the blame should be placed on the Japanese central bank for following tight money policies over the last decade, thereby "strangling" the economy. The central bank argues that its tight money policies have kept Japanese inflation in check.

¹⁴ To verify this, differentiate Equation 16 with respect to α . The sign of the resulting expression is negative.

¹⁵ Sargent (1987) discusses the effect a permanent open market sale of bonds has on the inflation rate. Given a fixed deficit, such a sale "bequeaths" a larger stock of interest-bearing debt to the future; eventually inflation would have to rise to pay for the outstanding interest obligations. Sargent and Wallace (1981) called this paradoxical phenomenon (tight money policies increase the eventual inflation rate) the "unpleasant monetarist arithmetic." See Bhattacharya and Haslag (1999) for a survey.

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