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Author(s): S. Borağan Aruoba and Francis X. Diebold

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Real-Time Macroeconomic Monitoring: Real Activity, Inflation, and Interactions

By S. BORAĞAN ARUOBA AND FRANCIS X. DIEBOLD*

Real economic agents, making real decisions in real time, need accurate and timely estimates of the state of macroeconomic activity. Every day, literally millions of economic agents (business people, retail and institutional investors, financial institutions, economists, households, ...) explicitly or implicitly attempt to form and update views on macroeconomic activity as new information arrives. Significant parts, for example, of the first few pages of any day's *Wall Street Journal* or *Financial Times* are typically devoted to recently released or soon-to-be-released data and their likely implications for business conditions.

To help meet this demand, we have earlier supplied and illustrated a framework for high frequency measurement of macroeconomic activity in a systematic, replicable, and statistically optimal manner (S. Borağan Aruoba, Francis X. Diebold, and Chiara Scotti 2009).¹ We are hardly alone in appreciating the desirability and benefits of high frequency measurement, however, as interest in the area has escalated rapidly. Academic research on high frequency (indeed real-time) macroeconomic

measurement is now voluminous, with leading reference works featuring it prominently (e.g., Dean Croushore 2006), and recently established annual conferences chronicling and promoting new developments.² Even Google is now in the game, as industry and academics work together to expand the frontier; see Hyunyoung Choi and Hal Varian (2009).

Improved real-time macroeconomic measurement is of interest not only to private agents, but also to policy makers. Both groups seek to use better information to make better decisions. Hence central banks and nongovernmental organizations (NGOs) worldwide have recently devoted significant resources to real-time macroeconomic monitoring, as for example with the Federal Reserve Bank of Philadelphia's Real-Time Data Research Center, the Bank of Italy and the Center for Economic and Policy Research's EuroCOIN project, and the Bank of Spain's Euro-STING project.

Similarly, leading policy-oriented academic macroeconomists are focusing squarely on real-time challenges, grappling with policy formulation and evaluation in the face of evolving current information, as for example in John Taylor's inaugural Feldstein address to the NBER (John B. Taylor 2009).

Against this background, in this paper we provide both retrospective and prospective assessment of progress in real-time assessment of macroeconomic activity. Our concern is with "nowcasting," not forecasting (that is, "coincident," not "leading," indexes). We work in a "small data" environment in the sense of Diebold (2003). Building on James H. Stock and Mark W. Watson (1989) and Roberto S. Mariano and Yasutomo Murasawa (2003) we specify

* Aruoba: Department of Economics, University of Maryland, College Park, MD 20742 (e-mail: aruoba@econ.umd.edu); Diebold: Department of Economics, University of Pennsylvania and NBER, Philadelphia, PA 19104 (e-mail: fdiebold@sas.upenn.edu). For helpful comments we thank seminar and conference participants at the 2010 Annual Meeting of the American Economic Association, the Fifth Annual Workshop on Data Revision in Macroeconomic Forecasting and Policy (CIRANO, Montreal), the Federal Reserve Bank of Philadelphia, Black Rock, and the University of Pennsylvania. We are especially grateful to Dean Croushore, Loretta Mester, Jeremy Piger, Calvin Price, Glenn Rudebusch, Keith Sill, Allen Sinai, Tom Stark, and Simon van Norden. For research support we thank the National Science Foundation and the Real-Time Data Research Center at the Federal Reserve Bank of Philadelphia.

¹ See also our more refined real-time implementation and additional materials maintained by the Federal Reserve Bank of Philadelphia at <http://www.philadelphiafed.org/research-and-data/real-time-center/business-conditions-index>.

² See for example the ongoing series of "Real-Time Data Conferences" sponsored by CIRANO (Montreal), the most recent of which is the October 2009 Fifth Annual Workshop on Data Revision in Macroeconomic Forecasting and Policy.

state-space dynamic-factor models and use the Kalman filter to produce optimal extractions of latent activity. To maximize transparency, in this paper we use a *monthly* base frequency for all analysis.³ We focus not only on real macroeconomic activity, which has received most attention to date, but also on inflation and its interaction with real activity. In Section I we assess real activity, in Section II inflation activity, and in Section III their interaction. We conclude in Section IV. We provide details in the online Appendix.

I. Real Activity

We use five indicators, from the 11/23/2009 data vintage: payroll employment (monthly, from the Bureau of Labor Statistics (BLS), 1960:2–2009:10), industrial production (monthly, from the Federal Reserve Board, 1960:2–2009:10), real personal income less transfers (monthly, from the Bureau of Economic Analysis (BEA), 1960:2–2009:9), real manufacturing and trade sales (monthly, from BEA, 1967:2–2009:8), and real GDP (quarterly, from BEA, 1960:II–2009:III). Note in particular the different ending dates of the indicators in the 11/23/2009 vintage, as is typical, due to differing release timeliness.

A plot of the five indicators (not shown to save space) reveals that idiosyncratic noise in the individual indicators masks much of the real activity information contained in them. The extracted real activity factor, in contrast, is much less noisy, as seen in Figure 1 together with NBER “recession bars.”⁴ The estimation results (again not shown to save space) reveal that all indicators load positively and significantly on the real activity factor in our estimated measurement equation. Conversely, the extracted factor is driven by all of the underlying indicators. In optimally extracting the state of real activity, however, the Kalman filter effectively eliminates much of the idiosyncratic noise by averaging both over the cross section and over time.

³ In addition, we use indicators seasonally adjusted by the relevant reporting agency, we transform all indicators to logarithmic changes, and we allow three autoregressive lags in the state-space transition equation. For details, see the working paper version of this paper, available at www.nber.org.

⁴ As of the date of writing (January 2010), the NBER ending date for the recent recession remains undeclared. We end the last recession bar in July 2009, which is when our real activity factor returns to zero.

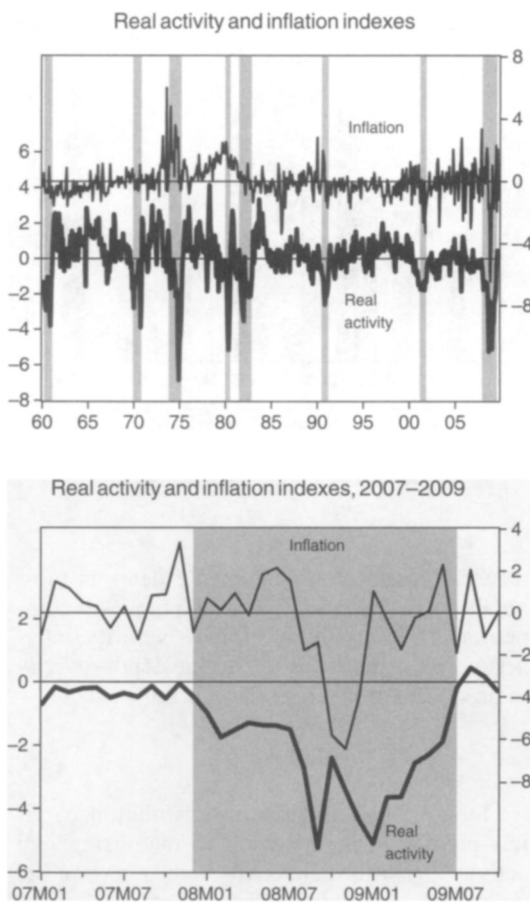


FIGURE 1. REAL ACTIVITY AND INFLATION OVER THE CYCLE

Several features of our real activity index are noteworthy. First, movements in our real activity factor cohere strongly with the NBER chronology, plunging during NBER recessions. Second, the roughly 1985–2007 “Great Moderation” in the volatility of real activity is clear, even if now relegated to the dustbin of history. Third, the recent recession, which is of special interest, begins in very late 2007, in accord with the NBER’s dating, and it shows a clear trough in January 2009, after which it recovers steadily, with the recession ending (in our assessment) in July 2009.⁵ And finally, Figure 2 reveals that the

⁵ The trough in September 2008 was caused by a set of exogenous events and should be discounted entirely. In particular, September industrial production was severely affected by a largely exogenous “triple shock” (hurricanes Gustav and Ike, and a strike at a major aircraft

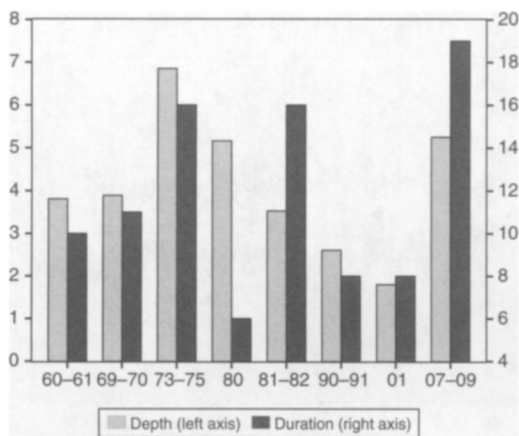


FIGURE 2. RECESSION DEPTH AND DURATION SEVERITY

recent recession, although quite deep, is most notably very long relative to its post-1960 competitors.⁶ The extreme duration severity interacts with the moderately extreme depth severity to produce extreme overall severity.⁷

II. Inflation

Our approach to measuring inflation parallels precisely our approach to measuring real activity. As with real activity indicators, we see many inflation indicators, each of which contains potentially valuable, but incomplete and noisy, information about the underlying common component. We include wages among our indicators because they are a crucially important price, and one not explicitly contained in standard price indexes.

Our inclusion of wages has both theoretical and empirical nuances. On the theoretical side, inclusion of wages is motivated by modern dynamic stochastic general equilibrium models, which suggest that optimal monetary policy rules may be approximated by Taylor-type rules that respond to price inflation *and* wage inflation

manufacturer), which caused an annualized September 2008 drop of nearly 50 percent and a correspondingly huge October rebound. September/October manufacturing and trade sales behaved similarly.

⁶ See (Diebold and Glenn D. Rudebusch 1992) for discussion and analysis of recession durations.

⁷ We define a recession's duration severity to be its length in months and depth severity to be its largest (absolute) real activity index value.

(e.g., Stephanie Schmitt-Grohe and Martin Uribe 2007).

On the empirical side, inclusion of wages raises the issue of what wage indicator(s) to use. Wage indicators effectively fall into one of two camps, "hourly compensation" or "unit labor cost." We focus on hourly compensation, as unit labor costs confound wage-rate movements with productivity movements.

We use six inflation indicators from the 11/23/2009 data vintage: the all-items consumer price index (monthly, from BLS, 1960:1–2009:10), the finished-goods producer price index (monthly, from BLS, 1960:1–2009:10), a nonenergy commodity price index (monthly, Standard and Poor's GSCI Non-Energy Commodities Index, 1970:1–2009:10), a spot oil price (monthly, West Texas Intermediate, from Federal Reserve Bank of St. Louis FRED database, 1960:1–2009:10), the GDP deflator (quarterly, from BEA, 1960:1–2009:III), and hourly compensation in the nonfarm business sector (quarterly, from BLS, 1960:1–2009:III).

We again use the Kalman filter to estimate a simple dynamic factor model and extract the latent state, resulting in an inflation index, which appears in Figure 1. The estimation results (not shown to save space) reveal that all indicators load significantly on the factor in our estimated state-space measurement equation.

Several features of the inflation index deserve mention. First, the inflation of the 1970s is apparent, as is its retreat, which began with Paul Volcker's appointment as Chairman of the Federal Reserve Board in August 1979, and which ended by roughly 1983. Second, not only inflation's level, but also its *volatility*, was low from then until the late 1990s. In contrast, inflation volatility shows a marked increase from the late 1990s onward, a phenomenon potentially linked to inflation's recent decreased forecastability, as documented by Stock and Watson (2007). Finally, the recent period 2007–2009 is especially important, so we zoom in on it in the bottom panel of Figure 1. The historically unprecedented (at least since 1960) 2008 inflation drop was extremely sharp but also extremely brief. The entire episode ultimately lasted just six months.

III. Interactions

Prices and quantities should be related over the business cycle, and the nature of the

relationship should convey information about the sources of shocks. (Demand shocks produce positive price-quantity correlation and supply shocks produce negative price-quantity correlation.) Hence we now proceed to examine real activity and inflation *together* over the cycle.

We plot our real activity and inflation indexes in the top panel of Figure 1, together with NBER recession bars. We plot real activity on the left scale (thick font) and inflation on the right (thin font), so that movements in the two series do not obscure each other. Movements in real activity and inflation cohere over the business cycle, and crucially, the nature of the coherence does indeed depend on whether recessions are demand- or supply-driven. The inflation index tends to drop in most recessions, consistent with adverse demand shocks, as for example in the “Volcker recession” of the early 1980s. In contrast, the mid-1970s and 1980 oil shock recessions show decreased real activity and *increased* inflation, consistent with adverse supply shocks.

In the bottom panel of Figure 1 we zoom in on the recent recession. Inflation falls both more sharply and later than real activity, plunging only in summer 2008, whereas real activity begins its descent in 2007. Inflation also *recovers* both more sharply and *sooner* than real activity, returning to baseline within approximately six months.

If differing descent and rebound patterns in real activity and inflation during the recent recession are interesting, the similarities are also striking and ultimately more important. The bottom panel of Figure 1 clearly shows strong positive co-movement of real activity and inflation during the recent recession, consistent with an adverse demand shock.

IV. Summary and Concluding Remarks

We have used a dynamic-factor approach to extract indexes of US real activity and inflation. Key aspects of our approach are its use of high-frequency data, its natural implementation in a state-space environment via Kalman filtering, and its related natural facilitating of real-time updating as data are released.

Historically, our real activity index closely matches the NBER chronology and captures widely discussed phenomena such as the “Great Moderation.” Our inflation index also follows the cycle, with the sign of the correlation

varying, depending on whether various recessions are supply- or demand-driven.

The recent recession is of central interest, not least because of its severity. In terms of real activity, our results indicate that it was the most severe since 1960. Interestingly, however, its depth does not appear to be the most severe since 1960, as the mid-1970s and 1980 recessions were a bit deeper. Instead, the most unusual aspect of the recent recession’s real activity movement is its duration. This extreme duration severity interacts with the moderately extreme depth severity to produce *very* extreme overall severity. A second extreme movement during the recent recession concerns inflation as opposed to real activity, as the 2008 collapse of inflation pressure appears to be the most pronounced on record since 1960, by far. Finally, real activity and inflation appear strongly positively correlated during the recent recession, consistent with a “traditional” Keynesian demand-based explanation. Indeed the recent recession, although the most severe during the last 50 years—as by definition one or another *must* be—is similar in its essentials to most others. Hence we are wary of assertions that “this time is different” not only with regard to financial market booms (as emphasized by Carmen M. Reinhart and Kenneth S. Rogoff 2009), but also with regard to business cycle busts.

The work begun here can be extended in several potentially fruitful directions. In work in progress, for example, we assess the possible presence of regime-switching in extracted factors, as in Diebold and Rudebusch (1996), both from the highbrow perspective of incorporating nonlinear aspects of the cycle, and from the pragmatic perspective of transforming our indexes in ways that may enhance their interpretability. In addition we are extending our framework to the global environment, estimating a hierarchical global dynamic factor model in the tradition of M. Ayhan Kose, Christopher Otrok and Charles H. Whiteman (2003), with country indicators depending on country factors, country factors potentially depending on regional factors, and regional factors potentially depending on global factors.

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