J.P.Morgan

JPMorgan Chase Bank, New York
Economic Research
September 5, 2012

The time is always now: Introducing J.P. Morgan's global nowcasters

- J.P. Morgan's global economics effort integrates bottom-up country forecasting with a top-down approach that analyzes the global economy as an integrated whole. This paper introduces two new top-down "nowcasting" tools that track growth in global economic activity.
- Our monthly global PMI index has proven to be a timely and accurate nowcaster over the past decade. However, J.P. Morgan also produces and tracks other important global economic activity indicators. These include measures of industrial production, retail sales volumes, auto sales, and capital good shipments.
- The DFM-Eco index introduced here efficiently uses our PMI and other activity indicators to extract a single time-series, reflecting the common movement across the data. This series provides a monthly estimate of global GDP growth that tracks current quarter growth as data are released.
- The DFM-Eco index is a remarkably good tracker, explaining 85% of the variation in global GDP growth from 1Q00 to 2Q12. This improves upon our global PMI, which explains 67% of GDP growth.
- The relative benefit of the DFM-Eco index is most significant during sharp swings in economic activity. The PMI is a diffusion index that tends to underestimate the intensity of business cycle swings. Thus, it failed to capture the depth of the recession and underpredicted the strength of the recovery of 2008-10. In contrast, the DFM-Eco index fits this historical experience very well.
- The modeling technique applied to the DFM-Eco index can be readily applied to daily commodity prices to identify the common movement across commodities. Assuming this common movement reflect shifts in broad-based demand, while idiosyncratic moves reflect supply shocks specific to individual commodity markets, it is a natural global activity nowcaster.
- The second new indicator, the DFM-Cmd index, does not forecast as accurately as our PMI and DFM-Eco nowcasting tools. It is an accurate indicator of global IP, however. Moreover, the index provides something no other economic indicator can: a weekly look at global GDP and IP growth. As are US weekly jobless claims, this weekly measure is noisy. But a moving average of this indicator smooths out much of the noise and provides a valuable guide to shifts in global growth momentum.
- Our DFM-Eco index is pointing to 1.3% current quarter GDP growth, below our current quarter estimate of 2% and 0.4%-point weaker than the nowscast of 2Q12. By contrast, the DFM-Cmd index points to a midyear bottom in global growth and has since started to move up. This divergence owes to the index's forecast of a rebound in global factory output, a signal at odds with the latest manufacturing PMI for August.

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The time is always now

J.P. Morgan global economics' effort is built on the interaction between a bottom-up and top-down analysis. Economists track and forecast developments in over 38 countries around the world to produce a bottom-up view of the global economy. At the same time, the global economy is analyzed as a single region, based on timely aggregates that enable analysis from a top-down perspective. The message from the top-down and bottom-up messages don't always align, and the insights gained from considering both approaches are central to the formation of our economic views—for individual countries as well as for the world as a whole.

Our top-down approach to tracking global GDP has relied heavily on the J.P. Morgan Global PMI. In its 14-year life, the PMI has tracked well sequential quarterly global real GDP growth, explaining 67% of all moves in global real GDP growth. The usefulness of the J.P. Morgan global PMI also owes much to its timeliness. The monthly global PMI is available in the first week after the end of the respective survey month. This makes it the earliest available global economic indicator. Indeed, by the time GDP reports for the previous quarter begin to be released, the PMI is already available for the first month of the next quarter.

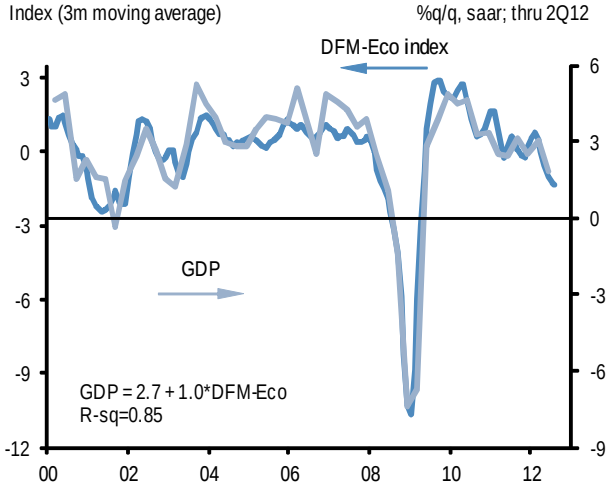
We integrate and quantify our top-down approach to aid our bottom-up method of tracking global GDP growth

In addition to the global PMI, J.P. Morgan produces and tracks a number of other global economic and financial indicators. These data track economic activity and provide a broader gauge of the business cycle, and all of them—plus others—inform our top-down global economic forecast. The purpose of the current analysis is to explore ways to most efficiently incorporate available global data as a means of "nowcasting" global GDP growth (the term "nowcast" refers to the fact that the goal is an optimal tracking of current quarter global GDP growth, as opposed to forecasting quarters further out). In this spirit, we employ a dynamic factor analysis (DFA) approach. In this framework, the dynamic of individual variables is represented as the sum of a component that is common to all variables in the economy and an orthogonal idiosyncratic residual. The global factor that is derived from this analysis can be viewed as a proxy for global GDP growth that is consistent with all the common movement in the observed economic indicators.

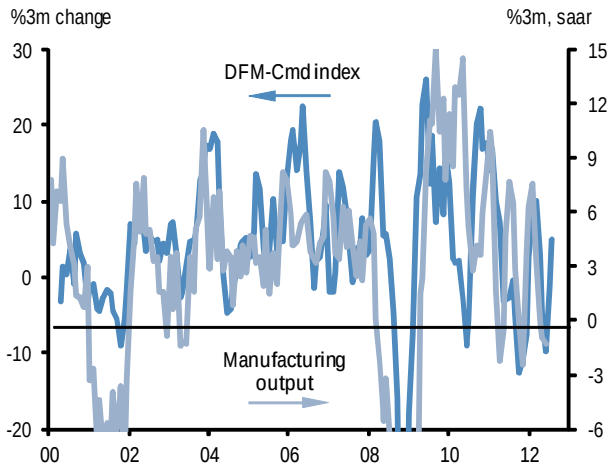
Our current top-down approach relies on several aggregates to provide qualitative assessments

The analysis in this paper focuses on the development of two global nowcasting tools. The first is the DFM-Eco index, which is based on six monthly indicators in-

Global dynamic factor model state and global real GDP



Common factor underlying commodity prices and global manufacturing



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We develop a method to optimally utilize our global aggregates in tracking current quarter global GDP

cluding manufacturing and service sector PMIs and our global aggregates of retail and auto sales, industrial production, and capital goods shipments. This tool provides a monthly global GDP estimate that allows us to track current quarter growth in real time as data are released. Second, we create a weekly growth tracking tool that extracts information from metals, energy, and agriculture prices. This DFM-Cmd index separates supply-driven price moves from demand influences, with the resulting global demand index providing a weekly measure of global growth in factory output, thus serving as a proxy for global GDP growth.

The DFM-Eco nowcaster of global GDP growth significantly outperforms global PMI alone

The DFM-Eco model is a remarkably good tracker of global real GDP growth, particularly given that no information on actual GDP outcomes is used in constructing the index. The indicator explains 85% of the variation in global GDP growth from 1Q00 to 2Q12. While historical fit is a validation of the usefulness of the DFM-Eco index, it is—more importantly—an accurate tracker of global GDP growth in real time. At the start of the quarter, the standard error of the model forecast based only on the lagged dynamics implicit in the DFM-Eco model is just under 1.6%-points annualized. As data become available during the quarter, this standard error declines steadily, reaching 0.9%-point annualized by the time the reading on global manufacturing output growth in the last month of the quarter becomes available; this is usually about a month and a half after the quarter has already ended. The improvement in the standard error is considerable, amounting to a 43% reduction. This improves upon the 22% improvement in forecasting accuracy using only the PMIs in a simple linear-regression model.

The large improvement of the DFM-Eco index relative to the PMI is not a mark against the PMI. Indeed, the PMI is the most important input to the DFM-Eco index. Of the total reduction in the standard error of the global GDP nowcast over the course of the data calendar in a given quarter, 40% owes to the manufacturing PMI alone, with an additional 15% coming from the services PMI. This is not to say that our other indicators of global GDP growth (factory output, retail sales, auto sales, and capital goods shipments) are any less important or less correlated with GDP growth. Rather, it reflects the timeliness of the PMIs being the first global aggregate indicator of the data calendar. In this sense, the DFM-Eco index quantifies the informational advantage of the PMIs. The overall better fit of the DFM-Eco index compared to the PMIs only owes to the more efficient use of the PMIs, the use of alternative global aggregates, and the use of lagged information on the indicators.

A simple commodity-based nowcaster, DFM-Cmd, provides a useful weekly nowcast of global IP

Along with the DFM-Eco index, we also use moves in commodity prices to generate the DFM-Cmd index as a high frequency tracker of global growth. By comparison to the DFM-Eco index, the DFM-Cmd performs noticeably worse. While the former has a standard forecast error for sequential global GDP growth of 0.9%-point annualized, the DFM-Cmd index has a standard error of nearly 1.9%-points. Not surprisingly, the DFM-Cmd index is a better nowcaster of global IP growth. But the usefulness of the index is that, on its own, it is statistically significant and incredibly timely. The index is unique—it is a weekly indicator of global GDP and IP growth.

Although the methodology will be fine-tuned over time, the DFM-Eco and DFM-Cmd indexes will become regular indicators tracked and reported by J.P. Morgan's economic research. As purely top-down indicators of global growth, they will serve as a useful alternative check against our bottom-up forecast. In this regard, the gap between the DFM-Eco nowcaster of current quarter GDP growth and our official

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projection will provide a quantitative measure of the risk bias in our official projection. Moreover, the empirical standard error in the nowcaster provides a natural metric for the degree of confidence in the risk bias.

The J.P. Morgan global PMI and global GDP growth

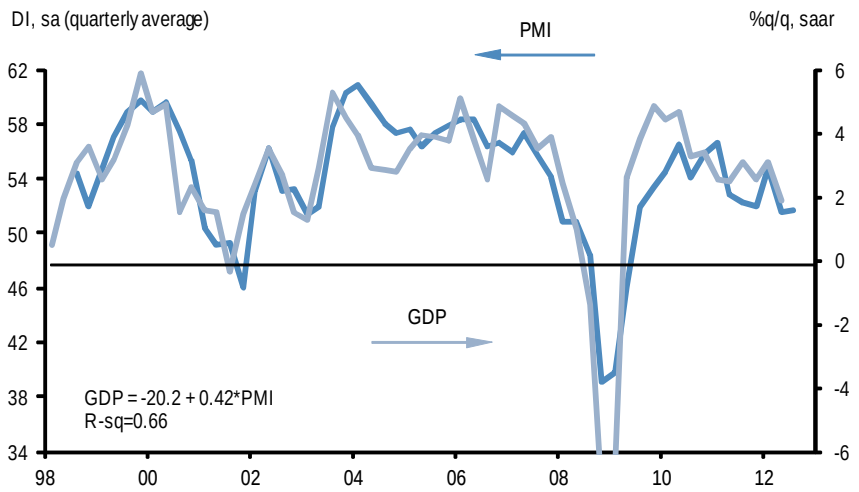
The J.P. Morgan global PMIs are the single-best nowcaster of global GDP growth

In our tracking of the global cycle, the monthly J.P. Morgan global all-industry (or composite) Purchasing Managers Index (PMI) has been the single best variable for nowcasting global real GDP growth. The PMI is a weighted average of the composite PMIs across 31 countries, where the weights reflect each country's value-added in global production. The composite PMI within each country is itself a weighted average of the output PMIs for the manufacturing and services industries, where the weights reflect the relative value-added of each industry. As diffusion indexes, the PMIs reflect the share of companies that are expanding output in a given month and so are not explicit indicators of the magnitude of output growth. However, the breadth of changes in production has tended to track the magnitude of output growth quite closely over time, making the PMIs a valuable asset in any forecaster's toolbox.

In general, our global PMI has tracked sequential quarterly global real GDP growth remarkably well over the past 14 years. We typically align the average of the three months of PMI readings within a given quarter with global real GDP growth in that quarter (%q/q saar). In doing do, this indicator has explained 67% of all moves in global real GDP growth since 1998, with a standard error of 1.34%-points annualized. For purposes of comparison, just knowing the previous quarter's growth outcome explains 45% of the variation in global real GDP growth, with a standard error of 1.7%-points (see text box for detailed statistic summary).

As a diffusion index that lies between 0 and 100, a value above 50 indicates more business are expanding than contracting. Empirically, global real GDP has tended on average to be expanding as long as the global PMI is above 47.9, according to the estimated parameters of the relationship. Specifically, a 1-point move up in the PMI has been associated with a 0.42%-point move up in global real GDP growth. This relationship is damped slightly if controlling for lagged GDP growth, but the explanatory power is little changed (and lagged GDP growth is statistically insignificant once the PMI is known).

Global PMI and real GDP



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Estimating the global PMI and real GDP growth relationship

In summarizing the relationship between the PMI and global real GDP growth, the regression analysis suggests (see table below):

- The PMI outperforms lagged GDP growth. Compared to the standard error in projecting global real GDP growth with only lagged GDP growth (1.7%-points annualized), the PMI-only model has a standard error of 1.3%-points (a 22% reduction; compare models i and ii).
- Excluding the financial crisis and initial recovery greatly improves the PMI's fit. Not surprisingly, the standard error falls considerably from 1.3%-points to 0.9%-point when a dummy variable for 3Q08 to 4Q09 is included (compare models i and iv).
- Outside of the financial crisis and initial recovery, the PMI is only a little better than lagged GDP growth alone. When including a dummy variable for 3Q08 to 4Q09, the standard error of the PMI-only model is 0.9%-point and 1%-point for the lagged-GDP growth model (compare models vi and vii). When both variables are included, they are both statistically significant but the impact of moves in the PMI is small (see model viii). In general, the PMIs are most useful in flagging breaks in growth dynamics.
- When both the PMI and lagged GDP growth are included, the PMI is statistically significant while lagged GDP growth is not. This is true over the full sample and excluding the financial crisis (compare models iii and viii).
- The manufacturing PMI has a disproportionate weight in explaining GDP growth. This is diminished—but not entirely—once the financial crisis is excluded (see models iv and ix).
- The services PMI is statistically insignificant over the full sample and only marginally significant when excluding the financial crisis (see models iv and ix).

PMI models of global real GDP growth
Regression of global real GDP growth (%q/q, saar); sample 1Q98-2Q12

	i	*ii*	*iii*	*iv*	*v*	*vi*	*vii*	*viii*	*ix*	*x*
Constant	-20.1	0.9	-18.4	-18.8	-19.4	-12.0	1.3	-9.9	-12.0	-10.0
	(-4.3)	(1.4)	(-2.8)	(-5.3)	(-3.5)	(-5.4)	(3.8)	(-3.5)	(-5.2)	(-3.3)
GDP, lag		0.67	0.09		-0.04		0.58	0.19		0.19
		(4.2)	(0.5)		(-0.2)		(6.8)	(1.4)		(1.2)
PMI	0.42		0.39			0.27		0.23		
	(4.9)		(3.0)			(6.8)		(4.0)		
PMI, Mfg				0.33	0.34				0.13	0.08
				(3.5)	(2.6)				(1.6)	(0.8)
PMI, Serv				0.07	0.08				0.14	0.14
				(1.0)	(1.3)				(1.7)	(1.7)
Excl. financial crisis	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Adj. R-sq	0.67	0.45	0.66	0.74	0.73	0.85	0.80	0.86	0.85	0.85
Std Error	1.34	1.71	1.35	1.19	1.20	0.88	1.02	0.88	0.89	0.89

Note. PMIs are the simple averages of the three months within the quarter. Where indicated, the exclusion of the financial crisis adds dummy variables to the regression for the period 3Q08 through 4Q09.

As indicators of breadth, and not magnitude, the PMIs failed to capture the depth of the downturn and strength of the initial recovery

The usual tight correlation between the breadth of moves in economic activity—as indicated by the PMI—and the actual changes in terms of magnitude tends to break down during outsized moves in economic activity. This was especially true around the time of the recent global recession, when global real GDP contracted by much more than indicated by the PMI. Although the PMI plunged to record lows in late 2008 and early 2009, it still "only" pointed to an outright contraction in global GDP

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of about 3.5% annualized in 4Q08 and 1Q09. By contrast, global GDP plummeted at a roughly 7% annualized pace in those quarters. This was a 2.6 standard deviation miss and 0.6 standard deviation larger than the next largest miss, which occurred just before the preceding recession in 2001. Similarly, the global PMI failed to capture the magnitude of sharp initial recovery in 2H09. Over the first year of the recovery, when global GDP jumped 4.5%, the global PMI pointed to a 2.7% gain. Removing the impact of the crisis on the estimation improves the fit considerably but does not alter the out-of-recession fit much at all. That is, although the beta is damped from 0.42 to 0.24, the fit outside of the crisis period is effectively unchanged.

Expanding the tool kit for tracking global GDP growth

While the global PMI may be the single best, and most timely, indicator of global activity, it is not the only indicator. Indeed, J.P. Morgan produces and routinely tracks a number of important global economic indicators. These include measures of production such as global manufacturing output and motor vehicles production, as well as measures of demand such as global retail sales volumes, auto sales, and capital good shipments. These data are not only useful in tracking economic activity but also provide a broader understanding of the state of the business cycle.

The J.P. Morgan global economic indicators

While the PMIs are the single best, J.P. Morgan also generates and tracks several other global aggregate demand and supply indicators

Much of our analysis in tracking global GDP growth over the cycle focuses on six monthly global variables . The indicators of economic activity include 1) the global manufacturing PMI, 2) the global services output PMI, 3) global manufacturing output PMI, 4) G-3 capital goods shipments as a proxy for global business equipment spending, 5) global retail sales volumes, and 6) global auto sale volumes. Our auto sales and retail sales data begin in 2000, while the rest begin in 1998. The data all share considerable common co-movement. The cross-correlations of 3-month %-changes (averages for the PMIs) among these indicators generally range well above 0.5, with the notable exception of a relatively small correlation of growth in global auto sales with the rest of the data.

Importantly, all data share a strong correlation with global sequential real GDP growth (%q/q saar). Not surprisingly, it is these relatively robust correlations with

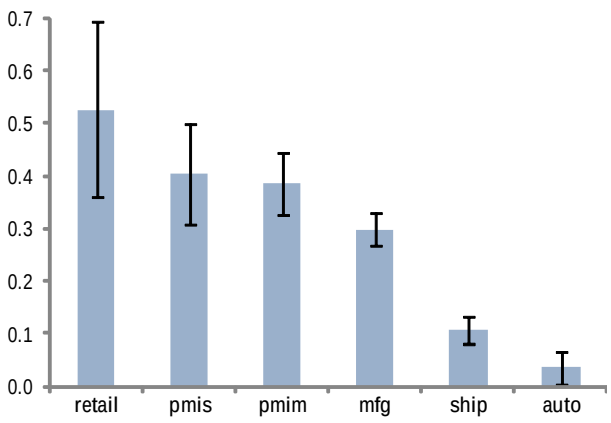
Correlations of global economic activity indicators and GDP growth

	pmim	pmis	mfg	ship	retail	auto	dly	Memo: Std dev
PMI, manufacturing (pmim)	1.00	0.85	0.82	0.78	0.39	0.08	0.87	5.1
PMI, services (pmis)	0.85	1.00	0.62	0.60	0.32	0.01	0.76	4.5
Manufacturing (mfg)	0.82	0.62	1.00	0.73	0.65	0.40	0.89	7.1
Capital good shipments (ship)	0.78	0.60	0.73	1.00	0.45	0.16	0.76	17.6
Retail sales volume (retail)	0.39	0.32	0.65	0.45	1.00	0.62	0.58	2.7
Auto sales (auto)	0.08	0.01	0.40	0.16	0.62	1.00	0.26	19.2
GDP (dly)	0.87	0.76	0.89	0.76	0.58	0.26	1.00	2.4

Note. Correlations based on all available data from 1998m1 forward. Correlations of indicators based on %3m changes in monthly data. Correlations with quarterly GDP growth are based on %3m changes over each respective quarter.

Impact on global GDP growth, univariate regression

%-point impact on %q/q, saar GDP growth (1-pt chg in PMI's, 1%-pt chg in %3m, saar growth for others); 1-std error band shown



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Principal component and Dynamic factor analysis

Given data limitations, it is not feasible to use all our global economic indicators to track global GDP with traditional regression models. Global GDP is measured quarterly and our global indicators only go back to 1998 for our global PMIs and back to 2000 for most of our other indicators. This leaves too few observations for estimating a multitude of parameters governing the relationship of each indicator with GDP. An alternative is to use principal component analysis (PCA), whereby a single sufficient statistic is extracted from a large set of data. This is then correlated with global GDP growth. In PCA, the sufficient statistic—principal component—is a weighted average of the data where the weights are chosen optimally to give the largest importance to variables that have the most systematic movement. The PCA method is commonly used in the measurement of business cycles. Perhaps the most popular is the Chicago Fed National Activity Index (CFNAI) based on the work of Stock and Watson (*Journal of Monetary Economics*, 1999) which extracts a single latent common factor from 85 variables describing US economic activity.

An extension of PCA is to allow for the possibility that the principal component depends not only on the current set of data but also its own lag. In this case, PCA is expanded to dynamic factor analysis (DFA), a technique dating back to Sargent and Sims ("Business cycle modelling without pretending to have too much a priori economic theory," 1977), Geweke ("The dynamic factor analysis of economic time series," 1977), and Stock and Watson more recently ("A probability model of the coincident economic indicators," 1991). In this framework, the dynamic of individual variables is represented as the sum of a component which is common to all variables in the economy and an orthogonal idiosyncratic residual. To account for a broad range of potential dynamics, both the idiosyncratic components of each observed variable and the common factor are assumed to be influenced by lagged values as well as random noise (technically, they are first-order Gaussian-Markov stochastic processes). See the technical appendix for the detailed setup of the model used to construct the DFM-Eco index in this report.

All of these indicators individually track global GDP reasonably well

global GDP growth that have led us to use the indicators as key guides to tracking the cycle. On their own, each variable has a sizable beta to global real GDP growth. The largest global GDP beta is with respect to our global retail sales volume growth proxy. A 1%-point annualized increase in global retail sales growth (%3m, saar) suggests a 0.5%-point increase in global GDP growth. In general, the PMI impact is consistent with the result from the previous section. The larger beta for retail sales than for the PMIs should not be confused with their relative importance (relative importance is reflected by the much stronger correlation of the PMI to GDP than retail sales, not the beta). A 1%-point rise in global manufacturing growth (%3m saar) adds 0.3%-point to global GDP growth. Growth in capital goods shipments and auto sales has very small individual effects on global GDP growth, suggesting the moves carry a considerable amount of noise. Indeed, the univariate beta on global auto sales is statistically insignificant.

Introducing the DFM-Eco index

The univariate regressions of global GDP growth on each indicator suffer from two problems. First, as univariate relationships, they do not account for the joint variation in the other indicators. And second, because the relation with GDP growth is estimated in a direct regression, the indicators are converted to quarterly averages,

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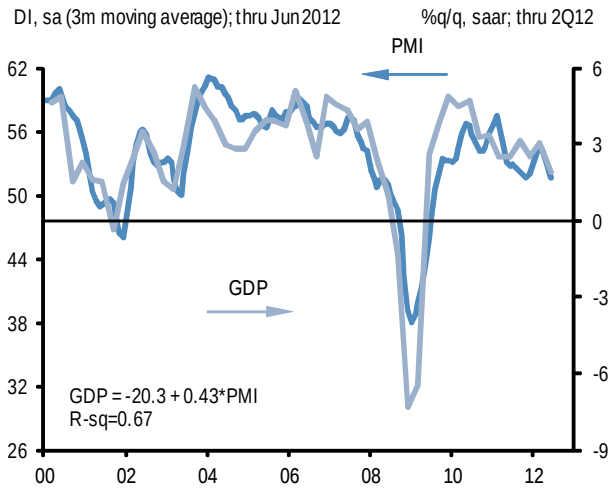
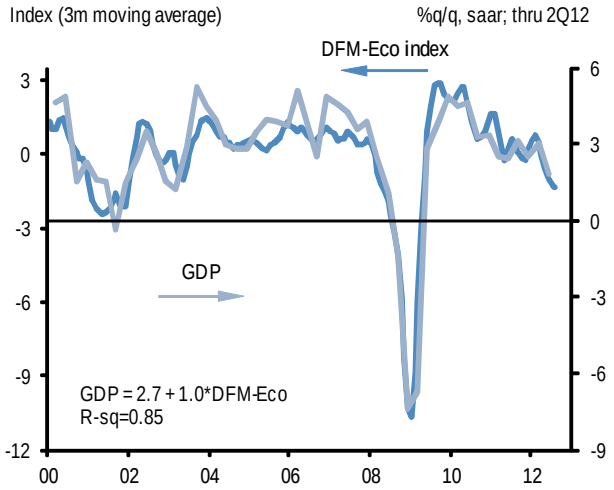
Global composite PMI and global real GDP



Global dynamic factor model and global real GDP



losing any information that may be available in the monthly moves. A more efficient use of the data that avoids these two problems is possible using Dynamic Factor Analysis. This approach extracts from the data a single time series that reflects the movement that is common across all the data at a given point in time. This time series is effectively a proxy for growth in global economic activity (see text box above). We use this methodology to construct the DFM-Eco index of global real GDP growth.

Optimally combining all our global aggregates into a single common factor yields the DFM-Eco index

The DFM-Eco index is a remarkably good tracker of global real GDP growth, particularly given that no information on actual GDP outcomes is used in the estimation process. To gauge its accuracy, quarterly global real GDP growth is regressed on the 3-month average of the DFM-Eco index. The factor explains 85% of the variation in global GDP growth from 1Q00 to 2Q12. This contrasts with our global PMI, which explains 67% of GDP growth. A simple graphical examination shows that the DFM-Eco index tracks economic activity noticeably better than the PMI. In particular, unlike the inability of the PMI to capture sharp breaks in economic growth—as noted above in the PMI section—the DFM-Eco index utilizes all our global aggregates to complement the PMIs. Outperformance of the DFM-Eco index is clear in 2004 when the PMI over-predicted growth, 2008-09 when the PMI failed to capture the depth of

Models of global real GDP growth

Regression of global real GDP growth (%q/q, saar), 2000q1 to 2012q2

	i	*ii*	*iii*	*iv*	*v*	*vi*	*vii*	*viii*	*ix*	*x*	*xi*	*xii*	*xiii*	*xiv*
Constant	0.8	-20.3	2.7	-4.8	2.0	-16.1	-4.5	1.2	-9.4	2.3	-2.2	1.2	-9.4	-2.2
	(1.2)	(-4.2)	(17.4)	(-2.1)	(3.8)	(-4.3)	(-2.0)	(3.1)	(-3.2)	(6.9)	(-0.8)	(3.2)	(-2.9)	(-0.7)
GDP, lagged	0.7							0.6	0.2	0.2	0.1	0.5	0.2	0.1
	(4.1)							(6.7)	(1.3)	(1.9)	(0.8)	(4.6)	(1.1)	(0.5)
PMI		0.43		0.14		0.34	0.13		0.22		0.09		0.22	0.09
		(4.8)		(3.3)		(5.0)	(3.2)		(3.5)		(1.7)		(3.3)	(1.5)
DFM-Eco index			1.0	0.8			0.8			0.8	0.6			0.7
			(16.5)	(17.5)			(10.9)			(6.6)	(5.2)			(5.2)
DFM-Cmd index					0.16	0.07	-0.01					0.03	0.00	0.00
					(3.7)	(2.5)	(-0.7)					(1.1)	(0.0)	(-0.2)
Excl. financial crisis	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.45	0.67	0.85	0.88	0.42	0.72	0.87	0.82	0.87	0.89	0.90	0.82	0.86	0.89
Standard error	1.78	1.39	0.93	0.85	1.84	1.28	0.86	1.01	0.88	0.78	0.77	1.02	0.90	0.78

Note. PMI is the average composite PMIs from the monthgs within a given quarter. DFM-Eco is the average of the index in the months of a given quarter (effectively a %3m change in activity over the quarter). The DFM-Cmd index is the %q/q change. PMI-only regressions differ slightly from results presented in preceeding section of this report owing to 2000q1 starting date compared to the 1998q3 starting date. Where indicated, the exclusion of the financial crisis adds dummy variables to the regression for the period 3Q08 through 4Q09.

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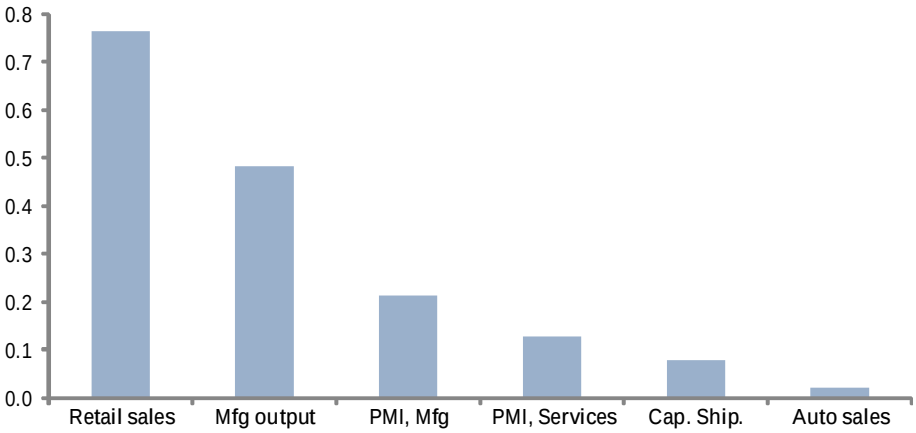
Impact of economic indicators on global GDP growth: The Kalman gain

%-pt, annualized (PMI's are 1-pt chg, all else are 1%-pt chg on m/m growth rate); kalman gain scaled by impact of factor on global GDP growth



the decline, and in 2009-10 when the PMI underpredicted the strength of the recovery. In all three cases, the DFM-Eco index fit the historical experience remarkably well. As with the individual PMIs alone, lags of global GDP growth do not generally improve the fit and are both statistically and economically insignificant.

The DFM-Eco index tracks global GDP growth considerably better than the PMI alone

The outperformance of the DFM-Eco index is by no means a mark against our global PMIs since the PMIs are included in the broader proxy. Rather, the DFM-Eco model is a quantitatively superior method for filtering all of the available global data, and so it is little surprise that—to the extent that the economic indicators are correlated with global GDP growth—the model is able to extract a global index that more effectively tracks global GDP growth. In this regard, a regression of global GDP growth on both our global composite PMI and the DFM-Eco index shows that, while the PMI remains statistically significant, the latter is considerably more significant both statistically and in terms of the magnitude of explained variation.

The outerformance of the DFM-Eco index reflects both more efficient use of the PMIs and the addition of new data

The impact of moves in the observed economic indicators on the global factor is estimated with the Kalman gain. Because the relationship between the DFM-Eco index and global GDP growth yields a beta of 1.0, the Kalman gain provides an estimate of the impact of each economic indicator on the monthly tracker of global GDP growth (annualized). Not surprisingly, the Kalman gain roughly resembles the betas from the univariate regressions reported on page 8. A 1%-point move up in retail sales volume growth (%m/m) leads to an 0.8-point move up in the DFM-Eco index and thus an equal sized move in global GDP growth. A 1%-point move up in the global factory output growth (%m/m) adds 0.5-point to the index. The index is less sensitive to the other indicators, with 1%-point monthly moves in G-3 capital goods shipments and global auto sales having essentially no impact on the global factor. Of course, as noted, these variables are more volatile and so large swings can still have a noticeable impact on the DFM-Eco index.

As with the univariate regressions, the Kalman gains should not be interpreted as measures of relative importance. Rather, they provide rules-of-thumb for gauging the impact on the model-based estimate of global GDP growth of moves in our global economic indicators. The concept of importance relates more to the standard error, a subject examined in more detail in the next section.

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Nowcasting global GDP growth

The usefulness of any economic indicator in tracking global GDP growth cannot be fully assessed by its historical fit but, rather, needs to be measured in a real-time environment. Given the usual lags in the reporting of data, the historical fit uses data that may not have been available at the time of the actual economic projection. It is in this real-time context that we evaluate the "nowcasting" ability of the PMI alone and the DFM-Eco index.

In real time as data become available in the quarter, the DFM-Eco index consistently generates a lower standard error than the PMI-only tracker

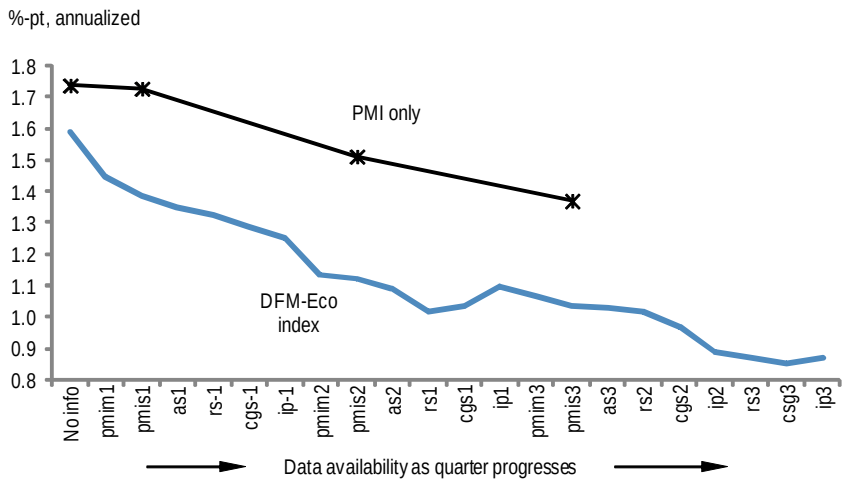
As noted above, the benefits of the J.P. Morgan global PMI owe as much to its timeliness as to its explanatory power of global GDP growth. The monthly global PMI is available in the first week of the month following the respective survey month. This makes it the earliest monthly global economic indicator released. To explore the real-time forecasting ability of the PMIs, we consider the current quarter forecasting error as each incremental monthly PMI is released. (See the text box for more details on the setup of the real-time forecasting exercise.)

The global composite PMI provides a steady improvement in forecasting ability in real-time over the course of the quarter. Prior to the quarter's first monthly PMI, the model using only lagged global GDP growth has a standard error of 1.7%-points annualized in forecasting current quarter GDP growth. The PMI in the first month is not able to provide much of an improvement but the standard error declines by about 20% to 1.4%-points with the addition of the PMI for the last month of the quarter.

While the PMI remains the single best indicator of global GDP growth, the DFM-Eco index has two advantages. First, it incorporates information from additional global economic indicators. Second, it utilizes the serial correlation in the data more efficiently than just taking simple averages of the PMIs in the current quarter. In this regard, the Kalman filter estimation and projection of the DFM-Eco index provides a natural real-time indicator. The addition of several economic indicators to the real time forecasting analysis, each of which becomes available at different times over the calendar and provides information on various lags in activity, makes the exercise more complicated. (See the text box for more details.)

The addition of new information over the quarter yields a marked improvement in the forecasting accuracy. At the start of the quarter, the standard error of the model

Standard error of global GDP forecast over data calendar



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The global data calendar in real time

Specifically, using the estimated PMI-to-GDP relationship, we compute the forecasting error based on three scenarios of data availability: 1) the PMI from the first month of the quarter, 2) the PMIs from the first and second months of the quarter, and 3) the PMIs from all three months of the quarter. In each case, the average of the available PMIs is treated as the average for the whole quarter when computing the GDP growth forecast. As a benchmark, the exercise begins by assuming no PMI information and that only global GDP growth from the prior quarter is available.

We also investigated the forecasting ability of the DFM-Eco index over the course of the data calendar. As with the real-time tracking using the PMI only, we consider the root-mean-squared error of the forecast of sequential quarterly real GDP growth over the course of each quarter from 1Q00 through 2Q12. At the start of the quarter, no information is available and so the DFM-Eco index is based solely on lagged information. Each monthly indicator has three observations within the quarter. However, because the quarter starts before fully knowing the data for the end of the previous quarter, this information is added to the tracking exercise (these data aid in the use of lagged information only as it becomes available).

Ordering the indicators according to their usual release-times during the quarter, we are able to compute a projection for the DFM-Eco index after the release of each new piece of information. All three months of the index are projected, and an average is computed to feed into the model with global GDP growth. In whole, the exercise provides 22 forecasts of global GDP growth for each quarter (one with no information at the start of the quarter, three forecasts as the data from the indicators for the end of the preceding quarter become available, and three forecasts for each of the six indicators in the three months of the quarter). The standard deviation of these errors over time for each of the 22 observations provides a standard error of the forecast using each respective information set.

Availability of data over a typical 1Q of a given year

	When available	Reference Month	Variable name
Eve of PMI report	n/a	n/a	No info
PMI manufacturing	Feb, week1	Jan	pmim1
PMI services	Feb, week1	Jan	pmis1
Auto sales volume	Feb, week2	Jan	as1
Retail sales	Feb, week2	Dec	rs-1
Capital goods shipments	Feb, week3	Dec	cgs-1
Manufacturing output	Feb, week3	Dec	ip-1
PMI manufacturing	Mar, week1	Feb	pmim2
PMI services	Mar, week1	Feb	pmis2
Auto sales	Mar, week2	Feb	as2
Retail sales	Mar, week2	Jan	rs1
Capital goods shipments	Mar, week3	Jan	cgs1
Manufacturing output	Mar, week3	Jan	ip1
PMI manufacturing	Apr, week1	Mar	pmim3
PMI services	Apr, week1	Mar	pmis3
Auto sales	Apr, week2	Mar	as3
Retail sales	Apr, week2	Feb	rs2
Capital goods shipments	Apr, week3	Feb	cgs2
Manufacturing output	Apr, week3	Feb	ip2
Retail sales	May, week2	Mar	rs3
Capital goods shipments	May, week3	Mar	csg3
Manufacturing output	May, week3	Mar	ip3

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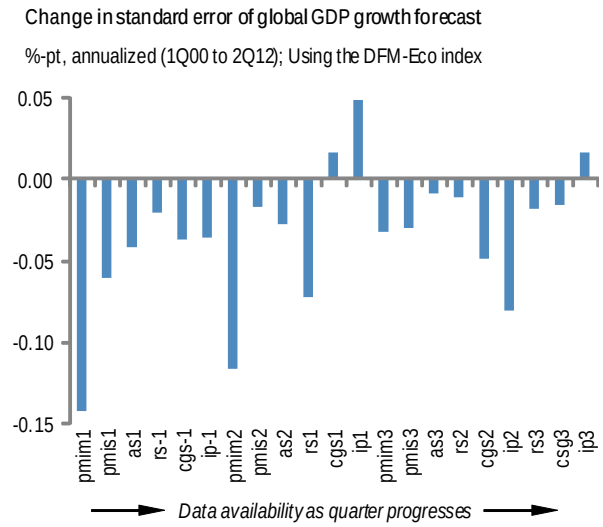

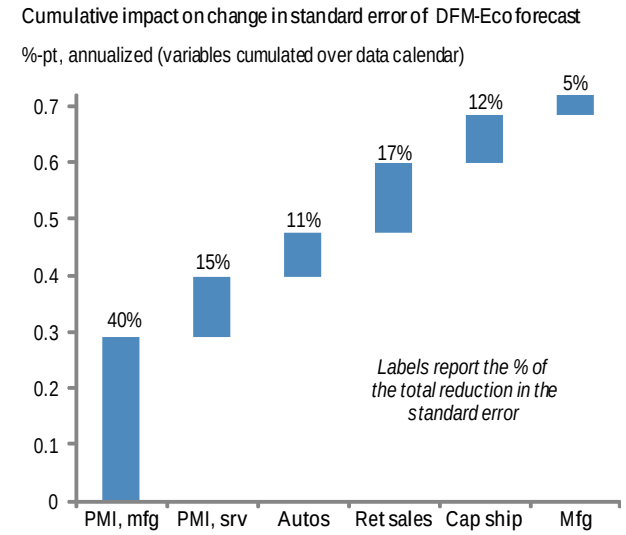

As new data become available over the quarter, the DFM-Eco index improves its forecasting accuracy by 45%

forecast based only on the lagged dynamics implicit in the DFM-Eco model is roughly 1.6%-points annualized. As data become available during the quarter, this standard error declines steadily, reaching 0.9%-point annualized by the time the reading on global manufacturing output growth in the last month of the quarter becomes available (usually about a month and a half after the quarter has already ended), a 45% reduction in the standard error. Because the DFM-Eco index utilizes all available economic information, the removal of the financial crisis does not lead to as large of an improvement as it does for the PMI-only model. In general, the DFM-Eco model is roughly as good as the PMI-only model during periods of "normal" activity, but is superior in picking up breaks in activity.

The domination of the PMI-only model largely reflects the more efficient use of the PMI data. Of the 0.72%-point decline in the standard error of the forecast, 55% owes to information from the PMIs. Specifically, 40% alone owes to the manufacturing PMI. Additional information from the services PMI contributes 15% of the improved accuracy. Beyond the PMIs, auto sales accounts for 11% of the increase in forecast accuracy, while retail sales and capital goods shipments data account for 17% and 12% of the improvement, respectively. Data covering manufacturing output account for only 5% if the improvement. This may seem odd given that factory output is so tightly correlated with GDP growth. However, the improvements reported here are the marginal improvements given all prior information for the quarter. Because the indicators are all largely correlated, the informational advantage accrues to the data that are released the earliest. This explains why the manufacturing PMI—the first release of the group in a given month—accounts for so much of the improvement in forecasting accuracy and why manufacturing output—the last release of the group in a given month—accounts for so little. A reordering of the timing of the releases would materially alter these contributions. In this sense, the relative contributions quantify the usefulness of the PMI's timeliness, especially the manufacturing PMI.

Real-time tracking global GDP growth with the DFM-Eco index

The DFM-Eco index provides an alternative top-down estimate of global real GDP growth to a bottom-up estimate based on the aggregation of our J.P. Morgan official country forecasts. Combined with the estimated standard errors discussed

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above, the DFM-Eco index relative to the official J.P. Morgan forecast highlights both the magnitude of risk and the degree of certainty around that risk. This is understood most easily by way of example. Consider the forecast for 1Q12. At the beginning of the quarter, the J.P. Morgan forecast was 2.6% annualized, roughly in line with the "no info" DFM-Eco index. However, the DFM-Eco index moved up sharply with the surge reported for December 2011 manufacturing output. The index steadily improved further as upbeat data continued to be reported early in the quarter. By late February, the DFM-Eco index was flagging considerable upside risk while the improved information set narrowed the confidence interval. At this point, the J.P. Morgan forecast began to be revised up. While some of the DFM-Eco index strength was trimmed with late-coming data, the model sent the appropriate signal that led to upward revisions to the J.P. Morgan forecasts.

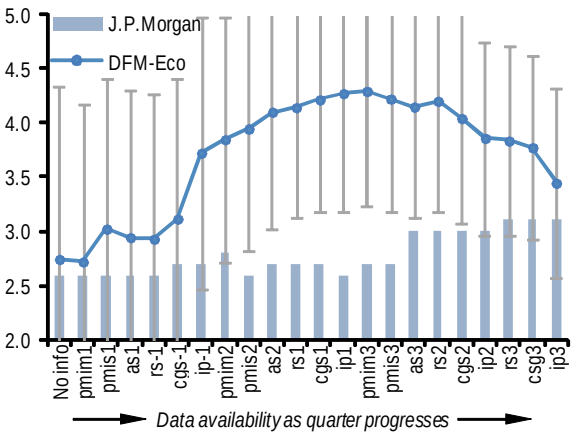
The DFM-Eco model can be used to gauge both the risk bias in our bottom-up forecast and the uncertainty around that risk bias

In contrast to 1Q12, the DFM-Eco index flagged upside risk to the J.P. Morgan forecast early in 2Q12. However, both the DFM-Eco index and the official forecast deteriorated as data became available. The DFM-Eco projection started the quarter at a relatively strong 3.5% annualized pace, well above the J.P. Morgan forecast at that time. The DFM-Eco index then slid in response to sharp declines in the April and May PMIs, along with a sharp deceleration in both manufacturing output and retail sales volumes. To a lesser degree, revisions to the J.P. Morgan forecast followed the slide in the DFM-Eco index. As of the June reading for global factory output (August 14, 2012), the DFM-Eco index and the J.P. Morgan forecast called for global real GDP growth to have expanded at a tepid pace of roughly 2% annualized.

The application of our new DFM-Eco index to the current quarter points to downside risk to the J.P. Morgan forecast. The bottom-up J.P. Morgan forecast is for global real GDP growth to remain at a weak 2% annualized in the current quarter. However, the weak trajectory of our monthly DFM-Eco coming into the quarter along with the most recent readings for the August PMIs points to a deceleration in activity to a very weak 1.3% annualized pace. It is still early in the quarter and so the confidence interval around the DFM-Eco nowcast is quite wide and includes the J.P. Morgan forecast. But until we see a more decisive turn up in our global economic indicators, the risk is biased to the downside.

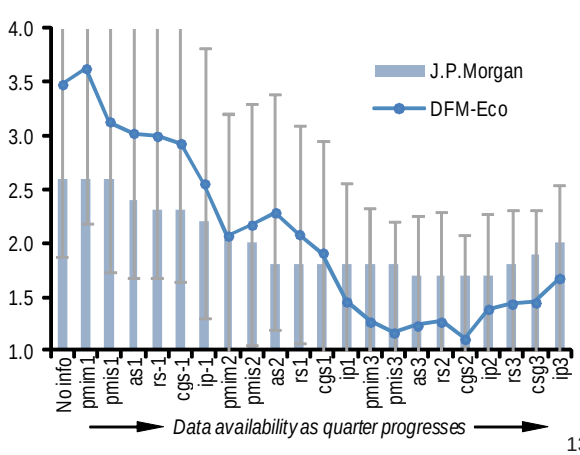
Nowcasting global real GDP, 1Q2012

%q/q, saar; Std error bars show std dev of errors from 1Q00 to 1Q12



Nowcasting global real GDP, 2Q2012

%q/q, saar; Std error bars show std dev of errors from 1Q00 to 1Q12



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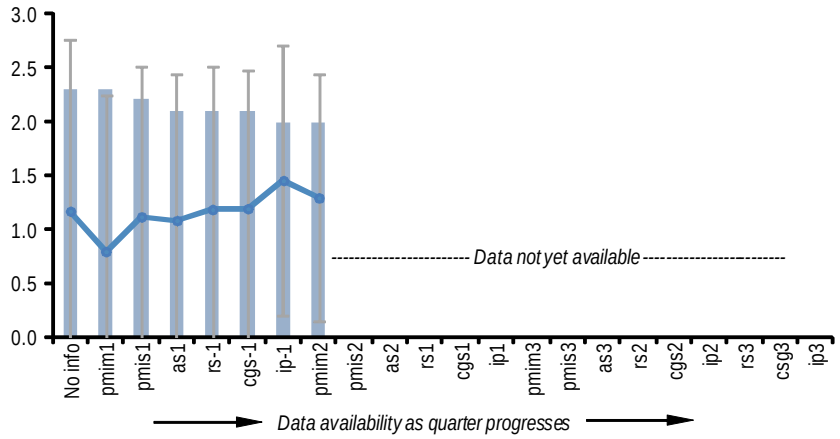
Nowcasting global real GDP, 3Q2012

%q/q, saar; Std error bars show std dev of model errors from 1Q00 to 1Q12



A weekly nowcast of global real GDP growth

If supply shifts are more idiosyncratic and demand shifts are more commonly shared, commodity price moves can be used to generate an indicator of economic activity

While most economic data are rarely available at frequencies higher than monthly, there are important indicators of activity at the weekly and even daily frequencies. Not surprisingly, these data come from financial markets. The most obvious choice in this space is commodity prices. In theory, the prices of commodities reflect the interaction of supply and demand. Separating supply-driven price moves from demand influences is not easy, making the simple estimation of the relationship between GDP growth and commodity price moves difficult to interpret. In past research, we have developed an equilibrium model of oil prices and global GDP growth to examine the hypothetical impact of supply shocks on economic activity (see "Modeling linkages between global GDP and oil prices," *Global Data Watch*, Feb 17, 2012). However, that exercise did not empirically differentiate supply from demand shocks. In this section, we explore a less parametric method of isolating the demand-side component of commodity price moves. In doing so, we develop a measure of global GDP growth that can be tracked at a weekly frequency. While this measure is understandably noisy, smoothed moves over lower frequencies are shown to track actual economic growth reasonably well, suggesting that the higher frequency moves contain some signal. The proxy is called the DFM-Cmd index (see the text box for details on the construction of this index).

A simple event analysis over the past two years shows the reasonableness of the results. Following an initial growth scare and the initiation of QE2 by the Fed, perceptions of the recovery improved into the end of 2010. Global manufacturing accelerated in 2H10 from a subpar 3.2% (3m, saar) pace in August to a robust 8% pace by December. Over this period, the common factor from the DFM model spiked, with the price of oil jumping nearly 20%. However, the manufacturing bounce proved short-lived, and the common factor began to subside in early 2011. However, the price of oil kept rising and spiked sharply in 1Q11. The DFM model attributes this spike entirely to factors idiosyncratic to the oil market. Not surprisingly, this was precisely the time of the Arab Spring. Over this same episode, agriculture prices began spiking owing to numerous weather-related factors in late 2010. The jump is attributed by the model to idiosyncratic moves. Similarly, the most recent spike in agriculture prices owing to drought conditions is viewed as

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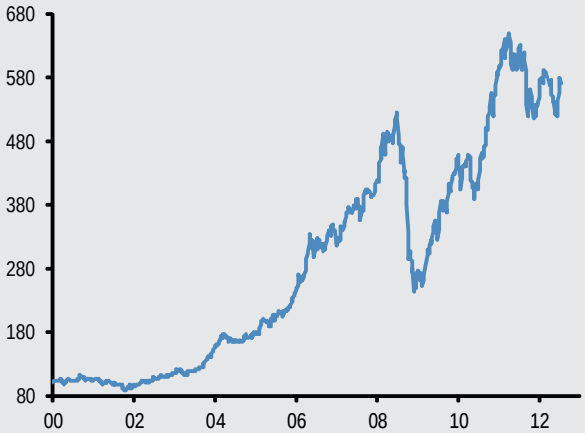
Commodity prices as an indicator of economic activity

The dynamic factor modeling technique applied to the DFM-Eco index has an intuitive interpretation that can be readily applied to movements in commodity prices. The technique seeks to extract a common movement from a set of data and thus decompose moves into those attributed to a common factor and those attributed to idiosyncratic factors. This decomposition can be applied to a complex of the commodity prices. Assuming that global GDP requires fixed inputs of production, then a rise in economic activity would lead to a common lift across commodities. By contrast, supply shocks tend be unique within particular commodities and so more likely represent idiosyncratic moves in prices. Although these supply shocks affect economic activity, this is only with a lag and so does not have any feedback on the measure of contemporaneous co-movement across commodity prices.

Using price changes in three broad commodity groups, we derive the commodity-based dynamic factor model (DFM-Cmd) index tracker for global GDP growth. These commodities groups include crude oil (as measured by Brent), industrial metals (as measured by the J.P. Morgan Commodity Curve Index for base metals), and agricultural goods (as measured by the J.P. Morgan Commodity Curve Index for farm goods). Using daily price data, we estimate the common and idiosyncratic moves in the 5-day percent changes from January 3, 2000, through August 3, 2012. The estimated factors are first converted to a daily index for presentation purposes. The level of the common factor generally tracks the broad contours of the level of global economic activity, with sharp exponential increases that peaked in early 2008 followed by a sharp decline and then gradual recovery with starts and stops aligning to the numerous growth disappointments seen since the start of the recovery. The estimated idiosyncratic moves in commodity prices also accord reasonably well with our understanding of the various supply shocks that have buffeted commodity markets over the past decade.

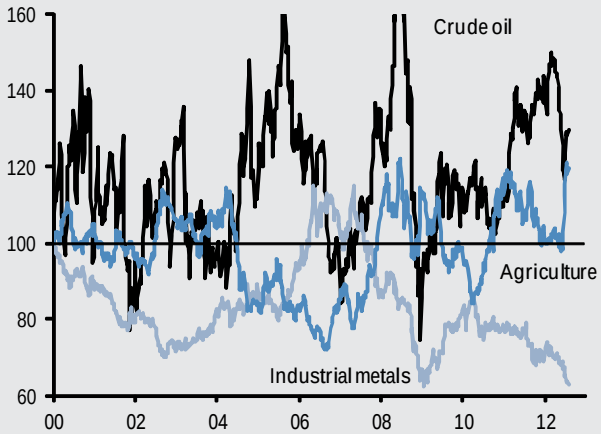
Common global commodity price factor, level

Index, 7 Jan 2000 = 100



Idiosyncratic component of commodity prices, level

Index, 7 Jan 2000 = 100



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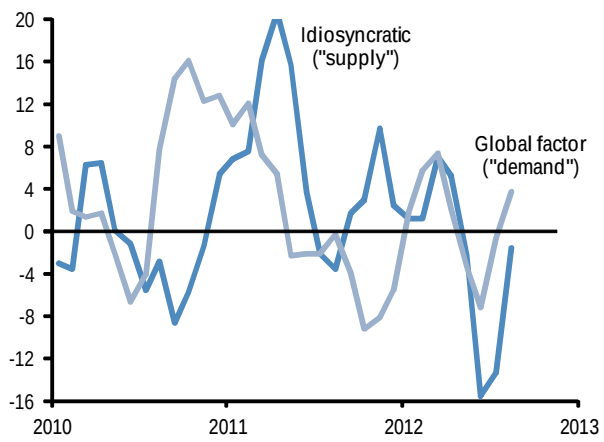
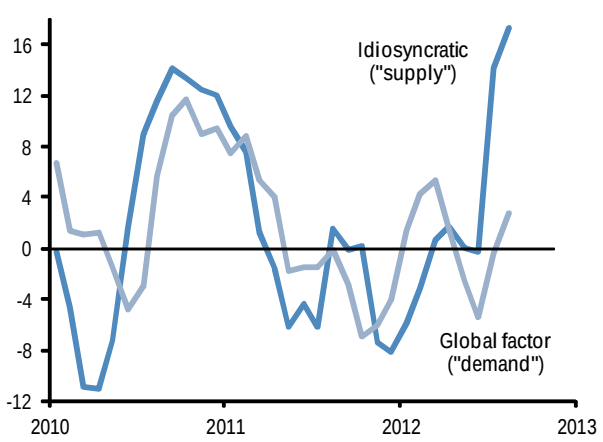
Crude oil price decomposition, Brent



Agriculture price decomposition, JPMCCI

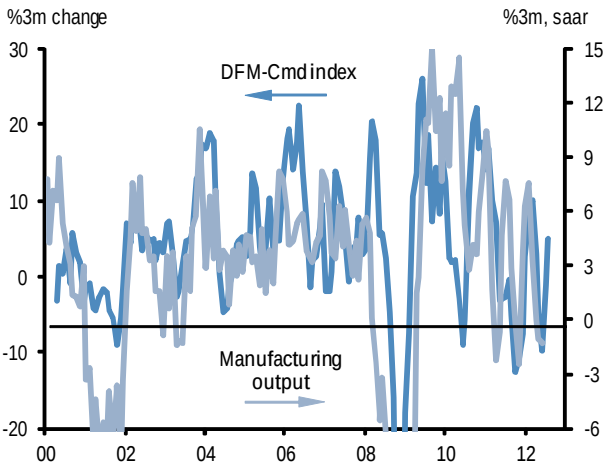


being generated by factors independent of the broader global cycle. Mechanically, the large move is not being shared by either oil or base metal prices, and so the model attributes the spike to the idiosyncratic component.

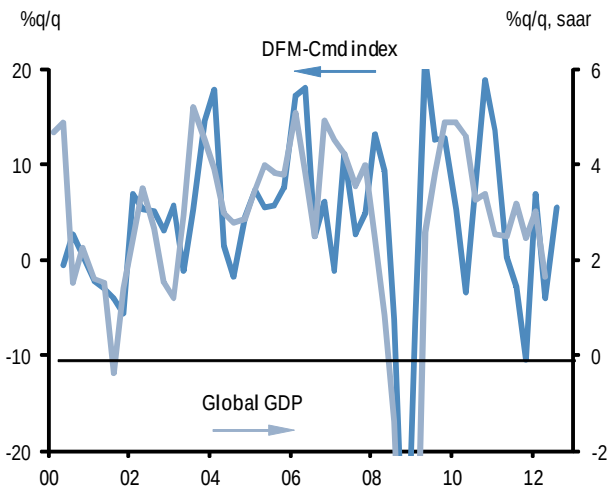
The DFM-Cmd index tracks global IP remarkably wel

The true test of the model is what it is able to convey regarding economic activity. In this regard, the results are impressive particularly given that the model only uses information on moves in commodity prices. The model produces a daily common factor that is interpreted as five-day percent changes in global economic activity. This DFM-Cmd index can be converted to lower frequencies to compare to our usual measures of global output. Given the important role commodities play in manufacturing, the DFM-Cmd index is first compared to our global industrial production. In terms of percent changes over three months, the DMF-Cmd index tracks global IP remarkably well as it only uses information on the movements of three commodity price aggregates. While noisier, there is a clear relationship with factory output growth, with the latest readings from the DFM-Cmd pointing to a pickup in the %3m change in global IP in July. Given the relatively tight relationship between global IP and global GDP, it is not surprising that the quarterly percent change in the DFM-Cmd also tracks the contours of global GDP growth reasonably well.

Common factor underlying commodity prices and global manufacturing



Common factor underlying commodity prices and global real GDP



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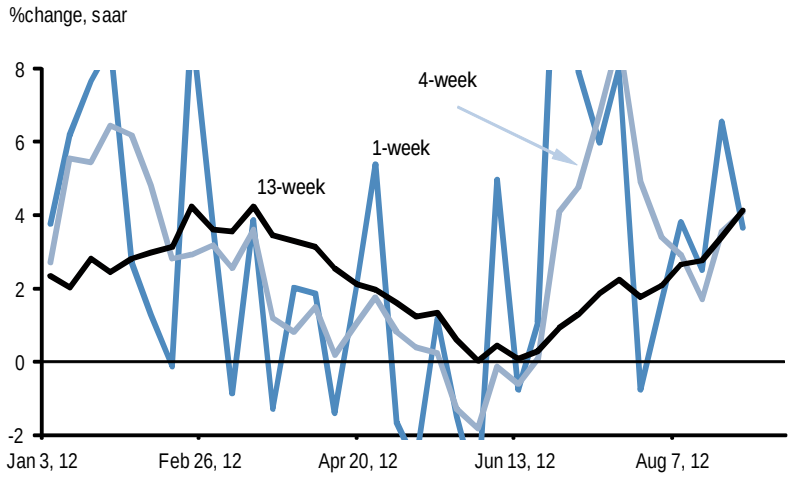
Weekly estimate of global real GDP based on common movements in commodity prices



The DFM-Cmd index tracks global GDP growth less well

More rigorous estimates of the relationship between the DFM-Cmd and actual activity are reported in the table on page 8. By comparison to the PMI and DFM-Eco index, the DFM-Cmd performs noticeably worse. While the former two indicators have standard forecast errors for sequential global GDP growth of 1.4%-points and 0.9%-point annualized, respectively, the DFM-Cmd index has a standard error of nearly 1.8%-points, no better than just knowing lagged GDP growth. Moreover, including either the PMI or the DFM-Eco index renders the DFM-Cmd index statistically insignificant.

But the usefulness of the DFM-Cmd index is that, on its own, it is statistically significant and incredibly timely. The index provides something no other economic gauge could come close to: a weekly indication of global GDP growth. To be sure, this weekly measure is noisy. But even the 4-week average of this indicator is much more timely and smooths out much of the weekly noise. At present through August 7, the DFM-Cmd weekly global GDP growth index is pointing to a notable deceleration in activity. But this comes on the heels of four very strong weeks. As such, the 4-week average is pointing to a pickup in global economic growth in late July. Indeed, the %3m change in the DFM-Cmd index is pointing to a solid acceleration in global factory output while the estimated current quarterly change is pointing to global GDP growth of roughly 3% annualized, just a touch below trend.

The power of the DFM-Cmd index comes from its timeliness, effectively provide a weekly measure of global IP or GDP growth

This upside risk assessment contrasts with the downside risk suggested by the DFM-Eco index based on data through June and the limited data available through July. To be sure, the DFM-Cmd index better captures the volatile swings in global IP, having tracked particularly well over the past few years. However, the upside risk signaled by the DFM-Cmd needs to be treated with caution given it is such a high frequency and parsimonious indicator. Agriculture prices are surely jumping up from drought in the US and weather disruptions in Asia, while oil prices have moved up on geopolitical concerns. The model may be incorrectly attributing too much to this common movement up as a reflection of demand. That the DFM-Cmd index is sending a very different signal from the latest move down in the August global manufacturing PMI underscores the tension. Further analysis will look to expand the set of commodities to try to better control for these problems.

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The DFM-Eco and DFM-Cmd indexes and future extensions

The analysis reported above suggests that a more rigorous treatment of the available global economic activity indicators provides a reasonable estimate of global GDP growth (and global manufacturing output growth) that can be used to both track global activity in real time and gauge the degree of risk embedded in our official J.P. Morgan bottom-up forecasts. This risk assessment can be undertaken several times a month as new monthly data become available. At even higher frequency, the DFM-Cmd index can be updated weekly, although some smoothing is required. We intend to provide regular updates of both the DFM-Eco and DFM-Cmd indexes in our regular publications.

We will regularly update and report the DFM-Eco and DFM-Cmd indexes in our future publications

There is still ample ground to be explored, and this will be undertaken in future research. Areas of particular interest include:

The indexes will continue to be fine-tuned and evolve in a number of areas

- **Country level information**. Our global aggregates are based on a weighted average of country data, where the weights reflect each country's nominal share in global GDP. While intuitive, an alternative weighting could provide better information in tracking the global cycle. Or perhaps, no weighting at all. The DFM technique can be used to explore the importance of particular country data. Indeed, the efficient consolidation of large amounts of data is one of the intents of the methodology. The most obvious benefit of using country data would be that it would allow for an earlier updating. Rather than wait for a critical mass of countries to report to form a global aggregate, the DFM-Eco index could be updated as soon as a particular country reports its data.
- **GDP data**. The DFM-Eco index does not incorporate any GDP data. While this provides a robust validation of the indexes usefulness, it ignores potentially useful information for tracking the global cycle. One could potentially introduce GDP by country to the DFM-Eco index as soon as it is reported. To be sure, GDP data are reported with a lag, but early reporters of GDP (US and China) could improve the forecasts of global GDP growth in the most recently ended quarter.
- **Forecasting**. The focus of this report has been purely on "nowcasting," the tracking of current-quarter global economic activity. A true "forecast" of the forthcoming quarter can also be considered. The DFM technique is not necessarily designed for forecasting but it is worth exploring whether a robust real-time indicator of economic activity provides a better gauge of economic activity in the immediate future. The goal will be to optimally and efficiently extract the leading information found in our current global economic indicators.
- **Expanding the commodity set**. As noted above, the relatively small set of commodities used in the DFM-Cmd index (oil, industrial metals, and agriculture aggregates) could be decomposed further. A more granular set of commodities would allow for a better construction of a true demand indicator.

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Appendix: the Dynamic Factor Model

Dynamic factor models have been widely used in econometrics to extract the common component (or factor) of various time series. One notable example has been developed by Stock and Watson (1991) to extract a coincident index from four economic variables. The DFM-Eco and DFM-Cmd models are based on this approach.

The common factor is easily obtained by applying a Kalman filter to the model, written in state space form. In the case of the DFM-Eco and DFM-Cmd, the state space form involves two steps.

A first equation, called the measurement equation, links the observed variables, y(i,t), to the unobserved common factor to be estimated, c(t), where *i* is the number of variables and *t* is the number of periods. Note that the common factor is the same across each observed variable:

$$y(i,t) = A(i)*c(t) + e(i,t)$$

The relationship between the common factor and the observed variables is given by the factors loading coefficient, A(i). The error terms, e(i,t), reflects idiosyncratic movements in the observed variable that is independent of the common factor. In the case of the DFM-Eco model, we have six measurement equations, where each observed variable is linked to the common factor to be estimated.

The second step describes the dynamics of the common factor and the residuals of the measurement equation. This is accomplished by setting the transition equations:

$$c(t) = B*c(t-1) + v(t) \qquad \text{where } v(t) \text{ is i.i.d } N(0,1)$$

$$e(i,t) = H(i)*e(i,t-1) + n(i,t) \qquad \text{where } n(i,t) \text{ is i.i.d } N(0,s(i))$$

In our setting, this means that both the common factor and the residuals of the measurement equation evolve as autoregressive processes.

Once the model is written in state space form, the Kalman filter is applied to obtain the common factor. The Kalman filter is a recursive process where, at each period, a guess is made about the relationship between the common component and the observed variables. When this guess is made, the predicted variables are compared to the observed variables and the subsequent guess is informed by any error made in the prior period.

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