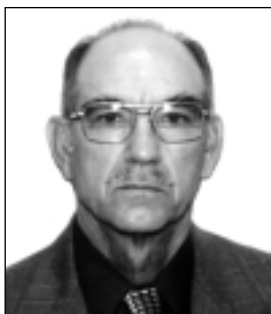


# *A Reassessment of the Purchasing Managers' Index*

*By Rolando F. Peláez*



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*Several recent papers have documented the effects of unexpected changes in the Purchasing Managers' Index (PMI) on domestic and overseas financial markets. Whereas other indices are re-weighted periodically to enhance their usefulness, the PMI remains a composite of five diffusion indices whose weights have not changed. This paper shows that the PMI is not optimally weighted, and develops a new index that is demonstrably superior to the PMI as an indicator of the growth rate of real GDP.*

**T**he Report on Business for manufacturing by the Institute for Supply Management (ISM), formerly the National Association of Purchasing Management (NAPM), is a highly significant indicator of economic activity (Niemira and Zukowski, 1998). The centerpiece of the report is the Purchasing Managers' Index (PMI), which has a history of inducing large swings in bond and equity prices upon its release at 10:00 AM EST on the first business day of each month. Out of twenty-four regularly scheduled announcements, Fleming and Remolona (1997) rank the ISM survey seventh in order of importance for trading activity in the Treasury bond market. Ederington and Lee (1993, 1996) also report a statistically significant effect of the ISM survey on interest rates in both the U.S. Treasury and Eurodollar markets. Other studies have analyzed various aspects of the relationship between the PMI and economic activity (see, e.g., Kauffman 1999, Harris 1991, Bretz 1990, Klein and Moore 1988, and Dasgupta and Lahiri 1992). To some extent, financial market reactions to unanticipated changes in the PMI stem from expectations that the Federal Reserve may change its policy stance. According to the "policy anticipations hypothesis," the Federal Reserve may change its target for the fed funds rate in response to macroeconomic news. The hypothesis argues that as the Fed's objectives change, so does the market's reaction to the arrival of unanticipated information, see, for example, Poole (1988) and Santomero (1991).

Given the PMI's importance, it is worth considering if a better index can be constructed using ISM diffusion

indices. This paper develops such an index. The new index outperforms the PMI as a predictor of the growth rate of real GDP. The plan of the work is as follows. The next section describes the PMI. This is followed by a comparison of the power of the PMI and of two alternative models to forecast the growth rate of real GDP. The discussion then turns to a new composite index of ISM indices. The final section concludes.

### The Purchasing Managers' Index

In 1931 the NAPM began to survey its members and to compute diffusion indices of various measures of economic activity for the manufacturing sector. The respondents answer questions that compare activity in the current month to the previous month. Responses are limited to better, worse, or unchanged. Adding the percentage reporting better and one-half of the percentage reporting unchanged, yields a diffusion index ranging from zero to 100 percent. Each index is seasonally adjusted individually, and the adjusted components then form the PMI. An increase in the PMI, say, from 60 to 70 indicates that an expansion is more widespread, but does not imply a proportionate acceleration in GDP growth.

In 1980, Theodore Torda, a senior economist with the U.S. Department of Commerce, introduced the PMI as an equally weighted index of five seasonally adjusted diffusion indices: new orders, production, employment, supplier deliveries, and inventories. In 1982, the Department of Commerce and the NAPM introduced a re-weighted PMI (Bretz, 1990). Torda selected the weights so as to maximize the correlation of the PMI with GDP growth (Torda, 1985). Unlike other indices that are re-weighted periodically to enhance their usefulness, the components' weights have remained fixed since 1982. Torda's PMI is,

$$(1) \text{PMI}_t = 0.3(\text{NOI}_t) + 0.25(\text{PI}_t) + 0.2(\text{EMI}_t) + 0.15(\text{SD}_t) + 0.1(\text{INV}_t),$$

where, NOI = new orders, PI = production, EMI = employment, SD = supplier deliveries, and INV = inventories, with all variables being expressed as diffusion indices.

The PMI provides the earliest indication of the strength of economic activity. Other monthly indicators released subsequently are subject to revisions that cloud their initial informational value. For example, the PMI precedes the advance release of GDP by one month and the final release by three months. It also precedes by three weeks the release of the Conference Board's composite coincident index, which initially reflects only three of four components: industrial production, nonfarm employment, and personal income less transfer payments. The fourth

component, manufacturing and trade sales, is unavailable for another two weeks. Moreover, all of the components undergo revisions in the subsequent two months. In contrast, the PMI itself is not revised, but the U.S. Department of Commerce revises the seasonal adjustment factors in January of each year.

Considering the scale of structural change in the economy over the last two decades, the fixed weight PMI has exhibited remarkable longevity. Economists have long known that sporadic breaks in parameters give rise to subsets of a sample with different parameter values (Keynes, 1921). A large body of recent literature confirms that the dynamics of many economic time-series shift unexpectedly. For example, Stock and Watson (1996) report that structural instability characterizes the behavior of seventy-six macroeconomic time-series. As a result, innovative econometric methods have been developed for dealing with structural breaks, for example, Hamilton's (1989) Markov switching model. Given that many of the empirical regularities depicting the complex of relationships in economic models have changed over the last two decades, it is worth considering if an improvement to the PMI can be found, in the light of an additional two decades of data.

### Alternative Models

This section compares the predictive value of the PMI to that of an unconstrained version of the PMI and a parsimonious model of three ISM indices. All diffusion indices are from the ISM's Report on Business for manufacturing. The seasonally adjusted monthly indices were compacted into quarterly observations by averaging GDP, seasonally adjusted, in chained (1996) dollars is from the U.S. Department of Commerce, Bureau of Economic Analysis.

The models are,

$$(2) G_t = \alpha_0 + \alpha_1 \text{PMI}_t + e_t,$$

$$(3) G_t = \alpha_0 + \alpha_1 \text{NOI}_t + \alpha_2 \text{PI}_t + \alpha_3 \text{EMI}_t + \alpha_4 \text{INV}_t + \alpha_5 \text{SD}_t + v_t,$$

$$(4) G_t = \alpha_0 + \alpha_1 \text{NOI}_t + \alpha_2 \text{EMI}_t + \alpha_3 \text{SD}_t + e_t,$$

Equation 2, regresses the quarterly growth rate of real GDP ( $G_t$ ) on the PMI. Equation 3 includes the five components of the PMI, but without a *priori* restrictions on their weights, that is, the model allows for time-varying coefficients and weights. This model outperforms Equation 2, confirming that the PMI is inefficiently weighted. Equation 4 consists of only the new orders, employment, and supplier deliveries indices.

Table 1 shows estimation results and tests of model adequacy for the period 1950:1—2003:1. Equation 2 is inferior to its rivals judging by the adjusted R-squared. The Schwarz criterion (SC) is a procedure for selecting

TABLE 1			
ESTIMATION RESULTS AND TESTS OF MODEL ADEQUACY			
	Models		
	Equation 2	Equation 3	Equation 4
<b>Regressors</b>			
PMI <sub>t</sub>	0.36 (12.8)		
PI <sub>t</sub>		0.29 (2.4)	
NOI <sub>t</sub>		0.05 (0.5)	0.26(6.8)
EMI <sub>t</sub>		0.13 (2.0)	0.20 (4.5)
INV <sub>t</sub>			-0.06 (-1.3)
SD <sub>t</sub>		-0.03 (-1.2)	-0.06(-2.9)
Constant	-15.6 (-10.4)	-17.2 (-10.6)	17.6 (-12.3)
Adj. R <sup>2</sup>	0.43	0.52	0.51
DW	1.78	2.06	2.20
SC <sup>a</sup>	2.26	2.17	2.16
AR 1-4 <sup>b</sup>	0.88[0.48]	0.38[0.82]	1.12[0.35]
ARCH 1-4 <sup>c</sup>	2.36[0.05]	0.21[0.93]	0.30[0.89]
Hetero test <sup>d</sup>	1.03[0.36]	0.63[0.79]	0.27[0.98]
Normality <sup>e</sup>	11.3[0.004]	11.5[0.003]	11.7[0.003]
Chow <sup>f</sup>	0.43[1.00]	0.70[0.96]	0.62[0.99]

<sup>a</sup>Schwarz (1978) Information Criterion.  
<sup>b</sup>Breusch (1978) and Godfrey (1978) F-test for serial correlation of residuals.  
<sup>c</sup>Engle's (1982) ARCH test (F-stat.) for autoregressive conditional heteroscedasticity of residuals.  
<sup>d</sup>White's (1980) test (F-stat.) for heteroscedasticity of residuals.  
<sup>e</sup>Doornik-Hansen (1994) Chi-squared test for normality of residuals.  
<sup>f</sup>Chow's (1960) forecast test (F-stat.). Split sample at 1976:3.

OLS estimation results for 1950:1 – 2003:1 The regressand, Gt, is the annualized growth rate of real GDP (t-statistics in parentheses, and P-values in brackets). T = 213.

TABLE 2						
CORRELATION MATRIX OF THE PMI'S COMPONENTS AND GDP GROWTH, (G) 1950:1—2003:1						
	PI	NOI	EMI	INV	VP	G
PI	1					
NOI	0.95	1				
EMI	0.85	0.76	1			
INV	0.58	0.53	0.75	1		
VP	0.59	0.60	0.69	0.73	1	
G	0.72	0.68	0.63	0.37	0.37	1

undominated parsimonious models. Since a low value is preferred, both equations 3 and 4 are preferred to equation 2. It is worth noting that only two components of the PMI (PI and EMI) enter equation 3 significantly. This is not surprising given the high degree of collinearity among the PMI's components. The pair-wise correlation coefficients in Table 2 show that some components are more strongly correlated with each other than with the growth rate of GDP. In fact, PI and NOI are almost perfect substitutes for each other. For all models, tests of the residuals reveal the absence of serial correlation, heteroscedasticity, and autoregressive conditional heteroscedasticity (ARCH). However, consistent with the presence of outliers, the Doornik-Hansen (1994) chi-squared test rejects the null of normality.

### Out-of-Sample Forecasts of Real GDP Growth Rates

Ex ante one-quarter-ahead forecasts were obtained by recursively sampling a moving window of seventy quarters. Each model was first estimated sampling 1948:3—1965:4, and forecasts for 1966:1 were obtained. The models were then re-estimated sampling 1948:4—1966:1 in order to obtain out-of-sample forecasts for 1966:2. At each step, the sample adds one more recent observation while discarding the most distant observation. This flexible procedure is motivated by the desire to allow the parameters to vary in response to structural changes and is also an attempt to confront a potential problem concerning supplier deliveries.

Supplier deliveries (SD), or vendor performance, is the sum of the percentage of respondents reporting slower deliveries and one-half of the percentage reporting *unchanged*. An increase in this index implies rising backlogs due to a more rapidly growing economy. As reported by the ISM, this series stretches back to January 1948, yet it consists of two series from different sources spliced together. The first segment from 1948 through 1970 is from the Purchasing Management Association of Chicago, while the segment since 1971 is from the ISM (Kauffman, 1999). Equation 1 shows that SD enters the PMI with a fixed weight of 0.15. However, in an unconstrained recursive regression framework, as in Equation 3, its coefficient is highly variable and ranges over positive and negative values. To some extent, parameter instability may be due to the splicing of two series; one with a regional focus and the other with a national focus. Attempting to mitigate this problem, the estimation used a seventy-quarter moving window of data, thus gradually phasing-out the earlier data set.

## Forecast Accuracy

The three most commonly used measures of forecast accuracy are mean squared forecast error (MSFE), mean absolute error (MAE), and Theil's inequality coefficient. Low values are preferred; indeed, all three measures are zero if forecasts are perfect. Formally, let  $F_2$ ,  $F_3$ , and  $F_4$  denote the one-step-ahead forecasts obtained with equations 2, 3 and 4, respectively. Table 3 shows that  $F_3$  and  $F_4$  outperform  $F_2$  according to all three measures. However, it is important to test if the difference in MSFE is statistically significant. Granger and Newbold (1977) point out that if the forecast errors from one model are correlated with those from another, the usual variance ratio or  $F$  test is inappropriate for this task. They develop a test of one-step-ahead forecasts that is valid given unbiased forecasts and absence of autocorrelated forecast errors. Their test is similar to a test proposed by Morgan (1939).

TABLE 3

### FORECAST ACCURACY

This table shows forecast statistics for one-step-ahead forecasts  $F_2$ ,  $F_3$ , and  $F_4$ , obtained with equations 2, 3 and 4, respectively. The forecast period is 1966:1 through 2003:1.

Statistic	$F_2$	$F_3$	$F_4$
Number of forecasts	149	149	149
MFE	-0.07	0.09	0.13
P-value for forecast bias	0.78	0.67	0.52
MAFE	2.16	1.94	1.97
MSFE	8.26	6.35	6.39
RMSFE	2.87	2.52	2.53
Theil's U	0.70	0.61	0.62
Jarque-Bera normality test	13.5	20.5	18.5
P-value for error normality	0.001	0.00003	0.0009

MFE and MAFE are the mean forecast error and the mean absolute forecast error, respectively. MSFE is the mean-squared forecast error, and RMSFE is the square root of the mean squared forecast error. Theil's U statistic, or inequality coefficient, assesses predictive accuracy relative to a naïve no-change model. It is unitary when the MSFE equals the mean square error of naïve no-change forecasts, and it is less than 1.0 if predictions are more accurate than no-change extrapolations. P-values are the significance levels of test statistics (i.e., the probability of getting a number at least as large under the zero null). The Jarque-Bera (1980) statistic tests for normality of the forecast errors.

The first step is to determine if there is systematic

bias in a forecast, that is if the MFE differs significantly from zero. This is carried out by regressing the forecast error on a constant and using the t-test to determine if the estimated constant (i.e., the MFE), differs significantly from zero. The test results (P-values for forecast bias) shown in Table 3 indicate that all three forecasts are unbiased.

Now, let two competing models produce forecast errors  $e_{1t}$  and  $e_{2t}$ . The Granger-Newbold test of equal forecast accuracy is based on the following orthogonalization,

$$(5) X_t = e_{1t} + e_{2t},$$

$$(6) Z_t = e_{1t} - e_{2t}.$$

The two forecast error variances, and hence the two expected squared forecast errors, will be equal only if the covariance between  $X_t$  and  $Z_t$  is zero,

$$(7) E[(e_{1t} + e_{2t})(e_{1t} - e_{2t})] = \sigma_1^2 - \sigma_2^2.$$

Harvey, Leybourne, and Newbold (1997) set up the Granger-Newbold test in the form of the following regression,

$$(8) X_t = \beta Z_t + \varepsilon_t.$$

Under the null of equal MSFE,  $X_t$  and  $Z_t$  are uncorrelated, i.e., the estimated  $\beta$  equals zero. The test results shown in Table 4 reject the null of equal MSFE for  $F_2$  and  $F_3$ , and for  $F_2$  and  $F_4$ , but not for  $F_3$  and  $F_4$ . Therefore, while the PMI-based  $F_2$  is demonstrably inferior to its rivals, the difference in MSFE between  $F_3$  and  $F_4$  is not significant.

TABLE 4

### RESULTS OF TESTING FOR EQUAL MSFE

The test statistic is the t-ratio of the regression coefficient in equation (8).

Forecasts	Test Statistic	Probability Value
F2 and F3	2.80	0.006
F2 and F4	2.95	0.004
F3 and F4	-0.24	0.81

## Forecast Encompassing

Forecast encompassing tests are important for evaluating competing models. Forecast encompassing is equivalent to the concept of conditional efficiency of Granger and Newbold (1973). A forecast is conditionally efficient

if combining it with a rival forecast does not yield a smaller forecast error variance than that of the original forecast alone. Denote the respective forecast errors  $e_2$ ,  $e_3$ , and  $e_4$ ,

$$(9) e_{2t} = G_t - F_{2t},$$

$$(10) e_{2t} = G_t - F_{3t},$$

$$(11) e_{2t} = G_t - F_{4t}.$$

If the difference between  $F_3$  and  $F_2$  explains a portion of  $e_2$ , then equation 2 can be improved by incorporating some features from equation 3. Equivalently, combining  $F_2$  and  $F_3$  will yield a better forecast than either  $F_2$  or  $F_3$  individually. These tests are part of a progressive research strategy designed to find a model that dominates its rivals (Clements and Hendry, 1998). Under the null,  $F_3$  does not encompass  $F_2$ . The null is rejected, that is,  $F_3$  encompasses  $F_2$  if in equation (12)  $\alpha$  differs significantly from zero,

$$(12) e_{2t} = \alpha (F_{3t} - F_{2t}) + vt.$$

TABLE 5

FORECAST ENCOMPASSING TESTS,  
1966:1 - 2003:1

Test	t-statistic	P. value*
$F_2$ encompasses $F_3$	1.21	0.23
$F_2$ encompasses $F_4$	0.70	0.48
$F_3$ encompasses $F_2$	6.81	0.00
$F_4$ encompasses $F_2$	6.61	0.00
$F_3$ encompasses $F_4$	1.40	0.16
$F_4$ encompasses $F_3$	0.91	0.36

\*P-values are the significance levels of test statistics (i.e., the probability of getting a number at least as large under the non-encompassing null hypothesis).

The results of forecast encompassing tests in Table 5 show that the PMI-based forecast,  $F_2$ , does not encompass  $F_3$  or  $F_4$ . However,  $F_3$  encompasses  $F_2$  leading to the inescapable conclusion that the PMI is inefficiently weighted, since the only difference between the information sets in equations 2 and 3 is in the components' weights.  $F_4$  also encompasses  $F_2$ ; therefore, both equations 3 and 4 dominate equation 2. Finally,  $F_3$  (forecasts from the unconstrained model) do not encompass  $F_4$ . Therefore, the inventories and production indices have no informational value in the presence of new orders, employment, and supplier deliveries, again underscoring the inefficiency of the PMI.

### A New Index

This section proposes a new index as an alternative to the PMI. The index consists of new orders, employment, and supplier deliveries and is designated as NES. Unlike the PMI, it is characterized by variable weights. Coefficients were obtained with rolling regressions estimated over a seventy-quarter moving window. The coefficients reflect only information available up to each point  $t$ . The sum of the recursive coefficients is  $S_t$ ,

$$(13) S_t = \alpha_{1t} + \alpha_{2t} + \alpha_{3t},$$

where the  $\alpha$ 's are the regression coefficients of equation (4).

Unlike the fixed-weighted PMI, the components' weights now evolve over time with the evolving recursive coefficients,

$$(14) WNOI_t = \frac{\alpha_{1t}}{S_t}$$

$$(15) WEMI_t = \frac{\alpha_{2t}}{S_t}$$

$$(16) WSD_t = \frac{\alpha_{3t}}{S_t}$$

In the proposed index the components' weights are lagged one quarter, so that at each point they reflect only past information,

FIGURE 1

NES AND PMI 1966:1 - 2003:1

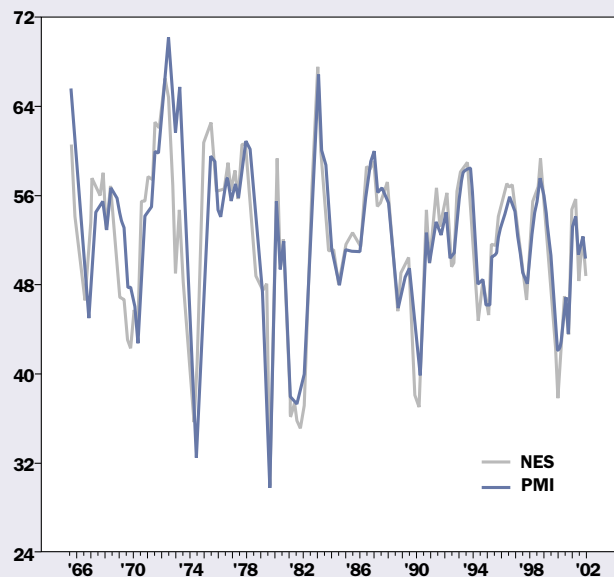


TABLE 6

REGRESSIONS OF THE GROWTH RATE OF GDP (GT), ON THE PMI AND ON THE CONSTANT-WEIGHTED NES, (t-statistics in parentheses).

	Adj. R <sup>2</sup>	DW	Sample Period
(6.1) $G_t = -15.2 + 0.35PMI_t$ (-10.5) (12.9)	0.43	1.91	1948:1—2003:1
(6.2) $G_t = -17.3 + 0.39NES_t$ (-12.5) (15.0)	0.50	2.11	1948:1—2003:1
(6.3) $G_t = -13.1 + 0.31PMI_t$ (-7.3) (9.0)	0.35	1.90	1966:1—2003:1
(6.4) $G_t = -15.3 + 0.35NES_t$ (-10.1) (12.2)	0.50	2.39	1966:1—2003:1

$$(17) NES_t = WNOI_{t-1} \times NOI_t + WEMI_{t-1} \times EMI_t + WSD_{t-1} \times SD_t.$$

Figure 1 plots the NES and the PMI (dotted line). For the sample period 1966:1—2003:1, the NES leads the PMI by one quarter or more at nearly every turning point.

Equation 17 is characterized by variable weights, but a simpler version with constant weights also outperforms the PMI. Constant weights may be obtained from regression coefficients, or simply by averaging the variable weights obtained for the period 1966:1—2003:1,

$$(18) NES_t = 0.8(NOI_t) + 0.43(EMI_t) - 0.23(SD_t).$$

The regressions in Table 6 show that a constant-weighted version of the NES also outperforms the PMI as a measure of economic activity over the extended sample period 1948:1—2003:1, as well as over the more recent 1966:1—2003:1.

## Conclusions

Theodore Torda's ingenious creation, the PMI, has enjoyed remarkable longevity as an indicator of economic activity, notwithstanding the declining importance of the manufacturing sector. While several studies have documented the effects on financial markets of unexpected changes in the PMI, the literature has ignored whether the PMI is optimally weighted. The evidence in this paper shows that it is not. Specifically, in the presence of the new orders, employment and supplier deliveries indices, the production and inventories indices contribute nothing to the explanation of GDP growth. The new composite index proposed in this paper has greater informational value than the PMI. Given the importance of the PMI for market participants, an

index that is as timely as the PMI and that provides a more accurate picture of the economy should be well received.

## ACKNOWLEDGEMENTS

The author acknowledges useful comments by Ralph Kauffman and by two anonymous referees.

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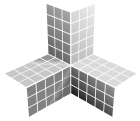
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