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Abstract

In this study, we try to uncover the information capacity of the Purchasing Managers Index (PMI) as a leading indicator of GDP growth of euro area. Our results show that PMI carries a significant amount of information that can be used to forecast the growth rate in the current as well as subsequent quarters. In particular, having verified that a PMI level around 50 works as the threshold distinguishing between positive and negative rates of GDP growth, we establish a sequence of other PMI thresholds to signify certain levels of GDP growth. Our estimation strategy reveals asymmetric responses of GDP growth to unit changes in PMI before and after the estimated threshold levels.

Keywords: Purchasing Managers Index, Leading Indicators, Thresholds.

JEL Classification: C24, C51, E27.

1. Introduction

Gross domestic product (GDP) is by far the most important macroeconomic variable as it summarizes all activities in the economy. Moreover, it directly affects the monetary and fiscal policy decisions of authorities as well as the behaviors of all other agents. However, the frequency of and tardiness in its measurement make it difficult for policymakers and other agents to take the best decision on time. Therefore, it is a critical task to generate proper and early enough forecasts of GDP.

Commensurate with its importance, there are several studies in the literature that takes upon this task and uses alternative techniques and ingredients to obtain the best estimate. Among these studies, a strand of the literature suggests that leading indicators are very useful in forecasting GDP growth in alternative economies. As put forward by Harris (1991), most of the studies in the literature show that although any of the leading indicators cannot serve as the only predictor of GDP growth, they might carry some useful incremental information while producing predictions of it.[1]

Table 1. Descriptive Statistics

	GDP growth rate	PMI_6	PMI_3
Mean	0.3119	52.7524	52.7402
Median	0.3820	52.9367	52.9261
Maximum	1.2335	60.5890	61.3036
Minimum	-2.8985	39.2499	37.8501
Standard deviation	0.6305	4.3844	4.5425
Skewness	-2.3619	-0.6815	-0.7362
Kurtosis	12.2910	3.7384	3.9611
Jarque-Bera	307.8082	6.8098	8.7601
p(Jarque-Bera)	0.0000	0.0332	0.0125
Sum	21.21	3587.16	3586.33
Sum of squared deviations	26.63	1287.99	1382.55
Number of observations	68	68	68

There is a large number of variables in the set of leading indicators where PMI is in the top quantile among these variables. There are strong advantages of using PMI while forecasting (or nowcasting) GDP growth. First, it is released (mostly) on the first week of the corresponding month, availing in advance of many economic indicators including GDP. Second, as the PMI questionnaire is sent to actively working executives, the index reflects business conditions instead of confidence-based measurements. Finally, in some countries, the index can be broken up to sectoral subcomponents, enriching its information content. All in all, PMI can serve as a strong candidate to provide information for GDP growth forecasts.

[1] See Banerjee *et al.* (2003) and the references therein for further discussion on this issue.

The literature contains several studies that empirically test the indicator power of PMI on GDP growth. While Koenig (2002) shows that PMI level above a certain threshold indicates a positive growth in GDP in the US, D'Agostino and Schnatz (2012) and Lahiri and Monokroussos (2013) report that marginal contribution of PMI in predicting GDP growth is pretty high. Similar results are also reported in Vermeulen (2012) for euro area and Akkoyun and Gunay (2012) and Eren (2014) for Turkey.

In this study, we empirically examine the predictive power of PMI on GDP growth in euro area. The reason behind the choice of euro area as the case study is that it is one of the largest economies in the world and having a reliable prediction of its GDP growth is critical for particularly the area's trading partners, such as Turkey.

Table 2. Results for Augmented Dickey-Fuller Unit Root Test

	Specification	Lag	t-stat	p(t-stat)
GDP growth rate	C	11	-3.832	0.004
PMI_6	C	10	-3.983	0.003
	C+T	10	-4.350	0.005
Δ(PMI_6)	C	10	-4.183	0.002
	C+T	10	-4.265	0.007
PMI_3	C	10	-3.886	0.004
	C+T	10	-4.124	0.009
Δ(PMI_3)	C	10	-5.126	0.000
	C+T	10	-5.085	0.000

Note 1: Null hypothesis is unit root for ADF test.
Note 2: A modified AIC is used for lag selection.
Note 3: C and T respectively denote inclusion of an intercept and linear trend term in the test equation.
Note 4: Δ stands for the difference operator.

As discussed by Eren (2014) sometimes information on the direction of the economy is as important as information on the comparison of the growth rate with a certain threshold. For instance, while investment decisions might change depending whether the growth rate is positive or negative, the monetary policy authority's decision on interest rate somewhat depends on the actual level of growth rate. Therefore, we employ the methodology proposed by Harris (1991) and Koenig (2002), which enables us to make both qualitative and quantitative evaluations simultaneously. In particular, we make an empirical search for uncovering the predictive power of PMI on GDP growth for alternative, i.e. positive and negative, growth regions.

2. Data

Our data set spans the period between 1998:Q3 and 2015:Q4. As for the GDP growth, we calculate quarterly growth rate of seasonally adjusted GDP of euro area. Monthly composite PMI series for euro area is collected from Bloomberg. To match the frequency of GDP, we

convert PMI series into quarterly frequency using two different ways. In the main case, we take the average of the PMI values across the last two quarters, which is named as PMI_6. In the second case, which we consider as a robustness check of our results, we take the average of the values in the last three months. The second series is labeled as PMI_3.

A summary of the descriptive statistics regarding the data used in the estimations are provided in Table 1. Before estimating the models, we apply standard unit root tests to the series and report the results in Table 2. The Augmented Dickey-Fuller unit root tests show that we can reject all the null hypotheses of unit root at 1%.

3. Model Specifications and Results

To examine the predictive power of PMI on GDP growth in euro area, we estimate a series of specifications starting with a pre-defined threshold, by employing slightly modified versions of the specification due to Koenig (2002). The results for all specifications are provided in Table 3.

At this point, it is worth to mention that a PMI value of 50, by its very construction, represents that managers do not expect a change in the economic activity. A level above (below) 50 signals increase (decrease) in the economic activity. Therefore, it does not have to be the critical level indicating a certain change in the growth rate. We start our analysis by estimating equation (1) so as to establish a baseline for our subsequent analyses:

$$g = \alpha_1(p - 50) + \alpha_4 \Delta p + \epsilon \qquad (1)$$

Here, g stands for the growth rate of GDP of euro area and p denotes PMI. Δ represents the difference operator with $\in$ being the error term. The equation, in a nutshell, assumes that growth rate is expected to be positive if PMI in the last six months averages above 50 (α_1) and the recent change in PMI is expected to provide statistically significant information for GDP growth rate (α_3). Note that response rates of GDP to PMI do not differ for values of PMI lower or higher than 50.

According to the results provided in the first column of Table 3, both level of PMI and the recent change in it carry statistically significant information for GDP growth. In particular, a PMI level above 50 significantly indicates a positive growth rate where a lower level points to a negative growth in GDP. In other words, PMI averaging equal to or above 50 in the last six months can serve as a threshold that indicates a positive growth in GDP. Moreover, a statistically significant parameter estimate for ΔPMI suggests that the impact of PMI continues in the next period as well, owing to the construction of our PMI series. Finally, a 1 point increase in PMI indicates 0.11 percentage point increase in GDP growth.

Table 3. Estimation Results for Alternative Specifications							
Specifications	1	2	3	4a	4b	4c	4d
$\boldsymbol{\alpha_1}$	0.10*** (10.39)	0.10*** (6.33)	0.19** (2.27)	0.17*** (2.80)	0.14*** (3.60)	1.76*** (9.07)	1.78 (0.41)
$\boldsymbol{\alpha_2}$	-	49.61*** (64.98)	48.01*** (64.00)	49.84*** (70.28)	52.80*** (64.02)	40.47*** (595.96)	40.34*** (15.37)
$\boldsymbol{\alpha_3}$	-	-	0.08*** (8.55)	0.06*** (6.41)	0.05*** (3.36)	0.05*** (18.74)	0.07*** (5.43)
$\boldsymbol{\alpha_4}$	0.11*** (4.26)	0.11*** (4.56)	0.11*** (4.97)	0.11*** (4.87)	0.11*** (4.71)	0.11*** (3.48)	0.10*** (4.27)
Adj. $\boldsymbol{R^2}$	0.72	0.72	0.78	0.78	0.77	0.78	0.81
Log likelihood	-20.95	-20.62	-14.75	-14.77	-15.48	-14.84	-10.09
# of obs.	67	67	56	56	56	56	56
Wald Tests							
$\boldsymbol{H_0: \alpha_2 = 50}$	-	0.26 (0.61)	7.06 (0.01)	0.05 (0.82)	11.52 (0.00)	1973.12 (0.00)	13.54 (0.00)
$\boldsymbol{H_0: \alpha_1 = \alpha_3}$	-	-	1.55 (0.22)	2.80 (0.10)	3.97 (0.05)	77.80 (0.00)	0.16 (0.69)
$\boldsymbol{H_0: \alpha_2 = 50}$ and $\boldsymbol{\alpha_1 = \alpha_3}$	-	-	4.09 (0.02)	3.97 (0.03)	63.01 (0.00)	34657.60 (0.00)	11316.16 (0.00)

Note 1: The dependent variable is quarter-on-quarter growth rate of euro area GDP. The independent variable is the average of last six months, which spans the current and previous quarters, of euro area composite PMI.
Note 2: Equations 4a-4d represent the specifications for growth rates of 0.25%, 0.50%, -0.25% and -0.50%, respectively.
Note 3: Parameters are presented with their t-statistics in parentheses.
Note 4: Null hypotheses are tested by Wald tests, which are presented with F-statistics and p-values in parenthesis.
Note 5: ** and *** denote significance at 5% and 1%, respectively.

In the next specification, we assume that the threshold is unknown to us and needed to be told by the data itself; therefore, we slightly modify equation (1) and estimate the following one to identify the threshold:

$$g = \alpha_1(p - \alpha_2) + \alpha_4 \Delta p + \epsilon \qquad (2)$$

This formulation is intended to locate a threshold, i.e. α_2, that distinguishes between positive and negative growth rates in GDP along with testing its impact on GDP growth rate. The results provided in the second column of table 2 show that the threshold is slightly lower than 50; however, Wald tests suggest that α_2 is not statistically different than 50. The other parameters are very close to their estimates in the first specification.

This is a big coincidence to obtain a level around 50 that distinguishes between positive and negative growth rates since some studies report different values than 50 for alternative economies. In other words, a value that is chosen to be a critical level during the construction process of the series does not have to be the actual critical level at all times. Koenig (2002), for instance, reports that the threshold that separates the positive and negative growth rates in the US is around 40 where Eren (2014) reports that it is around 47.5 for Turkey. In addition to this,

similar to the previous case a 1 point increase in PMI is associated with a 0.10 percentage point increase in GDP growth and the impact continues to be significant in the next quarter.

Next, we follow up the path of extracting more information regarding the quantitative potential of PMI for forecasting GDP growth. While doing this, however, we take into account the possibility that the information capacity of PMI is asymmetric, i.e. the response of GDP to PMI below and above the threshold is different. This might be due to the fact that PMI is a soft variable and reflects the responses of business managers regarding their own businesses. Therefore, the responses might be biased toward overweighing the cases with shrinking economic activity. Another possible explanation is that there might be a few observations that may drive this asymmetric relationship. Although getting rid of these observations and estimating a symmetric relationship might be an option, we keep these observations in the data set since we are trying to extract as much information as possible. Putting in plain terms, case of a crisis is very rare yet quite devastating. Following this vein, we estimate the following equation:

$$g = \alpha_1 I(p \leq \alpha_2)(p - \alpha_2) + \alpha_3 I(p > \alpha_2)(p - \alpha_2) + \alpha_4 \Delta p + \epsilon \qquad (3)$$

Equation (3) distinguishes between the cases that PMI being below or above the threshold of α_2 by means of the indicator function $I(.)$ which returns 1 when its logical argument holds and zero otherwise. With this specification, we re-estimate the threshold, α_2, instead of relying on the information above. According to the results provided in the third column of Table 3, the estimated threshold is again close to 50. However, a more striking result is that the response of GDP growth to change in PMI differs below and above the threshold. In particular, while a 1 point increase in PMI above the threshold results in a 0.08 percentage point increase in GDP growth, a 1 point decrease in PMI below the threshold calls for a 0.19 percentage point decrease in GDP growth.

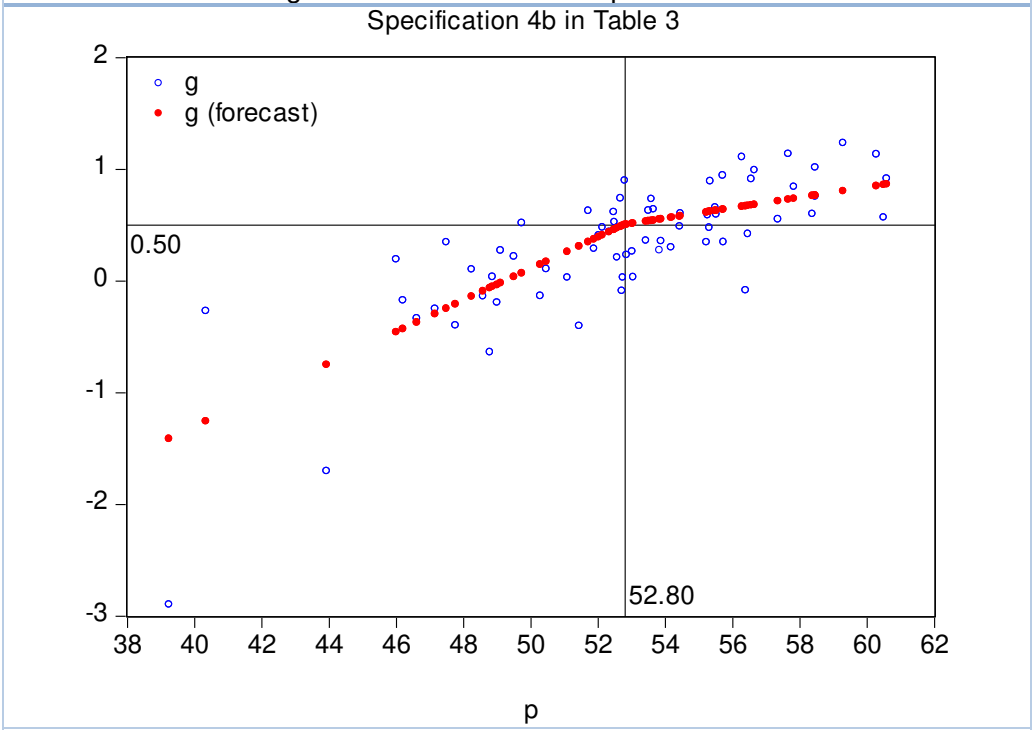
Finally, we introduce benchmark GDP growth levels, which are important in data surveillance, so as to reveal a richer set of threshold values of PMI. In particular, we estimate the following specification for $A \in \{0.25, 0.50, -0.25, -0.50\}$. Note that equation (3) is nothing but a special case of equation (4) with $A = 0$.

$$g - A = \alpha_1 I(p \leq \alpha_2)(p - \alpha_2) + \alpha_3 I(p > \alpha_2)(p - \alpha_2) + \alpha_4 \Delta p + \epsilon \qquad (4)$$

The estimates of equation (4) are reported in the last four columns of Table 1, respectively. First, when we look at the threshold levels, which are all statistically significant at 1%, they show that the managers' responses create a big asymmetry in the information content of PMI series. While a level of 49.84 is associated with 0.25% growth rate, for a similar but negative growth rate, the indicative level of PMI is 40.47. Furthermore, the results show that the level of

asymmetry varies a lot as the level of growth under interest changes. Therefore, not only there is an asymmetric relationship between PMI and GDP growth rate in euro area, but also the degree of asymmetry changes under alternative GDP growth benchmarks. A pictorial presentation of our analysis is given in Figure 1 on the basis of Specification 4b, i.e. growth rate of 0.50.

Figure 1. Presentation of Specifications



Note 1: The blue dots show the actual value pairs in data and red dots show the in-sample forecasts based on Specification 4b.
Note 2: The horizontal line drawn at g=0.50 corresponds to the benchmark growth rate of 0.50 percent per quarter as in Specification 4b. The vertical line drawn at p=52.80 is the estimated threshold value of PMI. Notice that the slope of the red curve differs for p being smaller or larger than 52.80. This, indeed, is the essence of all empirical analysis carried out in this study.
Note 3: While computing the figures depicted by the red curve, d(p) has been maintained at its sample average which is approximately zero.

A brief review of the Wald tests in Table 3 also seems to be essential to understand the main idea of our study. Here, we perform three different tests wherever applicable, namely a test of whether the estimated PMI threshold is statistically indistinguishable from 50, a test of whether GDP growth responds the same below and above the estimated PMI threshold and a joint test of threshold and asymmetry arguments. In that, specification 2 verifies 50 as the usual PMI threshold. In specification 3, the estimate of threshold differs from 50 yet the test of asymmetry by itself is not affirmative. The joint test, though, is supportive of both a threshold different than 50 and asymmetry. Wald tests for specifications 4a-4d are similar to that of specification 3 with marginal variations.

When we replicate Table 3 using quarterly average PMI as p, qualitative findings remain intact despite some small quantitative differences. Results of this robustness exercise can be found in Table 4.

4. Conclusion

Having a reliable forecast for the GDP growth is a critical task for all agents in the economy as well as for the policymakers since most of their decisions highly depends on it. The literature shows that leading indicators carry a significant amount of information that can be used to reliably forecast GDP growth where PMI is one of the most important one among these leading indicators.

In this note, we examine the predicting power of PMI on the growth rate of GDP in euro area. Our results show that PMI carries a significant information that can be used to forecast the growth in euro area GDP in the subsequent quarter. In particular, we show that a PMI level around 50 works as a critical threshold that distinguishes between a positive and negative rate of growth in GDP. Furthermore, we find that one point increase in PMI may be associated with 0.1 to 0.2 percentage point increase in GDP growth. Finally, we show that the information extracted from PMI series is asymmetrically reflected on GDP growth.

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Table 4. Estimation Results for Alternative Specifications

Specifications	1	2	3	4a	4b	4c	4d
α_1	0.11*** (10.88)	0.11*** (6.72)	0.24*** (5.49)	0.19*** (4.72)	0.17*** (4.90)	0.39*** (8.22)	0.46*** (13.51)
α_2	-	49.95*** (76.65)	47.50*** (78.87)	49.92*** (0.59)	52.23*** (79.18)	43.99*** (80.10)	42.84*** (156.07)
α_3	-	-	0.08*** (11.00)	0.07*** (8.47)	0.05*** (4.90)	0.07*** (16.76)	0.09*** (26.68)
α_4	0.05*** (3.38)	0.05*** (3.78)	0.05*** (2.78)	0.05*** (2.77)	0.05*** (2.95)	0.05*** (3.52)	0.04*** (3.46)
Adj. R^2	0.77	0.76	0.85	0.84	0.83	0.87	0.89
Log likelihood	-14.91	-14.90	-2.25	-5.24	-5.94	1.98	4.82
# of obs.	68	68	68	57	57	57	57
Wald Tests							
$H_0: \alpha_2 = 50$	-	0.01 (0.94)	17.26 (0.00)	0.02 (0.89)	11.39 (0.00)	119.65 (0.00)	680.76 (0.00)
$H_0: \alpha_1 = \alpha_3$	-	-	12.19 (0.00)	7.74 (0.01)	9.98 (0.00)	39.72 (0.00)	110.39 (0.00)
$H_0: \alpha_2 = 50$ and $H_0: \alpha_1 = \alpha_3$	-	-	9.43 (0.00)	9.01 (0.00)	81.08 (0.00)	102.45 (0.00)	1719.60 (0.00)

Note 1: The dependent variable is quarter-on-quarter growth rate of euro area GDP. The independent variable is the average of last three months, which spans the current and previous quarters, of euro area composite PMI.
Note 2: Equation 4a-4d represents the specifications for growth rates of 0.25%, 0.50%, -0.25% and -0.50%, respectively.
Note 3: Parameters are presented with their t-statistics in parenthesis.
Note 4: Null hypotheses are tested by Wald tests, which are presented with F-statistics and p-values in parenthesis.
Note 5: ** and *** denote significance at 5% and 1%, respectively.