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Variable Selection for Inflation: A Pseudo Out-of-sample Approach*

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Abstract

In this paper, we analyze the forecasting properties of a wide variety of variables for Turkish inflation, and thereby pin down the ones producing robust forecasts periodically. Defining the lag structure of a variable in two different ways, we determine the non-leading forecasters and leading indicators of inflation. We employ a pseudo out-of-sample approach and compare the forecasting performance of each variable *ex-post* with the benchmark model. We measure forecast errors over forecast horizons instead of over time for each horizon. Results suggest that no single variable gives the best forecasts at all times, hence inflation is best forecast by different variables each period. This finding promotes the use of forecast combination strategies and/or multivariate model settings.

Jel codes: C50, C53, E31, E37
Keywords: Inflation, variable selection, leading indicator, Turkey

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1 Introduction

The choice of variables in addition to models is at the core of forecasting and gets challenging with the ever-increasing data. This paper tries to formulate a methodology to choose variables that would be helpful in forecasting. We use single-equation models for forecasting Turkish inflation using a large set of variables. In doing so, our paper is related to the literature assessing the forecasting performances of various indicators for inflation represented by Stock and Watson (1999), Leigh and Rossi (2002), Stock and Watson (2003), Banerjee et al. (2005), Banerjee and Marcellino (2006), Altuğ and Uluceviz (2013).

We follow the pseudo out-of-sample approach of Stock and Watson (1999). In this respect, our paper is similar to Altuğ and Uluceviz (2013). However, unlike Altuğ and Uluceviz (2013) which employs monthly data, we use a sample of quarterly observations -since the monthly inflation in Turkey has a relatively high idiosyncratic component- to capture the macroeconomic relations better. Besides, this paper utilizes a different forecast evaluation methodology by adopting the approach of Banerjee et al. (2005). Finally, the sample in this paper covers the global financial crises, which might have led to a change in the behavior of macroeconomic variables, and the period after.

The aim of our paper is to analyze in detail the forecasting properties of a wide variety of macroeconomic variables for Turkish inflation, and thereby pin down the ones producing robust forecasts periodically. To this end, we first define a benchmark forecasting model for inflation. Then, we add candidate variables individually from our data set, containing 112 variables, to the benchmark model. Defining the lag structure of a variable in two different ways, we determine the variables affecting inflation contemporaneously and the ones affecting it with a time lag. We name the former as non-leading forecasters, while we call the latter as leading indicators of inflation.[1] The main focus of the paper is the leading indicators of inflation though we present the results of both.

Employing a pseudo out-of-sample approach, we compare up to four quarters ahead forecasting performances of the models with the benchmark. The comparison is done *ex-post*. That is, the future values of the independent variables are assumed to be known when evaluating their performances. Following Banerjee et al. (2005), we measure forecast errors over different forecast horizons instead of over time separately for each horizon. In this way, we evaluate whether a variable produces robust forecasts on a quarter-by-quarter basis.

Our main results can be summarized as follows. The best performing non-leading forecasters can be grouped into four main categories; survey-based, economic activity, financial and

[1] A "non-leading" variable might have a leading feature in practice, however if its contemporaneous effect on inflation dominates its leading effect, this variable is called as "non-leading". Therefore, we use the term "non-leading" in a non-strict manner throughout the text.

producer prices. Specifically, Business Tendency Survey (BTS) measure of "insufficiency of demand" has the best forecasting performance, while the producer price index (PPI), as well as its subcomponents also performs markedly. The majority of best leading indicators are economic activity variables such as gap forms of the GDP, output of industry and services sector and private consumption. This is a reasonable finding since key cost-push factors (i.e. exchange rate and import prices) are already included in the benchmark model. Similar to non-leading forecasters, the rest of the best leading indicators can be grouped as survey-based, producer prices and financial. Specifically, "current level of total order books" and "average unit cost expectations over the next 3 months" come to the forefront as the best survey-based leading indicators of inflation. PPI measure of non-durable goods prices appears to be good at capturing the cost-led pressures on consumer inflation arising from the food and agricultural sector though it shows poor performance in sensitivity analysis, signaling that its performance is episodic. Results suggest that no single indicator gives the best forecasts at all times. This is due to the fact that the economy is hit by different shocks over the period analyzed and the effects of these on inflation are best forecast by different variables each time. Finally, we present evidence for the robustness of the proposed leading indicators.

The remainder of this paper has the following structure. Section 2 discusses the methodology applied in the paper. Section 3 presents the data. Section 4 dicusses the results concerning the performance of the variables and assesses their robustness via sensitivity analysis. Section 5 concludes.

2 Methodology

2.1 Benchmark estimation

Setting a simple univariate model as benchmark is common in the literature.[2] Random walk, autoregression, and unconditional mean are examples of such benchmarks. A model, no matter how sophisticated it is, is worth using for forecasting if it can only provide better forecasts than a simple benchmark. Therefore, specifying the benchmark correctly is primarily important. Given that Turkey is a small open economy with relatively large share of imported inputs, import prices and the exchange rate are two fundamental determinants of inflation.[3] Taking this into account, we always include the current value and the first

[2] Stock and Watson (1999), Kholodilin and Siliverstovs (2005), Kapetanios et al. (2008) are a few to cite.

[3] From the consumption side, between 2003Q1-2013Q4, the share of imports to GDP is on average 28 percent in Turkey. From the production side, Andıç et al. (2014) show that the foreign share of real marginal cost in Turkey is about 60 percent. Besides, Kara and Öğünç (2012) find that a 10 percent shock to the Turkish lira denominated import prices leads to about 1.5 percentage points increase in inflation at the end of twelve months.

lag of the Turkish lira (TRY) denominated import prices in the benchmark specification in addition to the lags of inflation. Hence, the benchmark model takes the following form;

$$y_t = \alpha + \sum_{j=0}^{1} \gamma_j m_{t-j} + \sum_{i=1}^{a} \beta_i y_{t-i} + \varepsilon_t \tag{1}$$

where y_t is the quarter-on-quarter seasonally adjusted inflation rate calculated utilizing the CPI excluding unprocessed food, alcoholic beverages and tobacco. m_t is the quarterly change in import prices in TRY. Finally, a equals to $1, 2, 3, 4$. Therefore, we have restricted the maximum lag length of inflation to four. At each recursive estimation, the lag length of autoregressive part of the model is chosen according to the Schwarz Information Criterion (SIC), rather than being fixed.[4]

2.2 Model estimation

Our aim is to choose variables that perform consistently well in forecasting inflation compared to the benchmark model.[5] To this end, we use candidate variables in single equation models, which are estimated as follows;

$$y_t = \alpha + \sum_{j=0}^{1} \gamma_j m_{t-j} + \sum_{i=1}^{a} \beta_i y_{t-i} + \sum_{q=k}^{b} \delta_q X_{t-q} + \varepsilon_t \tag{2}$$

where X_t is a particular variable from our data set and can have a maximum lag length of four since $b = k, ..., 4$. We use two different values for k; 0 and 1. When k=0 (k=1), the current (first lagged) value of X as an explanatory variable is in the regression for sure. This is why, when k=0 (k=1) we present the best-performing variables under the name "non-leading forecasters" ("leading indicators"). At each estimation period, we compute the SIC for every possible combination of y_{t-i} and X_{t-q}, and select the model with the minimum SIC. Thus, we adopt a dynamic estimation for forecasting.

Models (1) and (2) are used to forecast one to four-step-ahead forecasts. Since y_t is defined independent of the forecast horizon (h), the same model is used for each h. Whenever future values of m_t or X_t is required to generate forecasts of inflation, actual values are used

[4] Banerjee and Marcellino (2006) report that there are some gains in allowing the lag length to change rather than keeping it fixed at each recursive estimation.

[5] The E-views code used in this paper is available upon request.

since the main interest of this study is to evaluate the indicators, not to acquire models that deliver superior inflation forecasts. Therefore, the performance of the benchmark and models is evaluated *ex-post*. As our goal is to unearth variables that might be useful when forecasting inflation, we choose to leave aside the evaluation in an *ex-ante* framework, that is using forecasts from autoregressive models for the unknown future values of the explanatory variables.[6]

2.3 Forecast evaluation

Models (1) and (2) are first estimated using a sample of eight years. Then they are re-estimated adding one quarter each time. At each estimation period, one to four-step-ahead forecasts are computed. Next, root mean squared forecast error is calculated out of four forecasts. To distinguish this forecast error from the standard $RMSE$ criterion; we have adopted the $RMSE$-h notation used in Banerjee et al. (2005).

The first estimation is done with the data 2003Q1-2010Q4, forecasts up to 2011Q4 are obtained and $RMSE$-h is computed. Then, the estimation sample is extended by one quarter, forecasts up to 2012Q1 are calculated and $RMSE$-h is recorded again. This process continues recursively until the estimation sample reaches to 2013Q1 and the four-quarter-ahead forecast is for 2014Q1.[7] Accordingly, the pseudo-out-of sample spans 2011Q1-2014Q1.[8]

In forecast literature $RMSE$ is usually computed over time separately for each horizon. However, as well explained in Banerjee et al. (2005), such approach masks the performance of an indicator over time, which can lead to selection of an indicator that has recently lost its relevance for forecasting. The $RMSE$-h approach is immune to this drawback, though it suffers from the fact that the series it is computed from is short and its elements can be correlated. Nevertheless, we believe that the advantage of $RMSE$-h outweighs its disadvantage and it is eminently more relevant for policy evaluations, especially from the practical point of view.

In this paper, we adopt two different criteria when selecting variables. The first criterion is employed to see the average performance while the second one is used to examine the periodicity of an indicator. As the first criterion we compute $RRMSESUM$-h, which is the sum of recursively obtained $RMSE$-h's of an indicator relative to that of the benchmark

[6] Clearly, an indicator that does not perform well in *ex-post* evaluation is not expected to outperform the benchmark in an *ex-ante* framework.

[7] However, if a variable ends at 2013Q4 and k=0, then the estimation sample is extended up to 2012Q4 so that the four-quarter-ahead forecast is for 2013Q4. Therefore, the number of recursive estimations of such a variable is smaller than that of a variable ending in 2014Q1.

[8] Relatively short estimation and the pseudo out-of-sample period is a prominent drawback of this study. To partly overcome this concern, we evaluate the robustness of our results for leading indicators in Section 4.1 by changing the length of forecast horizon and number of evaluation periods.

model. For a variable with 10 recursive estimations (i.e. with the last observation ending in 2014Q1) $RRMSESUM\text{-}h$ is calculated as;

$$RRMSESUM\text{-}h_i = \frac{\sum_{t=2010Q4}^{2013Q1} RMSE\text{-}h_{i_t}}{\sum_{t=2010Q4}^{2013Q1} RMSE\text{-}h_{b_t}} \tag{3}$$

where i and b represent the indicator and benchmark, respectively. $RMSE\text{-}h_{i_t}$ is the $RMSE\text{-}h$ of the equation with indicator i ending at time t. Therefore, $RRMSESUM\text{-}h$ gives an overall idea about the performance of an indicator across all forecasting horizons and recursive estimations. In other words, this criterion shows the average performance of an indicator. We consider 0.95 as a maximum for $RRMSESUM\text{-}h$.

The second criterion is the "outperform ratio". It is the ratio of the number of times an indicator outperforms the benchmark to the number of recursive estimations of that variable.[9] Therefore, this is the criterion that shows whether the performance of an indicator is periodic or not. If an indicator beats the benchmark in 6 of the 10 recursive estimations, the outperform ratio of that indicator is 0.6. In this paper, we use 0.6 as a minimum for this criterion. In addition to the outperform ratio, we have two more measures to show forecasting properties of the variables, i.e. the number of times the variable outperforms the benchmark by at least 10 percent and the number of times it produces the best forecast (Table 1 and 2).

To sum up, we adopt the following two-stage selection mechanism: a variable which improves on the benchmark forecasts by at least 5 percent overall, that is $RRMSESUM\text{-}h_i \leq 0.95$, and has an outperform ratio of 0.6 at least is considered to perform well when forecasting Turkish inflation.

3 Data

The data set covers the period 2003Q1-2014Q1 and has a ragged-edge. In other words, though most of the variables end at 2014Q1, some have the last observation at 2013Q4. We focus on the period after 2003 for two main reasons. First, due to the structural change experienced in Turkey after 2001 financial crises, the information content of the

[9] Banerjee et al. (2005) present "the number of times the indicator outperforms AR" in Table 4 and 5. However, since the data set used in this study has a ragged-edge, we prefer to proportion it to the number of estimations.

data belonging to pre-2003 episode is limited to shed light on the recent inflation dynamics. Second, the latest price index (2003=100) which is relatively well-behaved starts from 2003. Inflation rate is defined as the quarter-on-quarter change of seasonally adjusted CPI measure that excludes unprocessed food, alcoholic beverages and tobacco.[10] Our primary data sources are TURKSTAT, CBRT's Electronic Data Delivery System (EDDS) and Bloomberg.

Data are seasonally adjusted by the TRAMO-SEATS package of Demetra+ if required and transformed to be stationary. Altogether we use 112 indicators which might be grouped into eight main categories, namely "output, production, sales and orders indicators", "exchange rate and commodity prices", "interest rates and spreads", "monetary aggregates", "prices, expectations and wages", "loans", "other financial indicators" and "miscellaneous variables". Details of these groups including the data descriptions, transformations applied considering the stationarity properties of the variables and sources can be found in Appendix A.

4 Results

In this section, setting k equal to 0 and 1 in (2), we analyze the forecasting performances of 112 variables. Table 1 summarizes the performances of the best non-leading variables.[11] The best-performing non-leading forecasters can be grouped into four main categories; survey-based, economic activity, financial (mainly interest rates) and producer prices. BTS measure of "insufficiency of demand" -the main factor currently limiting the production- yields the lowest $RRMSESUM$-h with an outperform ratio of 0.9. This means that insufficiency of demand yields a better forecast than the benchmark model in 9 of the 10 evaluation periods. Furthermore, in 7 of the 9 cases it outperforms the benchmark by more than 10 percent and produces the best forecasts on three occasions (Table 1). "PPI intermediate goods prices" and "export gap of goods and services" perform almost equally well in terms of the two criteria with the former providing the best forecast for one period.

Primary expenditures over GDP beats the benchmark in all evaluation periods and improves on the benchmark forecasts by 20 percent overall.[12] Interestingly, inflation is positively correlated with the inverse of primary expenditures over GDP. This suggests that primary expenditures are counter-cyclical. When the economic activity slows down, inflation falls and primary expenditures rise to boost the economy. In general, producer prices and its

[10] Unprocessed food, alcoholic beverages, and tobacco prices exhibit the highest unexpected volatility within the CPI sub-components in Turkey (Öğünç 2010). Severe volatility, which is an inherent characteristic of the unprocessed food prices, and tax adjustments on tobacco cause a significant forecast uncertainty. Therefore, we prefer to use the CPI excluding these items.

[11] We only present the results of best performing variables based on our selection criteria; results concerning other variables are available upon request.

[12] Both HP filtered and differenced version of this variable perform well though we simply present the result of the HP filtered one in Table 1 due to its slightly better forecasting performance.

subcomponents, i.e. prices of intermediate, capital and durable goods, do a better job in forecasting current quarterly inflation. This is in line with the results of Altuğ and Uluceviz (2013) for the period of 2006-2010.[13] BTS measure of "domestic selling price expectations over the next 3 months" also performs well in forecasting the course of inflation. Every time it beats the benchmark, it improves on the benchmark forecasts by at least 10 percent. Moreover, among the non-leading forecasters, domestic selling price expectations have the highest number in outperforming the benchmark by a minimum of 10 percent.

Automobile sales outperform the benchmark 90 percent of the time and beat it by over 10 percent overall. Contrary to expectations, this indicator is also negatively related with inflation.[14] Other variables that are useful in forecasting current inflation are the interest rates, such as benchmark nominal and real interest rate, CBT policy rate (average funding rate) and 3 month TRY deposit rates. However, these variables have a positive correlation with the current period inflation, which is likely to reflect nothing more than the instantaneous response of the market rates or average funding rate to the current quarter's inflation release. As a matter of fact, we do not observe any of these interest rates among the best leading indicators up to four quarters ahead evaluations shown in Table 2.

Table 2 presents the forecasting performances of best leading indicators, which is the main focus of the paper. Several findings emerge from this analysis. First, majority of these are economic activity variables. This is not surprising given that the benchmark model already embodies the effect of key cost-push factors, namely exchange rates and import prices. Overall, gap forms of the GDP, output of industry and services sector, output of services sector, private consumption and final domestic demand variables are found to be good predictors of consumer inflation in Turkey. The performances of private consumption, final domestic demand and capacity utilization rate are remarkable in the last four evaluation periods, suggesting that their relevance in forecasting inflation has recently increased (Graph 1). Gap measure calculated from the value added of industry and services sector, which is the nonfarm GDP, produces slightly better forecasts than the GDP gap. This suggests that the fluctuations in agricultural output caused by the supply side shortages in Turkey leads to a poor forecasting performance for the agriculture component of the GDP.

[13] Altuğ and Uluceviz (2013) use monthly data to identify the leading indicators of change in inflation and IP growth over the sample 1998-2010 with three sub-samples. For the third sub-sample which corresponds to the period 2001-2010 (with a forecast period of 2006-2010), their results indicate that PPI inflation, the growth in VAT revenue and its change, the price-earnings ratio on the ISE100, several interest rate measures (such as overnight interest rate, the three-month deposit rate, Treasury auction rate) appear as important predictors of change in CPI inflation. Besides, monetary aggregates such as changes in M2Y and M3Y are found to perform well for inflation changes at relatively longer horizons.

[14] A possible explanation for this finding might be the role of exchange rate pass-through on inflation and automobile prices. If it is the price of automobile driving the domestic market sales, both consumer inflation and automobile prices may move in the same direction in marked depreciation or appreciation episodes, (given the high levels exchange rate pass-through) which at the end results in a negative correlation between automobile sales and consumer inflation.

The rest of the best leading indicators can be grouped as survey-based, producer prices and financial. Among them, BTS measure of "current level of total order books" improves on the benchmark forecasts by 25 percent overall and outperforms it in all evaluation periods (Graph 1). Another survey-based measure with good forecasting performance is "average unit cost expectations over the next 3 months", which outperforms the benchmark by at least 10 percent in every occasions it beats. Demeaned form of the capacity utilization rate performs well in terms of $RRMSESUM$-h, yet it barely satisfies the outperform ratio criterion of 0.6. Electricity production outperforms the benchmark in 8 of 10 evaluation periods and produces the best forecast once.[15] Similarly, PPI non-durable goods prices produce better forecasts than the benchmark model in 9 of the 10 cases. Manufacturing prices of food and nonalcoholic beverages constitutes about 70 percent of this price index. Hence, this indicator might capture the cost-led pressures on consumer inflation associated with food and agricultural strains. Finally, commercial loans appear to perform relatively well. However, hardly satisfying the two criteria, the performance of commercial loans can be sensitive to the length of forecast horizon or number of evaluation periods.[16]

Graph 1 shows the performances of the best leading indicators relative to benchmark in all evaluations periods. Two main results are in order. First, performance of an indicator is not stable over time. For instance, "current level of total order books" does better than the benchmark for the first 8 evaluation periods with a gradually increasing performance. Though it is still better, this course then reverses in the last two evaluation periods. Second, at a given point in time two best leading indicators can perform quite differently. Considering the third evaluation period, 2011Q3-2012Q2, electricity production improves on the benchmark forecasts by almost 40 percent while the expectation of average unit cost is outperformed significantly by the benchmark. These two conclusions, which are inferred with the adoption of $RMSE$-h criterion, point to the following. The Turkish economy is hit by different shocks over the period analyzed and the effects of these on inflation are best forecast by different variables each time. Hence, the performance of indicators seems to be episodic and no single indicator gives the best forecasts at all times. This finding promotes the use of forecast combination of models and/or multivariate model settings such as large Bayesian vector auto regressions.

[15] Increase in electricity production can signal a rise in industrial production, and thereby in inflation, in two ways. First, electricity production is strongly correlated with the subcomponent of industrial production index called electricity, gas and steam production and supply. Second, almost half of the electricity produced in Turkey is consumed by the industry.

[16] As it is stated, one of the caveats of the study is the relatively short sample period, which leads us to analyze the forecasting performance of the series up to four quarters ahead. However some indicators such as monetary aggregates, loans or interest rates might be effective on inflation at longer horizons, i.e. beyond one year. This study may not structurally capture those indicators, yet this does not mean that they do not have any predictive power for inflation.

4.1 Sensitivity analysis

In this section, we evaluate the robustness of our results for the leading indicators by changing the length of forecast horizon and number of evaluation periods given the relatively short sample period. First, instead of a forecast horizon of four quarters, we set h=2 and h=8, alternatively. That is, we average one-to-two and one-to-eight-step-ahead forecast errors. All of the leading indicators in Table 2, but the electricity production, are robust to this modification (Graph 2). Second, instead of setting the first estimation sample as 2003Q1-2010Q4, we use 2003Q1-2009Q4 and 2003Q1-2011Q4, alternatively. In other words, we analyze the role of number of evaluation periods, which is 14 in the former alternative and 6 in the latter, on the forecasting performance of the best leading indicators. All the indicators except for the PPI non-durable goods prices and commercial loans are robust to this modification, as well (Graph 3). Therefore, the sensitivity analysis show that nine of the twelve best leading indicators in Table 2 consistently perform well under different forecast horizons and evaluation samples.[17]

5 Conclusion

In this paper, we analyze the pseudo-out-of sample forecasting performances of 112 variables for Turkish inflation. We define inflation, calculated as the CPI excluding unprocessed food, alcoholic beverages and tobacco, as a function of its past and quarterly change in Turkish lira denominated import prices in the benchmark specification. Then, we estimate single equation models by adding variables individually to the benchmark specification. Defining the lag structure of a variable in two different ways, we determine the non-leading forecasters and leading indicators of inflation. We employ a pseudo out-of-sample approach and compare the forecasting performance of each variable *ex-post* with the benchmark model. We measure forecast errors over different forecast horizons instead of over time for each horizon considering that the interest of the study is to evaluate the performance of the variables periodically.

Several conclusions emerge from this analysis. First, the best-performing non-leading forecasters can be grouped into four main categories; survey-based, economic activity, financial and producer prices. Specifically, BTS measure of "insufficiency of demand" - the main factor currently limiting the production- has the best forecasting performance, while the aggregate producer price index, as well as the prices of intermediate, capital and durable goods also perform markedly. Second, the majority of best leading indicators are economic activity

[17] In the sensitivity analysis, $RRMSESUM$-h is always taken as 0.95. However, when evaluating the robustness of the indicators under different forecasting horizons we used outperform ratios other than 0.6. Specifically, we relaxed the outperform ratio to 0.5 when $h = 2$ and tightened it to 0.8 when $h = 8$. This shows that outperform ratio is sensitive to the forecasting horizon.

variables. This is not surprising given that the benchmark model already embodies the effect of key cost-push factors, namely exchange rates and import prices. Overall, gap forms of the GDP, output of industry and services sector, output of services sector, private consumption and final domestic demand variables are found to be good predictors of consumer inflation in Turkey. Gap measure calculated from the value added of industry and services sector, which is the nonfarm GDP, produces slightly better forecasts than the GDP gap, suggesting that the agriculture component of the GDP has a poor forecasting performance. The rest of the best leading indicators can be grouped as survey-based, producer prices and financial. Specifically, "current level of total order books" and "average unit cost expectations over the next 3 months" come to the forefront as the best survey-based leading indicators of inflation. PPI measure of non-durable goods prices appears to be good at capturing the cost-led pressures on consumer inflation arising from the food and agricultural sector though it shows poor performance in sensitivity analysis, signaling that its performance is episodic. Third, results suggest that no single indicator gives the best forecasts at all times. This is due to the fact that the economy is hit by different shocks over the period analyzed given its emerging market nature and the effects of these on inflation are best forecast by different variables each time. This finding promotes the use of forecast combination strategies and/or multivariate model settings. Finally, changing the length of the forecast horizon and number of the evaluation periods we undertake two the sensitivity analysis and find evidence for the robustness of the most of the leading indicators.

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Table 1: Forecasting performances of non-leading forecasters, up to four quarters ahead, first estimation covers 2003Q1-2010Q4.

				Number of times the variable;		
Variable	Trans.	*RRMSESUM-h*	Outperform ratio	Outperforms benchmark	Outperforms by at least 10%	Produces best forecast
BTS Q8B-insufficiency of demand	LN	0.66	0.90	9	7	3
PPI intermediate goods prices	PC	0.73	0.70	7	5	1
Export gap of goods and services	HP	0.74	0.78	7	6	0
Primary expenditures gap	HP	0.80	1.00	9	7	0
PPI capital goods prices	PC	0.81	0.70	7	6	0
BTS Q22-domestic selling price exp. over next 3m	LN	0.82	0.80	8	8	0
PPI	PC	0.82	0.80	8	6	0
Automobile sales	PC	0.88	0.90	9	6	0
Benchmark interest rate	D	0.90	0.80	8	5	0
PPI durable goods prices	PC	0.90	0.90	9	6	0
CBRT policy rate	D	0.91	0.90	9	4	0
Benchmark paper real interest rate gap	HP	0.91	1.00	10	4	0
Weighted avr. interest rate up to 3m for TRY deposits	D	0.91	0.80	8	3	1

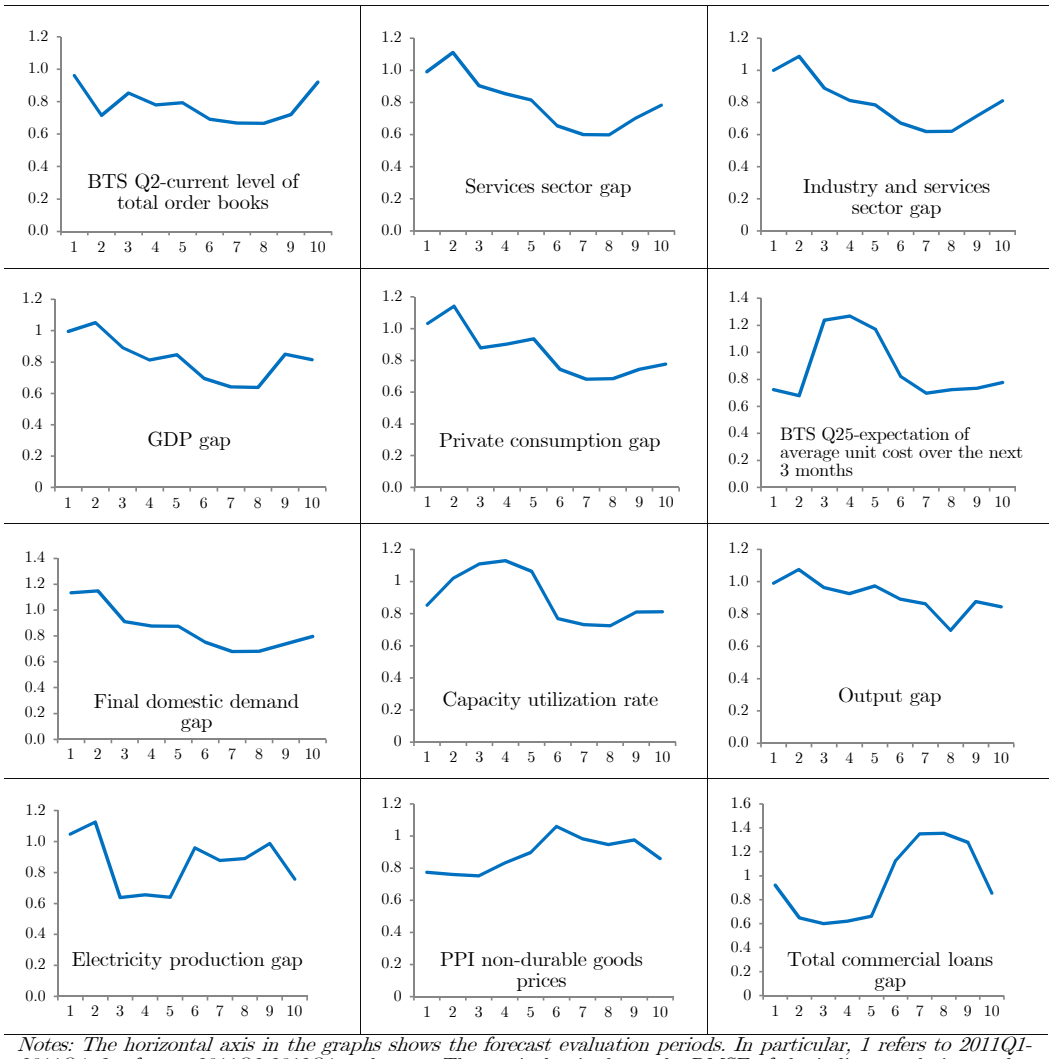
Notes:Non-leading forecasters are modelled as (2) with k=0.The mnemonics used for the transformations are; LN: natural logarithm, D: difference, PC: percentage change, HP: Hodrick Prescott filtered gap.

Table 2: Forecasting performances of leading indicators, up to four quarters ahead, first estimation covers 2003Q1-2010Q4.

				Number of times the variable;		
Variable	Trans.	*RRMSESUM-h*	Outperform ratio	Outperforms benchmark	Outperforms by at least 10%	Produces best forecast
BTS Q2-present level of total order books	LN	0.75	1.00	10	8	0
Services sector gap	HP	0.76	0.90	9	7	0
Industry and services sector gap	HP	0.76	0.90	9	8	0
GDP gap	HP	0.79	0.90	9	8	0
Private consumption gap	HP	0.82	0.80	8	6	0
BTS Q25-exp. of avr. unit cost over next 3m	LN	0.82	0.70	7	7	0
Final domestic demand gap	HP	0.82	0.80	8	7	0
Capacity utilization rate	DM	0.85	0.60	6	6	0
Output gap	L	0.89	0.90	9	5	0
Electricity production gap	HP	0.89	0.80	8	6	1
PPI non-durable goods prices	PC	0.91	0.90	9	6	0
Total commercial loans gap	HP	0.94	0.60	6	5	0

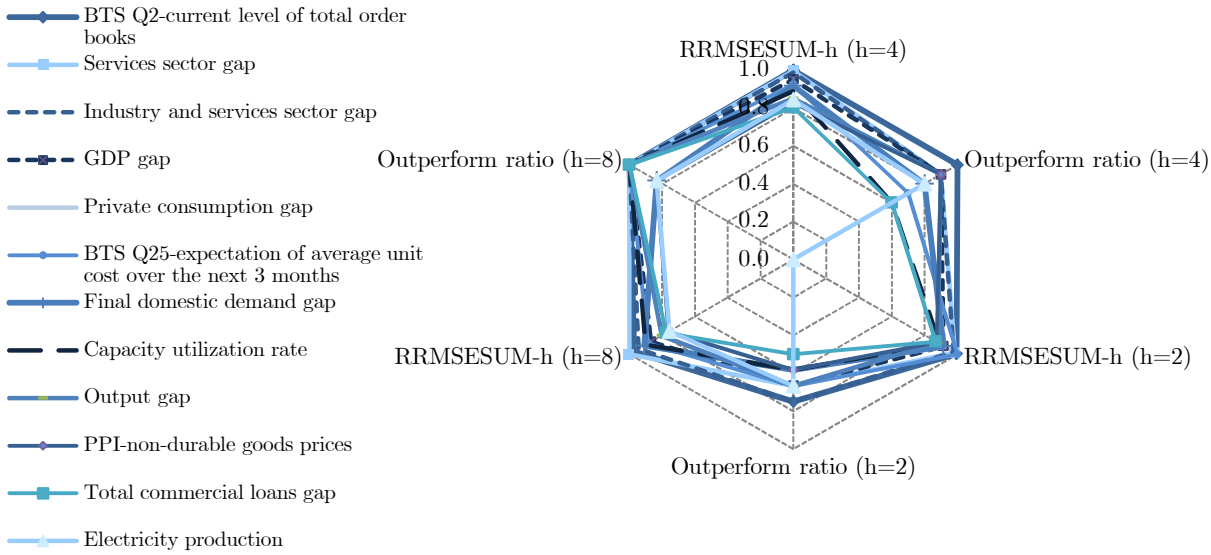
Notes:Leading indicators are modelled as (2) with k=1.The mnemonics used for the transformations are; L: level, LN: natural logarithm, PC: percentage change, HP: Hodrick Prescott filtered gap, DM: demeaned.

Graph 1: Performances of the best leading indicators relative to benchmark, up to four quarters ahead, first estimation covers 2003Q1-2010Q4.



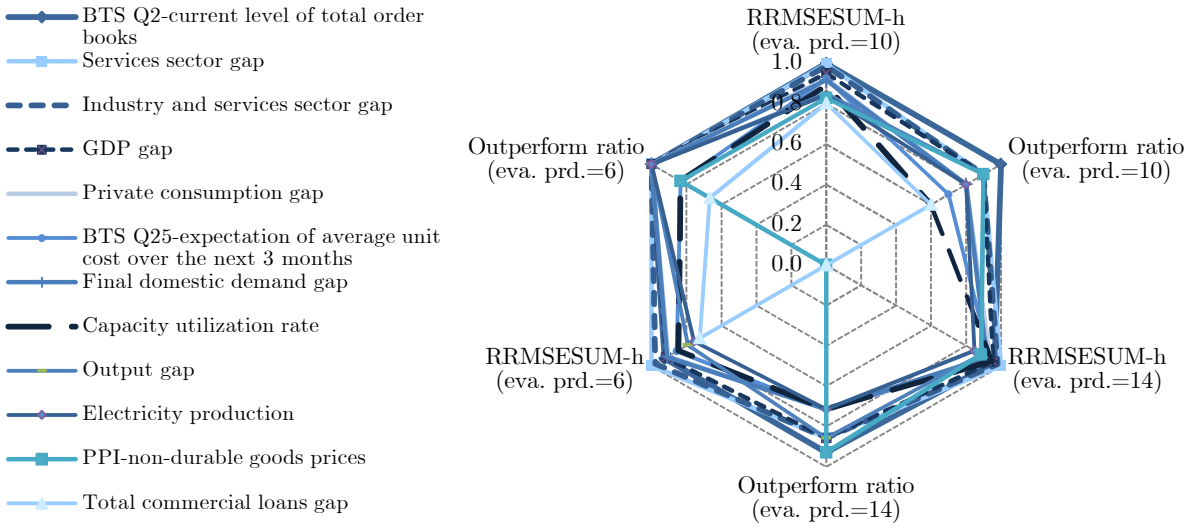
Notes: The horizontal axis in the graphs shows the forecast evaluation periods. In particular, 1 refers to 2011Q1-2011Q4, 2 refers to 2011Q2-2012Q1 and so on. The vertical axis shows the RMSE of the indicator relative to that of the benchmark model. A value smaller than 1 means indicator outperforms the benchmark.

Graph 2: Sensitivity analysis, different forecast horizons (h).



Notes: RRMSESUM-h in the graph is rescaled at each forecast horizon in such a way that an indicator with the lowest RRMSESUM-h has a value of 1. Hence, the closer an indicator moves to outer line of the spider web, the more robust it is to different forecast horizons. If two indicators overlap at a corner, they have similar performances under the same forecast horizon. Besides, a value of 0 shows that the indicator does not satisfy the evaluation criterion belonging to the corresponding corner.

Graph 3: Sensitivity analysis, different evaluation periods.



Notes: RRMSESUM-h in the graph is rescaled at each forecast horizon in such a way that an indicator with the lowest RRMSESUM-h has a value of 1. Hence, the closer an indicator moves to outer line of the spider web, the more robust it is to different forecast horizons. If two indicators overlap at a corner, they have similar performances under the same forecast horizon. Besides, a value of 0 shows that the indicator does not satisfy the evaluation criterion belonging to the corresponding corner.

Appendix A Data Description

This section lists the variables used in this paper. Each variable is categorized into a group. Format of the list is name, transformation, description and database of the series. The mnemonics used for the transformation are; L: level, LN: natural logarithm, D: difference, PC: percentage change, HP: Hodrick Prescott filtered gap, DM: demeaned, Flow/GDP: difference of stock variable/seasonally adjusted GDP. All the variables used are stationary. Finally, SA stands for the seasonal adjustment. For the Hodrick Prescott filter, we use the standard smoothing parameter of 1600 for quarterly data.

Variable	Trans.	Description	Database
Output, production, sales and orders			
GDP	PC	Gross domestic product (1998, SA)	TURKSTAT
GDP gap	HP	HP filtered gap of gross domestic product (1998, SA)	TURKSTAT, Authors' calculation
Private consumption	PC	Private consumption value added (1998, SA)	TURKSTAT
Private consumption gap	HP	HP filtered gap of private consumption value added (1998, SA)	TURKSTAT, Authors' calculation
Final domestic demand	PC	Final domestic demand value added (1998,SA)	TURKSTAT, Authors' calculation
Final domestic demand gap	HP	HP filtered gap of final domestic demand value added (1998,SA)	TURKSTAT, Authors' calculation
Output gap	L	Revised output gap estimate of Alp et al. (2012)	Authors' calculation
Goods and services export	PC	Goods and services export value added (1998, SA)	TURKSTAT
Export gap of goods and services	HP	HP filtered gap of goods and services export value added (1998, SA)	TURKSTAT, Authors' calculation
Goods and services import	PC	Goods and services import value added (1998, SA)	TURKSTAT
Import gap of goods and services	HP	HP filtered gap of goods and services import value added (1998, SA)	TURKSTAT, Authors' calculation
Net export	PC	Net export (1998, SA)	TURKSTAT
Net export in levels	L*(-1)/ 100000	Net export (1998, SA)	TURKSTAT, Authors' calculation
Agricultural output	PC	Agricultural sector value added (1998,SA)	TURKSTAT
Agricultural output gap	HP	HP filtered gap of agricultural sector value added (1998,SA)	TURKSTAT, Authors' calculation
Services output	PC	Services sector value added (1998,SA)	TURKSTAT, Authors' calculation

Services output gap	HP	HP filtered gap of services sector value added (1998,SA)	TURKSTAT, Authors' calculation
Industry and services output	PC	Industry and services sector value added (1998,SA)	TURKSTAT, Authors' calculation
Industry and services ouput gap	HP	HP filtered gap of industry and services sector value added (1998,SA)	TURKSTAT, Authors' calculation
Industrial production	PC	Total industrial production index (SA)	TURKSTAT
Industrial production gap	HP	HP filtered gap of total industrial production index (2010=100, SA)	TURKSTAT
Automobile sales	PC	Automobile sales (unit, SA)	Automotive Manufacturers Association
Capacity utilization rate	PC	Capacity utilization rate of manufacturing industry (SA)	CBRT (EDDS)
Capacity utilization rate	DM	Capacity utilization rate of manufacturing industry (SA)	CBRT (EDDS)
BTS Q8B- insufficiency of demand	LN	BTS Q8B- insufficiency of demand (Difference from 100)	CBRT (EDDS)
BTS Q2-current level of total order books	LN	BTS Q2-current level of total order books (Balance statistic, SA)	CBRT (EDDS)
Electricity production	PC	Electricity production (2005=100, SA)	EÜAŞ
Electricity production gap	HP	HP filtered gap of electricity production (2005=100, SA)	EÜAŞ
BTS Q7-expectation of employment over the next 3 months	LN	BTS Q7-expectation of firm's total employment over the next 3 months (Balance statistic, SA)	CBRT (EDDS)
Exchange rates and commodity prices			
Euro	PC	EUR/TRY foreign exchange rate	CBRT (EDDS)
USD	PC	USD/TRY foreign exchange rate	CBRT (EDDS)
Exchange rate basket	PC	Exchange rate basket (0.5*Euro+0.5*USD)	CBRT (EDDS)
REER	PC	CPI based real exchage rate index (2003=100)	CBRT (EDDS)
Import prices	PC	Import unit value index (2010=100, USD)	TURKSTAT
Import prices of food manufacturing	PC	Manufacturing sector, import unit value index (2010=100, USD, SA)	TURKSTAT
Brent	PC	Brent crude oil price per barrel	Bloomberg
GS energy prices	PC	Goldmans Sachs energy commodity price index (USD)	Bloomberg
GS commodity prices	PC	Goldmans Sachs commodity price index (USD)	Bloomberg

GS wheat prices	PC	Goldmans Sachs wheat price index (USD)	Bloomberg
Gold prices	PC	International gold prices	Bloomberg
GS non-energy commodity prices	PC	Goldmans Sachs non-energy commodity price index (USD)	Bloomberg
GS metal commodity prices	PC	Goldmans Sachs metal commodity price index (USD)	Bloomberg
FAO food prices	PC	FAO food price index (USD)	FAO
Interest rates and spreads			
CBRT policy rate	D	Weighted average cost of the CBRT funding	CBRT
BIST ON	D	BIST overnight interest rate	BIST
Benchmark interest rate	D	Interest rate of the benchmark paper	CBRT
Benchmark paper real interest rate	PC	Exante real interest rate calculated by using benchmark paper	CBRT, Authors' calculation
Benchmark paper real interest rate gap	HP	HP filtered gap of exante real interest rate calculated by using benchmark paper	CBRT, Authors' calculation
Weighted average interest rate up to 3 months for TRY deposits	D	TRY Deposit (weighted average) interest rate with the maturity of up to 3 months	CBRT (EDDS)
Interest rate for other consumer loans	D	Interest rate of (TRY) consumer loans other than housing and automobile, weighted average, flow data	CBRT (EDDS)
Interest rate for automobile loans	D	Interest rate of (TRY) automobile loans, weighted average, flow data	CBRT (EDDS)
Interest rate for housing loans	D	Interest rate of (TRY) housing loans, weighted average, flow data	CBRT (EDDS)
Interest rate for commercial loans (TRY)	D	Interest rate of (TRY) commercial loans, weighted average, flow data	CBRT (EDDS)
Interest rate for commercial loans (EUR)	D	Interest rate of (EUR) commercial loans, weighted average, flow data	CBRT (EDDS)
Interest rate for commercial loans (USD)	D	Interest rate of (USD) commercial loans, weighted average, flow data	CBRT (EDDS)
Interest rate for consumer loans	D	Interest rate of (TRY) consumer loans, weighted average, flow data	CBRT (EDDS)
Commercial loan deposit spread	L	Spread between commercial loan rate and deposit rates	CBRT, Authors' calculation
USA 10 year bond rate	D	Interest rate of United States 10 year treasury bond	Bloomberg
Monetary aggregates			
M3	PC	Money supply: M3 monetary aggregate	CBRT (EDDS)

M3 gap	HP	HP filtered gap of M3 monetary aggregate	CBRT, Authors' calculation
Currency in circulation	PC	Money supply: currency in circulation (SA)	CBRT (EDDS)
Currency in circulation gap	HP	HP filtered gap of currency in circulation	CBRT, Authors' calculation
Reserve money	PC	Money supply: reserve money, Central Bank analytical balance sheet	CBRT (EDDS)
Reserve money gap	HP	HP filtered gap of reserve money, Central Bank analytical balance sheet	CBRT, Authors' calculation
Price indexes, expectations and wages			
Fuel oil prices	PC	Composite fuel oil price index	CBRT, Authors' calculation
PPI-intermediate goods prices	PC	Producer price index, intermediate goods prices (2003=100)	TURKSTAT
PPI-durable goods prices	PC	Producer price index, durable goods prices (2003=100)	TURKSTAT
PPI-non-durable goods prices	PC	Producer price index, non-durable goods prices (2003=100)	TURKSTAT
PPI-capital goods prices	PC	Producer price index, capital goods prices (2003=100)	TURKSTAT
PPI	PC	Producer price index (2003=100)	TURKSTAT
EM consumer inflation	PC	Emerging market countries composite consumer price index	CBRT
BTS Q24- average unit cost expectations over the past 3 months	LN	BTS Q24- average unit cost expectations over the past 3 months (Balance statistic, SA)	CBRT (EDDS)
BTS Q25- average unit cost expectations over the next 3 months	LN	BTS Q25- average unit cost expectations over the next 3 months (Balance statistic)	CBRT (EDDS)
BTS Q22- domestic selling price expectations over the next 3 months	LN	BTS Q22- domestic selling price expectations over the next 3 months (Balance statistic, SA)	CBRT (EDDS)
Unit wage	PC	Nominal unit wage for manufacturing sector (2010=100, SA)	TURKSTAT, Authors' calculation
Unit wage gap	HP	HP filtered gap of nominal unit wage for manufacturing sector	TURKSTAT, Authors' calculation
Loans			
Consumer housing loans gap	HP	HP filtered gap of consumer housing loans	CBRT, Authors' calculation
Consumer automobile loans gap	HP	HP filtered gap of consumer automobile loans	CBRT, Authors' calculation

Consumer and other loans gap	HP	HP filtered gap of consumer and other loans	CBRT, Authors' calculation
Total consumer loans gap	HP	HP filtered gap of total consumer loans	CBRT, Authors' calculation
Consumer loans gap excluding housing gap	HP	HP filtered gap of total consumer loans excluding housing sector	CBRT, Authors' calculation
Total commercial loans gap	HP	HP filtered gap of total commercial loans	CBRT, Authors' calculation
Credit card expenditure gap	HP	HP filtered gap of total credit card expenditures	CBRT, Authors' calculation
Total loans gap	HP	HP filtered gap of total loans (consumer+commercial)	CBRT, Authors' calculation
Consumer housing loans	Flow/GDP	Quarterly difference of consumer housing loans over GDP	CBRT, Authors' calculation
Consumer automobile loans	Flow/GDP	Quarterly difference of consumer automobile loans over GDP	CBRT, Authors' calculation
Consumer and other loans	Flow/GDP	Quarterly difference of consumer and other loans over GDP	CBRT, Authors' calculation
Total consumer loans	Flow/GDP	Quarterly difference of total consumer loans over GDP	CBRT, Authors' calculation
Consumer loans gap excluding housing	Flow/GDP	Quarterly difference of total consumer loans excluding housing sector over GDP	CBRT, Authors' calculation
Total commercial loans	Flow/GDP	Quarterly difference of total commercial loans over GDP	CBRT, Authors' calculation
Credit card expenditure	Flow/GDP	Quarterly difference of total credit card expenditures over GDP	CBRT, Authors' calculation
Total loans	Flow/GDP	Quarterly difference of total loans (consumer+commercial) over GDP	CBRT, Authors' calculation
Other financial			
BIST100	PC	BIST100 stock price index, Borsa İstanbul	Bloomberg
MSCI	PC	MSCI, EM equity index	Bloomberg
S&P500	PC	S&P stock price index	Bloomberg
EMBI+ EM Sovereign Spread	PC	EMBI+ Emerging market sovereign spread	Bloomberg
EMBI+ TR Sovereign Spread	PC	EMBI+ Turkey sovereign spread	Bloomberg
Turkey CDS	PC	5 Year CDS rate of Turkey	Bloomberg
VIX	PC	Chicago Board Options Exchange volatility index	Bloomberg
VIX in levels	LN	Chicago Board Options Exchange volatility index	Bloomberg

EMBI + composite return	PC	JP Morgan Emerging Markets Bond Index plus composite	Bloomberg
EMBI + composite return gap	HP	HP filtered gap of JP Morgan Emerging Markets Bond Index plus composite	Bloomberg, Authors' calculation
EMBI + Turkey total return	PC	EMBI + Turkey total return	Bloomberg
EMBI + Turkey total return gap	HP	HP filtered gap of EMBI + Turkey total return	Bloomberg, Authors' calculation
Miscellaneous variables			
Fuel oil SCT	PC	Special consumption tax on fuel products	MoF Revenue Administration, Authors' calculation
Budget revenues	D	Budget revenues over GDP ratio	MoF Public Accounts, Authors' calculation
Budget revenues gap	HP	HP filtered gap of budget revenues over GDP ratio	MoF Public Accounts, Authors' calculation
Primary expenditures	D	Primary (non-interest) expenditures over GDP ratio	MoF Public Accounts, Authors' calculation
Primary expenditures gap	HP	HP filtered gap of primary expenditures over GDP ratio	MoF Public Accounts, Authors' calculation
OECD output gap	L	Output gap of the OECD region	OECD
PMI global	PC	Markit global sector PMI index	Markit
PMI global in levels	LN	Markit global sector PMI index	Markit

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