

## INDUSTRIAL PRODUCTION INDEX AND SUBJECTIVE FORECASTS: AN APPROACH BASED ON THE CONFIDENCE OF THE MANUFACTURING COMPANIES

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### SUMMARY

*The industrial production index is one of the most important indicators for assessing the health of a country's economy. When it comes to official data, the problem of delays in the publication of provisional estimates is a very topical issue. To this end, it is essential to have advance estimates of these indicators. Many studies have attempted to provide forecasts of the future trend of this indicator using different statistical models based on possible relationships with other micro- or macroeconomic variables. This study proposes a forecasting approach based on the subjective expectations about the future provided by entrepreneurs in manufacturing companies.*

*Keywords: Industrial Production Index, Cointegration Tie, Subjective Forecasts, Confidence Indicators.*

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### 1. INTRODUCTION

In this work, the main goal is to use data from the business confidence survey, which are published very promptly (monthly at time  $t$ , data for  $t-1$  are available), to try to partially overcome the time lag in the data published for the industrial production index (generally, at time  $t$ , only data up to  $t-3$  are available).

The general Industrial Production Index (IPI) measures the change over time in the physical volume of production in the industrial sector, defined in the strict sense (i.e., excluding the construction sector). It is based on a monthly statistical survey conducted among businesses, which provide detailed information on the production of specific goods. The index is well known and its data are continuously disseminated by newspapers and radio and television news programs, as well as being used in hundreds of scientific studies; therefore, it will not be explained here.

This indicator is analyzed in depth and, for an explanation, please refer to the official documents published by ISTAT and the numerous scientific publications on

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the subject, all of which are easily available online. On the other hand, data on business confidence are less well known and less widely disseminated, so it was considered appropriate to devote some space to explaining the origins and methods of construction of the business confidence indicator.

Italy's economic, political, and social landscape has been strongly influenced by its membership in the European Union and the benefits and rights that come with it. In particular, Italy's political and economic choices have often been subject to scrutiny—and, in some cases, mandates—by the European Commission, which aims to preserve and promote the economic and social development of the European area as a whole.

In this context, the ability to make informed decisions about future economic trajectories is crucial; consequently, economic forecasts are of fundamental importance for economic policy-making. A leading role in the search for techniques to predict economic trends is played by the European Commission, which supports these developments by providing analysis and policy advice on international economic issues. Specifically, the Directorate-General for Economic and Financial Affairs (DG EC-FIN) produces various types of economic forecasts on behalf of the European Commission, which differ in terms of scope and time horizon.

Among the various forecasting methodologies, this study examines and analyzes the subjective forecasts conducted by the Commission using survey-based methods. To ensure the harmonization of these surveys at the European level, the Commission has developed the “EU Joint Harmonized Program of Business and Consumer Surveys” (BCS).

The overall objective of this program is to collect data on the economic situation of EU Member States and candidate countries in order to facilitate the comparison of their economic cycles for the purposes of managing Economic and Monetary Union (EMU). The results of these surveys have become an essential source of information for all actors interested in economic trends, including public institutions, business managers, researchers, and, above all, policymakers at the national, EU, and Eurozone levels. The main purpose of this contribution is to provide a systematic approach for obtaining very short-term forecasts for the industrial production index using the long-term relationship between this time series and the confidence of manufacturing companies in terms of judgment and expectations. An important source of information is surveys of subjective qualitative expectations aimed at businesses.

In reality, entrepreneurs are often able to pick up on certain signals from the economic system, unlike statistical models, which are unable to anticipate unexpected events. In particular, among the qualitative surveys, the focus is on Istat's Economic Sentiment Indicator (IESI). Since June 2012, Istat has been publishing a composite indicator of confidence in the entire Italian manufacturing sector.

The indicator was calculated by aggregating the balances of the variables (seasonally adjusted and standardized) included in the confidence indicator for the following sectors: manufacturing (assessments of orders, production expectations, and assessments of inventories); construction (assessments of orders and/or construction plans and employment expectations); market services sector (assessments and ex-

pectations regarding orders and assessments of the business situation); retail trade sector (assessments and expectations regarding the business situation and assessments of inventories).

The main idea behind this innovation is to use production expectations for the next three months as a possible leading indicator directly linked to the IPI. By making this link explicit, it is possible to use it to make short-term forecasts of the IPI. Before researching the link between production expectations and the IPI, it is necessary to ensure that these expectations are consistent with the assessments in the same survey. This consistency could be verified using an approach based on the classification of turning points in a time series. If this consistency between assessments and expectations is verified, it is possible to research a long-term relationship between expectations and the IPI.

The paper is organized as follows. Section 2 describes the importance of the subjective forecasting for economic variables. Section 3 presents the surveys about confidence climate indicators at European and Italian level. Section 4 introduces the steps of the proposed approach presenting the turning point theory, the multivariate time series techniques and forecast methods. Section 5 presents the application of the approach to the Industrial Production Index. Finally, Section 6 is reserved to discussion and final remarks.

## 2. THE IMPORTANCE OF SUBJECTIVE FORECASTING FOR ECONOMIC VARIABLES

Economic forecasting is the specific activity of identifying and quantifying the evolution of an economic variable over time in the future. Strictly speaking, forecasting refers to the application of a model – including mental models – to a set of data and information to determine the future trajectory of one or more variables within a predetermined time horizon.

The primary objective of economic forecasting is to facilitate timely decision-making by providing clear and concise predictive indicators. For any economic activity, it is essential to have analytical indicators both to interpret the daily economic landscape and to accurately predict immediate future scenarios.

In economics, forecasts investigate collective phenomena characterized by uncertain outcomes; therefore, multiple elements must be considered to meet forecasting standards. No forecasting method is inherently superior or inferior to others; rather, a method is more or less suitable – and more or less expensive – depending on the specific circumstances.

The primary classification of forecasting methods distinguishes between quantitative and qualitative (or subjective) methods. While the former aim to provide a measurement of the future evolution of economic variables, the latter serve primarily to indicate the direction in which changes will occur.

The starting point is the choice of forecasting approach, where the key factor is the reference period: short, medium, or long term. Short-term (or cyclical) forecasts generally do not go beyond 12 months and serve as support for operational decisions.

Medium-term forecasts cover a period of up to 24 months and support decisions related to aggregate production plans. Finally, long-term forecasts extend beyond two years, although considerable difficulties arise when trying to forecast more than ten years ahead. Long-term forecasts typically concern the economic impacts of technological innovations, which are often only in their early stages of development.

The economic importance of these time limits lies in the fact that they roughly represent the time needed for economic agents (households, businesses, and public administrations) to change their behavior. Consequently, within these intervals, the trends of certain variables can be considered largely given.

Objective forecasts are based on quantitative data and rigorous statistical methods, using deterministic or probabilistic approaches through univariate, multivariate, and econometric models. The goal is to build an optimal predictive model capable of producing replicable results. A quantitative forecast can be applied when three specific conditions are met: historical information is available; this information can be quantified numerically; and it can be assumed that certain aspects of the past will continue in the future. This last condition, known as the continuity assumption, is the premise underlying all quantitative forecasting methods and some qualitative methods, regardless of their complexity.

When the data available for studying an economic phenomenon are insufficient to produce a reliable forecast, or when highly timely data are needed, qualitative methods are used. While quantitative methods aim to provide an accurate measurement of the future evolution of economic variables, subjective methods serve primarily to provide indications of the direction of change in the immediate future and to identify turning points in economic trends in advance.

Qualitative methods mainly aim to capture the trajectory and potential changes in phenomena, which are essential for timely decision-making. These are informal, empirical, and intuitive methods based on the judgments, opinions, and intentions of economic operators; they generally derive from opinion polls or role-playing exercises. The use of subjective methods is well established in cyclical analysis; in particular, the shorter the time frame available for decision-making, the greater the likelihood of resorting to such forecasting procedures.

Data collection is carried out through surveys and is based on the judgments of economic operators regarding the overall performance of their businesses or, more generally, the current and future economic outlook. Responses are generally qualitative, based on predefined alternatives. The usefulness of this method lies in its ability to provide information on operators' expectations (regarding demand, production, prices, etc.) and, consequently, on their subsequent behavior (see Piatier, 1979).

As a result, subjective indices are constructed to provide a well-defined overview of specific market trends and, more generally, of the country's economic situation.

The main strength of these indicators lies in the extremely short time between data collection and publication, which provides significant support to decision-makers who need to anticipate future developments in their target markets. In fact, the speed with which these indicators can be generated after data collection is the main reason why a subjective rather than a quantitative approach was chosen.

A further advantage is the cost-effectiveness of these surveys. Often conducted via email questionnaires, they are significantly less expensive in terms of both data acquisition and analysis. In addition, the high qualification of the respondents helps to minimize errors resulting from a lack of specific expertise in the field. Since the same respondents are interviewed several times throughout the year, they are also able to provide a longitudinal perspective based on their evolving situation.

The main disadvantages of qualitative methods lie in their practical application, as they require a large number of specialized staff and depend to a considerable extent on the analytical skills of the users. Potential errors include systematic biases due to preconceptions regarding the forecasting context, as well as “optimism bias” where forecasts reflect the interviewees’ aspirations rather than their objective expectations. Finally, errors related to anchoring – the tendency to assume that the future will mirror the past or that no significant changes will occur in the short term – can undermine the accuracy of the results.

The disadvantages common to all qualitative methods are the lack of extensive data to support emerging hypotheses and the absence of the rigorous methodology typical of quantitative research. A solution to the latter issue has been provided by the European Commission, which developed a manual specifying a common methodology for business and consumer surveys to be adopted by all EU Member States: “The Joint Harmonised EU Programme of Business and Consumer Surveys.”

### 3. SUBJECTIVE FORECASTS THROUGH BUSINESS AND CONSUMERS SURVEYS

The objective of the “Harmonized EU Program of Business and Consumer Surveys” is to collect data on the economic situation of EU Member States and candidate countries in order to facilitate the comparison of their economic cycles for the purposes of managing the Economic and Monetary Union (EMU) (European Commission, 2023).

Business and consumer surveys are a key tool for obtaining timely information on economic developments. Consequently, the Commission, through the Directorate-General for Economic and Financial Affairs (DG ECFIN), coordinates regular, harmonized surveys in various economic sectors in EU Member States and candidate countries.

These are qualitative economic surveys designed to meet the needs of short-term economic analysis, both quantitative and qualitative. Several short-term forecasting methods based on survey data have been developed, which often outperform classical econometric models in forecasting macroeconomic developments.

The value of survey data for both qualitative and quantitative analysis stems from their timely availability compared to quantitative information from other sources, such as official statistics, which are often subject to considerable delays. Thus, the Joint Harmonised EU Programme of Business and Consumer Surveys serves as an effective instrument for monitoring the economic situation in the EU, the Eurozone, and individual Member States. Beyond the Commission, the ECB (European Central

Bank), national central banks, research institutes, and financial institutions frequently employ European survey data for their analytical frameworks.

The ongoing development of the program has also stimulated surveys of businesses and consumers outside the EU. The harmonized EU framework is increasingly being adopted as an international standard; in this regard, harmonized EU surveys continue to serve as a benchmark for future cooperation.

The surveys are conducted at national level in cooperation with institutions such as ministries, statistical offices, central banks, economic research institutes, professional associations, and private companies. These institutions use harmonized survey questionnaires developed in cooperation with the Commission services.

Conducting surveys according to a common methodology improves the comparability of data between Member States and allows for the calculation of valid aggregate cyclical indicators for the euro area and the EU.

Survey responses are aggregated into “balances”, calculated as the difference between the percentages of respondents giving positive and negative answers. These balance series are then used to construct composite indicators.

First, for each sector under review, the Commission calculates confidence indicators as the arithmetic mean of the (seasonally adjusted) balances of a selection of questions closely linked to the reference variable (e.g., industrial production for the industrial confidence indicator). Second, the results for the five sectors surveyed (industry, services, construction, retail trade, and consumers) are aggregated to form the Economic Sentiment Indicator (ESI). The purpose of the ESI is to track GDP growth at the Member State, EU, and Eurozone levels. The calculation of balances and composite indicators will be described in detail in the following sections.

### 3.1 *Common properties of the surveys*

The principle of harmonization underlying the Commission’s survey program aims to produce a set of data that is comparable across countries. Harmonization is essential to enable the comparison of economic cycles between Member States, as well as the calculation of meaningful cyclical indices for the euro area and the EU as a whole.

Harmonization does not, however, imply uniformity. National questionnaires may include additional questions beyond those harmonized. Similarly, the sectoral breakdown in national questionnaires may be more detailed than that established in the program. Furthermore, national partner institutes are free to organize the fieldwork in the manner best suited to their specific context. Although the sample design, sample size, survey mode, and other methodological considerations are, in principle, decided at the discretion of the national institutes, these parameters must be chosen in such a way as to ensure a high degree of representativeness and to minimize irregular short-term fluctuations (noise) in the data. To this end, large, frequently updated samples and a high response rate are considered essential. The survey methodologies of national institutes are subject to periodic review by the Commission.

The timing is common to all harmonised surveys. Fieldwork for monthly surveys is generally conducted during the first two to three weeks of each month. Quarterly surveys are carried out during the same period in the first month of each quarter (January, April, July, and October). Survey results are transmitted to the Commission via email at least five working days before the end of the reference month, following a predefined format.

Harmonized surveys provide information on a wide range of variables useful for monitoring cyclical developments. Almost all questions are qualitative in nature. The industrial sector survey, in particular, is largely subjective. Key questions concern assessments of recent production trends, current order and inventory levels, and expectations regarding future production, selling prices, and employment.

The format of the responses is different for quantitative questions. These concern capacity utilization, months of guaranteed production, and potential increases in the volume of activity. In these cases, respondents are required to provide data as a percentage or as a specific number of months. For questions on factors limiting production, a list of potential constraints is provided, and respondents are asked to select one or more factors.

With regard to data collection, in order to improve the efficiency of a random sample (obtaining a smaller sample for a given level of precision), many institutes use stratified random sampling. This involves dividing the population into non-overlapping sub-populations, known as strata, which have similar variance with regard to the key variables of the survey. Stratification is applied according to various criteria. For business surveys, these criteria mainly concern the size of the business and the sector of activity. For consumer surveys, the selection of respondents is commonly based on gender, age, education, income, and occupation. In business surveys, the sample does not vary significantly from one period to another; in most cases, a panel of businesses is established and interviewed on a monthly basis. This approach is justified by the structure of the production system itself, which does not change significantly from one period to another and is often highly concentrated. Evaluating the same enterprises offers several advantages: responses are received more quickly, the variability of results between successive surveys is reduced, and this has a positive effect on the required sample size. It is recommended that the same panel be maintained over time for business surveys, with regular updates or the periodic replacement of a small fraction of the sample (rotating panels).

### *3.2 Confidence indicators of the qualitative surveys*

Business and consumer surveys provide monthly assessments and anticipations regarding various aspects of economic activity across different sectors: industry, services, construction, retail trade, and the consumer sector. Based on the detailed results of the harmonised programme, the Commission calculates and publishes a series of monthly composite indicators. First, for each of the five sectors examined, “confidence indicators” are calculated to reflect overall perceptions and expectations

within a single sector through a one-dimensional index. Second, to enable the monitoring of global economic activity, the broader Economic Sentiment Indicator (ESI) has been calculated since 1985, summarising developments across all five surveyed sectors.

For each confidence indicator, specific questions are selected from the full set of questions within each individual survey. This selection is guided by the objective of achieving the highest possible correlation between the confidence indicator and a reference series – such as the year-on-year growth of industrial production – at both the EU and Eurozone levels.

The Economic Sentiment Indicator is composed of 15 individual components derived from sectoral confidence indicators. In calculating this composite indicator, explicit weights are assigned to the various sectors: Industry (40%), Services (30%), Consumers (20%), Construction (5%), and Retail Trade (5%).

These weights were determined based on two criteria: the “representativeness” of the sector and its fitting performance relative to the reference variable. Given the broad scope of the ESI, the corresponding reference variable is naturally GDP growth, which tracks the movements of the economy as a whole.

It is important to note that these weights are not applied directly to the five confidence indicators, but rather to the series of their individual standardised components. Prior standardisation is essential to ensure that individual component series are comparable in terms of both mean levels and volatility before aggregation, particularly when components pertain to developments in diverse economic sectors.

The composition of the ESI, and specifically the weights assigned to different sectors, underscores the significance of the manufacturing industry within the European economy and its influence on the economic growth of the EU and its Member States. Consequently, the Industrial Confidence Indicator carries substantial weight in subjective forecasting as the most critical confidence metric. For this reason, the performance analysis of the BCS programme in this study is conducted by examining the Industrial Confidence Indicator in relation to its reference variable: industrial production.

The Industrial Confidence Indicator is the arithmetic mean of the balances (in percentage points) of responses to questions regarding production expectations, order books for finished products, and stocks of finished products (the latter with an inverted sign). Unlike the ESI, which is published as an index (base=100), the industrial confidence indicator is expressed in balances.

In Italy, the survey – conducted under the Harmonised BCS Programme approved by the European Commission on 12 July 2006 (most recently regulated by COM (2006) 379) – is carried out by the National Institute of Statistics (ISTAT). The results are subsequently transmitted to the Commission and are available on the official EU portal (Istat, 2025).

The survey aims to collect qualitative variables such as assessments and short-term expectations (3 months) regarding key corporate variables (orders, production, liquidity, and prices; assessments of finished product stocks; employment expectations) alongside a general assessment of the Italian economic trend. Quarterly, addi-

tional information is requested regarding various aspects of the firm's situation (competitive position, production capacity, hours worked, new orders, raw material stocks, export volumes, production barriers, duration of assured production, and capacity utilisation rates).

The unit of observation and analysis is the firm. The reference universe consists of active firms with at least five employees within the manufacturing sector, as identified in Section C of the ATECO 2007 classification. The survey is monthly, conducted using a longitudinal panel via CATI (Computer Assisted Telephone Interviewing). This technique ensures extremely rapid results and high data quality. The sampling design is stratified random sampling. The list of sampling units is drawn from ASIA (Statistical Register of Active Enterprises), stratified by size, economic activity sector, and geographical area. Complete historical series are available in the I.Stat database.

Monthly, the manufacturing confidence index is calculated and disseminated for the total economy, by territorial division (North-West, North-East, Centre, South), by Main Industrial Groupings (Consumer Goods, Intermediate Goods, and Capital Goods), and by specific activity sectors. The confidence indicator is calculated as the arithmetic mean of the seasonally adjusted balances related to assessments of total orders, stock levels (inverted sign), and short-term production expectations. For manufacturing surveys, confidence indicators are seasonally adjusted using the indirect method: the balance series of the component variables are first seasonally adjusted and then aggregated; finally, the confidence climate series are indexed (base 2010=100).

#### 4. METHODS

In this section will be illustrated the techniques used for pursuing the research goal previously presented. Firstly, in order to verify a potential relationship between the time series of the Industrial Production Index and the expectations on the confidence climate indicator, the turning point analysis will be described. Secondly, multivariate time series methods as the representation of multiple time series through the use of Vector Error Correction Model and the cointegration link will be introduced. After the presentation of these two techniques, finally the forecast method will be shown.

##### *4.1 Definition and classification of turning points*

In times of uncertainty for economic time-series, great attention is about to the analysis of turning points, representing a topic of interest for many researchers. Starting from the 1970s, Stekler (1972) proposed a probabilistic approach to detect the turning points of the FRB (Federal Reserve Board) Index of Production applied to the 1957 and 1960 Cyclical Peaks. Wecker (1979) analysed the turning points of the quarterly seasonally adjusted GNP in the USA discussing the relationship between the theory of minimum mean square error linear prediction and the turning point

prediction problem. Kling (1987) tried to extend Wecker's analysis to the case of the multiple time-series model considering most sources of model uncertainty. In most recent years, Hamilton (2011) surveyed literature on business cycle dating using modern time series methods, showing various approaches applied to a variety of data sets and specifications and Stock and Watson (2014) proposed to estimate turning points using large data sets. Finally, even in this context, the attention has been recently pointed out on Machine Learning techniques for the prediction of turning points using real-time algorithms (Phillips and Wang, 2025).

In this contribution, to define a turning point, the approach proposed by Naik and Leuthold (1986) will be followed, not only for the classification of the time series points but above all for the computation of the indexes measuring the coherence in movements of two or more series. This choice is motivated by the fact that the authors are primarily interested in investigating the presence of co-movements between the IPI and the expectations on the confidence climate indicator. According this approach, each time-series point can be classified as a turning point in 4 categories:

- Peak (P)
- Trough (T)
- Upward (U)
- Downward (D)

where the belonging to a category is explained by the possible situations presented in Figure 1, a point is a peak when it is preceded and followed in its immediately before and after moments by lower values; a trough is defined when it is preceded and followed in its immediately before and after moments by higher values; an upward is obtained when the value of the series in the previous point is lower and in the next point is higher; finally a downward is present when the value of the series in the previous point is higher and in the next point is lower.



FIGURE 1. – *Definition of turning points in time-series*

Beyond the definition of the turning points, in order to check the movements of two time series, the frequency distribution of the classified points can be represented in a cross tabulation or a 4x4 contingency table as reported in Table 1. In this table  $f_{11}$  is the number of moments in which a peak is present in both time series and most generally speaking all the frequencies in the main diagonal are symptoms of coher-

ence in the movement of the two series. Starting from this cross tabulation, some indexes could be computed to measure the coherence between two time-series (Naik and Leuthold, 1986).

TABLE 1. – *Frequency table of turning points to obtain the turning points indexes*

	<b>P</b>	<b>T</b>	<b>U</b>	<b>D</b>
<b>P</b>	$f_{11}$	$f_{12}$	$f_{13}$	$f_{14}$
<b>T</b>	$f_{21}$	$f_{22}$	$f_{23}$	$f_{24}$
<b>U</b>	$f_{31}$	$f_{32}$	$f_{33}$	$f_{34}$
<b>D</b>	$f_{41}$	$f_{42}$	$f_{43}$	$f_{44}$

Four coherence indexes are obtained and they are defined as follows: Ratio of Accurate Forecasts (RAF), Ratio of Worst Forecasts (RWF), Ratio of Accurate to Worst Forecasts (RAWF), Ratio of Inaccurate Forecasts (RIF). The formulas of the four indexes are following represented:

$$RAF = (f_{11} + f_{22} + f_{33} + f_{44}) / \sum_i \sum_j f_{ij}$$

$$RWF = (f_{12} + f_{21} + f_{34} + f_{44}) / \sum_i \sum_j f_{ij}$$

$$RAWF = RAF / RWF$$

$$RIF = (f_{13} + f_{14} + f_{23} + f_{24} + f_{31} + f_{32} + f_{41} + f_{42}) / \sum_i \sum_j f_{ij}$$

In order to have coherence, it would be desirable to have high values for RAF and low values for RWF, for this reason, the RAWF has been computed as the ratio between RAF and RWF. Finally, the last index measures the presence of moments in which it is present a peak or a trough in the first series and an upward or a downward in the second one, generating an inaccurate forecast.

The theory of the turning points is useful to verify the coherence between the assessments on the confidence climate indicator and the expectations of the stakeholders guaranteeing the coherence between the two time series in order to use this as anticipatory variable to predict the IPI. If this coherence between assessments and expectations is verified, then it is possible to search for a long-term relationship between the expectations and the IPI.

#### 4.2 *Multivariate time series methods*

Another interest tool to analyse time series movements and co-movements can be found in the theory of univariate and multivariate time series analysis (see Wei 2006).

According to this theory a single time series can be represented through a model of the ARIMA(p,d,q) (Auto-Regressive and Moving Average) class, where p repre-

sents the order of the AR component,  $q$  the order of the MA one and  $d$  is the number of differences necessary to reach the stationarity of the series, that is to remove the stochastic trend.

In a multivariate frame, the natural extension of the application of ARIMA model is the use of the VAR( $p$ ) (Vector Auto-Regressive) with the negligible loss of information of the Moving Average component. As in the univariate case, a lot of importance is devoted the concept of stationarity and the choice of the order  $p$  of the model. The stationarity guarantees the possibility to represent the VAR model in a joint form and use the OLS (Ordinary Least Squares) to estimate the parameters. The choice of the order  $p$  of the model indicates the number of the significant lags for each time series and therefore the number of parameters in each equation of the model.

Following the theory of Nelson and Plosser (1982), the majority of US macroeconomic time series follow a RW (Random Walk) process and it is grown the attention about the presence of stochastic trends in the empirical analysis. This led to the suggestion to differentiate the starting time series in order to obtain the stationarity. This operation deletes the long-period component allowing to only study the short-period relationships. To model such long-term relationships, the concept of cointegration was formalized. Two variables are co-integrated when it exists a stationary linear combination between non stationary time series (Granger, 1986; Engle and Granger, 1987; Wei, 2006). If this combination exists, then a long period relationship of equilibrium among the variables of the model is present. This concept has been widely used in applications in the area of economics and finance (Kremers, 1989).

The co-integrated systems are vectors of processes integrated of order 1 (stationary after applying the first difference), that become stationary through a particular linear combination called cointegration tie. A mandatory condition for the existence of the cointegration tie is that the two time series must have the same integration order. The ECM (Error Correction Model) allows to decompose the long-period behaviour in a non-stationary component and the short period behaviour in a stationary component.

The study of the cointegration ties in a VAR( $p$ ) model has been obtained starting from the ECM representation and consists in the estimate of the coefficients of the model and the verify of the cointegration relationships through the cointegration tests (Lutkepohl, 2006). Among these, one of the most used is the Johansen test (Johansen, 1988). This procedure consists in the computation of the rank of the cointegration matrix, if this rank is equal to 1, then a cointegration tie is detected. The detection is the cointegration tie between the subjective expectations of the confidence climate indicator and the IPI is fundamental to obtain forecasts on the latter one using the anticipatory explanatory variable.

#### 4.3 *Forecast of the IPI*

The cointegration vector measuring the long-term relationship between the subjective expectations and the IPI led to the estimation of a cointegration coefficient  $\beta$  according the following relationship:

$$y = IPI + \beta * expectations$$

For the  $y$  cointegration vector, a standard Box-Jenkins procedure has been used to obtain forecasts for the three following periods (Box and Jenkins, 1968). This approach provides forecasts through an ARIMA (Auto-Regressive Integrated Moving Average) model generating  $y_{t+1, t+2, t+3}$ .

For the time series of the expectations, data about last three months are available and they measure the expectations of the confidence climate indicator for the periods  $t+1$ ,  $t+2$  and  $t+3$ . Therefore, it is possible to obtain forecasts of the IPI for the next three months just using these expectations the cointegration coefficient and the forecasts of the cointegration vector just overturn the previous equation according the following equation:

$$IPI_{t+1, t+2, t+3} = y_{t+1, t+2, t+3} - \beta * expectations_{t+1, t+2, t+3}$$

where  $\beta$  is the cointegration coefficient and  $expectations_{t+1, t+2, t+3}$  are the values declared by entrepreneurs in the last 3 months for the future.

## 5. APPLICATION TO THE ITALIAN IPI

To evaluate the performance of EU-ISTAT surveys – and, consequently, the subjective forecasts derived from them – it is necessary to compare the industrial confidence indicator with the corresponding industrial production index of the country under analysis.

The proposed approach has been applied on the two time-series from 2010 to 2024. The preliminary results show a similarity between judgment and expectations of the manufacturing companies about the production. This is a mandatory condition to use the expectations as a predictor of the Industrial Production Index.

The confidence climate is built as an arithmetic average of the balances on the assessments on the order books and the stocks of finished products (with a negative sign) and the expectation on the production over the next 3 months.

To verify the coherence between the assessments and the expectations on the production, the four indexes presented in the previous sections have been achieved, the RAF is equal to 37.4%, the RWF is equal to 19.3%, the RAWF is equal to 1.939 and the RIF is equal to 43.3%. These values and the two graphs reported in Figure 2 seem to confirm the coherence between the two time-series.

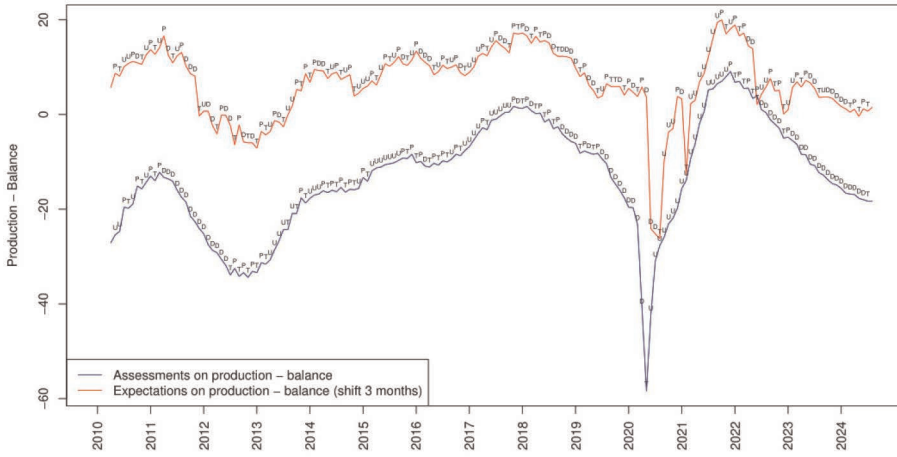


FIGURE 2. – *Turning points for assessments and expectations on production, Italy, 2010-2024*

Once the hypothesized coherence is confirmed, the next step is about the comparison between the expectations on production by the entrepreneurs and the Industrial Production Index (IPI) time series after applying a procedure of seasonal adjustment to avoid the well-known calendar effects. This is represented in Figure 3 where a correlation of 0.35 suggests the possibility of a cointegration tie.

To obtain reliable values for the cointegration link, the expectations on production have been standardized in the same scale of IPI.

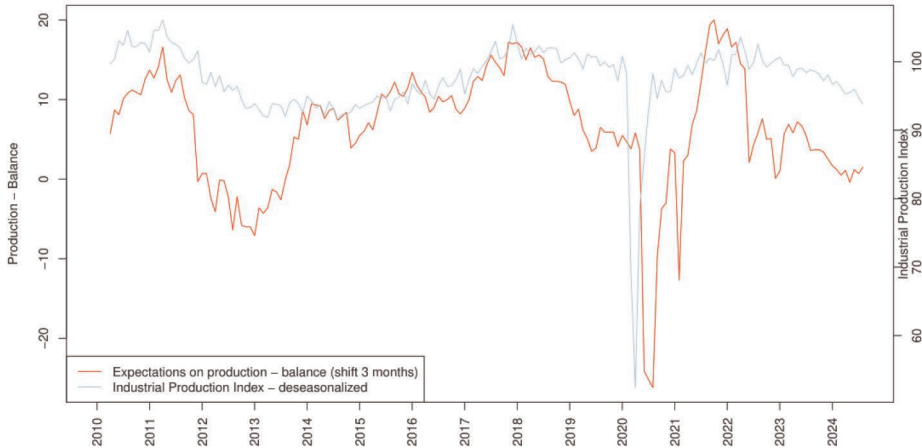


FIGURE 3. – *Relation between expectations on production and IPI, Italy, 2010-2024*

The Johansen test confirms the existence of a cointegration tie, using the Vector Error Correction Model (VECM) and this long-term relationship is equal to  $y = IPI - 0.55309 * \text{expectations}$ . The expectation on production, the seasonally adjusted IPI and the cointegration tie are represented in Figure 4.

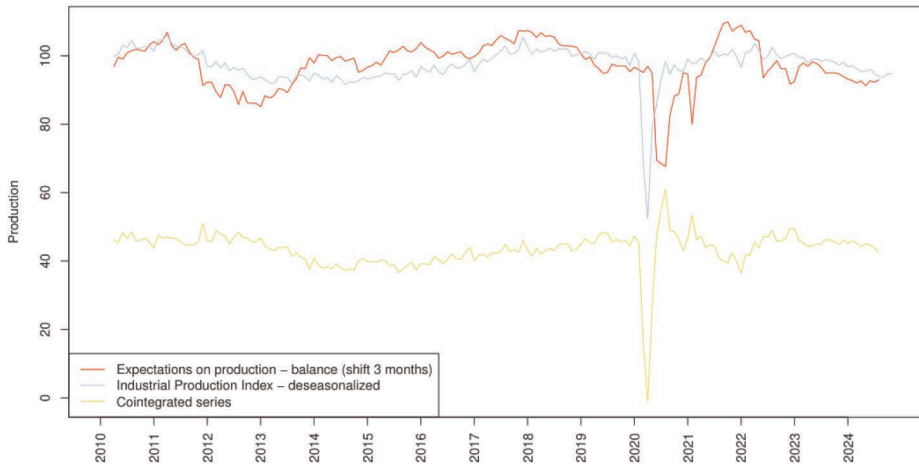


FIGURE 4. – *Representation of cointegration tie between expectations on production and IPI, Italy, 2010-2024*

Using the last step of the procedure, forecasts for the cointegrated series  $y_{t+1, t+2, t+3}$  has been obtained through ARIMA models, in particular an ARIMA (1, 1, 2) with 3 parameters, one for the auto-regressive part and two for the moving average part and one integration order. These forecasts are included in the equation:

$$IPI_{t+1, t+2, t+3} = y_{t+1, t+2, t+3} + 0.55309 * \text{expectations}_{t+1, t+2, t+3}$$

where  $\text{expectations}_{t+1, t+2, t+3}$  are last values of confidence declared by the entrepreneurs. These predictions are shown in Figure 5 with the orange line obtained according the proposed approach.

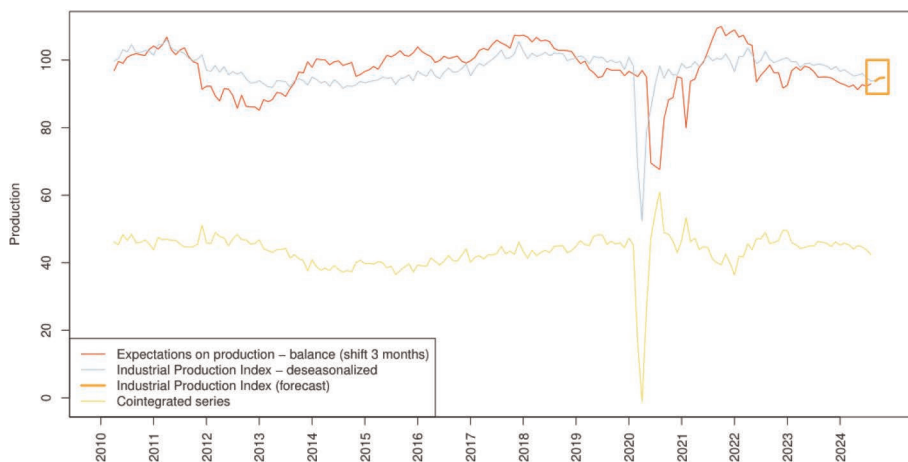


FIGURE 5. – Representation of predictions for IPI using the cointegration tie, Italy, 2010-2024

In particular, the proposed approach generated predictions for IPI for September, October and November of 2024, in the following table, the forecasts are compared with the real values in Table 2.

TABLE 2. – Comparison between real and forecasts for IPI using the cointegration tie, Italy, Sep-Nov 2024

	Sep 2024	Oct 2024	Nov 2024
<b>IPI real</b>	94.3	94.2	94.2
<b>IPI forecasts</b>	93.8	94.7	94.8

The short-term forecasts obtained are in line with the expected values of the entire time-series. Even if the procedure led to a computation of only three period predictions, this could have a big impact because of its anticipatory function.

## 6. CONCLUSIONS

The proposed approach was used to detect short-term movements in the industrial production index in order to anticipate possible anomalies in the time series due to possible crises. This study proposes a forecasting approach based on subjective expectations about the future provided by entrepreneurs in manufacturing companies, used as leading variables for the industrial production index through a long-term relationship.

The cointegration-based approach confirms the existence of a relationship be-

tween the two time series, producing reliable estimates of the IPI three months in advance. The values obtained were compared with the actual IPI values in order to verify the robustness of the proposed approach. In this application, the values obtained are in line with the actual values, justifying this approach in standard situations. The effectiveness of this approach needs to be verified in the event of an economic crisis, justifying its use as an anticipatory tool.

As regards limitations, the forecast period is very short because the qualitative survey only asks for subjective expectations for the next three months. From a methodological point of view, possible improvements could concern the application of this approach to periods of economic crisis when data on subjective forecasts and real macroeconomic variables are available. Another important development could involve implementing this approach at the NUTS-1 level, as the Italian economy is strongly influenced by regional differences, such as the well-known North-South divide, and confidence data are available at this level. This could help to verify the reliability of stakeholders' expectations from a geographical perspective.

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