EURO-MEDITERRANEAN AND AFRICAN NETWORK FOR ECONOMIC STUDIES

WORKING PAPER

What Drives Business Cycles in Egypt? An Analysis of Coincident and Leading Indicators[1]

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EMANES Working Paper Nº 61 / October, 2022

Abstract

The paper proposes a chronology for the Egyptian economy, by detecting phases of expansions and recessions during the period (2002-2019). It examines the cyclical behaviour of variables that are considered potentially useful in measuring or predicting aggregate economic activity. To do so, we combine the National Bureau of Economic Research (NBER) approach, together with time series analysis techniques, to select the variables best suited to play the role of coincident and leading indicators. This methodology is found to be the most appropriate when there is no well-established reference chronology as a benchmark for the cyclical analysis, which is the case of Egypt. As a result, two composite indexes are constructed: 1) The composite index of Coincident Economic Indicators (CEI), which can be considered as an adequate measure for the Egyptian business cycle. 2) The composite index of Leading Economic Indicators (LEI) that showed good performance in anticipating aggregate economic activity in Egypt. Moreover, the empirical results indicate that total employment, consumption and investment moved coincidently with the reference cycle, whilst exchange rate and interest rate variables appeared to lead the reference cycle and showed strong predictive power for economic activity in Egypt.

JEL Classification: E32.

Keywords: business cycles, coincident indicators, leading indicators, cyclical properties, aggregate economic activity.

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1 Introduction

The two seminal publications of Mitchell & Burns (1938) and Burns & Mitchell (1946) marked the start of a new era in business cycle analysis. They brought to attention the fact that business cycles are considered as fluctuations in economic activity, taking place across multiple sectors of the economy and occurring at roughly the same time. This motivated the development of Business Cycle Indexes (BCIs) that can serve as summary measures of the behaviour of different economic indicators and give a broader description of the state of the economy.

The method of constructing BCIs was first initiated in the mid-1930s, at the National Bureau of Economic Research (NBER). Since then, the NBER approach has become the official methodological framework for developing BCIs for the U.S. and a number of other countries. It has also been widely used in the literature (e.g., Zarnowitz (1992) and Zarnowitz and Lee (2006) and Ozyildirim (2010)).

A key step in constructing BCIs - coincident and leading composite indexes - is identifying the components of each of these indexes. Mitchell & Burns (1938), as well as Moore (1950), laid out the foundation for identifying coincident and leading indicators from a large economic data set, whereas Moore and Shiskin (1976) expanded the criteria for classifying cyclical indicators to be based on their timing (with respect to the reference series), conformity, smoothness, economic significance and statistical adequacy. Other studies rely on more statistically oriented methods for classifying cyclical indicators, utilising time series analysis to characterise the cyclical behaviour of economic series and identify coincident and leading indicators, e.g., Stock and Watson (1990 and 1999) and Altissimo et al. (2000).

A voluminous literature has emerged to examine the cyclical properties of economic indicators and to construct BCIs, most of which focused on the U.S. and the European economies, with very little attention given to developing countries. More specifically, in the case of Egypt, there is a dearth of studies examining the behaviour of cyclical indicators relevant to the Egyptian economy and there is a noticeable lack of composite indexes measuring cyclical fluctuations in the country[5]. In addition, recent policy changes, such as the introduction of limited exchange rate flexibility and the

[5] To our knowledge, there is only one study (Moursi et al. (2005)) that identifies cyclical indicators and estimates BCIs for Egypt, by employing the Generalised Dynamic Factor Model (GDFM) and relying on 20 annual indicators for the period 1984-2003.

phasing out of hydrocarbon subsidies, introduced more complexity to the economic outlook. All these considerations imply the need for constructing composite indexes that can monitor cyclical fluctuations and track the economy in a broad sense.

Moreover, the presence of a baseline (reference) chronology makes it possible to identify coincident and leading indicators, as well as assessing their quality. It also helps macroeconomists anticipate possible fluctuations over the business cycle. Noting that, in the case of Egypt, there is neither a well-established business cycle chronology that can be used as a benchmark for empirical analysis, nor an institution that officially propose a reference chronology for the country.

Accordingly, this paper aims to identify variables that are best suited to playing the role of coincident and leading indicators in the Egyptian economy. It screens the business cycle properties of a set of economic indicators using time series techniques, closely following Stock & Watson (1990) and Alissimo et al. (2000). The first step in the process is the construction of a dataset - of quarterly time series - representing most of the real and monetary aspects of the Egyptian economy. Each individual series is examined, based on its co-movement properties, as well as its predictive content with respect to the reference series, which is real GDP. To our knowledge, this is the first attempt to examine cyclical properties for a set of indicators for the Egyptian economy that is as comprehensive as possible, which marks the first contribution of this paper.

Furthermore, selected coincident indicators are aggregated using the NBER approach to construct a composite index of Coincident Economic Indicators (CEI), which monitors the cyclical behaviour of the Egyptian economy, whilst selected leading indicators are aggregated to construct a composite index of Leading Economic Indicators (LEI) that can help predict approaching turning points.

The study also proposes a business cycle chronology for Egypt, by dating its peaks and troughs during the period under study (2002-2019), noting that up till now and, to the best of our knowledge, such chronology is not available for Egypt. This marks the second contribution of the study.

The rest of the paper is organised as follows. Section 2 reviews the literature that tackles the process of identifying coincident and leading indicators, as well as studies addressing the methodology of constructing BCIs. Section 3 gives a brief description of the dataset used. Section 4 focuses on identifying coincident indicators and constructing the CEI index. It also presents the dating of the Egyptian business cycles, by detecting phases of expansions and recessions during the period under study. Section 5 describes the process of selecting leading indicators and constructing the LEI index. Section 6 presents the business cycle properties of selected coincident and leading indicators

relevant to the Egyptian economy. Section 7 provides a conclusion.

2 Literature Review

The literature shows that there are two different but related concepts of business cycles. First, the *classical* approach was initiated by Burns and Mitchell (1946) and completed at the NBER. It is defined as the sequential pattern of expansions and contractions in the aggregate economic activity. Second, the *growth* cycle approach, introduced by Lucas (1976), traces fluctuations in the business cycle through the deviation of the actual growth rate of the economy from the long-term growth rate of (potential) output. Since we closely follow the NBER approach, our study adopts the classical definition of business cycles.

The classical definition by Burns and Mitchell (1946) describes the business cycle as fluctuations in aggregate economic activity. However, they did not give a clear notion of how this aggregate activity should be measured. Real GDP and the Industrial Production (IP) index were the most frequently used single series to represent aggregate economic activity. For instance, Schirwitz (2009) used real GDP as a proxy for aggregate economic activity, whilst Christoffersen (2000) used the IP index. Moreover, Andrea et al. (2017) argued that both the GDP and IP index can fully represent the German cyclical fluctuations. Nevertheless, they preferred to use real GDP as a reference series for the sake of consistency with the OECD and Eurostat, which both consider real GDP as the most suitable indicator for monitoring the EU economic cycle.

Nevertheless, the literature pioneered by the NBER suggests that an index combining a variety of coincident variables is a better indicator of the macroeconomic activity, rather than a single series (Moore (1982) and Dua and Banerji (1999)). More recently, Ahking (2014) compared the ability of real GDP and a composite index of coincident economic indicators in replicating the features of the U.S. business cycle. He concluded that a coincident index could act as a better overall indicator for US economic activity than real GDP. Also, Bhadury et al. (2021) constructed a coincident index for India, using a number of indicators representing various sectors of the economy and which have high contemporaneous correlation with its GDP. The constructed index turned out to provide a real-time assessment of the state of the economy and help identify sectors that contribute to economic fluctuations.

Considering the *selection of coincident and leading indicators*, the seminal work of Mitchell and Burns (1938) initiates the first guidelines for selecting and classifying cyclical indicators, by examining the cyclical properties of a large number of economic

indicators (approximately 500 series) for the US[6]. They come up with a set of 21 indicators that are considered the most trustworthy indicators for cyclical revivals in the country[7]. A second comprehensive review by Moore (1950) built on Mitchell and Burns (1938). He provides a comprehensive economic classification for 225 series, after examining a set of 800 series for the US economy based on their conformity (with historical business cycles) and timing (with respect to the reference series). He reached a tentative list of 21 indicators, where the selected variables are classified according to their timing at business cycle peaks and troughs, into three categories (leading, coincident, and lagging).

Subsequently, Moore and Shiskin (1967) contribute to the previous selection process by expanding the criteria of selecting indicators into six broad types, amongst which are timing, conformity, smoothness, economic significance and statistical adequacy. They developed an explicit scoring plan that helps in the evaluation and selection of coincident and leading indicators, such that for every series examined, scores are assigned for each criterion considered and posted on a "scoresheet". Moreover, Zarnowitz and Boschan (1975a and 1975b) use the same scoring system for evaluating business cycle indicators and introduced new leading indicators.

On the other hand, Stock and Watson (1990 and 1999) and Altissimo et al. (2000) departed from the NBER tradition to quantify cyclical co-movements. They utilised techniques derived from time series analysis to characterise the cyclical behaviour of economic indicators, in an attempt to identify coincident and leading indicators.

As for the *methodology of constructing BCIs*, it was originally developed at the NBER, as described in Burns and Mitchell (1946) and summarised in Zarnowitz (1992).[8] The NBER approach (also referred to as The Conference Board (TCB) represents the non-model approach[9] for constructing BCIs and it was extensively used in literature. For example, Altissimo et al. (2000) followed the same spirit of Stock and Watson (1990 and

[6] Cyclical indicators are classified into three categories (coincident, leading and lagging) based on the timing of their movements compared to the reference cycle. Coincident indicators, move contemporaneously with the aggregate economic activity; thus, they define the business cycle. Leading indicators, tend to shift direction in advance of the reference cycle. (The Conference Board, 2001)

7 They first selected a set of 71 indicators, which are considered reasonable indicators of revival. Then, a closer examination of the 71 series resulted in a set of 21 indicators that are supposed to be the most trustworthy. Noting this, Mitchell and Burns (1938) provided a detailed explanation of the selection criteria and documented the cyclical behaviour of each series.

[8] It is important to note that, in late 1995, The Conference Board (TCB) took over the responsibility of maintaining and regularly publishing the "NBER method" indexes.

[9] The NBER approach is considered a non-model approach for constructing composite indexes of cyclical indicators, as it is based on the aggregation of standardised selected series by implementing the step-wise procedure, developed at The Conference Board. Furthermore, it doesn't provide a statistical framework to compute standard errors around the composite index. (see Moauro (2017), P.303)

1998), in an attempt to develop business cycle indexes for the Italian economy. They used time series analysis techniques to identify a set of coincident and leading indicators from a large data universe. The composite indexes of CEI and LEI have been constructed along the lines of the NBER methodology.

Moreover, some studies followed the TCB approach in both selecting the components of the coincident and leading indexes, as well as in the methodology used to develop these indexes. For example, Dua and Banerji (1999) constructed coincident and leading business cycle indexes for India using the TCB approach. Ozyildirim et al. (2013) developed similar indexes for Brazil and concluded that the resulting TCB coincident index closely follows the Brazilian Business Cycle Dating Committee chronology. However, Ozyildirim and Wu (2012) used a set of new commodity indicators as an alternative for some components of the existing TCB indexes for China. They found that, although the CEI index provided by the TCB is robust in predicting the cyclical fluctuations of the Chinese GDP, the commodity-based indicators (that reflect the movements in the industrial output) better represent the GDP dynamics in China.

Further studies tried to construct business cycle indexes, using the TCB approach in a scarce data environment. Abberger et al. (2013) and Abberger and Nierhaus (2015) constructed a quarterly reference series for Abu Dhabi, using the temporal disaggregation method. Meanwhile, Ozyildirim et al. (2015) constructed a proxy-CEI and a proxy-LEI for each of Bahrain, Kuwait, Saudi Arabia, Oman, Qatar and the United Arab Emirates, using alternative indicators according to data availability.

On the other hand, amongst the model-based approaches for constructing BCIs are dynamic factor models. They are more statistically oriented methods, that began with Sargent and Sims (1977) and Geweke (1977) and were later popularised with the work of Stock and Watson (1989 & 1991). Amongst the popular applications of dynamic factor models is the Generalised Dynamic Factor Model (GDFM), introduced by Forni et al. (2000) and Forni and Lippi (2001). The GDFM can construct BCIs using large panels of time series (where the number of variables is possibly larger than the time dimension). Using the GDFM, Moursi et al. (2005) estimated BCIs of coincident and leading economic indicators for the Egyptian economy, whilst Al-Hassan (2009) constructed a single coincident index for the Gulf Cooperation Council.

From the above review, we can conclude that studying cyclical indicators and construction BCIs have been developed extensively for the U.S. and the Euro area, whilst research on developing countries has remained quite scant. More specifically, in the case of Egypt, the lack of a reference business cycle chronology, in addition to the limited research analysing cyclical indicators and constructing BCIs for the country, is considered

a gap that the study aims to fill.

3 Data

In the selection process of potential coincident and leading indicators, we study the business cycle properties of 58 series that are potentially relevant for economic activity and assess their degree of conformity with the aggregate cycle. The variables include measures of output, labour market conditions, investment activity, consumption, monetary aggregates, interest rates and external trade, in addition to international variables such as the US, China and the European Union's real GDP.

The complete list of variables in the dataset is presented in Table A.1 of Appendix A, together with the series description and sources. The period under study is from 2001: Q2 to 2019: Q4. This starting point was chosen because most of the macroeconomic data for Egypt is available on a quarterly basis, starting with the FY 2001/2002.[10]

Some of the series are transformed prior to subsequent analysis, as the level term of these series turned out not to well reflect its fluctuation over the business cycle. In choosing the suitable transformation, we are primarily guided by the nature of the cyclical pattern of each series. Variables, whose level terms are found not to be moving over the business cycle, are transformed into growth rates. However, other series whose level terms actually vary over the business cycle are taken with no transformation (e.g., Suez Canal revenues, tourism revenues, etc.). Moreover, transformations carried out in Stock & Watson (1990) are taken as additional guidelines, where series measuring real or nominal quantities (e.g., output, labour and money supply), as well as price indexes, are generally transformed into growth rates.

In our analysis, most of the series under study exhibited no seasonal component[11], however, some series showed a seasonal pattern. Thus, additional transformation is required to remove the seasonal component, using the X-13 ARIMA SEATS Seasonal Adjustment Programme provided by the United States Census Bureau[12]. The transformation chosen for each of the series is also presented in Table A.1 of Appendix A.

[10] It is noted that variables that are available annually (e.g. employment by sector) were interpolated to obtain quarterly series, using cubic splines and implemented in Matlab.
[11] The underlining pattern of a given time series can be decomposed into four main components (trend, cyclical, seasonal and noise component). The *trend component* captures long-term growth or decline in the series, whilst the *cyclical component* represents slow-moving swings around the trend line. The *seasonal component* captures seasonal variation and the *noise component* represents residual random error variation (Gerbing (2016)).
[12] More details on the programme are available at: https://www.census.gov/srd/www/x13as/

4 Constructing a Composite Coincident Index and Dating the Egyptian Business Cycle

This section provides a descriptive analysis of the co-movement properties (coherence & cross-correlation) of a set of economic variables, which are potentially relevant to the Egyptian economy, noting that the starting point of measuring cyclical co-movements in business cycle research is the identification of the "reference series" (Altissimo et al. (2000)).

The reference series is normally chosen from the available measures of aggregate economic activity. It is either a single series (GDP or industrial production index) or a composite index of coincident indicators. In the case of Egypt, there is neither an updated coincident index nor an official cyclical chronology that can provide a sound basis to build upon. Thus, in our analysis, real GDP (RGDP) is chosen as the reference series.

4.1 Selecting Coincident Indicators:

In an attempt to select variables that move contemporaneously with economic activity, we thoroughly examined the business cycle properties of the 58 series in the dataset. The series showing the best co-movement properties with the RGDP are selected and aggregated into the CEI, which can be used as a satisfactory proxy for business cycle fluctuations in Egypt.

Following Stock & Watson (1990) and Altissimo et al. (2000), we examine the co-movement of each series with the aggregate economic activity presented by the reference series (RGDP). We consider two different properties at business cycle frequencies, one in the frequency domain and the other in the time domain. In the frequency domain, the coherence (R^2 by frequency) is considered. In the time domain, the cross-correlation between the aggregate cycle and each individual series is examined [13].

Although the time dimension is a standard tool of business cycle analysis and is widely used in expressing the dynamic properties of economic time series, nevertheless, information on time series dynamics obtained from the time domain can be complemented by the frequency domain approach "spectral analysis". This is because the

[13] The co-movements identified, using the coherence between each variable and the reference variable, are based on a definition of the business cycle which is close to that of the growth-cycle approach, yet, the selection of coincident indicators is completed using the turning points analysis (part of the NBER tradition), which introduces the classical definition into the approach.

frequency domain can present a clearer picture of the business cyclical fluctuations with the same amount of information available in the time domain and it can also provide a description of the main oscillatory pattern of a time series. A starting tool for doing this is the periodogram[14] which is used to identify the dominant periods in a time series. For more details on the theoretical representation of the spectral analysis, see Appendix B.

In the frequency domain approach, we carried out two sets of summary statistics. The first set examines the univariate properties of each series in the data set, whilst the second set describes the cross-spectral analysis, i.e., co-movement of each series with respect to the reference series (RGDP).

The results are presented in Table A.2 of Appendix A. The first four columns present the univariate spectral analysis. They report estimates of the spectral density over four frequency bands, corresponding respectively to periods of greater than 6 years, 2-6 years, 1-2 years and less than one year. These estimates are the unweighted average of the periodogram ordinates over the indicated frequency band. They are expressed as a ratio of the periodogram estimate over the band, to the average value of the periodogram over the entire frequency range [-π, π]. A relatively high value of the spectral density indicates that the given frequency band has relatively more importance in explaining the oscillation pattern of the observed series. For example, for employment (series 3), the average value of the periodogram for frequencies with periods greater than 6 years is 1.107 times the average value of the periodogram over the entire frequency range, whilst the average periodogram for periods of less than one year (high frequencies) is only 0.014 times the overall average. This means that the frequency band of greater than 6 years is the best for explaining the oscillation pattern of the employment series.

The next four columns represent the cross-spectral analysis. They report the coherence (a measure of R^2 by frequency) between the growth of RGDP and the series in question over the four frequency bands. The greater the coherence at a given frequency band, the more closely the series moves with the RGDP growth. For instance, employment growth showed to be moving closely with the RGDP growth at the frequency band of greater than 6 years (i.e., low frequencies), such that the coherence between the two series is 0.925. However, at a frequency band of less than one year (i.e., high frequencies), employment growth does not closely follow RGDP growth (coherence is only 0.2). Noting

[14] The periodogram graphs a measure of the relative importance of possible frequency values that might explain the oscillation pattern of the observed data (Bátorová (2012)).

this, the coherence presented in Table A.2 are averages of the point-wise coherence at the indicated frequency band.

For the time domain analysis, to quantify the co-movement properties of variables in the dataset with respect to the reference series (RGDP), we examined the "cross-correlation" between each trial series and the reference series at different leads and lags (in the range between -6 to +6). In Stock & Watson (1990), they filtered series in the dataset, to isolate the cyclical components and analyse the co-movements amongst these components separately. However, in the case of Egypt, due to the relatively short time span available, the computation of filtered variables caused a loss of observations that hindered the process of quantifying co-movements with the aggregate cycle.

In Table A.2 of Appendix A, the final three columns report the cross-correlation between the logarithm of RGDP and the series in question. The first column gives the contemporaneous correlation (r_0), the second column gives the maximal correlation (r_{max}), and the third column (t_{max}) gives the lead or lag at which the correlation is maximal. For example, the "Unemployment Rate" (series 2), has an absolute maximal correlation of 0.33 at the time of -4, indicating that the unemployment rate at time (t) has a maximum correlation (0.33) with the RGDP growth at time (t+4). This means that unemployment leads the overall economic activity in Egypt by 4 quarters, such that the unemployment rate increases to report a trough 4 quarters before the actual trough takes place in the aggregate cycle. Consequently, the reported lead (or lag) can be interpreted as a measure of the number of quarters by which the series leads (-) or lags (+) overall economic activity. Moreover, employment (series 3) appears to move contemporaneously with the aggregate economic activity (no leads or lags). This means that turning points in both RGDP and employment series occur at approximately the same time.

We reviewed the co-movement properties of each of the 58 variables, according to all the above-mentioned criteria. In order to make the selection, we focus on a number of criteria: Firstly, we relied on the statistics of coherence and cross-correlation between each trial series and the reference series presented in Table A.2. From each category, series that exhibited very good co-movement properties with the aggregate cycle (i.e., having relatively high measures of coherence and cross-correlation) are selected. For the coherence, we consider series with a coherence measure greater than or equal to 0.7. Yet, for cross-correlation, series with maximum values of the cross-correlogram[15] ranging

[15] A cross-correlogram, is a chart graphing the cross-correlations between two time series at different leads and lags

between 0.8 and 0.9 are selected.[16] For most of the selected variables, the peak of the cross-correlogram is reached at zero leads or lags and in very few cases with a lead or lag of one quarter, which is the maximum lead (or lag) allowed in a coincident series within the traditional NBER approach (Altissimo et al. (2000)).

Secondly, we avoided redundancy, i.e., did not choose more than one or two variables of the same type or from the same source (Altissimo et al. (2000)). For example, most of the disaggregated employment variables across sectors were potentially qualified as coincident indicators, but we selected total employment and employment in manufacturing only.

Thirdly, we tried to achieve some balance between categories. Some of the categories tended to be over-represented, as they contain many variables that showed good co-movement properties with the reference series, such as measures of output and labour market conditions. However, other categories, such as external trade and exchange rate variables, didn't show good co-movement properties with the aggregate cycle. Yet, following Altissimo et al. (2000), to extend the composite indicator to as many sectors and aspects of the economic activity as possible, we included variables from the external trade category, as well as the Nominal Effective Exchange Rate (NEER) for Egypt, despite them not satisfying the minimum requirements of co-movement with the reference series.

According to the above criteria, we have selected the first subset of 15 series that are approximately coincident with the aggregate activity and presented in Table 1.

Table 1: *Co-movement Properties of the Selected Coincident Series*:

Series	Characteristics		Spectral Density				Coherence				Cross-Correlation		
Code	Seas. Adj.	Transformation	> 6 yrs	2-6 yrs	1-2 yrs	< 1 yr	> 6 yrs	2-6 yrs	1-2 yrs	< 1 yr	ro	rmax	tmax
Employment	No	d ln	1.11	0.08	0.07	0.01	0.92	0.77	0.39	0.20	0.975	0.975	0
Employment in manufacturing	No	d ln	0.65	2.13	2.10	0.01	0.53	0.57	0.51	0.47	0.912	0.912	0
Employment in construction	No	d ln	0.38	0.98	0.77	0.01	0.87	0.45	0.20	0.35	0.967	0.967	0
Suez Canal revenues	Yes	No Transf.	11.50	4.59	1.17	0.93	0.75	0.70	0.50	0.20	0.715	0.715	0

[16] In the selection process, we are guided by Stock & Watson (1990) and Altissimo et Al. (2000) in choosing the minimum values of coherence and cross-correlation.

Real GDP at factor cost	Yes	d ln	1.69	2.00	0.73	0.28	0.99	0.99	0.97	0.95	0.987	0.987	0
Household consumption	Yes	d ln	4.40	2.61	1.67	2.28	0.76	0.70	0.42	0.11	0.952	0.952	0
Investments and inventory	Yes	d ln	4.16	4.27	1.94	0.24	0.44	0.33	0.18	0.23	0.919	0.919	0
Lending rate	No	No Transf.	42.20	11.38	3.85	1.14	0.82	0.78	0.58	0.22	-0.175	-0.253	-1
Money supply (M1)	No	d ln	0.31	0.76	7.02	6.84	0.80	0.73	0.50	0.19	0.931	0.931	0
Domestic liquidity (M2)	No	d ln	2.36	2.90	2.37	0.46	0.81	0.78	0.54	0.18	0.903	0.903	0
Imports of intermediate goods	No	d ln	1.28	3.23	2.26	0.01	0.30	0.23	0.09	0.01	0.728	0.728	0
Imports of non-durable goods	No	d ln	3.38	1.85	0.61	0.01	0.35	0.32	0.24	0.11	0.857	0.857	0
Exports of raw materials	No	d ln	0.38	0.39	0.11	0.01	0.64	0.52	0.24	0.05	0.867	0.867	0
Exports of semi-finished goods	No	d ln	0.63	1.50	1.03	0.06	0.24	0.22	0.22	0.13	0.821	0.821	0
Nominal effective exchange rate for Egypt	No	d ln	3.82	2.50	0.50	0.00	0.20	0.17	0.12	0.05	-0.847	-0.847	0

As a last step, to select the final set of coincident indicators, we evaluate their co-movement properties with the aggregate cycle. More specifically, the timing of peaks and troughs of the selected variables are compared to the corresponding ones in the reference cycle. The identification of peaks and troughs of the fifteen series is performed using the Bry-Boschan[17] algorithm for quarterly data (BBQ), proposed by Harding and Pagan (2002), which states that a potential peak is identified in a quarter if the value is a local maximum. And correspondingly, a potential trough is identified if the value is a local minimum. Looking for maxima and minima takes place over a window of five quarters.

In the analysis, the BBQ algorithm is employed, such that, the minimum length of a complete cycle and the minimum length of a single phase in the analysis are set to twelve and five quarters, respectively. For each series, having identified its peaks and troughs, enabled us to compute the lead and lag of each turning point, with respect to the corresponding one in the reference cycle. The results are presented in Table 2. Cycles of the reference chronology missed by a given series are denoted by a dash and, conversely,

[17] The Bry-Boschan dating algorithm was originally introduced by Bry and Boschan (1971) and modified by Harding and Pegan (2002)

cycles that are observed in a given series and absent in the economy as a whole, are denoted by "extra cycles" and reported in the last two columns of Table 2. [18]

[18] A reference turning point is said to be missed by the series, if we failed to match a peak (trough) in the series with a peak (trough) in the reference series without an intervening trough (peak), whilst an "extra cycle" is identified when a series exhibits a peak and a trough not associated with the reference chronology (Ozyildirim (2017)).

Table 2: *Leads & Lags of the fifteen selected Coincident Indicators with respect to the Reference Cycle:*

[+ve & -ve signs corresponds to lag and lead with respect to the reference chronology]					
	Peak	**Trough**	**Peak**	**Extra cycles**	
Reference Cycle	**2007q1**	**2011q1**	**2018q1**	Peaks	Troughs
Employment	-1 (2006 q4)	+1 (2011q2)	--		2004q2
Employment in manufacturing	0	+1 (2011q2)	-7 (2016q2)		
Employment in construction	+10 (2009q3)	+9 (2013q2)	-4 (2017q1)		2018q2
Suez Canal revenues	+5 (2008q2)	--	+1 (2018q2)		2015q3
Real GDP at factor cost	0	0	0		
Household consumption	+1 (2007q2)	-4 (2010q1)	+1 (2018q2)	2012q1	2015q2
Investments and inventory	+5 (2008 q2)	+2 (2011q3)	--		
Lending rate	--	0	-1 (2017q4)	2013q2	2015q4
M1	-6 (2005q3)	-8 (2009q1)	-3 (2017q2)	2013q1	2016q1
M2	+1 (2007q2)	--	-5 (2016q4)	2013q1	2008q4
Imports of Intermediate goods	+4 (2008q1)	0	-2 (2017q3)	2014q1	2015q4
Imports of non-durable goods	+1 (2007q2)	+8 (2013q1)	--	2014q4	2017q2
Exports of raw materials	+2 (2007q3)	-2 (2010q3)	--	2014q3	2017q2
Exports of semi-finished goods	-3 (2006q2)	--	-4 (2017q1)	2011q2	2015q4
NEER	-4 (2005q4)	+1 (2011q2)	--	2015q2	2017q1

Note that: The –ve sign corresponds to a lead with respect to the RGDP, whilst the +ve sign corresponds to a lag. NEER= the Nominal effective exchange rate for Egypt.

Besides the above-mentioned criteria for selecting indicators to be included in the CEI index, we evaluated the economic significance and timing of turning points of the fifteen variables with respect to the reference cycle, to come up with a final set of nine coincident indicators.

From the labour market category, we chose between total employment and labour force, as both series showed high measures of coherence (at greater than 6 years' frequency band) and cross-correlation. However, total employment (EMPL) was preferred over the labour force, since the labour force is correlated with the population growth and, thus, can be a misleading indicator for economic activity.

Moreover, since sectoral disaggregation of employment is included in our dataset to capture how the activity in different sectors moves with the aggregate cycle, we wanted to include at least one variable from this category. In this context, we chose between employment in manufacturing (EMPL_MANU) and employment in construction

(EMPL_CONS), as both of them exhibited good co-movement properties with the reference series. However, employment in manufacturing (EMPL_MANU) is selected in the final set, as it reflects activity in the industrial sector and its turning points turned out to move more coincidently with those of the aggregate cycle.

From the sources of foreign currency, Suez Canal revenues (SUEZCNL_REV) are the only series from this category that appeared to move approximately coincident with the reference series, showing the best measures of coherence and cross-correlation. Furthermore, since revenues from the Suez Canal are aligned with global business cycles and reflect international trade activity, they are selected in the final set of coincident indicators.

Additionally, real GDP at factor cost (RGDP_FC) is by far the most representative and proved to be coincident with the aggregate cycle in all respects (coherence, cross-correlation and dating of turning points). Thus, it is also included in the final set of coincident indicators.

Two components of aggregate demand are considered - household consumption (HHCONS) and investments and inventory (INV). Although household consumption showed more satisfactory co-movement properties with the aggregate series, it was still decided to include investments. This is because it is a broader indicator that not only influences aggregate demand, but also influences the rate at which the economy grows (long-term aggregate supply).

Furthermore, indicators measuring interest rates are examined. The lending rate (LEND_RATE) is chosen, since it exhibited the best co-movement properties amongst interest rate measures (coherence, cross-correlation and the occurrence of turning points with respect to corresponding ones in the reference chronology). It also reflects the short- and medium-term financing needs of the private sector.

As for monetary aggregates, both M1 and M2 exhibited high measures of coherence and cross-correlation. However, their turning points occurred relatively far from the corresponding ones in the aggregate cycle. Yet, given that M2 is an indicator of possible changes in inflation levels and is considered to be a more comprehensive measure of the money supply when compared to M1, it is, therefore, selected in the final set.

Additionally, amongst the indicators of foreign trade, neither imports of intermediate goods (IM_IMGR) nor imports of non-durable goods (IM_NONDUR) satisfy the minimum requirements of co-movement with the aggregate cycle, especially with respect to the coherence with the reference series. As a result, they are excluded from the selection of the final set. On the other hand, exports of raw materials (EX_RMGR) are preferred over exports of semi-finished goods (EX_SEMIFIN), since the former showed

better co-movement properties with the reference series. Besides this, exports of semi-finished goods appeared to perform better as a leading indicator, as illustrated in section 5.[19]

To sum up, the nine variables that are finally selected to construct the CEI index are: two indicators from the labour market [i.e,, total employment and employment in manufacturing]; one indicator from sources of foreign currency [i.e., Suez Canal revenues]; one measure of aggregate output [i.e., real GDP at factor cost]; one variable from the interest rate category [i.e., lending rate]; an aggregate measure of investments [i.e., investments and inventory]; one indicator from the monetary aggregates [i.e., domestic liquidity=M2]; an indicator from the foreign trade category [i.e., exports of raw materials]; and an exchange rate indicator [i.e., nominal effective exchange rate for Egypt].

4.2 Constructing the Composite Index of Coincident Economic Indicators (CEI):

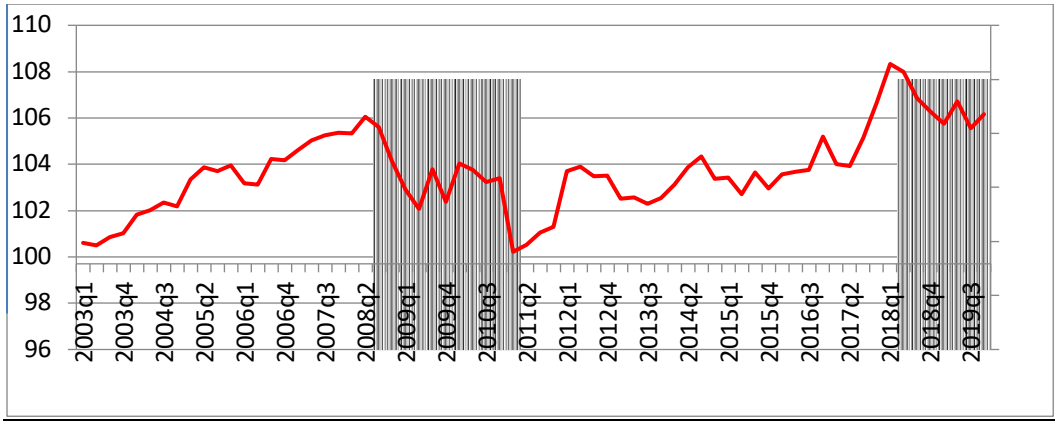
Having selected a set of coincident indicators that seem to perform well in tracking Egyptian business cycles, it is now possible to construct a composite index that can summarise the underlying cyclical co-movements. In choosing the aggregation procedure, we followed the traditional approach, initiated at the NBER and continued by The Conference Board (TCB), to construct a coincident index that is consistent with the classical definition of the business cycle.

Before aggregating selected coincident variables, Altissimo et. al (2000) smoothed each series to remove the high-frequency fluctuations (corresponding to irregular components) that can blur the detection of cyclical fluctuations. However, for the case of Egypt, as mentioned earlier, we skipped the data filtering step, as it led to the loss of observations that hindered the process of quantifying co-movements with the aggregate cycle.

[19] It is worth noting that, although trade balance is not included amongst foreign trade indicators in our dataset, when calculating its cross-correlation with real GDP, results showed strong contemporaneous correlation with economic activity in Egypt (-0.85), with evidence of counter-cyclical behaviour (i.e., real GDP declines as trade deficit increases). This finding supports literature that uses trade balance as a proxy for business cycle movements.

Following the TCB approach[20], the composite index of coincident indicators (CEI) is constructed by aggregating the quarterly percentage change of each series. The quarterly contributions of each series are standardised, to equalise the volatility of each component and prohibit variables having wider fluctuations from dominating the movements of the index. This is done by taking the weighted average of each series using the inverse of the volatility as weights. The adjusted quarterly contributions were then aggregated to obtain the CEI index, which is shown in Figure 1. Further explanation of the TCB approach can be found in Appendix C.

Figure 1: *A Composite Index of Coincident Economic Indicators (CEI) for the Egyptian Economy:*



Note: The shaded areas correspond to recession phases, as defined by the chronology proposed in this paper. (see Table 3).[21]

It is important to note that we didn't apply the trend adjustment procedures, used by the TCB to equate the average growth rates of the constructed CEI index to that of the reference series. This is because there is a satisfactory correspondence between the growth rates of the CEI index and that of the Real GDP over the period under study. Moreover, the cyclical variability of Real GDP is less than that of the components of the CEI, thus normalising with respect to the variability of Real GDP reduced oscillations in the CEI.

[20] More details on the TCB/NBER approach are available at: https://www.conference-board.org/data/bci/index.cfm?id=2154

[21] The period following 2018q1 (Peak) and until the end of the study period is marked as a recession phase. This is because, according to the TCB definition, recessions start at the peak of a business cycle and end at the trough.

The constructed CEI index appears to capture only one complete cycle over the period under study. It illustrates the prolonged expansionary period that prevailed in Egypt from the early 2000s until the first quarter of 2008, which was marked as a peak. A recessionary period followed between the end of 2008 until mid-2009, as a result of the contagious effect of the 2008 global financial meltdown that originated in the United States, which shed its negative effect on trade and investments in Egypt. This contraction continued over the following few years, when the economy hit a trough in the first quarter of 2011, due to the outbreak of the Egyptian revolution in January 2011. The political unrest that accompanied the 2011 uprising triggered a slowdown in all aspects of economic activity, such that, the growth rate slowed down, unemployment increased, FDI inflows as well as tourism revenues witnessed a sharp decline and foreign exchange reserves dropped significantly.

Since 2011, the economy has entered into a gradual recovery phase, incited by the reform programme that took place starting 2014/2015, where the government tried to stabilise the economy and re-ignite economic activity through a bundle of measures. The reform measures focused on energy subsidy reform, boosting investment-led growth through reforms that enhance FDI, as well as the liberalisation of the foreign exchange market towards a market-based exchange rate (OECD Report Egypt (2018)). The upturn continued until the economy reached local maxima (peak) during the first quarter of 2018.

The CEI index also reports the alternation of short-term recoveries and mild recession that occurred between the years 2011 and 2018, amongst which is the contraction that came about by the end of 2016, as a result of floating the Egyptian pound and the hydrocarbon subsidy adjustments that took place in November 2016.

Moreover, having identified the turning points of the CEI, using the Bry & Boschan routine for quarterly data (as applied by Harding and Pagan (2002)), it turned out that the turning points identified closely correspond to those of the reference chronology. This means that the proposed chronology, based on the CEI index, neither missed any aggregate cycle, nor reported any extra cycle (see Table 3).

4.3 Identifying Clusters of Upturns and Downturns in Coincident Indicators and the CEI

This section presents the dating of the Egyptian business cycles (i.e., identifying phases of expansions and recessions) during the period under study, by jointly analysing

peaks and troughs of the individual components of the constructed CEI, as well as the index itself.

As defined by Zarnowitz (1992) P.283, business cycles are *"recurrent sequences of alternating phases of expansion and contraction that involve a great number of diverse economic processes and show up as distinct fluctuations in comprehensive series on production, employment, income, and trade (i.e aspects of aggregate economic activity)"*. Accordingly, the end of an expansionary phase is marked by a cluster of peaks in the selected indicators, with the end of a contraction phase by a cluster of troughs.

Hence, we present the clustering of upturns (peaks) and downturns (troughs) in the selected individual coincident indicators, as well as the CEI (i.e., identifying the consensus of the corresponding turning points amongst these series). In general, we scrutinised a total of eleven series, after adding to the nine components of the CEI the index itself and the real GDP, as it presents the most comprehensive measure of aggregate economic activity. The turning points of the series examined are reported in Table 3, together with the reference chronology and the one proposed in this paper.

Table 3: *Turning Points of selected Coincident Indicators, RGDP and the CEI:*

	Peak	**Trough**	**Peak**	**Extra cycles**	
				Peaks	Troughs
RGDP (Reference Cycle)	**2007 q1**	**2011 q1**	**2018 q1**		
CEI	**2008 q2**	**2011 q1**	**2018 q1**		
Employment	2006 q4	2011 q2	--		2004q2
Employment in manufacturing	2007 q1	2011 q2	2016 q2		
Suez Canal revenues	2008 q2	--	2018 q2		2015q3
Real GDP at factor cost	2007 q1	2011 q1	2018 q1		
Investments and inventory	2008 q2	2011 q3	--		
Lending rate	--	2011 q1	2017 q4	2013q2	2015q4
M2	2007q2	--	2016q4	2013q1	2008q4
Exports of raw materials	2007 q3	2010 q3	--	2014q3	2017q2
NEER	2005q4	2011 q2	--	2015q2	2017q1

Note that:
- Cycles of the reference chronology missed by a given series are denoted by a dash. Cycles which are observed in a given series and absent in the economy as a whole are denoted by "extra cycles" and reported in the last two columns.
- NEER= the Nominal effective exchange rate for Egypt.

In general, the results in Table 3 show that there are very limited differences between the reference chronology and that based on the CEI we have just constructed. That is, out of the three turning points over the period considered, only one (the first upturn in the CEI) lagged the corresponding upturn in the reference cycle by five quarters. For the following two turning points (a trough in 2011q1 and a peak in 2018q1), they occurred at exactly the same timing for both the reference chronology and the chronology proposed in this paper.

Moreover, as for the turning points of the selected indicators, they nearly coincided around the first peak of the reference chronology, with a maximum lag of five quarters. It is also clear from Table 3, that more consensus is observed on the 2011 trough, such that all the selected indicators (except Suez Canal revenues & M2) exhibited a downturn around the first quarter of 2011, with a maximum lead or lag of only two quarters. This was contemporaneous with the outbreak of the 2011 revolution, which adversely affected multiple sectors of the economy and caused a general economic slowdown in Egypt.

Regarding the final peak (2018q1) marked in the reference chronology, only six indicators out of the ten series exhibited a peak around the first quarter of 2018. Employment in manufacturing appears to be amongst the selected coincident variables that reached a peak point around 2018q1. This could be explained by the fact that the manufacturing sector has been at the forefront of the government's substantive plans for economic growth since 2014. The sector endured a period of growth guided by the Sustainable Development Strategy and Egypt Vision 2030 (launched in 2015). Both initiatives had set ambitious goals for the manufacturing sector. including increasing manufacturing growth rate to 10%, as well as increasing manufacturing value-added, to reach 18% of GDP by 2030 (Khurana et al. (2019)).

Moreover, Suez Canal revenues also exhibited an upturn around the first quarter of 2018. Since the Suez Canal is one of the most important pillars of the Egyptian economy, a vital source of foreign currency and plays a crucial role in stabilising the Egyptian pound, it is likely that cyclical fluctuations of Suez Canal revenues closely follow turning points in the aggregate economic activity.

The two monetary policy variables - broad money supply (M2) and lending rate – witnessed a peak around the first quarter of 2018. This is to be expected, given that they exhibit strong co-movement properties with the reference cycle. It is also noted that M2 and the lending rate, led the CEI peak in 2018q1 by five quarters and one quarter, respectively, indicating that the two indicators can also be useful in predicting aggregate economic activity (see section 6).

As a final point, since only six indicators out of the ten series exhibited a peak around the first quarter of 2018, thus, the identification of this peak is much less clear-cut. However, it is identified in both the reference chronology as well as the proposed chronology, which is based on the constructed CEI. Given that the CEI is constructed as a weighted average of the nine coincident indicators and that the evidence from several independently compiled indicators is more reliable than the evidence from any single series (Zarnowitz (1992)). Thus, the 2018 peak is included in the proposed dating of the Egyptian business cycles.

Furthermore, there is insufficient consensus on the extra cycles reported in some of the selected indicators and, thus, they couldn't be counted as official turning points in dating the cyclical fluctuations in Egypt during the period under study. For this reason, they are excluded from the proposed chronology.

To sum up, the analysis of the Egyptian business cycle over the period under study was able to capture only one complete cycle (from Peak to Peak). Such that, the duration of one complete business cycle in Egypt turned out to be approximately 40 quarters (i.e., 10 years), whilst that of a single recessionary phase (from peak to trough) is 12 quarters and a single expansion phase (from trough to peak) is 28 quarters. In comparison, the average duration of one complete cycle in the United States over the same period is approximately 36 quarters, with an average of 4 quarters for a recessionary phase and 32 quarters for an expansion phase. [22] However, Altissimo et al. (2000) reported that the average duration of the Italian business cycle is 13 quarters, with an average of 4 quarters of recessionary phase and 8 quarters of expansionary phase. This means that business cycles in Egypt tend to be more protracted when compared to the above-mentioned economies.

5 Constructing Composite Leading Index for the Egyptian Business Cycles

In this section, we investigate the predictive power of variables in the dataset, as well as the timing of their turning points with respect to the RGDP. Accordingly, variables that appear to be useful in predicting the direction of future economic activity in Egypt

[22] A history of the US Business Cycles Expansions and Contractions can be found at: https://www.nber.org/research/data/us-business-cycle-expansions-and-contractions

are selected and aggregated into a composite leading index, using the TCB/NBER methodology described in the previous section.

Under the NBER tradition, Moore and Shiskin (1967) initiated an explicit scoring system for cyclical indicators, which can help in evaluating their performance with respect to economic activity and, particularly, their usefulness in short-term forecasting. Marcellino (2006) followed the steps of Moore and Shiskin (1967) to formalise a number of broad requirements (scoring system) for a series to be considered a good leading indicator. Amongst these criteria, a series should exhibit good forecasting properties for the reference cycle, namely; can systematically anticipate peaks and troughs of the reference series (target variable); has economic significance[23]; and should be available regularly, without major later revisions.

Along the lines of the above requirements, Stock and Watson (1990) and Altissimo et al. (2000) argued that an economic variable is considered a leading indicator if it helps in forecasting total output (the reference series), according to different models that present the predictive content of candidate variables, as well as the cross-correlation of these variables with the reference series.

5.1 Selecting Leading Indicators

In our analysis, to select leading indicators, firstly, we assess the forecasting properties of candidate variables with respect to the reference series, by testing the predictive content of the 58 candidate indicators for the RGDP following Stock and Watson (1990) and Altissimo et al. (2000). Secondly, we examine the cross-correlations previously calculated, which provide an indication of whether, and how strongly, a trial series is related to the reference series (RGDP) at business cycle frequencies. Finally, we examine the timing of the turning points of each of the candidate variables with respect to the reference series (RGDP), to come up with a broad set of variables that appear to be good potential leading indicators.

As a first step, following Stock and Watson (1990), various summaries of the predictive power of each of the 58 series, with respect to the reference series (RGDP), are estimated and presented in Table A.3 of Appendix A. The first six columns indicate whether lags of the candidate variable are significant in forecasting RGDP growth. This is

[23] To be supported by economic theory, either as a possible cause of business cycle or as rapidly responding to positive and negative shocks.

done by regressing RGDP growth on its 4 lags and, respectively, 2 and 4 lags of the candidate variable. The next six columns present R^2 resulting from the regression of the RGDP growth over the next K quarters on 2 lags of each of the quarterly RGDP growth and of the trial series[24]. The statistics presented are the R^2s and their ranks among the series for k=1, 2, and 4.

The final four columns of Table A.3 (Appendix A) refer to the statistics that examine the sub-sample stability of forecasting the two-quarter growth of the RGDP on 2 lags of each of the RGDP growth and of the series under consideration. Given that, the first two of these columns refer to the regression estimated over the full sample period (2002q1-2019q4), where the Root Mean Square Error (RMSE) is computed when the forecasted sub-samples are (2002q1-2012q4) and (2013q1-2019q4), respectively. For the final two columns, the regression is estimated between (2002q1- 2012q4), and the RMSE is recalculated for the same two forecasted samples. Thus, the final column simulates an out-of-sample forecasting for two-quarter growth of RGDP. [25]

Our purpose is to organise the information presented in Table A.3, in an attempt to develop a list of variables that appear to contain useful information about the direction of future economic activity in Egypt. Accordingly, Table 4 provides two lists of potential leading indicators, based on the marginal predictive power of candidate variables for forecasting two-quarter growth of RGDP. The first ranking (column A) presents indicators with the greatest R^2 resulting from in-sample forecasting of two quarters of RGDP growth (based on results in Table A.3: Column 10). The second ranking is based on out-of-sample forecasting for two-quarter growth of RGDP (based on results in the last column of Table A.3).

Moreover, the third list of potential leading indicators sorts the size of the maximal absolute correlation amongst indicators that turned out to be leading the reference cycle (based on results in Table A.2, column 13). According to the cross-correlation results carried out in the previous section, only 11 series out of the 58 examined appeared to lead the reference cycle. These series are then ranked according to the strength of the maximal correlation (r_{max}) and presented in Table 5.

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[24] That is, defining Y as the RGDP and X as each of the 58 candidate variables, these columns refer to the regression of $\ln(Y_{t+k}/Y_t)$ regressed on $\ln(Y_t/Y_{t-1})$, $\ln(Y_{t-1}/Y_{t-2})$ and $\ln(X_t/X_{t-1})$, $\ln(X_{t-1}/X_{t-2})$, plus a constant, where k=1, 2, and 4.

[25] To avoid getting spurious results, before running regressions in Table D.3, we investigated the co-integration between each trial series and the reference series (RGDP) by applying the ARDL Bounds Test of co-integration. Results confirmed that the variables of interest are bound together in the long-run.

Table 4: Potential Leading Indicators classified by the Predictive Content for RGDP Growth as reported in Table A.3:

A. Classified by Two-Quarters ahead in-sample R2				B. Classified by Two-Quarters ahead out-of-sample RMSE		
Rank	Series	R^2		Rank	Series	RMSE
1	Nominal Exchange Rate	0.874		1	Cement Consumption	0.0494
2	Real Exchange Rate Misalignment	0.869		2	Brent Crude Oil Price	0.0511
3	Lending Rate	0.862		3	M1	0.0534
4	M2	0.859		4	M0	0.0536
5	Deposit Rates	0.856		5	Employment in Transportation Storage and Communication	0.0536
6	Exports of Fuel	0.854		6	REER_EG	0.0536
7	Official Discount Rate	0.853		7	EGX30	0.0538
8	Imports of Durable Consumer Goods	0.853		8	Exports of semi-finished Goods	0.0538
9	Exports of semi-finished Goods	0.852		9	Employment	0.0538
10	Employment in Manufacturing	0.850		10	Investments & Inventory	0.0539
11	Reserve Money	0.848		11	Imports of Raw Materials	0.0539
12	HH Consumption	0.848		12	NEER_EG	0.0539
13	Employment in Wholesale & Retail Trade	0.847		13	Employment in Electricity & Gas supply	0.0539
14	Investments & Inventory	0.846		14	Real GDP at Factor Cost	0.0539
15	Remittances of Egyptians working abroad	0.845		15	Exports of Raw Cotton	0.0540

Note that: REER_EG= Egypt Real effective exchange rate; EGX30= Stock Price Index (EGX 30) (closing prices); and NEER_EG= Nominal effective exchange rate in Egypt.

Table 5: Potential Leading Indicators classified by the lead at Maximal Absolute Correlation (Kmax) as reported in Table A.2:

Leading Indicators classified by lead at Maximal Absolute Correlation(Kmax) as reported in Table B			
Rank	**Series Name**	**rxy(Kmax)**	**Kmax**
1	Unemployment	0.4804	-1
2	Brent Crude Oil Prices	0.4379	-5
3	Employment in Agriculture	0.4212	-6
4	Real Exchange Rate Misalignment	0.3783	-4
5	Unemployment Rate	0.3294	-4
6	Nominal Exchange Rate	0.3092	-3
7	Exports of Raw Cotton	0.2725	-5
8	Lending Rates	0.2532	-1
9	Deposit Rates	0.18	-4
10	Exports of Fuel	0.1477	-6
11	Remittances of Egyptians working abroad	0.1272	-3

In addition to the above lists, having a closer look at the first six columns of Table A.3 enabled us to come up with another set of potential leading indicators. This is done by selecting variables that entered significantly into the regression, including 4 lags of RGDP growth as well as 2 and 4 lags of the candidate variables. These variables are: employment in agriculture; real GDP at factor cost; deposit rate; lending rate; domestic liquidity (M2); exports of fuels; exports of semi-finished goods; exchange rate and exchange rate misalignment.

Consequently, by aggregating the above-selected variables with those in Tables (4) and (5), we constructed a set of all potential leading indicators (26 variables) that appeared to have good forecasting properties for the RGDP growth in Egypt. Such that, statistics of the predictive power, as well as cross-correlation of these 26 variables, are summarised in Table A.4 of Appendix A.

The next step is to select a final subset of the best leading indicators to be included in the construction of the index of Leading Economic Indicators (LEI). The selection is based on two criteria: firstly, choosing the series that feature the best forecasting properties and the highest correlation; secondly, trying to broaden the index by including one or more series from each category, such that all categories are presented in the index.

In general, results show that variables belonging to exchange rates, interest rates and monetary aggregates categories come amongst the most important indicators that appear to lead the business cycle in Egypt. More specifically, the *exchange rate category* comes out on top of the list, where each of the nominal exchange rate (EGP per USD) and the real exchange rate misalignment[26] are ranked as the first and second indicators with the highest R^2 based on their ability to forecast two-quarter growth of the RGDP (see Table 4). Furthermore, they appeared to be significant in explaining future values of RGDP growth (see Table A.4 of the Appendix). These results are also confirmed by co-movement analysis, as the nominal exchange rate and exchange rate misalignment lead the reference series (RGDP growth) with three and four quarters, respectively. Accordingly, both series are included in the final set of leading indicators.

Secondly, for the *monetary aggregates* category, a broad look at the statistics in Table A.4 of Appendix (A) reveals that both M0 and M2 have the best predictive power amongst all monetary aggregates for RGDP growth in Egypt. Moreover, each of M0 and M2 were amongst the top 15 indicators with the highest R^2 based on their ability to forecast two-quarter growth of the RGDP, (see Table 4). Thus, they are selected in the final set of leading indicators.

The *interest rate* category is also amongst the most presented categories, where each of the *lending rate*, *deposit rate* and *discount rate* appeared amongst the potential leading indicators (see Table A.4). By examining the predictive content of the interest rate variables, it is noted that lending rate, as well as deposit rate, featured better forecasting properties for RGDP growth than the discount rate. Nevertheless, we included the *lending, deposit, and discount rates* in the construction of the LEI index, such that, eliminating any of the three series from the LEI turned out to deteriorate the overall predictive power of the index with respect to the RGDP growth.

As for the *labour market* category, many labour market variables appeared amongst the potential leading indicators (Table A.4). However, the *unemployment rate* showed the best forecasting properties for the RGDP growth[27]. Additionally, employment in agriculture is the only variable amongst this category where its lagged values appeared to be significant in forecasting RGDP growth. Besides this, it constitutes the highest share

[26] The Real Exchange Rate Misalignment is the deviation of the real effective exchange rate (REER) from the equilibrium real exchange rate (ERER). If the REER is higher (lower) than the ERER, then the currency is considered overvalued (undervalued) (Noureldin (2018))

[27]Unemployment rate is ranked first and sixteenth based on its ability to forecast one-quarter and two-quarter growth of RGDP, respectively.

of total employment. As such, both the unemployment rate and employment in agriculture are selected in the final set of indicators included in the LEI construction.

Regarding *sources of foreign currency* in Egypt, *inflows of remittances* is the only variable in this category to be listed amongst potential leading indicators. Likewise, it has good predictive power for RGDP growth[28], such that, eliminating it from calculating the LEI index deteriorated its overall predictive power for RGDP growth. Thus, it is included in the final set for constructing the LEI.

As we move to measures of *consumption*, it is noted that two measures of consumption appeared amongst the potential leading indicators, namely, household consumption and cement consumption[29]. However, since *household consumption* has the largest weight amongst aggregate demand components, it is considered a more representative indicator and is selected in the construction of the LEI.

Finally, for the *foreign trade* category, *exports of semi-finished goods,* as well as *exports of fuels* are selected in the final set of leading indicators, as both series show strong predictive power for economic activity[30]. It is noted that, although exports of fuels are mainly compelled by exploration/production of oil and gas and don't reflect the real manufacturing activity in the economy, it appeared to contain useful information for the direction of future economic activity in Egypt, such that, eliminating it from the construction of the LEI deteriorated the overall predictive content of the index. As for the imports, results show that *imports of durable goods* feature satisfactory predictive content for the RGDP growth and it is selected in the final set of leading indicators.

Accordingly, a subset of *fourteen series* is selected in the construction of the LEI. These series are nominal exchange rate; the real exchange rate misalignment; reserve money (M0); domestic liquidity (M2); lending rate; deposit rate; discount rate; unemployment rate; employment in agriculture; remittances of Egyptians working abroad; household consumption; exports of semi-finished goods; imports of durable goods; and exports of fuels.

Finally, how the turning points of the selected leading indicators behave with respect to the reference cycle (RGDP) is presented in Table 6. However, as mentioned

[28] It is ranked eighth and the fifteenth based on its ability to forecast one-quarter and two-quarter growth of RGDP, respectively.
[29] HH consumption is amongst the top 15 indicators based on their ability to forecast in-sample two-quarter growth of RGDP, whilst cement consumption has the lowest RMSE when forecasting out-of-sample two-quarters ahead of RGDP growth
[30] Exports of semi-finished goods series ranked ninth based on its ability to forecast two-quarter growth of RGDP, whilst exports of fuels ranked sixth.

above, when selecting the leading indicators, we didn't rely mainly on the timing of the indicator turning point, but on the co-movement properties, as well as the econometric analysis that pointed to the forecasting ability of the series under study.

Table 6: *Turning Points of the constructed LEI and the selected Leading Indicators with respect to Real GDP:*

	Peak	Trough	Peak	Extra cycles	
				Peaks	Troughs
RGDP (Reference Cycle)	**2007 q1**	**2011 q1**	**2018 q1**		
LEI	**2005 q3**	**2009 q3**	**2017 q4**	2013 q2	2015 q4
CEI	**2008 q2**	**2011 q1**	**2018 q1**		
Nominal Exchange Rate	--	--	-4 (2017q1)	2004q4	2008q3
Real Exchange Rate Misalignment	--	--	-8 (2016q1)	2010q3	2003q4
M2	+1 (2007q2)	--	-5 (2016q4)	2013q1	2008q4
M0	--	--	-1 (2017q4)		2015q3
Deposit Rates	+7 (2008q4)	-4 (2010q1)	0 (2011 q1)	2013q2	2006q4
Lending Rate	_	0 (2011 q1)	-1 (2017q4)	2013q2	2015q4
Official Discount Rate	-5 (2005q4)	+2 (2011q3)	-1 (2017q4)		2004q1
Unemployment Rate	--	--	--		2008q2
Employment in Agriculture	+6 (2008q3)	+8 (2013q1)	+1 (2018q2)	2014q3	2016q3
Remittances of Egyptians working abroad	+5 (2008 q2)	-5 (2009q4	-4 (2017q4)	2014q2	2015q4
HH Consumption	-3 (2006q2)	--	--		2017q3
Exports of semi-finished goods	-3 (2006q2)	--	-4 (2017q1	2011q2	2015q4
Exports of Fuel	+4 (2008q3)	+5 (2012q2)	--	2014q1	2016q2
Imports of durable consumer goods	-8 (2005q1)	-7 (2009q2)	--	2014q4	

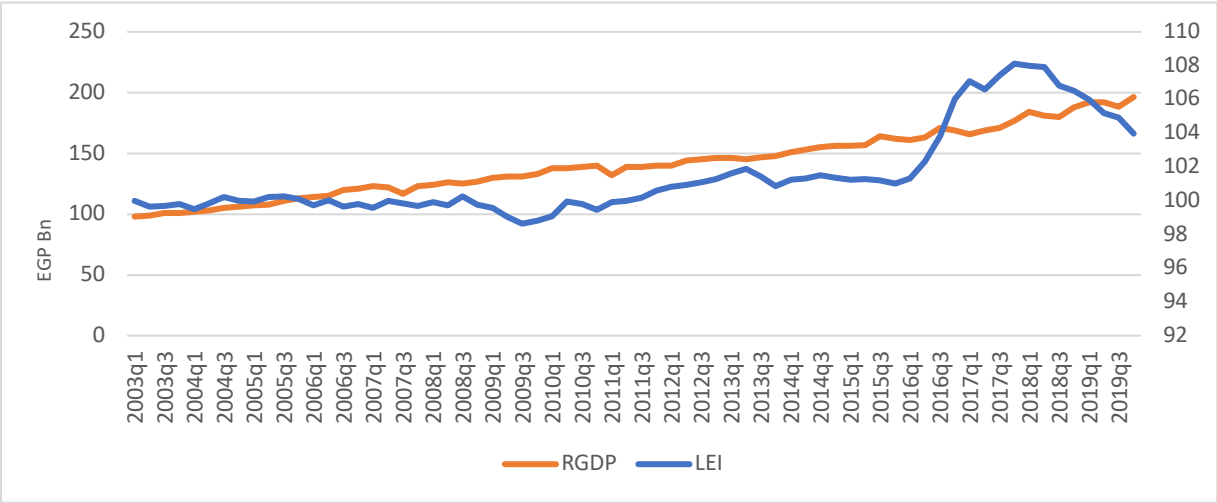
Note: The –ve sign corresponds to a lead with respect to the RGDP, whilst the +ve sign corresponds to a lag.

5.2 Construction of the Composite Index of Leading Economic Indicators (LEI):

After selecting a final set of leading indicators that are useful in forecasting the reference cycle, it is possible to construct a composite index of LEI that can help predict future economic activity for the Egyptian economy. As for the aggregation procedure, we followed the same computational steps adopted to construct the composite index of CEI, as explained in section 4.2.

It is worth noting that before aggregating the selected indicators, Altissimo et al. (2000) smoothed out each series to eliminate high-frequency fluctuations that hinder the detection of cyclical fluctuations. However, for the case of Egypt, we skipped the data filtering step, as it led to the loss of observations and hampered the process of examining the predictive power of candidate series with respect to RGDP.

Figure 3: *The Composite Leading Index (LEI) with respect to RGDP*



A visual examination of the constructed LEI index with respect to the RGDP (Figure 3) indicates that the LEI is almost leading the RGDP. This observation is confirmed by econometric analysis (predictive content), which verifies the notable forecasting ability of the index. On one hand, the regression of the RGDP growth on its own four lags and on four lags of the leading index, shows that the LEI has an additional predictive power. More specifically, three and four lags of the growth rate of LEI appeared to be strongly significant in such a regression. On the other hand, R2 of the regression of

RGDP growth (one and two quarters ahead) on the lagged growth rates of the LEI, was found to be higher than those featured by analogous regressions based on any of the 58 series examined, which validates the argument that the composite index performs better than any single component (see the last row of Table A.3 in Appendix A).

6 Key Features of Selected Coincident and Leading Indicators Relevant for the Egyptian Economy

In this section, we summarise the business cycle properties of selected variables from each category. The analysis is done in light of Table A.2, which contains univariate statistics and estimates of coherence and cross-correlation with respect to RGDP, as well as Table A.3, which reports statistics examining the predictive content with respect to the same reference series.

- ***Labour Market Indicators***:

Most of the employment-related variables moved almost coincidently with the economic activity in Egypt, with the exception of unemployment, unemployment rate and employment in agriculture, which appeared to lead the reference cycle.

As for employment, it exhibited high coherence (0.925 at a frequency greater than 6 years) and a strong positive contemporaneous correlation (0.97) (pro-cyclical) with the aggregate activity. However, plotting the growth rate of employment against RGDP growth reveals that economic recovery was not always accompanied by higher employment levels. Such that, the employment level remained stagnant during both the pick-up that followed the 2011 revolution, as well as the recovery phase that took place in early 2017. Thus, the quantity and quality of jobs in Egypt have not improved despite the economic recovery, which can be justified by the decline in real wages as a result of the inflationary wave, following the Egyptian pound devaluation at the end of 2016 (Assaad et al. (2019)). (see Appendix D, Figure D.1).

Moreover, both employment in manufacturing and employment in construction show pro-cyclical behaviour with the aggregate activity. Such that, employment in manufacturing is found to have a strong positive contemporaneous correlation with the reference series (0.912), which points out the vital role of the sector in boosting aggregate economic activity in Egypt. Also, fluctuations at cyclical frequencies of employment in construction show high coherence with the reference series and it appears to be strongly

positively correlated with it, indicating that expansion in the construction sector is accompanied by high economic growth.

On the other hand, both unemployment and unemployment rates led the reference cycle with one and four quarters, respectively. A plot of unemployment and unemployment rate against the RGDP growth reflects a counter-cyclical behaviour of both series, which validates the negative correlation between each of the two series and the reference series (see Figure D.1: Graphs B & C). It is also noted that the unemployment rate in Egypt showed good forecasting properties for RGDP growth, indicating that high unemployment rates could be considered (amongst other factors) as an early warning signal for an economic slowdown in Egypt. Our results are also consistent with Moursi et al. (2005), who concluded that the unemployment rate led the economic activity in Egypt and exhibited a counter-cyclical behaviour.

Another interesting series is employment in agriculture, which is also included in the LEI and shows good predictive power for RGDP growth in Egypt. It exhibits a weak negative correlation with economic activity (-0.395), indicating a counter-cyclical behavior i.e., an increase in the number of workers in the agricultural sector is associated with a subsequent decline in the economic performance. One explanation for this negative correlation is the relatively low wages in the agricultural sector, especially in rural areas, which makes unskilled workers only willing to move to the agricultural sector during periods of stagnant growth, when alternative opportunities in other sectors become scarce.

- ***Sources of Foreign Currency***:

As we move to sources generating foreign currency, Suez Canal revenues come out on top of the list. They exhibit good coherence and a strong positive contemporaneous correlation with aggregate economic activity (pro-cyclical). The results are consistent with the significant role of Suez Canal revenues in stabilising the Egyptian pound and generating public revenues. A plot of the canal revenues and the RGDP validates the above positive correlation, where the canal revenues exhibited more frequent cyclical fluctuation. They experienced a sharp decline during the 2008 financial meltdown and during the period between early 2015 until the end of 2016 (due to falling oil prices and international trade contraction), more than the decline reflected in the reference cycle (see Figure D.2: Graph A). This confirms the fact that Suez Canal revenues are aligned with international business cycles and they are more sensitive to movements in international trade activity.

The tourism sector is another vital source of foreign currency for the Egyptian economy and is one of the largest employers (employing almost 10 % of the labour force

in 2019), yet it showed average coherence and weak (positive) contemporaneous correlation with the RGDP and is excluded from the CEI index. Additionally, the remittances inflows of Egyptians working abroad appeared to have good predictive power for RGDP growth in Egypt. Our results also showed that remittances inflows to Egypt are negatively correlated with RGDP growth (maximal correlation of -0.127). This negative impact is consistent with results in Qutb (2021) who concluded that remittances are countercyclical, in the sense that they have a long-term negative impact on economic growth. It also implies that remittances to Egypt are mainly directed to consumption expenditures rather than to productive investments, hence, they do not help reach the long-term steady state that chiefly depends on physical and human capital.

- ***Consumption and Investment:***

Household consumption has the largest weight amongst aggregate demand components and it exhibited a pro-cyclical behaviour, verified by a strong positive correlation with the reference series (0.95), as well as good coherence over more than a 6 year period (0.76). Nevertheless, it is not selected for the construction of the CEI. This is because household consumption came out amongst the top 15 indicators based on their ability to forecast in-sample two-quarter growth of RGDP, led the reference series with three quarters and, thus, proved to perform better as a leading indicator than as a coincident one. Our results confirm earlier findings in Moursi et al. (2005), where household consumption also turned out to be a leading indicator for the Egyptian economy.

Government consumption is also considered a fundamental indicator of aggregate demand and amongst the fiscal policy measures used to stabilise the economy during business cycles. Our results show that government consumption is positively correlated with real GDP, however, earlier studies (e.g., El-Husseiny (2018)) found evidence of a "counter-cyclical" behaviour of total public expenditure with respect to economic activity in Egypt. This is justifiable, as government consumption included in the paper is only a portion of the total public expenditure and, thus, in isolation did not reflect the public expenditure counter-cyclical behaviour with respect to aggregate economic activity in Egypt.

Finally, investments (gross capital formation) showed a pro-cyclical behaviour, exhibiting a strong contemporaneous correlation with the reference series and is included in the CEI index. Our results confirm previous findings on the pro-cyclicality of investment spending during the business cycle (e.g., El khishin and Zaky (2019)).

- ***Foreign Trade***

Results refer to a positive contemporaneous correlation between each of the import indicators and the reference series. This could be justified by the pro-cyclicality of the marginal propensity to import in Egypt. [31]

Alternatively, the evidence from export indicators is much more assorted and slightly different from the consensus view. Total exports of goods and services are found to be poorly correlated with the reference series (0.44), whereas exports of raw materials and those of semi-finished goods are strongly correlated with the RGDP and moved contemporaneously with it, exhibiting a positive correlation of 0.87 and 0.82, respectively.

It is also observed that, besides having a strong correlation with the RGDP, exports of semi-finished goods proved to be a good leading indicator that is significant in forecasting future values of RGDP growth in Egypt. A plot of exports of semi-finished goods growth against RGDP growth, confirms its leading feature (see Figure D.3: Graph C), indicating that exports with some amount of value-added could be a potential source of fueling economic growth.

- ***Exchange Rates, Monetary Aggregates and Interest Rates***

As mentioned earlier in the previous section, exchange rate indicators are amongst the most important indicators that appear to lead the business cycle in Egypt. The nominal exchange rate and the exchange rate misalignment exhibited very strong predictive power for the RGDP growth, such that, their lagged values were significant in explaining future values of RGDP growth. They also topped the list of potential leading indicators with respect to their ability to forecast two-quarter growth of the RGDP. These results are supported by correlation analysis, where the nominal exchange rate and the exchange rate misalignment led the reference cycle with three and four quarters, respectively (See Table 5).

Our results also reveal a negative correlation between the RGDP growth in Egypt and each of the nominal exchange rate and the exchange rate misalignment. This implies that devaluation in local currency, as well as a rise in exchange rate misalignment, are considered as factors that trigger a decline in economic activity. The observation is consistent with previous empirical studies arguing that the real exchange rate

[31] The average marginal propensity to import in Egypt was estimated by Abou Elseoud (2018) to be 0.48 during 1980-2017.

misalignment has adverse effects on economic growth in Egypt (Hosni & Rofael (2015), Noureldin (2018) and Hosni (2021)).

On the other hand, the monetary aggregates appear to be very closely related to the overall economic fluctuation in Egypt. Our results support the view of the pro-cyclicality of money, such that, both M1 and M2 show a strong positive contemporaneous correlation with the reference cycle, with a cross-correlation of 0.931 and 0.903, respectively. This indicates that the government expands the amount of money during expansionary periods and tightens it during recessions.

As for interest rate measures, both lending and deposit rates show a "counter-cyclical" [32] behaviour. They have a negative correlation with the reference series, lead the reference cycle with one and four quarters, respectively and, thus, are both included in the construction of the LEI. Accordingly, our results are consistent with the macroeconomists' perspective, which views changes in the quantity of money as a dominant and important source of economic fluctuations, where interest rates and price levels are the transmission channels from monetary changes to real activity (King & Watson (1996)). Results also confirm earlier findings arguing that the influence of money and interest rates on business cycles operates with a lag, where the timing of the influence is highly variable and unpredictable (Davis (1968); King & Watson (1996)).

7 Conclusion

In this paper, we propose a chronology for the Egyptian economy by detecting phases of expansions and recessions during the period 2002-2019, based on the more comprehensively constructed CEI index. The proposed chronology appeared to capture only one cycle during the period under study. It provided an overall picture of the Egyptian economy, which is characterised by a prolonged expansionary period from the beginning of the millennium until early 2008, followed by a recessionary period that marked a trough in early 2011, then a gradual recovery phase evolved, during which an alternation of short-term recoveries and mild recession took place.

The methodology adopted in the paper combined the NBER approach together with time series techniques of cyclical analysis, to select the variables best suitable to play the role of coincident and leading indicators. This methodology appeared to be the most

[32] Counter-cyclical behaviour of interest rates indicates that higher levels of lending/deposit rate are associated with slow economic growth rates.

suitable when it is not possible to rely on a well-established reference chronology as a benchmark for the empirical analysis, which is the case of Egypt.

By selecting the best coincident and leading indicators through a multi-step selection procedure, we are able to construct two composite indexes using the NBER approach. The first one is a coincident index (CEI) - comprising nine coincident variables - which can be considered as an adequate measure for the Egyptian business cycle. It can also act as the reference indicator in future analysis of cyclical co-movements in Egypt. The second index is the composite index of leading economic indicators (LEI) – including fourteen leading variables – that showed strong predictive power for the RGDP and exhibited good performance in anticipating future turning points.

Moreover, we examined the cyclical behaviour of most of the economic variables that are considered potentially useful in measuring or predicting aggregate economic activity in Egypt. Thus, the paper made available a documentation of the cyclical properties for a mostly comprehensive set of variables, providing insights into their co-movements with the reference cycle. In this regard, amongst the significant findings are the synchronisation of turning points across different economic sectors and the contemporaneous pro-cyclicality of employment, employment in manufacturing, consumption, and investment indicators. Additionally, exchange rate, exchange rate misalignment and interest rate variables came out on top of indicators that lead the reference cycle and have strong predictive power for economic activity in Egypt.

More specifically, our results reveal a high correlation and a pro-cyclical behaviour of employment in manufacturing with the aggregate economic activity. This implies that policies enhancing the international competitiveness of the manufacturing sector and increasing its productivity - such as supporting domestic producers that provide them with technical assistance and efficient financial services - should be prioritised by the government. Also, the strong correlation between investments with the economic activity and its pro-cyclical behaviour provides assurance that boosting investment-led growth through reforms that streamline licensing and operations, as well as providing a safe environment for both domestic and foreign investors, are preferred in the case of Egypt.

At the same time, the empirical findings show that exports of both raw materials, as well as semi-finished goods, appear to be strongly and positively correlated with economic growth in Egypt, whilst exports of finished goods show positive, but weak coherence and cross-correlation with it. This implies that more attention should be given to restructuring Egyptian exports in favour of manufacturing exports. In particular, focusing on increasing the efficiency and productivity of industries where Egypt has a

comparative advantage can enhance the role played by manufacturing exports in the overall growth process.

Findings also prove that the deviation of the real effective exchange rate from the equilibrium levels (real exchange rate misalignment) is considered an early warning signal of a possible slowdown in Egypt. Accordingly, it is not recommended for monetary authorities to defend a disequilibrium exchange rate, such that high levels of exchange rate misalignment can be a triggering factor for economic slowdown and currency crisis in the country.

The above-mentioned bundle of measures can also be complemented by policies that eliminate import-intensive production. This helps reduce pressure on the local currency and improves the country's domestic economic fundamentals, which makes it more tolerant towards internal/external short-term shocks.

In the light of the above discussion, it is expected that the recent Russian-Ukrainian war, as well as the negative repercussions of the pandemic outbreak, are likely to have adverse effects on the Egyptian economy, potentially inducing a recession. High inflation is eroding real incomes and foreign exchange shortages are adversely affecting business conditions. The recent growth slowdown in the economy is also partly related to a slowdown in potential output growth, which points to the necessity of reforms that boost export-oriented sectors and support private investments, which are necessary to augment the economy's resilience and international competitiveness.

Finally, as a further area of research, we suggest re-computing the BCIs for Egypt, using the more statistically oriented method "Generalised Dynamic Factor Model (GDFM)", which represents the model-based approach for constructing BCIs. It also allows for identifying coincident and leading indicators from a large data universe, where the cross-section dimension could exceed the time dimension.

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Appendix A: Tables

Table A.1: Variables descriptions and sources:

Series		Characteristics		Range	Source
Code	Description	Seas. Adj.	Transformation		
RGDP	Real GDP at Market Prices (Bn EGP)	Yes	d ln	2001:Q3 - 2019:Q4	Ministry of Planning
UNEMPL	Unemployment (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2002Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, Central Agency for Public Mobilisation and Statistics (CAPMAS)
UNEMPRATE	Unemployment Rate: unemployment as a percentage of labour force	No	No Transf.	2001:Q4 - 2019:Q4	Labour Force Survey, CAPMAS
EMPL	Employment (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2002Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
LABFORCE	Labour Force (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2002Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
EMPL_AGR	Employment in Agriculture (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
EMPL_MANU	Employment in Manufacturing (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
EMPL_ELEC	Employment in Electricity & Gas supply (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS

EMPL_CONS	Employment in Construction (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
EMPL_WHOLESALE	Employment in Wholesale & Retail Trade (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
EMPL_TRANS	Employment in Transportation, Storage and Communication (# of persons 1000)	No	d ln	2001:Q4 - 2019:Q4 (N.B: Quarterly data during 2001:Q4 - 2005Q4 are interpolated using cubic splines and implemented in Matlab)	Labour Force Survey, CAPMAS
RAILWAY_TRANS	Railway Transportation (Ton-km (mn))	Yes	No Transf.	2001:Q3 - 2019:Q2	CEIC database citing The Egyptian National Railways
SUEZCNL	Deflated Suez Canal Revenues (Mn USD)	Yes	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, The Central Bank of Egypt (CBE)
TOURISM	Deflated Tourism Revenues (Mn USD)	Yes	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
REMITTANCES	Deflated Remittances of Egyptians working abroad (Mn USD)	No	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
NFDI	Deflated Net Foreign Direct Investments (Mn USD)	No	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
RGDP_FC	Real GDP at Factor Cost (Bn EGP) (at 2001/2002 prices)	Yes	d ln	2001:Q3 - 2019:Q4	Ministry of Planning
HH_CONS	Household Consumption at 2001/2002 Prices (Bn EGP)	Yes	d ln	2001:Q3 - 2019:Q4	Ministry of Planning
GOV_CONS	Government Consumption at 2001/2002 prices (Bn EGP).	Yes	d ln	2001:Q3 - 2019:Q4	Ministry of Planning
INV	Investments & Inventory (Gross Capital Formation) at 2001/2002 Prices (Bn EGP)	Yes	d ln	2001:Q3 - 2019:Q4	Ministry of Planning
ELEC_CONS	Total Electricity Consumption (Mn Kw/hr)	Yes	No Transf.	2002:Q4 - 2019:Q4	Monthly Statistical Bulletin, CBE
CEM_CONS	Total Cement Consumption (1000 tons)	No	No Transf.	2002:Q4 - 2019:Q4	Monthly Statistical Bulletin, CBE
STEEL_CONS	Reinforcement-Steel Consumption (1000 tons)	No	No Transf.	2002:Q2 - 2019:Q4	Monthly Statistical Bulletin, CBE

BOP	Brent Crude Oil Price (Dollars per Barrel)	No	d ln	2001:Q3 - 2019:Q4	US Energy Information Administration (EIA)
INF_RATE	Inflation Rates	No	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
DEP_RATE	Deposit Rates	No	No Transf.	2001:Q3 - 2019:Q4	International Financial Statistics - IMF Data
LEND_RATE	Lending Rate	No	No Transf.	2001:Q3 - 2019:Q4	International Financial Statistics - IMF Data
DIS_RATE	Official Discount Rate	No	No Transf.	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, The Central Bank of Egypt
M0	Reserve Money (Mn EGP)	No	d ln	2002:Q2 - 2019:Q4	Monthly Statistical Bulletin, The Central Bank of Egypt
M1	Money Supply (Mn EGP)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
M2	Domestic Liquidity (Mn EGP)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
CUR_CIRC	Currency in Circulation outside the Central Bank (Mn EGP)	No	d ln	2002:Q2 - 2019:Q4	Monthly Statistical Bulletin, CBE
EGX30	Stock Price Index (EGX 30) (closing prices)	No	d ln	2001:Q3 - 2019:Q4	https://www.investing.com/indices/egx30-historical-data
IM_FUEL	Deflated Imports of Fuel (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
IM_RM	Deflated Imports of Raw Materials (Mn USD	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
IM_IMG	Deflated Imports of Intermediate Goods (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
IM_INV	Deflated Imports of Investment Goods (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
IM_DUR	Deflated Imports of Durable Consumer Goods (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE

IM_NONDUR	Deflated Imports of `Non-Durable Consumer Goods (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
IM_TOTAL	Deflated Total Imports (Mn USD	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_FUEL	Deflated Exports of Fuel (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_COTT	Deflated Exports of Raw Cotton (Million USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_RM	Deflated Exports of Raw Material (Million USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_SEMFIN	Deflated Exports of Semi-Finished Goods (Million USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_FIN	Deflated Exports of Finished Goods (Million USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
EX_TOTAL	Deflated Total Exports (Mn USD)	No	d ln	2001:Q3 - 2019:Q4	Monthly Statistical Bulletin, CBE
TOT	Terms of Trade	No	No Transf.	2001:Q3 - 2018:Q4	Noureldin, D. (2018)
EXRATE	Nominal Exchange Rate for the US Dollar (EGP per USD)	No	No Transf.	2001:Q3 - 2019:Q4	OANDA Exchange Rates (https://www.oanda.com)
EXRATE_MISA	Real Exchange Rate Misalignment	No	No Transf.	2001:Q3- 2018Q4	Noureldin, D. (2018)
NEER_EG	Egypt Nominal Effective Exchange Rate considering 65 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
REER_EG	Egypt Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
REER_US	United States Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
REER_GRM	Germany Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS

REER_IT	Italy Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
REER_FR	France Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
REER_UK	United Kingdom Real Effective Exchange Rate (CPI-based) considering 38 trading partners	No	d ln	2001:Q3 - 2019:Q4	BRUEGEL DATASETS
RGDP_US	United States Real GDP	Yes	d ln	2001:Q3 - 2019:Q4	OECD.Stat
RGDP_EU	European Union Real GDP	Yes	d ln	2001:Q3 - 2019:Q4	OECD.Stat
RGDP_CHINA	China Real GDP	Yes	d ln	2001:Q3 - 2019:Q4	OECD.Stat

Table A.2: Univariate descriptive statistics and bivariate coherence and correlations with the reference series:

Series	Characteristics		Spectral Density				Coherence				Cross-Correlation		
Code	Seas. Adj.	Transform.	> 6 yrs	2-6 yrs	1-2 yrs	< 1 yr	> 6 yrs	2-6 yrs	1-2 yrs	< 1 yr	ro	Rmax	tmax
UNEMPL_GR	No	d ln	1.438	1.344	0.367	0.006	0.094	0.231	0.384	0.488	- 0.4310	- 0.4804	-1
UNEMPRATE	No	d ln	37.557	17.715	3.854	2.050	0.830	0.444	0.196	0.209	- 0.228	- 0.3294	-4
EMPL	No	d ln	1.107	0.085	0.075	0.014	0.925	0.770	0.394	0.204	0.975	0.975	0
LABFORCE	No	d ln	4.950	3.659	1.034	0.105	0.950	0.664	0.218	0.026	0.963	0.963	0
EMPL_AGR	No	d ln	3.024	3.381	1.357	0.016	0.054	0.235	0.232	0.114	-0.193	-0.395	-6
EMPL_MANU	No	d ln	0.654	2.131	2.096	0.005	0.530	0.570	0.512	0.468	0.912	0.912	0
EMPL_ELEC	No	d ln	0.726	0.892	0.297	0.027	0.030	0.260	0.346	0.118	-0.267	-0.311	+4
EMPL_CONS	No	d ln	0.379	0.978	0.770	0.007	0.873	0.446	0.198	0.350	0.967	0.967	0
EMPL_WHOLESALE	No	d ln	2.377	2.566	2.041	0.039	0.358	0.244	0.141	0.243	0.908	0.908	0
EMPL_TRANS	No	d ln	0.810	1.239	0.782	0.008	0.704	0.526	0.282	0.200	0.967	0.967	0
RAILWAY_TRANS	Yes	N	16.060	7.921	0.722	0.157	0.831	0.540	0.206	0.103	-0.879	-0.879	0
SUEZCNL_REV	Yes	N	11.500	4.594	1.166	0.926	0.755	0.697	0.505	0.201	0.715	0.715	0
TOURISM_REV	Yes	N	24.149	4.890	0.883	0.689	0.795	0.746	0.504	0.161	0.125	0.125	0
REMITTANCES	No	N.	11.470	6.621	0.220	0.322	0.525	0.489	0.456	0.233	-0.0038	-0.1272	-3
NFDI	Yes	d ln	2.629	1.957	1.117	0.098	0.237	0.213	0.164	0.158	0.203	0.203	0
RGDP_FC	Yes	d ln	1.691	1.998	0.735	0.278	0.988	0.987	0.966	0.954	0.987	0.987	0
HH_CONS	Yes	d ln	4.396	2.606	1.672	2.281	0.764	0.700	0.424	0.109	0.952	0.952	0
GOV_CONS	Yes	d ln	0.353	0.529	0.426	0.279	0.645	0.538	0.240	0.047	0.884	0.884	0
INV	Yes	d ln	4.163	4.269	1.944	0.238	0.436	0.332	0.184	0.234	0.919	0.919	0
ELEC_CONS	Yes	N	8.376	3.773	0.891	0.377	0.804	0.641	0.248	0.141	0.942	0.942	0
CEM_CONS	No	N	5.876	1.928	1.166	0.599	0.796	0.642	0.300	0.099	0.765	0.765	0

STEEL_CONS	No	N	16.668	4.691	2.812	0.666	0.567	0.530	0.276	0.247	0.878	0.878	0
BOP	No	d ln	26.226	18.982	1.077	0.675	0.547	0.471	0.322	0.126	-0.097	0.438	-5
INF_RATE	No	d ln	2.607	0.650	0.168	0.007	0.628	0.551	0.307	0.069	-0.162	-0.162	0
DEP_RATE	No	N	38.462	8.518	3.049	0.672	0.763	0.723	0.520	0.180	-0.167	-0.180	-4
LEND_RATE	No	N	42.202	11.376	3.853	1.142	0.822	0.782	0.583	0.218	-0.175	-0.253	-1
DIS_RATE	No	N	36.702	9.881	2.823	0.941	0.789	0.748	0.504	0.175	0.609	0.609	0
M0	No	d ln	2.447	2.895	2.737	2.553	0.611	0.438	0.156	0.051	0.923	0.923	0
M1	No	d ln	0.310	0.765	7.019	6.843	0.803	0.731	0.496	0.191	0.931	0.931	0
M2	No	d ln	2.357	2.898	2.368	0.460	0.812	0.778	0.542	0.178	0.903	0.903	0
CUR_CIRC	No	d ln	0.932	1.682	19.922	19.620	0.670	0.565	0.332	0.133	0.949	0.949	0
EGX30	No	d ln	13.153	7.653	4.806	4.181	0.531	0.434	0.190	0.056	0.827	0.827	0
IM_FUEL	No	d ln	1.305	0.996	0.488	0.201	0.152	0.082	0.216	0.426	0.875	0.875	0
IM_RM	No	d ln	8.447	5.538	1.535	0.115	0.061	0.052	0.052	0.060	0.229	0.229	0
IM_IMG	No	d ln	1.276	3.227	2.259	0.007	0.296	0.229	0.088	0.012	0.728	0.728	0
IM_INVG	No	d ln	5.608	1.645	1.665	0.341	0.162	0.105	0.046	0.079	0.481	0.481	0
IM_DUR	No	d ln	1.743	3.835	2.103	0.123	0.201	0.145	0.111	0.067	0.756	0.756	0
IM_NONDUR	No	d ln	3.376	1.846	0.606	0.011	0.348	0.316	0.244	0.107	0.857	0.857	0
IM_TOTAL	No	d ln	10.131	12.320	8.246	0.148	0.210	0.134	0.037	0.015	0.821	0.821	0
EX_FUEL	No	d ln	1.056	0.773	0.057	0.006	0.112	0.086	0.041	0.022	0.077	-0.148	-6
EX_COTT	No	d ln	28.575	6.590	1.104	0.537	0.170	0.120	0.103	0.300	0.009	0.273	-5
EX_RM	No	d ln	0.384	0.389	0.109	0.005	0.636	0.522	0.245	0.051	0.867	0.867	0
EX_SEMFIN	No	d ln	0.634	1.503	1.032	0.064	0.236	0.217	0.224	0.127	0.821	0.821	0
EX_FIN	No	d ln	26.604	48.948	43.645	7.738	0.223	0.139	0.102	0.075	0.581	0.581	0
EX_TOTAL	No	d ln	0.912	1.512	0.272	0.001	0.136	0.082	0.056	0.043	0.444	0.444	0
TOT	No	N	3.526	4.052	0.840	0.253	0.794	0.744	0.608	0.260	0.414	0.451	+5
EXRATE	No	N	89.727	32.931	4.481	0.803	0.669	0.640	0.537	0.231	-0.048	.-0.3092	-3

EXRATE_MISA	No	N	35.076	31.958	10.311	2.948	0.112	0.062	0.037	0.061	0.063	-0.378	-4
NEER_EG	No	d ln	3.823	2.500	0.502	0.004	0.196	0.172	0.120	0.046	-0.847	-0.847	0
REER_EG	No	d ln	3.517	3.206	0.834	0.010	0.008	0.016	0.050	0.039	0.633	0.633	0
REER_US	No	d ln	7.375	3.219	1.813	0.004	0.010	0.038	0.072	0.097	0.519	0.558	2
REER_GRM	No	d ln	2.071	3.418	1.346	0.004	0.056	0.041	0.015	0.125	-0.438	-0.488	3
REER_IT	No	d ln	2.132	2.201	0.794	0.017	0.061	0.040	0.017	0.203	-0.243	-0.376	6
REER_FR	No	d ln	1.591	1.946	0.873	0.006	0.024	0.017	0.012	0.198	-0.629	-0.663	2
REER_UK	No	d ln	12.611	3.639	0.833	0.013	0.121	0.087	0.065	0.048	-0.600	-0.600	0
RGDP_US	Yes	d ln	24.045	10.124	1.612	0.102	0.442	0.354	0.153	0.175	0.968	0.968	0
RGDP_EU	Yes	d ln	7.278	6.914	1.026	0.010	0.278	0.199	0.064	0.229	0.042	0.385	-5
RGDP_CHINA	Yes	d ln	3.713	1.827	0.482	0.081	0.848	0.795	0.471	0.109	0.025	0.326	-5

Notes:
The definitions of the series are given in Table A.1.
The transformation codes are: (N= No transformation), (dln=first difference of the log of the series, i.e., growth rates)
The first four columns present the univariate spectral estimates. These estimates are the unweighted average of the periodogram ordinates over the indicated frequency band. They are expressed as a ratio of the periodogram estimate over the band to the average value of the periodogram over the entire frequency range [-π, π]. The second four columns report the coherence (a measure of R2 by frequency) between the growth of RGDP and the transformed series in question over the four frequency bands. The final four columns report statistics based on cross-correlogram between logarithm of RGDP and the series in question.

Table A.3: Predictive Content for the reference series (RGDP):

Series	Predictive Content		Predictive Content			Sub-Sample Stability: RMSE's	
	2 lags	4 lags	1-step ahead	2-steps ahead	4-steps ahead	The model Estimated over the full sample	The model Estimated till 2012q4

Code	F-value	Prob (F-Statistic)	P-value (of 2 lags of the trial series	F-value	Prob (F-Statistic)	P-value (of 4 lags of the trial series	R^2 (1)	Rank	R^2 (2)	Rank	R^2 (4)	Rank	The period until 2012q4	2013q1 - 2019q4	The period until 2012q4	2013q1 - 2019q4
UNEMPL	3.255	0.006	0.511	2.626	0.013	0.286	0.797	14	0.831	53	0.165	13	0.0593	0.0529	0.0582	0.0613
UNEMPRATE	4.906	0.000	0.290	4.329	0.000	0.153	0.813	1	0.845	16	0.066	56	0.0593	0.0530	0.0586	0.0580
EMPL	2.808	0.014	0.967	2.612	0.014	0.305	0.787	31	0.832	50	0.105	38	0.0574	0.0529	0.0572	0.0539
LABFORCE	1.952	0.078	0.387	1.644	0.126	0.727	0.780	46	0.828	58	0.096	39	0.0586	0.0511	0.0567	0.0651
EMPL_AGR	1.829	0.099	0.249	2.154	0.040	0.019	0.780	47	0.842	25	0.132	25	0.0581	0.0397	0.0565	0.0494
EMPL_MANU	3.249	0.006	0.438	2.801	0.009	0.305	0.793	22	0.850	10	0.129	26	0.0573	0.0499	0.0563	0.0579
EMPL_ELEC	1.901	0.086	0.859	2.054	0.050	0.925	0.794	20	0.843	20	0.140	19	0.0588	0.0488	0.0583	0.0511
EMPL_CONS	1.607	0.152	0.808	1.672	0.118	0.459	0.784	39	0.828	57	0.116	31	0.0595	0.0528	0.0590	0.0564
EMPL_WHOLESALE	2.174	0.050	0.922	2.120	0.043	0.315	0.790	30	0.847	13	0.198	8	0.0584	0.0532	0.0571	0.0629
EMPL_TRANS	1.886	0.088	0.916	1.638	0.127	0.700	0.786	32	0.832	51	0.225	2	0.0583	0.0527	0.0573	0.0645
RAILWAY_TRANS	1.678	0.133	0.510	1.283	0.268	0.687	0.794	17	0.839	32	0.077	52	0.0590	0.0528	0.0577	0.0841
SUEZCNL_REV	1.709	0.125	0.593	1.334	0.241	0.744	0.793	23	0.837	37	0.069	55	0.0573	0.0523	0.0570	0.0536
TOURISM_REV	1.991	0.072	0.430	1.700	0.111	0.377	0.797	13	0.842	21	0.093	41	0.0593	0.0522	0.0591	0.0534
REMITTANCES	1.723	0.122	0.755	1.762	0.096	0.139	0.802	8	0.845	15	0.085	46	0.0592	0.0526	0.0587	0.0559
NFDI	1.631	0.145	0.708	1.237	0.292	0.982	0.777	52	0.834	46	0.106	36	0.0573	0.0511	0.0570	0.0525
RGDP_FC	16.869	0.000	0.051	14.292	0.000	0.034	0.777	53	0.833	47	0.065	57	0.0582	0.0526	0.0579	0.0538
HH_CONS	4.035	0.001	0.131	3.116	0.004	0.476	0.794	19	0.848	12	0.077	53	0.0588	0.0535	0.0580	0.0583
GOV_CONS	2.213	0.046	0.749	1.709	0.109	0.861	0.778	51	0.832	48	0.063	58	0.0594	0.0530	0.0592	0.0539
INV	2.984	0.010	0.583	3.043	0.005	0.467	0.806	6	0.846	14	0.075	54	0.0590	0.0529	0.0587	0.0546

ELEC_CONS	1.557	0.167	0.868	1.407	0.208	0.746	0.783	41	0.831	56	0.128	27	0.0587	0.0527	0.0584	0.0541
CEM_CONS	1.912	0.084	0.450	1.506	0.169	0.460	0.791	29	0.836	42	0.122	29	0.0587	0.0533	0.0583	0.0547
STEEL_CONS	1.596	0.155	0.677	1.561	0.150	0.111	0.780	48	0.842	24	0.089	44	0.0592	0.0529	0.0589	0.0541
BOP	1.573	0.162	0.781	1.353	0.232	0.269	0.793	25	0.842	23	0.088	45	0.0592	0.0529	0.0589	0.0544
INF_RATE	2.055	0.063	0.409	1.834	0.082	0.691	0.779	49	0.836	43	0.135	23	0.0591	0.0526	0.0586	0.0547
DEP_RATE	2.260	0.042	0.542	2.589	0.014	0.038	0.811	2	0.856	5	0.176	11	0.0578	0.0519	0.0574	0.0540
LEND_RATE	2.616	0.020	0.633	2.577	0.015	0.046	0.811	4	0.862	3	0.205	7	0.0594	0.0530	0.0590	0.0550
DIS_Rate	2.738	0.016	0.911	2.448	0.020	0.124	0.811	3	0.853	7	0.171	12	0.0590	0.0524	0.0587	0.0538
Mo	2.230	0.045	0.291	2.563	0.016	0.385	0.785	35	0.848	11	0.320	1	0.0592	0.0592	0.0590	0.0590
M1	1.922	0.082	0.346	1.500	0.171	0.612	0.785	36	0.837	39	0.117	30	0.0594	0.0527	0.0590	0.0545
M2	2.696	0.017	0.025	2.715	0.011	0.036	0.804	7	0.859	4	0.189	9	0.0593	0.0545	0.0591	0.0556
Curr_Circ	3.551	0.003	0.644	2.573	0.015	0.963	0.791	28	0.841	26	0.083	48	0.0592	0.0529	0.0564	0.2087
EGX30	2.038	0.065	0.290	1.678	0.116	0.356	0.799	11	0.842	22	0.145	17	0.0582	0.0539	0.0568	0.0666
IM_FUEL	2.859	0.012	0.582	2.191	0.036	0.966	0.793	24	0.838	36	0.079	50	0.0595	0.0525	0.0592	0.0539
IM_RM	1.635	0.144	0.939	1.237	0.292	0.867	0.776	56	0.832	52	0.094	40	0.0594	0.0525	0.0592	0.0536
IM_IMG	1.718	0.123	0.681	1.329	0.243	0.658	0.780	45	0.836	40	0.114	32	0.0595	0.0528	0.0592	0.0541
IM_INVG	1.868	0.092	0.842	1.866	0.076	0.108	0.781	44	0.835	44	0.082	49	0.0591	0.0528	0.0588	0.0543
IM_DUR	1.794	0.106	0.620	1.986	0.058	0.363	0.797	12	0.853	8	0.136	22	0.0590	0.0529	0.0587	0.0546
IM_NONDUR	2.152	0.052	0.439	1.698	0.111	0.449	0.776	55	0.835	45	0.079	51	0.0590	0.0529	0.0587	0.0546
IM_TOTAL	1.882	0.089	0.702	1.490	0.174	0.494	0.775	58	0.831	55	0.113	33	0.0591	0.0528	0.0586	0.0550
EX_FUEL	1.779	0.109	0.982	2.436	0.020	0.012	0.785	34	0.854	6	0.219	5	0.0594	0.0530	0.0591	0.0541

EX_COTT	1.693	0.129	0.835	1.619	0.132	0.506	0.784	38	0.843	19	0.132	24	0.0593	0.0530	0.0591	0.0540
EX_RM	2.024	0.067	0.631	1.524	0.162	0.974	0.779	50	0.831	54	0.083	47	0.0570	0.0532	0.0566	0.0557
EX_SEMFIN	2.574	0.022	0.096	3.195	0.003	0.040	0.800	10	0.852	9	0.106	37	0.0593	0.0529	0.0582	0.0613
EX_FIN	1.986	0.072	0.697	1.669	0.118	0.826	0.782	43	0.836	41	0.222	3	0.0593	0.0530	0.0586	0.0580
EX_TOTAL	1.634	0.144	0.953	1.787	0.091	0.046	0.776	54	0.839	30	0.143	18	0.0574	0.0529	0.0572	0.0539
TOT	1.435	0.211	0.641	1.426	0.201	0.120	0.794	21	0.838	35	0.219	4	0.0586	0.0511	0.0567	0.0651
EXRATE	1.749	0.115	0.906	3.149	0.004	0.004	0.806	5	0.874	1	0.184	10	0.0581	0.0397	0.0565	0.0494
EXRATE_MISA	1.592	0.158	0.274	2.288	0.030	0.009	0.801	9	0.869	2	0.210	6	0.0573	0.0499	0.0563	0.0579
NEER_EG	2.305	0.038	0.523	2.305	0.038	0.523	0.792	27	0.843	17	0.112	34	0.0588	0.0488	0.0583	0.0511
REER_EG	2.416	0.031	0.266	1.968	0.061	0.306	0.795	15	0.843	18	0.089	43	0.0595	0.0528	0.0590	0.0564
REER_US	1.529	0.176	0.829	1.181	0.325	0.757	0.775	57	0.832	49	0.136	21	0.0584	0.0532	0.0571	0.0629
REER_GRM	1.790	0.107	0.356	1.387	0.216	0.980	0.785	37	0.840	29	0.162	14	0.0583	0.0527	0.0573	0.0645
REER_IT	1.754	0.114	0.345	1.399	0.211	0.535	0.783	40	0.837	38	0.123	28	0.0590	0.0528	0.0577	0.0841
REER_FR	1.764	0.112	0.333	1.346	1.346	0.903	0.783	42	0.838	34	0.145	16	0.0573	0.0523	0.0570	0.0536
REER_UK	2.090	0.059	0.076	1.804	0.088	0.214	0.785	33	0.840	27	0.110	35	0.0593	0.0522	0.0591	0.0534
RGDP_US	1.601	0.153	0.974	1.486	0.176	0.195	0.795	16	0.840	28	0.153	15	0.0592	0.0526	0.0587	0.0559
RGDP_EU	1.809	0.103	0.211	1.505	0.169	0.328	0.793	26	0.838	33	0.139	20	0.0573	0.0511	0.0570	0.0525
RGDP_CHINA	1.921	0.082	0.477	1.594	0.139	0.316	0.794	18	0.839	31	0.092	42	0.0582	0.0526	0.0579	0.0538
LEI	**1.929**	**0.082**	**0.626**	**3.943**	**0.001**	**0.035**	**0.825**		**0.874**		**0.172**					

Notes:

The first two columns report the F-statistics and the p-value of the test hypothesis that none of the two lags of the indicated series enter significantly into a regression of the RGDP growth and 4 lags of the RGDP growth and 2 lags of the trial series. The next two columns report the same statistics when 4 lags of the trial series are used.
The next six columns present R^2 resulted from the regression of the RGDP growth over the next K quarters on 2 lags of each of the quarterly RGDP growth and of the trial series. The statistics presented are the R^2's and their ranks amongst the series for k=1, 2 and 4. The "Rank" following the $R^2(K)$ is the rank of the $R^2(K)$ statistics for that row series, amongst all $R^2(K)$ reported in this column.
The last four columns report the root mean square error (RSME) of forecasting the future two quarters growth of the RGDP on 2 lags of each of the RGDP growth and the trial series. Such that, the first two of these columns refer to the regression estimated over the full sample period (2002q1-2019q4), where the Root Mean Square Error (RMSE) is computed when the forecasted sub-samples are (2002q1-2012q4) and (2013q1-2019q4), respectively. For the final two columns, the regression is estimated using (2002q1- 2012q4) and the RMSE is recalculated for the same two forecasted samples.

Table A.4: List of all Potential Leading Indicators:

	Cross-Correlation (with RGDP)			Predictive Content						Predictive Content					
				2 lags			4 lags			1-step ahead		2-steps ahead		4-steps ahead	
	Ro	rmax	tmax	F-value	Prob (F-Statistics)	P-value (of 2 lags of the trial series	F-value	Prob (F-Statistics)	P-value (of 4 lags of the trial series	$R^2(1)$	rank	$R^2(2)$	rank	$R^2(4)$	rank
UNEMPL	-0.4310	-0.4804	-1	3.255	0.006	0.511	2.626	0.013	0.29	0.797	14	0.831	53	0.165	13
UNEMPRATE	-0.2276	-0.3294	-4	4.906	0.000	0.290	4.329	0.000	0.15	0.813	1	0.845	16	0.066	56
EMPL_AGR	-0.1931	-0.3948	-6	1.829	0.099	0.249	2.154	0.040	0.02	0.780	47	0.842	25	0.132	25
EMPL_MANU	0.912	0.912	0	3.249	0.006	0.438	2.801	0.009	0.31	0.793	22	0.850	10	0.129	26
EMPL_WHOLESALE	0.9076	0.9076	0	2.174	0.050	0.922	2.120	0.043	0.32	0.790	30	0.847	13	0.198	8
REMITTANCES	-0.0038	-0.1272	-3	1.723	0.122	0.755	1.762	0.096	0.14	0.802	8	0.845	15	0.085	46
RGDP_FC	0.9868	0.9868	0	16.869	0.000	0.051	14.292	0.000	0.03	0.777	53	0.833	47	0.065	57
HH_CONSGR	0.952	0.952	0	4.035	0.001	0.131	3.116	0.004	0.48	0.794	19	0.848	12	0.077	53
BOP	-0.0966	0.4379	-5	1.573	0.162	0.781	1.353	0.232	0.27	0.793	25	0.842	23	0.088	45
CEM_CONS	0.7654	0.7654	0	1.912	0.084	0.450	1.506	0.169	0.46	0.791	29	0.836	42	0.122	29
INF_RATE	-0.1617	- 0.1617	0	2.055	0.063	0.409	1.834	0.082	0.69	0.779	49	0.836	43	0.135	23
DEP_RATE	-0.1667	-0.18	-4	2.260	0.042	0.542	2.589	0.014	0.04	0.811	2	0.856	5	0.176	11
LEND_RATE	-0.1746	- 0.2532	-1	2.616	0.020	0.633	2.577	0.015	0.05	0.811	4	0.862	3	0.205	7
DIS_RATE	0.609	0.609	0	2.738	0.016	0.911	2.448	0.020	0.12	0.811	3	0.853	7	0.171	12
M0	0.9227	0.9227	0	2.230	0.045	0.291	2.563	0.016	0.39	0.785	35	0.848	11	0.320	1
M1	0.9307	0.9307	0	1.922	0.082	0.346	1.500	0.171	0.61	0.785	36	0.837	39	0.117	30
M2	0.9027	0.9027	0	2.696	0.017	0.025	2.715	0.011	0.04	0.804	7	0.859	4	0.189	9
EGX30_GR	0.8273	0.8273	0	2.038	0.065	0.290	1.678	0.116	0.36	0.799	11	0.842	22	0.145	17
INV_GR	0.9186	0.9186	0	2.984	0.010	0.583	3.043	0.005	0.47	0.806	6	0.846	14	0.075	54
IM_DURGR	0.7556	0.7556	0	1.794	0.106	0.620	1.986	0.058	0.36	0.797	12	0.853	8	0.136	22
EX_FUELGR	0.0772	-0.1477	-6	1.779	0.109	0.982	2.436	0.020	0.01	0.785	34	0.854	6	0.219	5

EX_SEMFINGR	0.821	0.821	0	2.574	0.022	0.096	3.195	0.003	0.04	0.800	10	0.852	9	0.106	37
EXRATE	-0.0476	-0.3092	-3	1.749	0.115	0.906	3.149	0.004	0.00	0.806	5	0.874	1	0.184	10
EXRATE_MISA	0.0627	-0.3783	- 4	1.592	0.158	0.274	2.288	0.030	0.01	0.801	9	0.869	2	0.210	6
NEER_EG	-0.8473	-0.8473	0	2.305	0.038	0.523	2.305	0.038	0.52	0.792	27	0.843	17	0.112	34
REER_EG	0.6331	0.6331	0	1.529	0.176	0.829	1.181	0.325	0.76	0.775	57	0.832	49	0.136	21

Appendix B. Theoretical Representation of Spectral Analysis

The spectral analysis can be captured in the 'spectral representation theorem' which states that any covariance stationary process[33] $\{Y_t\}_{t=-\infty}^{\infty}$ can be expressed as a combination of cosine (sine) waves with different periods and frequencies:

$$Y_t = \mu + \int_0^{\pi} \alpha(\omega).\cos(wt)\, d\omega + \int_0^{\pi} \beta(\omega).\sin(\omega t) d\omega \quad (1)$$

Where:

- ω: is the frequency, which controls how rapidly the curve oscillates. It corresponds to a unique time horizon (T), such that, $T = 2\pi/\omega$. Thus, the process Y_t is a periodic function with frequency ω or with period T.
- The weights $\alpha(\omega)$ & $\beta(\omega)$: are random variables with zero mean.

Given that spectral analysis identifies the important frequencies in a time series, a starting tool of doing this is the ***periodogram***, which can identify the dominant periods (frequencies) in the series under study. A periodogram is one type of the univariate spectral analysis, which graphs a measure of the relative importance of possible frequencies that can explain the oscillation pattern of the observed data (Shumway et. al. (2011) & Bátorová (2012)).

A theoretical representation of "spectral density function" and "periodogram" can be summarised as follows:

Following Hamilton (1994) and Bátorová (2012), let $\{Y_t\}_{t=-\infty}^{\infty}$ is a covariance stationary process with mean $E(Y_t) = \mu$ and with autocovarinces $\{\gamma_j\}_{j=-\infty}^{\infty}$, such that the jth autocovariance[34] is defined as:

$$\gamma_j = E(Y_t - \mu)(Y_{t-j} - \mu) \qquad (2)$$

Assume that the sequence of autocovariances is absolutely summable, thus, the autocovariance-generating function for Y_t is defined as the summation of the jth autocovariance multiplied by z, and raised to the jth power over all possible values of j:

[33] If Y_t is a covariance stationary process, this means that the covariance between $y_t$and y_{t-1} (cov (y_t, y_{t-1})) is constant over the whole series across time.
[34] The autocovariance: describes the relationship between two different observations of Y_t

$$g_Y(z) = \sum_{j-\infty}^{\infty} \gamma_j z^j, \qquad (3)$$

Such that z is a complex scalar and represented as:

$$z = \cos(\omega) - i.\sin(\omega) = e^{-i\omega} \qquad (4)$$

Given that i is a complex unit and ω is a real number, the autocovariance-generating function for a time series Y_t can be rewritten as:

$$g_Y\left(e^{-i\omega}\right) = \sum_{j-\infty}^{\infty} \gamma_j e^{-iwj} \quad (5)$$

If the autocovariance generating function is divided by 2π, we can get a formula of the "*population spectrum*" or the "*spectral density function*" for the time series Y_t:

$$s_Y(\omega) = \frac{1}{2\pi} g_Y\left(e^{-i\omega}\right) = \frac{1}{2\pi} \sum_{j=-\infty}^{\infty} \gamma_j e^{-i\omega j} \qquad \omega \epsilon [0, \pi] \quad (6)$$

From equation (6), it can be inferred that the population spectrum ($s_Y(\omega)$) of the time series (Y_t) with the set of autocovariaces $\{\gamma_j\}_{j=-\infty}^{\infty}$ can be computed at any value of ω.

Moreover, if the set of autocovariances is known, the value of the spectral density $s_Y(\omega)$ can be obtained. The opposite is true, if the spectrum is known for all ω from $[0, \pi]$, the jth autocovariance can be calculated from:

$$\gamma_j = \int_{-\pi}^{\pi} s_Y(\omega)\, e^{i\omega j}\, d\omega \qquad (7)$$

If (j) in equation (7) is set to zero, we can get:

$$\int_{-\pi}^{\pi} s_Y(\omega)\, d\omega = \gamma_0 \qquad (8)$$

This means that the total variance (γ_0) of (Y_t), can be expressed as the sum of the spectral densities over all possible frequencies. In other words, the area under the spectral density function between $[-\pi, \pi]$ gives (γ_0), which is the variance of (Y_t).

Given that the population spectrum for Y_t is defined in equation (6), let $y_1, y_2, \ldots\ldots\ldots y_\tau$ be a sample of (T) observations of the series (Y_t) which provides T-1 autocovariances:

$$\hat{\gamma}_j = \frac{1}{T} \sum_{t=j+1}^{T} (y_t - \bar{y})(y_{t-j} - \bar{y}) \qquad \text{for } j = 0,1,2, \ldots\ldots, T-1 \qquad (9)$$

Where the sample mean: $\bar{y} = T^{-1} \sum_{t=1}^{T} y_t$

Thus, the **sample periodogram** (which is an estimator of the population spectrum) can be constructed as follows:

$$\hat{s}_y(\omega) = \frac{1}{2\pi} \sum_{j=-T+1}^{T-1} \hat{\gamma}_j \, e^{-i\omega j} \qquad (10)$$

Similar to the relation between the population spectrum and the total variance, the area under the periodogram is the sample variance of y:

$$\int_{-\pi}^{\pi} \hat{s}_y(\omega) d\omega = \hat{\gamma}_0 \qquad (11)$$

We can now develop a sample analog to the spectral representation theorem mentioned in equation (1). In particular, for any given T observations on a time series process $(y_1, y_2, \ldots . y_T)$, there are $(\omega_1, \omega_2, \ldots . \omega_m)$ frequencies, and $(\hat{\mu}, \hat{\alpha}_1, \hat{\alpha}_2 \ldots \ldots . . \hat{\alpha}_M, \hat{\delta}_1, \hat{\delta}_2, \ldots . . \hat{\delta}_M)$ coefficients, such that the value of y at time t is defined as:

$$y_t = \hat{\mu} + \sum_{j=1}^{M} \{\hat{\alpha}_j . \cos[\omega_j (t-1)] + \hat{\delta}_j . \sin[\omega_j (t-1)]\} \qquad (12)$$

Such that, the sample variance of y is $T^{-1} \sum_{t=1}^{T} (y_t - \bar{y})^2$ and the portion of this variance that can be attributed to cycles with frequency ω_j can be inferred from the sample periodogram $\hat{s}_y(\omega_j)$.

If the sample size (T) is an odd number and y_t (is expressed in terms in terms of periodic function as equation (12)) has $M = (T-1)/2$ different frequencies. The frequencies $\omega_1 \, \omega_2 \, \omega_3 \ldots\ldots \omega_M$ are specified as follows:

$$\omega_1 = 2\pi/T, \omega_2 = 4\pi/T, \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{and } \omega_M = 2M\pi/T \qquad (13)$$

Thus, the highest frequency considered is: $\omega_M = \frac{2(T-1)\pi}{2T} < \pi$ (14)

If an OLS regression is performed to estimate y_t, such that:

$$y_t = \mu + \sum_{j=1}^{M} \{\alpha_j . \cos[\omega_j (t-1)] + \delta_j . \sin[\omega_j (t-1)]\} + u_t \qquad (15)$$

Equation (15) can be viewed as a standard regression model of the form:

$$y_t = \grave{\beta} X_t + u_t \qquad (16)$$

Where:

$$X_t = \Big[1 \quad cos\,[\,\omega_1 (t-1)] \quad \sin[\omega_1 (t-1)] \quad cos[\omega_2 (t-1)] \quad \sin[\omega_2 (t-1)] \quad \ldots \ldots$$

$cos[\omega_M (t-1)] \quad \sin[\omega_M (t-1)]\Big]$ (17)

$\hat{\beta} = [\quad \mu \quad \alpha_1 \; \delta_1 \quad \alpha_2 \quad \delta_2 \ldots\ldots \quad \alpha_M \quad \delta_M \,]$ (18)

Noting that, X_t has (2M+1) = T elements, thus, there are as many explanatory variables as observations. The coefficients of this regression have the property that $\frac{1}{2}(\hat{\alpha}_j^2 + \hat{\delta}_j^2)$ represents the portion of sample variance of y that can be attributed to cycles with frequency ω_j. This magnitude $\frac{1}{2}(\hat{\alpha}_j^2 + \hat{\delta}_j^2)$ turned out to be proportional to the sample periodogram evaluated at ω_j. Thus, any time series process $y_1, y_2, y_3, \ldots\ldots y_T$ can be expressed in terms of periodic functions (equation 15), where the periodogram can determine the portion of sample variance that is attributed to the cycles with frequency ω_j . Accordingly, a relatively large value of the periodogram at frequency ω_j indicates relatively more importance for the frequency ω_j in explaining the oscillating pattern of the series under study.

- Cross-Spectral Analysis:

While univariate spectral analysis examines movements inside a single series, cross-spectral analysis can examine simultaneously the relationship between two time series as a function of frequencies. It decomposes their covariance in frequency components and allows for the characterisation of the cyclical relationship, which are difficult to model in the time domain (Bátorová (2012)).

To illustrate the concept of cross-spectrum and its components:

According to Bátorová (2012), let $\{Y_t\}_{t=-\infty}^{\infty}$ is a covariance stationary process with mean $E(Y_t) = \mu_y$, and $\{X_t\}_{t=-\infty}^{\infty}$ is also a covariance stationary process with mean $E(X_t) = \mu_X$. The cross-spectrum from Y_t to X_t is defined as:

$$s_{YX}(\omega) = \frac{1}{2\pi} \sum_{j=-\infty}^{\infty} \gamma_{YX}^{(j)} e^{-i\omega j}$$

$$= \frac{1}{2\pi} \sum_{j=-\infty}^{\infty} \gamma_{YX}^{(j)} \{\cos(\omega j) - \sin(\omega j)\} \quad (19)$$

Where $\gamma_{YX}^{(j)}$ is the j-th autocvariance between Y and X, such that:

$$\gamma_{YX}^{(j)} = E(Y_t - \mu_Y)(X_{t-j} - \mu_X)$$

By analogy from the relation in equation (8), the area under the cross-spectrum is equal to the covariance between X and Y:

$$\int_{-\pi}^{\pi} s_{YX}(\omega)d\omega = E(Y_t - \mu_Y)\,(X_t - \mu_X) \qquad (20)$$

Given that the cross-spectrum is a complex number, it can be expressed as a sum of real and imaginary components: $s_{YX}(\omega) = C_{YX}(\omega) + i.q_{YX}(\omega)$ (21)

- The real component of the cross spectrum ($C_{YX}(\omega)$) is called "cospectrum" between Y and X and it can be expressed as the portion of covariance between X and Y that corresponds to cycles with frequency (ω). It is defined as: $C_{YX}(\omega) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty}\gamma_{YX}^{(j)}\cos(\omega j)$ (22)
- The imaginary component of the cross spectrum ($q_{YX}(\omega)$) is called "quadrature spectrum" from Y to X and is defined as: $q_{YX}(\omega) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty}\gamma_{YX}^{(j)}\sin(\omega j)$ (23)

Appendix C. Calculating the Composite Indexes

According to the TCB approach, if there are (n) variables included in the index and X_{it} denote the i-th quarterly component of the index, the CEI index can be constructed through the following steps:

(1) **Quarter to quarter changes are computed for each component series:** If series X is in the form of percentage change or an interest rate, arithmetic differences are calculated:

$x_t = X_t - X_{t-1}$. If the component is not in percent change form, a symmetric alternative to the traditional percent change formula is used: $X_t = 200 * \left(\frac{X_t - X_{t-1}}{X_t + X_{t-1}}\right)$

(2) **Standardisation:** The quarterly contributions of component series are adjusted to equalise the volatility of each series. After computing the Standard deviations (V_x) of the changes in each component, these statistical measures of volatility are inverted ($W_x = \frac{1}{V_x}$), their sum is calculated (k = {sum over [x]} W_x) and they are restated so the index's component standardisation factors sum to one ($r_x = \left(\frac{1}{k}\right) * W_x$). The adjusted quarterly contribution of each series is calculated by multiplying its quarterly contribution by the corresponding component standardisation factor

($m_t = r_x * x_t$).

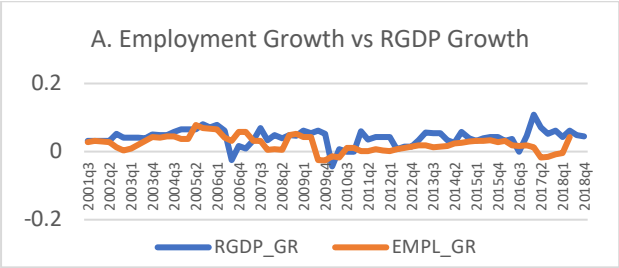
(3) **The rate of growth of the CEI**: is computed by adding the adjusted contribution across the components for each quarter. This results in the sum of the adjusted contributions (i_t = {sum over [x]} m_{xt}) which is the growth rate of the index.

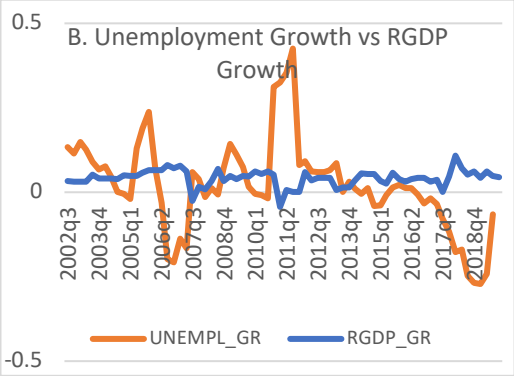
(4) **The level of the index is computed recursively** starting by an initial value of 100 for the first quarter of the sample period (i.e., 2003q1). The following formula is used recursively to compute the index levels for each quarter through which the data is available.

$$CEI_t = CEI_{t-1} \frac{(200 - c_t)}{(200 + c_t)}$$

Appendix D: Graphical Representation of Selected Indicators

Figure D.1: Cyclical Dynamics of Employment Indicators against RGDP:





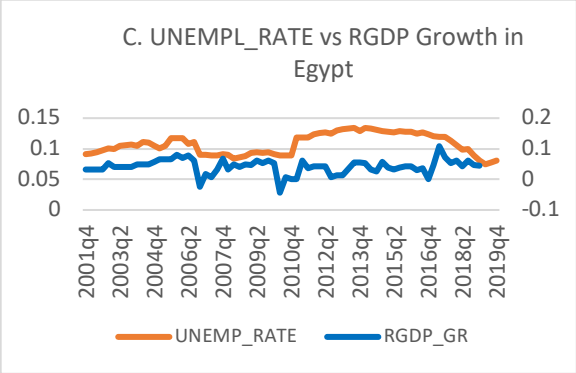
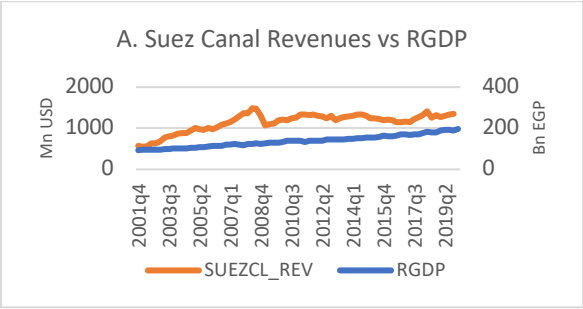
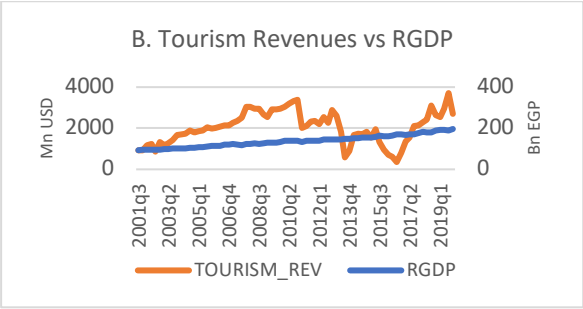


Figure D.2: Cyclical Dynamics of source of foreign currency indicators against RGDP:





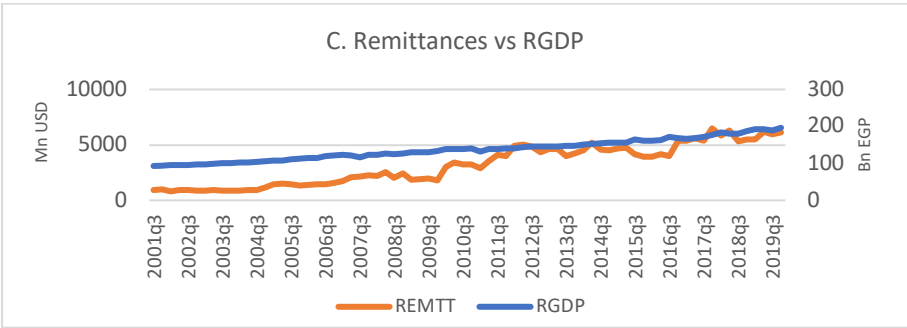
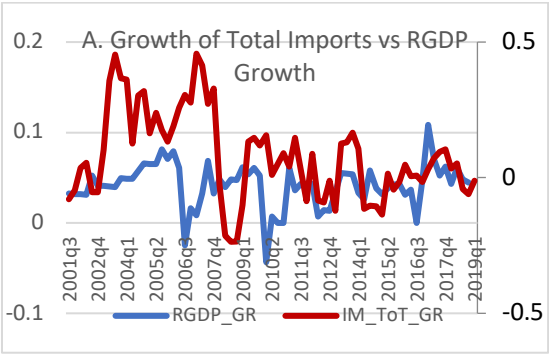
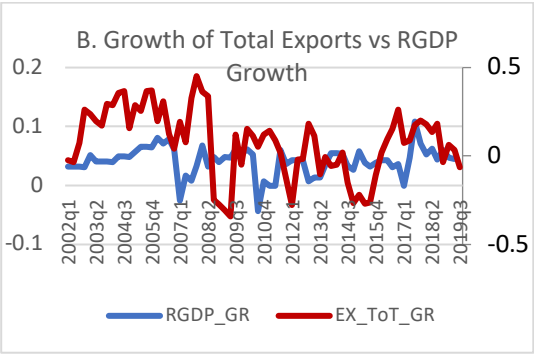


Figure D.3: Cyclical Dynamics of Foreign Trade indicators against RGDP:





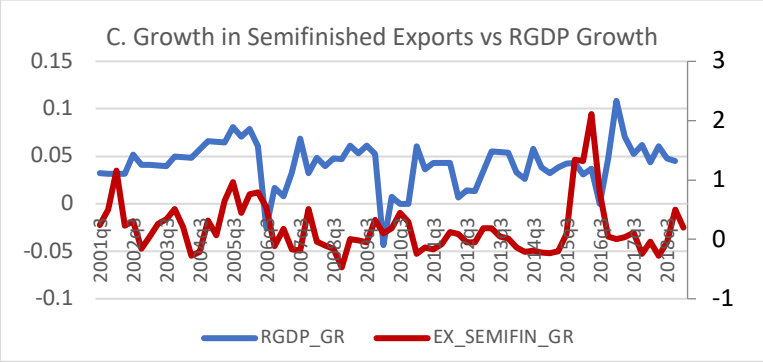
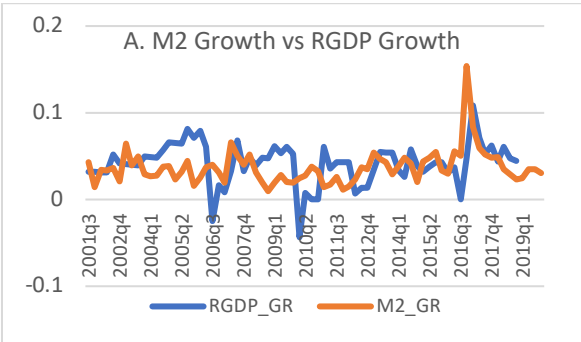
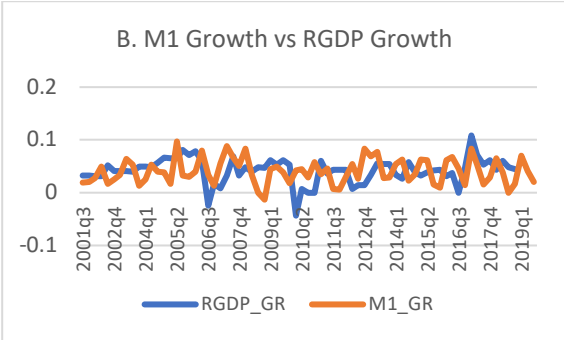
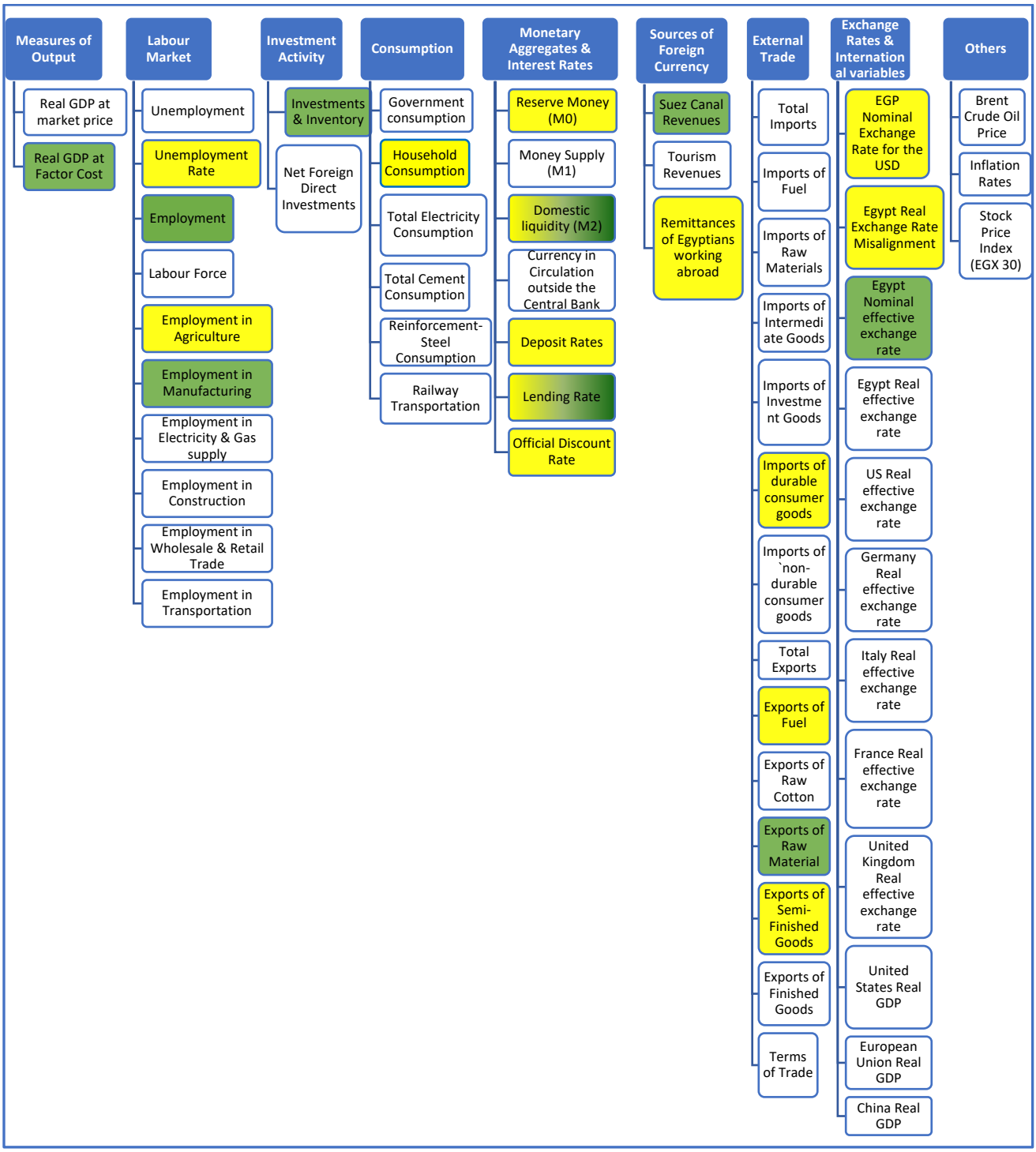


Figure D.4: Cyclical Dynamics of Monetary Aggregates against RGDP:





Appendix E: Summary of all variables in the dataset with the selected Coincident and Leading Indicators highlighted:



Note: Variables included in the CEI are highlighted in green; variables included in the LEI are highlighted in yellow; and variables included in the construction of both indexes CEI and LEI are highlighted in yellow/green.

ABOUT EMANES

The Euro-Mediterranean and African Network for Economic Studies (EMANES) is a network of research institutions and think tanks working on socio-economics policy in Europe, the Mediterranean and Africa. EMANES is coordinated by the Euro-Mediterranean Economists Association (EMEA).

The research conducted by EMANES Researchers, Associates and Fellows aims to design sound and innovative socio-economic models that are inclusive, sustainable and employment creative, to devise new models for regional integration and to provide policy recommendations towards this goal.

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- Private sector, micro, small and medium –sized enterprises development, entrepreneurship and social business;
- Digital economy;
- Healthcare policy;
- Human capital development, education, innovation, skill mismatch and migration;
- Labor markets, employment and employability;
- Finance, financial inclusion and the real economy;
- Sustainable development;
- Regional integration;
- Euro-Mediterranean economic partnership;
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EMANES research and outputs are underpinned on the **four fundamental principles: Independence, Scientific Excellence, Policy Relevance and Deep Knowledge of European, the Mediterranean and African Affairs**.

EMNES acknowledges the financial assistance of the European Union within the context of the EU project "Support to economic research, studies and dialogue of the Euro-Mediterranean Partnership" under contract number ENPI/2014/354-488 (2014-2019).