

## **The Bank of Israel's Composite State of the Economy Index**

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**The Composite State of the Economy Index is a synthetic indicator for examining the direction of the development of real economic activity, in real time. It is calculated based on 12 different indicators: the industrial production index; the retail trade revenue index; the services revenue index; consumer goods imports; imports of manufacturing inputs; goods exports; services exports; the number of employee posts in the private sector; the job vacancy rate, the number of building starts, electricity consumption, and credit card purchases.**

**The Index is calculated by the Bank of Israel's Research Department once a month, close to the date that the Industrial Production Index is published by the Central Bureau of Statistics.**

**The Composite Index is made up of two elements: (1) the long-term growth rate of business sector product (which changes slowly over time); and (2) the short-term common dynamic of the Index components compiled in terms of standard deviations. The parameters of the model are estimated at mixed (monthly and quarterly) frequency through a Kalman filter and are updated on an ongoing basis.**

The Composite Index has been calculated at the Bank of Israel since the early 1990s, and in its current format since the beginning of 2013.<sup>1</sup> The changes in the Index methodology are due to changes in data compiling and classification by the Central Bureau of Statistics (CBS)<sup>2</sup>, new sources for end-of-series inference, and upgraded mixed-frequency model specification.

The main changes in the Composite Index, beginning in 2013, are:

- 1) The expansion of the number of Index components;
- 2) Estimating the model at mixed (monthly-quarterly) frequency;
- 3) Estimating the Index in terms of monthly Business-sector GDP growth;
- 4) Using additional sources of information for imputation of missing values in Index components.
- 5) Adding data on credit card purchases as a real time predictor for Retail Trade Revenue and data on electricity consumption.

The twelve (seasonally adjusted) components of the Index are (see also Appendix C for further description):

- the monthly rate of change in the Industrial Production Index;
- the monthly rate of change in the Services Revenue Index (excluding the public administration and the education sectors)
- the monthly rate of change in the Retail Trade Revenue Index;
- the monthly rate of change in consumer goods imports;
- the monthly rate of change in imports of manufacturing inputs (excluding fuels);
- the monthly rate of change in goods exports (excluding diamonds, ships and aircraft);

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<sup>1</sup>For articles outlining previous versions of the Index, please see:

Golan, Y. and R. Melnick (1991). "Measuring Business Cycles in Israel", Bank of Israel, Research Department, Discussion Papers Series 1991.01

Marom, A., Y. Menashe and T. Suhoy (2003), "The State-of-the-Economy Index and the Probability of Recession: The Markov Regime-Switching Model." Bank of Israel Research Department, Discussion paper 2003.05.

<sup>2</sup> The methodological change in 2013 was due to the transition at the Central Bureau of Statistics to the 2011 Industry Classification, which in terms of the Composite Index led to a statistical break in the series of industrial production, trade and services revenue, services exports and employee posts in the private sector; the latter was previously evaluated as business-sector employment based on industrial classification.

- the monthly rate of change in business services (excluding start-ups) and tourism services;
- the monthly rate of change in employee posts in the private sector;
- the monthly job vacancy rate;
- the quarterly rate of change in building starts.
- the monthly rate of change in electricity consumption.
- the rate of change in credit card purchases over the last week.

Most of the components (industrial production, revenue, imports, exports, and job vacancy rate) are contemporaneously dependent on the common factor of growth cycle; the employee posts component is contemporaneously dependent on the growth cycle as well as in its two monthly lags.

The index components are demeaned and standardized to unit variance<sup>3</sup>, thus becoming scale-free. Based on the model, each component depends linearly<sup>4</sup> on the common (cyclical) factor and also contains an idiosyncratic term and random noise. The common factor is assumed to follow an AR(1) process with high persistence.

Given the monthly evaluated cyclical growth, the long-term growth can be identified from the quarterly changes in the business-sector GDP (hereinafter, GDP), measured in the original scale (as log-differences).<sup>5</sup> The long-term growth is assumed to follow a random-walk process. In this way, an additional GDP component incorporated into the model accumulates both the monthly dynamic of the common (cyclical) factor during the course of the quarter as well as the long-term growth. The GDP component contributes to the model the ability to balance between various information sources (that is, monthly and quarterly statistics) and calibrates the Index in (monthly) terms of change in GDP. The full version of the model is in Appendix A.<sup>6</sup>

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<sup>3</sup> Outliers identified as exceeding 3 standard-deviations from the mean, calculated over a five-year moving window are trimmed at this value before data transformation.

<sup>4</sup> Without intercept, due to demeaned Index components.

<sup>5</sup> In order to handle the model at a monthly frequency, the quarterly GDP rate is assigned to the mid-of-quarter month, and missing values in other months within the quarter.

<sup>6</sup> The appendices and graphs are updated for the 10 indicator version of the index.

This model has been estimated through an iterative process seeking an improvement in the likelihood function, until convergence. Each iteration includes an estimation step, which evaluates unobservable (state) variables with help of a Kalman filter, given observable Index components and system parameters, and a maximization step, intended to improve the system parameters, conditional on previously evaluated state variables and observable data. Appendix B presents the parameters of the model estimated in July 2019.

Figure 1 presents the changes in the Composite Index alongside the long-term growth rate obtained from the model (upper graph), and the probability of a slowdown in the growth rate relative to the long-term growth rate (lower graph). Figure 2a compares the quarterly amounts of changes in the Composite Index with the quarterly changes in business sector GDP (fixed prices, seasonally adjusted) based on historical data since 1998. Figure 2b excludes the extreme observations from COVID-19, but is identical to Figure 2a

In view of weakening correlation between the employment and output data documented in 2011–12<sup>7</sup>, the model allows for a temporary change of job-vacancy rate elasticity; as a result, the weight of this component in the Index has declined. Appendix C presents the weights of the Index components compared with the weights obtained since the beginning of 2017.

Electricity consumption and credit card purchases are additional data that became available from 2020. Electricity consumption is an indicator of economic activity and is uncorrelated with other indicators. Credit card purchases are real time data which allow a real time estimation of retail trade revenue.

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<sup>7</sup> See the Bank of Israel 2015 Annual Report, Chapter 2: Aggregate Activity: GDP and Employment.

**Figure 1: The Composite State of the Economy Index (monthly change, %) and the probability of slowdown (relative to the long term growth rate) for the period 1998:02–2019:06 (Updated for the 12 indicator index version)**

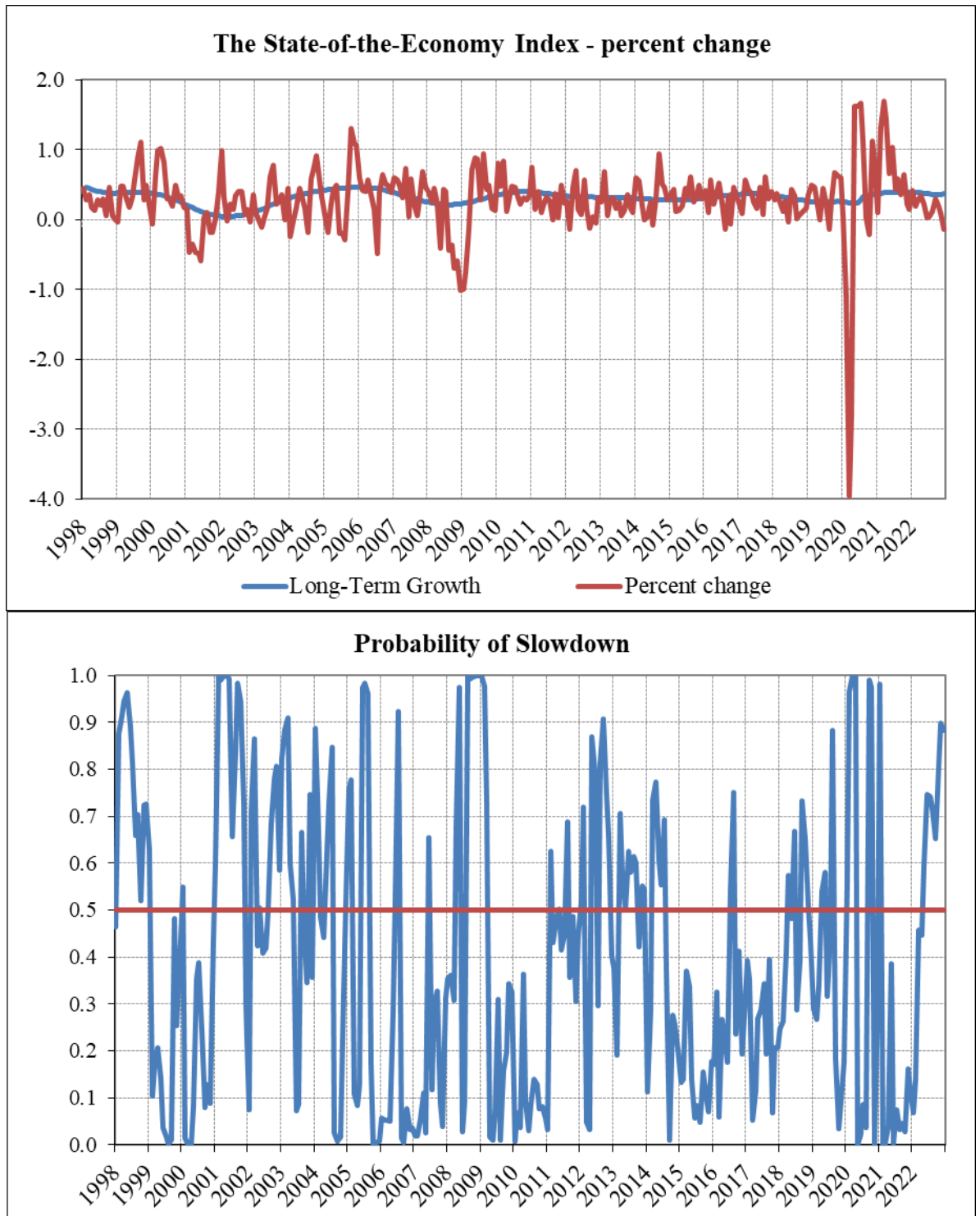


Figure 2a: The Composite Index (monthly % change, in quarterly terms) alongside quarterly changes in Business-sector GDP for the period 1998-2022 (Updated for the 12 indicator index version)

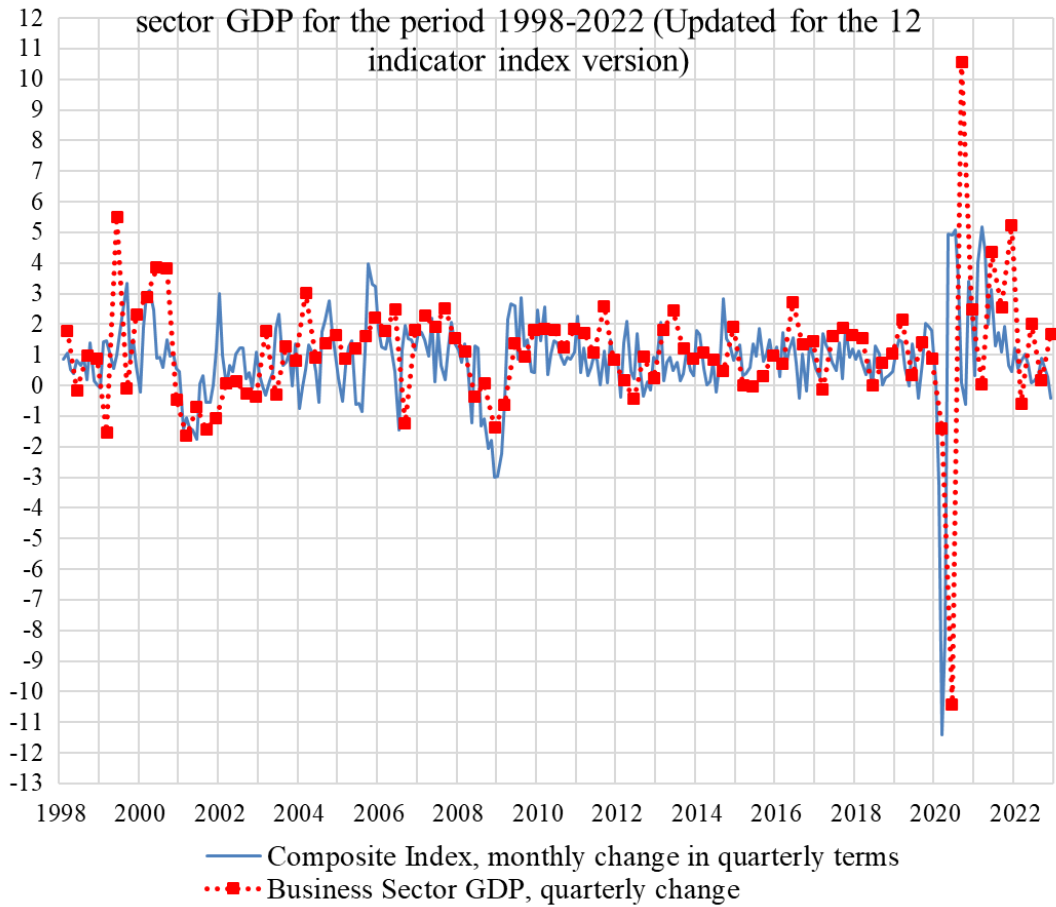
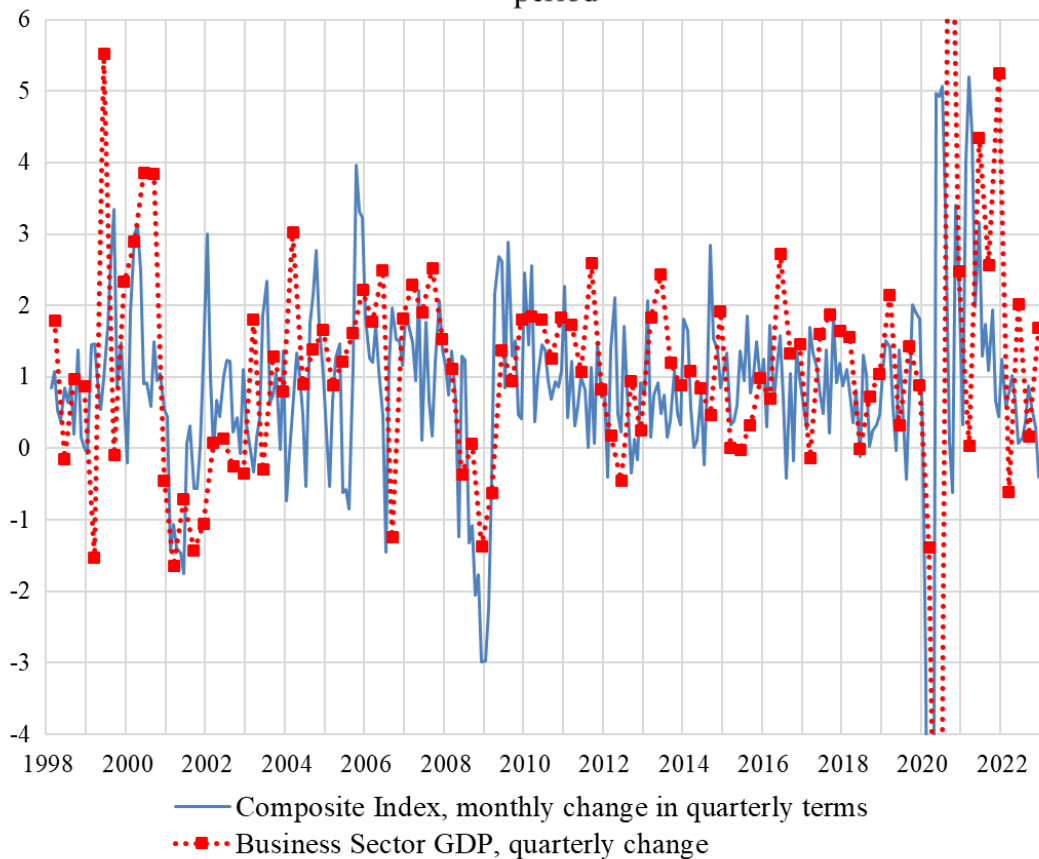


Figure 2b: Figure 2a without the extremes of the COVID-19 period\*



\*The Composite Index without March-April 2020, Business Sector GDP without Q2-Q3 2020.

Due to the delay in availability of some of the components of the Composite Index in real time, end-of-series observations are forecast based on statistical models that are supported by additional sources of information. In particular:

- The changes in services exports in the month to which the Index refers and in the preceding month are derived from the combination of two estimates: (1) tourism services, which are estimated by a regression of tourist entries into Israel; (2) business services, which are projected based on daily statistics kept by the Bank of Israel based on reports by companies providing services to abroad and transactions in foreign currency by individuals;
- The changes in employee posts in the month to which the Index refers and in the preceding month are estimated based on the balances of opinions related to the number of employed in the manufacturing and services industries from the Business Tendency Survey (CBS);
- The monthly changes in building starts are projected based on the balances of opinions related to building activities from the Business Tendency Survey (CBS);
- The monthly change in industrial production and trade and services revenue in the month of interest has been extrapolated based on corresponding MA(1) processes.

#### **Appendix A: Description of the Composite Index's State Space model** (Updated for the 10 indicator index version)

This appendix presents the structure of the model, including two types of equations: (1)-(11) are measurement equations connecting observable components of the Index with latent (state) variables, such as the common cyclical factor  $S_t$  and its aggregation over time to a quarterly average  $AS_t$ , the long-term growth  $LR_t$ , and idiosyncratic (moving average) terms in the Index components; (12)-(22) are transition equations that outline the dynamics of state variables. This system is solved by the iterative EM method, where each

iteration includes an estimation step (a Kalman filter pass) and a maximization step. The initial parameters of the system are set on the basis of the first principal component of the observed variables, based on the methodology of Doz, Giannone, and Reichlin (2006).<sup>8</sup> The aggregation of the state variable  $S_t$  over time is carried out based on the methodology of Brave and Butters (2011).<sup>9</sup>

Notations:

**Observable variables (seasonally adjusted, log-differenced (excluding job vacancy rate), demeaned and standardized to unit variance<sup>10</sup>:**

$IP_t$  - Industrial Production Index (excluding mining and quarrying);

$Rev_{S_t}$  – Services Revenue Index (excluding education and public administration);

$Rev_{C_t}$  – Retail Trade Revenue Index;

$Im_{C_t}$  – Imports of consumer goods;

$Im_{Inp_t}$  – Imports of manufacturing inputs (excluding fuels);

$X_{G_t}$  – Exports of goods (excluding agriculture);

$X_{S_t}$  – Exports of services (excluding transportation);

$Emp_t$  – Number of employee posts in the private sector;

$Vac_t$  – Job vacancy rate;

$Starts_t$  – Building Starts, monthly interpolated by additional variable;

$GDP_{tq}$  – Business-sector GDP quarterly growth rate (in monthly terms, one observation per quarter, attributed to the middle month of the quarter);

**State variables estimated through a Kalman filter and conditional on system parameters:**

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<sup>8</sup> See: Doz, C., D. Giannone, and L. Reichlin (2006), "A Quasi Maximum Likelihood Approach for Large Approximate Dynamic Factor Models", ECB Working Paper No. 674.

<sup>9</sup> See: Brave, S., and R. A. Butters (2011), "Diagnosing the Financial System: Financial Conditions and Financial Stress", *International Journal of Central Banking* 8(2), pp.191-240.

<sup>10</sup> Excluding GDP growth rate, which is not standardized.



$S_t$  – monthly short-term comovement;

$AS_t$  – short-term comovement, quarterly average;

$m_t$  – calendar indicator used for aggregation of  $S_t$  over time, that obtains values:

1. if  $t$  is the last month in the quarter (March, June, September, December),
2. if  $t$  is the first month in the quarter (January, April, July, October),
3. if  $t$  is the second month in the quarter (February, May, August, November)

$LR_t$  – long-term growth rate, in monthly terms;

$u_t^{IP}, \dots, u_t^{Emp}$  – idiosyncratic terms specified as first-order moving averages;

$\{\mu\}, \{\xi\}, \varepsilon, \eta$  – random residuals.

The parameters  $b_1, \dots, b_{10}; d_1, \dots, d_8; \rho$  and the variances  $\sigma_\mu^2, \sigma_\xi^2, \sigma_\varepsilon^2, \sigma_\eta^2$  of the residuals are estimated from the system equation with linear constraints (Appendix B) conditional on state variables evaluated in the preceding step.

For simplicity, the system is presented in the form of equations rather than in a matrix form.

**The measurement equations are:**

$$(1) IP_t = b_1 S_t + u_t^{IP} + \mu_t^{IP}$$

$$(2) Rev\_S_t = b_2 S_t + u_t^{Rev-S} + \mu_t^{Rev-S}$$

$$(3) Rev\_C_t = b_3 S_t + u_t^{Rev-C} + \mu_t^{Rev-C}$$

$$(4) Im\_C_t = b_4 S_t + u_t^{Im-C} + \mu_t^{Im-C}$$

$$(5) Im\_Inp_t = b_5 S_t + u_t^{Im-Inp} + \mu_t^{Im-Inp}$$

$$(6) X\_G_t = b_6 S_t + u_t^{X-G} + \mu_t^{X-G}$$

$$(7) X\_S_t = b_7 S_t + u_t^{X-S} + \mu_t^{X-S}$$

$$(8) Emp_t = b_{80} S_t + b_{81} S_{t-1} + b_{82} S_{t-2} + \mu_t^{Emp}$$

$$(9) Vac_t = b_9 S_t + u_t^{Vac} + \mu_t^{Vac}$$

$$(10) \text{Starts}_t = b_{10}S_t + \mu_t^{\text{Starts}}$$

$$(11) \text{GDP}_{tq} = LR_t + b_{11}AS_t + \mu_t^{\text{GDP}}$$

**The transition equations are:**

$$(12) S_t = \rho S_{t-1} + \varepsilon_t$$

$$(13) AS_t = \frac{\rho}{m_{t-1}} S_{t-1} + \frac{m_{t-1}-1}{m_{t-1}} AS_{t-1} + \frac{1}{m_{t-1}} \varepsilon_t$$

$$(14) LR_t = LR_{t-1} + \eta_t$$

$$(15) u_t^{IP} = d_1 u_{t-1}^{IP} + \xi_t^{IP}$$

$$(16) u_t^{\text{Rev}_S} = d_2 u_{t-1}^{\text{Rev}_S} + \xi_t^{\text{Rev}_S}$$

$$(17) u_t^{\text{Rev}_C} = d_3 u_{t-1}^{\text{Rev}_C} + \xi_t^{\text{Rev}_C}$$

$$(18) u_t^{\text{Im}_C} = d_4 u_{t-1}^{\text{Im}_C} + \xi_t^{\text{Im}_C}$$

$$(19) u_t^{\text{Im}_\text{Inp}} = d_5 u_{t-1}^{\text{Im}_\text{Inp}} + \xi_t^{\text{Im}_\text{Inp}}$$

$$(20) u_t^{X-G} = d_6 u_{t-1}^{X-G} + \xi_t^{X-G}$$

$$(21) u_t^{X-S} = d_7 u_{t-1}^{X-S} + \xi_t^{X-S}$$

$$(22) u_t^{\text{Vac}} = d_9 u_{t-1}^{\text{Vac}} + \xi_t^{\text{Vac}}$$

**The Composite Index is calculated as follows:**

$$\text{Madad}_t = \exp(S_t + LR_t) - 1$$

Due to decreasing correlation between the labor market and other Index components, we allow the time-varying parameter  $b_9$  as well as a change in variance  $\sigma_{\text{Vac}}^2$ . The gradual change in system parameters was assessed through rolling-window estimation between 1998 and 2016; since 2017 the parameters have been estimated based on expanding data span starting in 2003:01.

**Appendix B: System parameters (initial and after convergence)<sup>1) 2)</sup>, as estimated for the Composite Index for June 2019 (Updated for the 10 indicator index version)**

Equation	Dependent variable	Param.	Initial values			Final values		
<b>Panel A: Measurement equation parameters</b>								
(1)	<i>IP</i>	$b_1$	0.381	[ 0.034 ]	***	0.351	[ 0.078 ]	**
(2)	<i>Rev_S</i>	$b_2$	0.259	[ 0.032 ]	***	0.251	[ 0.071 ]	***
(3)	<i>Rev_C</i>	$b_3$	0.419	[ 0.029 ]	***	0.350	[ 0.125 ]	*
(4)	<i>Im_C</i>	$b_4$	0.353	[ 0.029 ]	***	0.329	[ 0.056 ]	***
(5)	<i>Im_Inp</i>	$b_5$	0.351	[ 0.030 ]	***	0.310	[ 0.147 ]	*
(6)	<i>X_G</i>	$b_6$	0.341	[ 0.029 ]	***	0.343	[ 0.097 ]	**
(7)	<i>X_S</i>	$b_7$	0.202	[ 0.043 ]	***	0.362	[ 0.187 ]	*
(8)	<i>Emp</i>	$b_{80}$	0.405	[ 0.042 ]	***	0.826	[ 0.252 ]	**
(8)		$b_{81}$	0.102	[ 0.029 ]	***	0.012	[ 0.029 ]	
(8)		$b_{82}$	0.044	[ 0.028 ]	*	0.059	[ 0.028 ]	*
(9)	<i>Vac</i>	$b_9$	0.021	[ 0.009 ]	*	0.010	Bounded	
(10)	<i>Starts</i>	$b_{10}$	0.214	[ 0.042 ]	**	0.100	Bounded	
(11)	<i>GDP</i>	$b_{11}$	0.298	[ 0.060 ]	***	0.251	[ 0.102 ]	**
(11)	Intercept (initial <i>LR</i> )		0.325	[ 0.039 ]	***	-	-	
<b>Panel B: Transition equation parameters</b>								
(12)	<i>S</i>	$\rho$	0.750	Bounded		0.750	Bounded	
(15)	$u^{IP}$	$d_1$	0.438	[ 0.039 ]	***	0.391	] 0.050 [	***
(16)	$u^{Rev_S}$	$d_2$	0.546	[ 0.040 ]	***	0.568	] 0.045 [	***
(17)	$u^{Rev_C}$	$d_3$	0.508	[ 0.038 ]	***	0.522	] 0.041 [	***
(18)	$u^{Im_C}$	$d_4$	0.462	[ 0.041 ]	***	0.617	] 0.036 [	***
(19)	$u^{Im_Inp}$	$d_5$	0.507	[ 0.039 ]	***	0.512	] 0.043 [	***
(20)	$u^{X_G}$	$d_6$	0.559	[ 0.040 ]	***	0.563	] 0.042 [	***
(21)	$u^{X_S}$	$d_7$	0.166	[ 0.053 ]	*	0.106	] 0.060 [	*
(22)	$u^{Vac}$	$d_9$	-0.933	[ 0.020 ]	***	-0.912	] 0.023 [	***

<sup>1)</sup> Standard deviations of parameters are given in brackets.

<sup>2)</sup> \*, \*\*, \*\*\* indicate significance at the 10%, 5%, and 1% levels, respectively.

**Appendix C: Average weights of the Index components for the period 1998–2016 compared with the weights for 2017 onward (Updated for the 10 indicator index version)**

Lag in months	Industrial production	Retail Trade Revenue	Services Revenue	Consumer Imports	Imports of manufact. Inputs	Exports of goods	Exports of services	Employee posts in private sector	Job vacancy rate	Building starts
	<b>Average weights in period 1998-2016</b>									
<b>0</b>	13.50%	5.72%	4.85%	4.56%	7.07%	6.42%	7.63%	5.81%	5.97%	4.83%
<b>1</b>	4.00%	1.08%	0.89%	0.74%	1.76%	1.07%	3.59%	3.02%	3.53%	2.84%
<b>2</b>	1.79%	0.28%	0.23%	0.04%	0.68%	0.20%	2.11%	1.92%	2.17%	1.72%
<b>3</b>	1.12%	0.17%	0.14%	-0.02%	0.42%	0.11%	1.36%	1.32%	1.40%	1.09%
<b>Total</b>	<b>20.40%</b>	<b>7.25%</b>	<b>6.12%</b>	<b>5.31%</b>	<b>9.93%</b>	<b>7.80%</b>	<b>14.69%</b>	<b>12.07%</b>	<b>13.06%</b>	<b>10.48%</b>
	<b>Weights in period 2017 onward</b>									
<b>0</b>	10.06%	8.29%	5.03%	7.30%	7.41%	8.29%	7.27%	8.31%	2.68%	3.70%
<b>1</b>	2.56%	2.83%	1.62%	0.95%	2.00%	1.75%	2.87%	4.58%	1.48%	1.57%
<b>2</b>	1.11%	0.40%	0.45%	0.05%	0.63%	0.48%	1.67%	2.74%	0.90%	1.00%
<b>3</b>	0.69%	0.18%	0.24%	-0.10%	0.32%	0.22%	1.08%	1.79%	0.59%	0.69%
<b>Total</b>	<b>14.43%</b>	<b>11.71%</b>	<b>7.34%</b>	<b>8.20%</b>	<b>10.36%</b>	<b>10.75%</b>	<b>12.89%</b>	<b>17.42%</b>	<b>5.65%</b>	<b>6.96%</b>

**Appendix D: The components of the Composite Index** (Updated for the 10 indicator index version)

Series name (Source for all series is Central Bureau of Statistics, seasonally adjusted)	Price base	Units base	Frequency	Method of processing source data	Transformation	Additional source for completing end observations	Notes
Industrial Production	Fixed	Index, base: 2011=100	Monthly	Chained to historical data	Log-difference	-	Excluding education and public administration industries.
Retail Trade Revenue	Fixed	Index, base: 2011=100	Monthly	Chained to historical data	Log-difference	-	
Service Industries Revenue	Fixed	Index, base: 2011=100	Monthly	Chained to historical data	Log-difference	-	
Consumer goods imports	Current	\$ million	Monthly	Conversion to fixed prices (in dollars) and chained to historical data	Log-difference	Cross rates (Bank of Israel) for completing end observations in price indices of foreign trade	
Imports of manufacturing inputs	Current	\$ million	Monthly	Conversion to fixed prices (in dollars) and chained to historical data	Log-difference	Cross rates (Bank of Israel) for completing end observations in price indices of foreign trade	
Goods exports	Current	\$ million	Monthly	Conversion to fixed prices (in dollars)	Log-difference	Cross rates (Bank of Israel) for completing end observations in price indices of foreign trade	
Services exports	Current	\$ million	Monthly	Conversion to fixed prices (in dollars)	Log-difference	Bank transfers in respect of services exports (Bank of Israel), tourist entries (Central Bureau of Statistics)	
Employee posts in the private sector	Not relevant	Units (thousands)	Monthly	Chained to historical data	Log-difference	Business Tendency Survey (Central Bureau of Statistics), employment in manufacturing and services industries	
Job vacancy rate	Not relevant	Percent	Mixed	Chained to historical data	-	-	
Building starts—total for economy	Not relevant	Square meters	Quarterly	Monthly interpolation with additional data	Log-difference	Business Tendency Survey (CBS): ongoing activities	
Business sector product	Fixed	NIS million	Quarterly	Chained to historical data	Log-difference	-	