**Supplementary Files 1.**

Analysis of the dynamics of COMB components

After removing inappropriate responses, individuals who had responses to all four scales were:

|  |  |  |  |
| --- | --- | --- | --- |
| **Day** | **Total answers** | **Complete answers** | **Incomplete answers** |
| 1 | 1652 | 596 | 1056 |
| 2 | 1668 | 601 | 1067 |
| 3 | 1619 | 566 | 1053 |
| 4 | 1750 | 591 | 1159 |
| 5 | 1671 | 609 | 1062 |
| 6 | 1576 | 568 | 1008 |
| 7 | 1665 | 579 | 1086 |
| 8 | 1660 | 604 | 1056 |
| 9 | 1687 | 606 | 1081 |
| 10 | 1692 | 574 | 1118 |
| 11 | 1768 | 654 | 1114 |
| 12 | 1672 | 614 | 1058 |
| 13 | 1677 | 600 | 1077 |
| 14 | 1556 | 610 | 946 |
| 15 | 1585 | 559 | 1026 |
| 16 | 1650 | 602 | 1048 |
| 17 | 1677 | 576 | 1101 |
| 18 | 1685 | 604 | 1081 |
| 19 | 1665 | 580 | 1085 |
| 20 | 1493 | 541 | 952 |
| 21 | 1661 | 576 | 1085 |
| 22 | 1633 | 628 | 1005 |
| 23 | 1626 | 589 | 1037 |
| 24 | 1656 | 586 | 1070 |
| 25 | 1675 | 662 | 1013 |
| 26 | 1464 | 582 | 882 |
| 27 | 1532 | 575 | 957 |
| 28 | 1657 | 652 | 1005 |
| 29 | 1678 | 643 | 1035 |
| 30 | 1671 | 635 | 1036 |

Trend modeling is done with seven models:

* Exponential. The reason for choosing this model is that its regression coefficient can be interpreted as an average growth rate;
* Linear. The reason for choosing this model is that its regression coefficient can be interpreted as an average growth;
* Polynomials from the second to the sixth degree. The reason for choosing these models is that they are an extension of the linear model (which is a polynomial of the first degree) and are very often used for modeling in dynamics. The highest degree is sixth, as this is the maximum that can be used in MS Excel.

Different criteria are used to select the best model. The most frequently used are Adjusted R Square, AIC and BIC (Atanasov, 2018: 89-90, 177-179). The best model is that which has the largest Adjusted R Square and/or the smallest AIC and BIC.

All three criteria show that the best model for describing the dynamics of Capability is a polynomial of the third degree (See Table 1.1 in Appendix 1). All model coefficients are statistically significant (See Table 1.2 in Appendix 1). The whole period can be divided into three sub-periods:

* The first seven days Capability increases;
* From the eighth to the twenty-fourth day Capability decreases;
* From the twenty-fifth to the thirtieth day Capability increases again.



Fig. 1. Dynamics of Capability

All three criteria show that the best model to describe the dynamics of Opportunity is the sixth-degree polynomial. All coefficients, except the first one, are statistically significant (See Table 1.4 in Appendix 1). The whole period can be divided into six sub-periods:

* Opportunity increases:
	+ From the third to the sixth day
	+ From the twelfth to the sixteenth day
	+ On the twenty-first day
* Opportunity decreases:
	+ In the first two days
	+ From the seventh to the eleventh day
	+ From the seventeenth to the twentieth day



Fig. 2. Dynamics of Opportunity

According to Adjusted R Square the best model for describing the dynamics of Motivation is the fifth-degree polynomials. AIC shows that the best model is the third-degree polynomial and BIC shows that the best model is the linear model (See Table 1.5 in Appendix 1). When there is a discrepancy between the different criteria, it is preferable to use BIC because it is more conservative and better protects against overfitting (Atanasov, 2018: 178). Therefore, the linear model is chosen. All coefficients of this model are statistically significant (See Table 1.6 in Appendix 1). In this case, -0.0065 means that the average daily decrease is 0.0065 scores.



Fig. 3. Dynamics of Motivation

Adjusted R Square shows that the best model to describe the dynamics of Behavior is the fifth-degree polynomial. However, the AIC and BIC show the linear model as the best, albeit by a very small margin compared to the exponential model (See Table 1.7 in Appendix 1). Therefore, the linear model was chosen. All coefficients of this model are statistically significant (See Table 1.8 in Appendix 1). In this case, -0.0010 means that the average daily decrease is 0.0010 scores.



Fig. 4. Dynamics of Behavior

Analysis of the relationships between COM-B components

Granger himself defines the simple causal two-variable model as follows (Granger, 1969: 431):

$$X\_{t}=\sum\_{j=1}^{m}a\_{j}X\_{t-j}+\sum\_{j=1}^{m}b\_{j}Y\_{t-j}+ε\_{t}$$

$$Y\_{t}=\sum\_{j=1}^{m}c\_{j}X\_{t-j}+\sum\_{j=1}^{m}d\_{j}Y\_{t-j}+η\_{t}$$

The definition of causality given by Grander “implies that $Y\_{t}$ is causing $X\_{t}$ provided some $b\_{j}$ is not zero. Similarly $X\_{t}$ is causing $Y\_{t}$ if some $c\_{j}$ is not zero. If both of these events occur, there is said to be a feedback relationship between $X\_{t}$ and $Y\_{t}$.” (Granger, 1969: 431)

That means that:

* if the current state of X depends on the past states of Y, but the current state of Y does not depend on the past states of X, then Y is causing X
* if the current state of Y depends on the past states of X, but the current state of X does not depend on the past states of Y, then X is causing Y
* if both the current state of X depends on the past state of Y, and the current state of Y depends on the past states of X, then there is mutual relationship between Y and X
* if neither the current state of X depends on the past states of Y, nor the current state of Y depends on the past states of X, then there is no relationship between Y and X

Granger sets the following requirements (Granger, 1969: 431):

1. $X\_{t}$ and $Y\_{t}$ must be stationary time series with zero means.
2. $ε\_{t}$ and $η\_{t}$ must be two uncorrelated white-noise series.
3. $m$ must be finite and shorter than the given time series.

If the time series are stationary with non-zero means, then we have to include constants in the model:

$$X\_{t}=α\_{1}+\sum\_{j=1}^{m}a\_{j}X\_{t-j}+\sum\_{j=1}^{m}b\_{j}Y\_{t-j}+ε\_{t}$$

$$Y\_{t}=α\_{2}+\sum\_{j=1}^{m}c\_{j}X\_{t-j}+\sum\_{j=1}^{m}d\_{j}Y\_{t-j}+η\_{t}$$

In his Nobel lecture Granger mentions that “standard statistical procedures […] assume data to have a property known as “stationarity.” Many series in economics, particularly in finance and macroeconomics, do not have this property and can be called “integrated” or, sometimes incorrectly, “non-stationary”.” (Granger, 2003: 361) “As a result, often researchers transform non-stationary time series data by first differencing to make the series stationary.” (Baker and al., 2015, 145) That means that in the case of non-stationarity we have to use the first differences instead of the data in level form:

$$∆X\_{t}=α\_{1}+\sum\_{j=1}^{m}a\_{j}∆X\_{t-j}+\sum\_{j=1}^{m}b\_{j}∆Y\_{t-j}+ε\_{t}$$

$$∆Y\_{t}=α\_{2}+\sum\_{j=1}^{m}c\_{j}∆X\_{t-j}+\sum\_{j=1}^{m}d\_{j}∆Y\_{t-j}+η\_{t}$$

In addition, Granger continues: „It turns out that the difference between a pair of integrated series can be stationary, and this property is known as “cointegration”. [,,,] For cointegration, a pair of integrated, or smooth series, must have the property that a linear combination of them is stationary.” (Granger, 2003: 361) “Once we know that a pair of variables has the cointegration property it follows that they have a number of other interesting and useful properties. […] Further, they can be considered to be generated by what is known as the “error-correction model,” in which the change of one of the series is explained in terms of the lag of the difference between the series, possibly after scaling, and lags of the differences of each series. The other series will be represented by a similar dynamic equation. Data generated by such a model is sure to be cointegrated. The error-correction model has been particularly important in making the idea of cointegration practically useful.” (Granger, 2003: 361-362) “If a pair of series was cointegrated then at least one of them must cause the other.” (Granger, 2003: 366) That means that in the case of cointegration we have to add error correction term (ECT) to the model:

$$∆X\_{t}=α\_{1}+β\_{1}ECT\_{t-1}+\sum\_{j=1}^{m}a\_{j}∆X\_{t-j}+\sum\_{j=1}^{m}b\_{j}∆Y\_{t-j}+ε\_{t}$$

$$∆Y\_{t}=α\_{2}+β\_{2}ECT\_{t-1}+\sum\_{j=1}^{m}c\_{j}∆X\_{t-j}+\sum\_{j=1}^{m}d\_{j}∆Y\_{t-j}+η\_{t}$$

These considerations lead to the following algorithm:



Fig. 5. General algorithm of the relationships analysis

The stationarity test was done with Augmented Dickey-Fuller (ADF), which is the most popular and most commonly used Unit Root test. With it, the null hypothesis is that the time series has a single root, i.e., the time series is non-stationary. The results show (See Table 2.1) that the time series of the data in level form of Capability ($p=0.016$) and Behavior ($p=0.006$) do not have a unit root, i.e., they are stationary. However, the time series of Opportunity ($p=0.116$) and Motivation ($p=0.425$) in level form have a unit root, i.e., they are non-stationary. On the other hand, time series of first differences of Opportunity ($p=0.003$) and Motivation ($p=0.000$) are stationary. Following the above algorithm, further analysis was done with time series of first differences of Opportunity and Motivation. Time series of Capability and Behaviour will be analyzed in level form.

Cointegration test was done with the Johansen Cointegration Test. With it, the null hypothesis is that there is no cointegration. The results show (See Table 2.2 ) that in four of the pairs there is no cointegration – Capability and Motivation ($p=0.619$), Capability and Behaviour ($p=0.758$), Opportunity and Behaviour ($p=0.299$), and Motivation and Behaviour ($p=0.232$) and in the other two pairs there is cointegration – Capability and Opportunity ($p=0.049$) and Opportunity and Motivation ($p=0.038$). Following the above algorithm, VECM will be used for Capability and Opportunity as well as for Opportunity and Motivation. For all other pairs VAR will be used.

The results show that:

* Capability affects Opportunity ($t=-3.13, p=0.007$), but not vice versa (See Table 2.3).
* Neither Motivation affects Capability nor Capability affects Motivation (See Table 2.4).
* Capability affects Behaviour ($t=-2.41, p=0.023$), but not vice versa (See Table 2.5).
* Motivation affects Opportunity ($t=-3.91, p=0.001$), but not vice versa (See Table 2.6).
* Neither Behavior affects Opportunity nor Opportunity affects Behaviour (See Table 2.7).
* Neither Motivation affects Behaviour nor Behaviour affects Motivation (See Table 2.8).

The entire relationships analysis can be summarized graphically:



Fig. 6. Statistically significant relationships

In this diagram, the direction of the arrows indicates the directionality of the influence.

Since ECT itself is a regression model of the type $ECT\_{t-1}=γ\_{0}+γ\_{1}X\_{t-1}+Y\_{t-1}$, it is possible to represent graphically statistically significant relationships:



Fig. 7. Statistically significant relationship between Capability and Opportunity



Fig. 8. Statistically significant relationship between Capability and Behaviour



Fig. 9. Statistically significant relationship between Motivation and Opportunity

Fig. 7-9 allow to determine the direction of the relationships. In the following figure, positive relationships are marked in green and negative relationships are marked in red.



Fig. 13. Statistically significant relationships

**References**

Baker, D., R. Merkert, M. Kamruzzaman. 2015. Regional Aviation and Economic Growth: Cointegration and Causality Analysis in Australia. Journal of Transport Geography, No. 43, pp. 140–150

Granger, C. 2003. Time Series Analysis, Cointegration, and Applications. Nobel Lecture, December 8, pp. 360-366

Granger, C. 1969. Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, Vol. 37, No. 3, pp. 424-438

Атанасов, А. 2018. Статистически методи за анализ на динамични редове. София: Издателски комплекс – УНСС [Atanasov, A. 2018. Statisticheski metodi za analiz na dinamichni redove. Sofia: Izdatelski kompleks – UNSS]

Estimation of trends

Table 1.1. Goodness-of-fit criteria of the models (Capability)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Models** | **Number of independent variables** | **R Square** | **Adjusted R Square** | **AIC** | **BIC** |
| Exponential | 1 | 0,245 | 0,218 | -125,04 | -123,64 |
| Linear | 1 | 0,245 | 0,218 | -125,04 | -123,64 |
| Polynomial | 2 | 0,260 | 0,205 | -123,62 | -120,82 |
| 3 | 0,452 | **0,389** | **-130,64** | **-126,43** |
| 4 | 0,465 | 0,380 | -129,38 | -123,77 |
| 5 | 0,473 | 0,363 | -127,80 | -120,80 |
| 6 | 0,474 | 0,337 | -125,88 | -117,47 |

Table 1.2. Coefficients of the polynomial of the third degree (Capability)

|  |  |  |  |
| --- | --- | --- | --- |
| **Independent variables** | **Coefficients** | **t Statistics** | **p-value** |
| Intercept | 3,964588 | 178,75 | **0,000** |
| $$t$$ | 0,016955 | 2,78 | **0,010** |
| $$t^{2}$$ | -0,001410 | -3,11 | **0,004** |
| $$t^{3}$$ | 0,000029 | 3,02 | **0,006** |

Table 1.3. Goodness-of-fit criteria of the models (Opportunity)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Models** | **Number of independent variables** | **R Square** | **Adjusted R Square** | **AIC** | **BIC** |
| Exponential | 1 | 0,079 | 0,031 | -99,23 | -98,18 |
| Linear | 1 | 0,079 | 0,031 | -99,23 | -98,19 |
| Polynomial | 2 | 0,152 | 0,057 | -98,95 | -96,86 |
| 3 | 0,207 | 0,067 | -98,37 | -95,24 |
| 4 | 0,315 | 0,144 | -99,44 | -95,26 |
| 5 | 0,317 | 0,089 | -97,50 | -92,28 |
| 6 | 0,626 | **0,466** | **-108,17** | **-101,90** |

Table 1.4. Coefficients of the polynomial of the sixth degree (Opportunity)

| **Independent variables** | **Coefficients** | **t Statistics** | **p-value** |
| --- | --- | --- | --- |
| Intercept | 2,86933170 | 55,85 | **0,000** |
| $$t$$ | -0,11445969 | -2,02 | 0,063 |
| $$t^{2}$$ | 0,05575047 | 2,72 | **0,017** |
| $$t^{3}$$ | -0,01032146 | -3,09 | **0,008** |
| $$t^{4}$$ | 0,00088656 | 3,28 | **0,005** |
| $$t^{5}$$ | -0,00003567 | -3,37 | **0,005** |
| $$t^{6}$$ | 0,00000054 | 3,40 | **0,004** |

Table 1.5. Goodness-of-fit criteria of the models (Motivation)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Models** | **Number of independent variables** | **R Square** | **Adjusted R Square** | **AIC** | **BIC** |
| Exponential | 1 | 0,654 | 0,642 | -104,47 | -103,07 |
| Linear | 1 | 0,656 | 0,643 | -104,60 | **-103,20** |
| Polynomial | 2 | 0,671 | 0,647 | -104,00 | -101,20 |
| 3 | 0,706 | 0,672 | **-105,32** | -101,11 |
| 4 | 0,724 | 0,680 | -105,29 | -99,68 |
| 5 | 0,736 | **0,681** | -104,57 | -97,56 |
| 6 | 0,739 | 0,671 | -102,93 | -94,52 |

Table 1.6. Coefficients of the polynomial of the linear model (Motivation)

|  |  |  |  |
| --- | --- | --- | --- |
| **Independent variables** | **Coefficients** | **t Statistics** | **p-value** |
| Intercept | 3,5196 | 221,80 | **0,000** |
| $$t$$ | -0,0065 | -7,30 | **0,000** |

Table 1.7. Goodness-of-fit criteria of the models (Behaviour)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Models** | **Number of independent variables** | **R Square** | **Adjusted R Square** | **AIC** | **BIC** |
| Exponential | 1 | 0,199 | 0,170 | -155,79 | -154,39 |
| Linear | 1 | 0,199 | 0,170 | **-155,79** | **-154,39** |
| Polynomial | 2 | 0,220 | 0,162 | -154,58 | -151,78 |
| 3 | 0,221 | 0,131 | -152,61 | -148,41 |
| 4 | 0,239 | 0,117 | -151,34 | -145,73 |
| 5 | 0,331 | **0,191** | -153,17 | -146,16 |
| 6 | 0,355 | 0,187 | -152,29 | -143,88 |

Table 1.8. Coefficients of the linear model (Behaviour)

|  |  |  |  |
| --- | --- | --- | --- |
| **Independent variables** | **Coefficients** | **t Statistics** | **p-value** |
| Intercept | 3,8107 | 563,60 | **0,000** |
| $$t$$ | -0,0010 | -2,64 | **0,013** |

**Stationarity and cointegration tests, VAR and VECM**

Table 2.1. Augmented Dickey-Fuller test

|  |  |  |
| --- | --- | --- |
| **Variable** | **Level – intercept** | **First differences – intercept** |
| **Test statistics** | **p-value** | **Lag** | **Test statistics** | **p-value** | **Lag** |
| Capability | -3,48 | **0,016** | 0 |  |  |  |
| Opportunity | -2,57 | 0,116 | 0 | -4,46 | **0,003** | 0 |
| Motivation | -1,69 | 0,425 | 0 | -6,49 | **0,000** | 0 |
| Behaviour | -3,89 | **0,006** | 0 |  |  |  |

Table 2.2. Johansen cointegration test

|  |  |  |
| --- | --- | --- |
| **Pairs of variables** | **Trace Statistics** | **p-value** |
| Capability | Opportunity | 20,35 | **0,049** |
| Capability | Motivation | 10,22 | 0,619 |
| Capability | Behaviour | 8,76 | 0,758 |
| Opportunity | Motivation | 21,09 | **0,038** |
| Opportunity | Behaviour | 13,86 | 0,299 |
| Motivation | Behaviour | 14,90 | 0,232 |

Table 2.3. Vector error correction model of relationship between Capability and Opportunity

|  | **ΔOpportunity** | **t Statistics** | **p-value** | **ΔCapability** | **t Statistics** | **p-value** |
| --- | --- | --- | --- | --- | --- | --- |
| ECT | -0,65 | -3,13 | **0,007** | 0,003 | 0,27 | 0,788 |
| ΔOpportunity(-1) | 0,27 | 1,29 | 0,216 | 0,19 | 0,56 | 0,583 |
| ΔCapability(-1) | -0,16 | -1,42 | 0,177 | -0,60 | -3,13 | **0,007** |
| Constant | 0,002 | 0,53 | 0,601 | -0,0001 | -0,02 | 0,983 |
| R-square | 0,488 | 0,386 |
| Adjusted R-square | 0,386 | 0,271 |
| F Statistic | 4,77 | 3,35 |
| p-value | **0,016** | **0,045** |
| AIC | -4,99 | -4,00 |
| BIC | -4,79 | -3,96 |

Table 2.4. Vector autoregression of relationship between Capability and Motivation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ΔMotivation** | **t Statistics** | **p-value** | **Capability** | **t Statistics** | **p-value** |
| ΔMotivation(-1) | -0,23 | -1,18 | 0,251 | -0,06 | -0,51 | 0,612 |
| Capability(-1) | -0,17 | -0,58 | 0,565 | 0,43 | 2,42 | **0,023** |
| Constant | 0,66 | 0,58 | 0,568 | 2,28 | 3,23 | **0,004** |
| R-square | 0,072 | 0,190 |
| Adjusted R-square | -0,002 | 0,125 |
| F Statistic | 0,98 | 2,93 |
| p-value | 0,391 | 0,072 |
| AIC | -3,00 | -3,94 |
| BIC | -2,86 | -3,80 |

Table 2.5. Vector autoregression of relationship between Capability and Behaviour

|  | **Behaviour** | **t Statistics** | **p-value** | **Capability** | **t Statistics** | **p-value** |
| --- | --- | --- | --- | --- | --- | --- |
| Behaviour(-1) | 0,17 | 0,97 | 0,343 | -0,29 | -0,92 | 0,364 |
| Capability(-1) | 0,25 | 2,41 | **0,023** | 0,43 | 2,35 | **0,027** |
| Constant | 2,16 | 3,11 | **0,005** | 3,39 | 2,74 | **0,011** |
| R-square | 0,244 | 0,178 |
| Adjusted R-square | 0,186 | 0,115 |
| F Statistic | 4,20 | 2,82 |
| p-value | **0,026** | 0,078 |
| AIC | -5,08 | -3,92 |
| BIC | -4,94 | -3,78 |

Table 2.6. Vector error correction model of relationship between Opportunity and Motivation

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **ΔMotivation** | **t Statistics** | **p-value** | **ΔOpportunity** | **t Statistics** | **p-value** |
| ECT | 0,02 | 1,18 | 0,256 | -0,79 | -3,91 | **0,001** |
| ΔMotivation(-1) | -0,20 | -0,82 | 0,424 | -0,15 | -1,89 | 0,078 |
| ΔOpportunity(-1) | 0,57 | 0,91 | 0,379 | 0,32 | 1,57 | 0,137 |
| Constant | -0,004 | -0,35 | 0,730 | 0,002 | 0,55 | 0,591 |
| R-square | 0,102 | 0,524 |
| Adjusted R-square | -0,066 | 0,428 |
| F Statistic | 0,61 | 5,50 |
| p-value | 0,620 | **0,009** |
| AIC | -2,78 | -5,06 |
| BIC | -2,58 | -4,86 |

Table 2.7. Vector autoregression of relationship between Opportunity and Behaviour

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Behaviour** | **t Statistics** | **p-value** | **ΔOpportunity** | **t Statistics** | **p-value** |
| Behaviour(-1) | -0,16 | -0,73 | 0,475 | 0,59 | 1,81 | 0,089 |
| ΔOpportunity(-1) | 0,28 | 1,75 | 0,099 | -0,13 | -0,57 | 0,579 |
| Constant | 4,41 | 5,28 | **0,000** | -2,23 | -1,81 | 0,089 |
| R-square | 0,168 | 0,175 |
| Adjusted R-square | 0,070 | 0,071 |
| F Statistic | 1,71 | 1,69 |
| p-value | 0,210 | 0,215 |
| AIC | -5,28 | -4,62 |
| BIC | -5,13 | -4,47 |

Table 2.8. Vector autoregression of relationship between Motivation and Behaviour

|  | **Behaviour** | **t Statistics** | **p-value** | **ΔMotivation** | **t Statistics** | **p-value** |
| --- | --- | --- | --- | --- | --- | --- |
| Behaviour(-1) | 0,25 | 1,35 | 0,189 | 0,08 | 0,16 | 0,872 |
| ΔMotivation(-1) | 0,09 | 1,15 | 0,261 | -0,25 | -1,27 | 0,215 |
| Constant | 2,83 | 3,96 | **0,001** | -0,31 | -0,17 | 0,870 |
| R-square | 0,122 | 0,061 |
| Adjusted R-square | 0,052 | -0,014 |
| F Statistic | 1,74 | 0,81 |
| p-value | 0,196 | 0,457 |
| AIC | -4,90 | -2,99 |
| BIC | -4,75 | -2,85 |