Chapter Eleven

Measuring the Quality of European Statistics

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Because of the Stability and Growth Pact criteria the euro countries have an incentive to manipulate their macroeconomic statistics. In a recent study we showed a significant deviation from Benford's Law of the first digits distribution of Greek financial statistics. This result supports the effectiveness of Benford's Law in detecting fraud, as Greece has been convicted of data manipulation. In this chapter we use a different approach: we analyze Greek statistics which are not relevant to government deficit spending, and compare the findings with the results of our prior research. Our hypothesis was that the social data set should conform better with Benford's Law than the financial data set, as the incentive for manipulation is lower. Our results show that in contrast to their financial data, the Greek social statistics data have a good fit with Benford's Law. Once again, we interpret our outcome as a sign for the effectiveness of the Benford test.

11.1 INTRODUCTION

For a company, an excessively high level of debt can lead to bankruptcy, whereas a country is able to use inflation to reduce public debt denominated in domestic currency. However, if a country is a member of a monetary union, an unsustainable level of debt may endanger the monetary system in the entire union. For this reason, current and prospective members of the European Monetary Union are obliged by the Stability and Growth Pact to restrict public deficit to 3 percent and public debt to 60 percent of **Gross Domestic Product** (**GDP**).

If a euro country does not meet the criteria of the Stability and Growth Pact, the European Commission can apply **Excessive Deficit Procedures** (**EDP**) to this country. EDP include restrictions for the country's government's policies and expanded fiscal monitoring of the deficit.

However, EDP have not yet been successful in restricting public debt to a sustainable level in all euro states. Some of the euro countries reach ratios of government debt to GDP of more than 100 percent ([EUC1], 2012): These countries are

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Greece (165.3%), Italy (120.1%), Ireland (108,2%) and Portugal (107,8%). Since the beginning of the euro crisis in 2010, tremendous efforts have been necessary to stabilize the monetary union.

Given the high pressure from both the financial markets and the European Commission for the euro countries to meet the criteria of the Stability and Growth Pact, there is an incentive for governments to manipulate their data related to fiscal monitoring. Therefore, the quality of the statistics in the European Union (**EU**) is an important prerequisite for effective debt monitoring. To ensure the quality of the statistics, effective auditing methods are necessary. Benford's Law has been successfully applied to detect manipulation and "cosmetic earnings management" in the accounting data of companies. Since macroeconomic data are similar in nature to accounting data, Benford's law should be applicable to them as well.

In this chapter, we pose the question of whether there is a difference in the quality of data for statistics which are related to fiscal monitoring and for social statistics, which have no relation to fiscal monitoring. Our hypothesis is that the quality of EU government statistics related to fiscal monitoring could be affected by the pressure of the financial markets and the European Commission. For both types of statistics, we compare the distribution of the first digits with the distribution of the first digits generated by Benford's Law.

11.2 MACROECONOMIC STATISTICS IN THE EU

European Government Finance Statistics are currently provided on the basis of the **European System of Accounts** (**ESA** 95). These data are the "basis for fiscal monitoring in the EU." The data for the statistics are reported by the different member states. The member states and their statistical authorities are responsible for the compliance of the reported data with legal provisions. On the level of the European Union, Eurostat, the EU statistical authority, is responsible for the statistical methodology and for the quality of assessment of the data provided by the member states, including data provided in the context of the EDP (cf. [EUC2], 2011).

EDP can be applied by the European Commission and the European Council to countries which do not fulfill the criteria of the Stability and Growth Pact. The Stability and Growth Pact limits the permitted government debt for the countries of the eurozone to three percent of GDP (cf. [EUC2], 2011).

In the last few years, there have been discussions concerning the quality of the statistics reported to Eurostat, especially in the case of those reported by Greece. In a report on the Greek EDP data and statistics, the European Commission (cf. [EUC3], 2010) pointed out that "These most recent revisions are an illustration of the lack of quality of Greek fiscal statistics (and of macroeconomic statistics in general) and show that the progress in the compilation of fiscal statistics in Greece and the intense scrutiny of the Greek fiscal data by Eurostat since 2004 (including 10 EDP visits and 5 reservations on the notified data), have not sufficed to bring the quality of Greek fiscal data to the level reached by other EU Member States."

As a consequence of the lack of quality in the EU statistics, Eurostat (cf. [EUC2], 2011) was given more power in 2010. This includes a "system of regular monitor-

ing and verification of upstream public financial data." The extended competence of Eurostat also includes more "in-depth, methodological visits to the Member States." For the future, the European Commission plans to "support the implementation of public accounting standards" to provide the ESA-based information.

11.3 BENFORD'S LAW AND MACROECONOMIC DATA

Similarly to the accounting data of companies, unmanipulated macroeconomic data from different sources with different distributions can be expected to be Benford distributed. This is confirmed in Nye and Moul ([NyM], 2007), Gonzales-Garcia and Pastor ([GonPa], 2009) and Rauch et al. ([RauGBE], 2011). However, one has to be careful when interpreting a deviation from Benford's Law in a certain data set. It cannot be considered as conclusive proof of poor data quality, since it could be based on e.g. structural shifts in the data set, as argued by Gonzales-Garcia and Pastor ([GonPa], 2009). Nevertheless, in our opinion a deviation from Benford's Law should be regarded as a "red flag," indicating data that need closer inspection and further testing.

Consequently, we do not use a hypothesis framework to investigate the conformity of a data set with Benford's Law. Rather, we compare data sets according to the extent of their deviation from Benford's Law. This relation is used to establish a ranking of data sets, i.e., of countries. The position of each country in this ranking can be used to indicate the probability of manipulation in its data and determines the order in which further auditing procedures should be carried out.

We restrict the analysis to the first valid digit. The evaluation of the data sets' conformity with Benford's Law is based on χ^2 test statistic,

$$\chi^2 = n \sum_{i=1}^{9} \frac{(h_i - p_i)^2}{p_i} \tag{11.1}$$

where n denotes sample size, p_i expected and h_i observed relative frequencies.

Furthermore, to ensure that the ranking induced by χ^2 test statistics is not a result of variation in sample size between the countries or the choice of a particular measure, we use three measures of the distance between the actual data distribution and the Benford distribution which are insensitive to sample size. The first measure is the χ^2 statistics divided by the sample size n as in Leemis et al. ([LeScEv], 2000):

$$c = \chi^2/n. \tag{11.2}$$

The other measures are the normalized Euclidian distance d^* as in Cho and Gaines ([ChGa], 2007),

$$d^* = \frac{\sqrt{\sum_{i=1}^{9} (h_i - p_i)^2}}{\sqrt{\sum_{i=1}^{8} p_i^2 + (1 - p_9)^2}}, \tag{11.3}$$

and the distance measure a^* used by Judge and Schechter ([JuSc], 2009),

$$a^* = \frac{|\mu_e - \mu_b|}{9 - \mu_b}, \tag{11.4}$$

where μ_e denotes the mean of the data set and μ_b denotes the mean of the Benford distribution of first digits.

11.3.1 EDP-Related Statistics

In a recent study (cf. [RauGBE], 2011) we analyze EU macroeconomic data published in the Eurostat database.[1] The aim of the study is to analyze macroeconomic data related to the EDP and to provide a ranking of the EU member states based on the deviation of their data from Benford's Law. This ranking could be useful as an indicator for manipulated data. The data set consists of the following categories:

1. Government statistics / government deficit and debt: government deficit / surplus, debt and associated data.
2. Government statistics / annual government finance statistics: government revenue, expenditure and main aggregates.
3. National accounts / annual national accounts: GDP and main components—current prices
4. Financial accounts: balance sheets, assets and liabilities consolidated.
5. Financial accounts: financial transactions, assets and liabilities consolidated.

Our study analyzes the first digits of 156 single positions per country and per year covering the period from 1999 to 2009. The analysis consists of two steps. First, we analyze the aggregated data set. For this set, the results of the three distance measures independent of sample size show a good fit of the first digit distribution with Benford's Law. Second, investigating each country individually, we calculate the mean of the χ^2 test statistics for each country and rank the countries according to this mean value.

On the individual level, among all euro countries Greece shows the highest deviation from Benford's Law with a mean value of 17.74 for the χ^2 test statistics, followed by Belgium with a value of 17.21 and Austria with a value of 15.25. In contrast, we calculate the lowest deviation for the Netherlands with 7.83. The introduced measures independent of sample size, χ^2/n, d^* and a^*, support the results of the χ^2 test statistics.

The so-called PIIGS countries, an acronym for Portugal, Italy, Ireland, Greece and Spain, are strongly affected by a high level of debt and might therefore be expected to manipulate data. However, as far as the PIIGS states are concerned, apart from Greece only the Irish data indicates a substantial deviation from Benford's Law in our study. Potentially poor data was indicated only by a^* and d^* for Italy; for Spain and Portugal, we could not find any such indication. Furthermore, Portugal shows the second-lowest mean of the χ^2 test statistics. Our results do not support the common assumption that data reported by the "PIIGS" are generally of lower quality than those reported by other euro states.

[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database.

For all measures, Greece shows the highest deviation from Benford's Law among all euro countries. As mentioned above, the European Commission concluded in a report that the quality of Greek EDP data and macroeconomic statistics is insufficient (cf. [EUC3], 2010). At least in the case of Greece, the high deviation from Benford's Law could be interpreted as an indicator for low data quality.

11.3.2 Social Statistics

As mentioned before, there is high pressure for the euro countries to comply with the Stability and Growth Pact criteria. This in turn gives countries an incentive to falsify statistics related to the fiscal monitoring of euro countries and EDP. Our hypothesis is that countries are more willing to falsify their statistics if they have an incentive to do so. On the contrary, if there is no incentive for data manipulation for the countries, the data quality will be higher.

The aim of our study is to use Benford's Law to investigate the quality of macroeconomic data which is not related to fiscal monitoring and EDP provided by EU member states. If there is no data manipulation, one would expect that the data will conform well with Benford's Law. As the Greek data produced the highest deviation from Benford's Law in our recent study (cf. [RauGBE], 2011) and the manipulation of Greek data was criticized by the European Commission (cf. [EUC3], 2010), we decided to investigate our hypothesis using Greek statistics.

We choose social statistics, which are not related to fiscal monitoring and the EDP process, as these are more likely to be subject to fluctuations than population statistics or area data. We assume that there is no pressure or incentive for Greece to falsify these data and we would therefore expect no significant deviation for this data from Benford's Law. Our data set contains Greek data taken from the database of Eurostat[1] in June 2012. We select the data from two different subsections of the Eurostat database. The first part of the data is from the group "social protection" under the theme "living conditions and welfare." The other part of the data set is from the group "labour market policy" under the theme "population and social conditions." Our sample includes the following categories:

1. Social Protection Expenditure
2. Social Protection Receipts
3. Public expenditure on labor market policy interventions

The data set contains 1,322 observations for the period from 1999 to 2009 with a total of 267 possible observations per year and an average of 120.18 observations per year. The main reason for the difference between possible observations and average observations is that data from the third group include a considerable number of entries with missing values, especially for the years 1999 to 2005 and the year 2009. Data are expressed in absolute values in millions of euros; currency conversions were calculated by Eurostat.

Again we calculate the χ^2 test statistics and the three measures independent of sample size, χ^2, χ^2/n, d^* and a^*, for the whole data set and per year. Results are presented in Figure 11.1.

Our results indicate a good fit of the investigated data for the whole sample as well as for the single years. We could not find a significant deviation for any one of the single years or for the sample as a whole. The results for the three measures independent of sample size support the results of the χ^2 test statistics.

Digit	Benford	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	0.30	0.28	0.26	0.30	0.29	0.34	0.34	0.27	0.30	0.34	0.27	0.33
2	0.18	0.20	0.18	0.19	0.17	0.17	0.18	0.18	0.20	0.16	0.17	0.18
3	0.12	0.11	0.11	0.10	0.15	0.11	0.08	0.11	0.06	0.11	0.16	0.08
4	0.10	0.13	0.10	0.12	0.06	0.10	0.16	0.12	0.13	0.09	0.07	0.07
5	0.08	0.08	0.11	0.07	0.11	0.10	0.05	0.09	0.07	0.09	0.06	0.07
6	0.07	0.08	0.09	0.08	0.08	0.07	0.07	0.08	0.08	0.06	0.10	0.07
7	0.06	0.03	0.02	0.07	0.09	0.04	0.06	0.03	0.07	0.07	0.07	0.10
8	0.05	0.06	0.06	0.01	0.02	0.05	0.04	0.06	0.05	0.06	0.05	0.05
9	0.05	0.05	0.09	0.07	0.02	0.02	0.02	0.05	0.04	0.03	0.05	0.05
	χ^2	3.50	9.01	6.29	8.78	3.99	11.26	3.91	7.20	3.74	7.03	6.31
	χ^2/n	0.03	0.09	0.06	0.09	0.04	0.10	0.04	0.05	0.02	0.04	0.06
	d*	0.06	0.08	0.06	0.08	0.06	0.09	0.05	0.07	0.05	0.06	0.07
	a*	0.00	0.06	0.00	0.01	0.05	0.05	0.02	0.01	0.01	0.03	0.01
	Size	104	104	101	98	106	116	110	142	173	161	107

Notes: Table includes test statistics from the χ^2 goodness of fit test.
Values for χ^2/n, d*,a* are provided for comparision reasons.
5% significance level 15.51.

Figure 11.1 Distribution of first digits for Greek social statistics.

11.3.3 EDP-Related Statistics versus Social Statistics

Figure 11.2 summarizes the results for Greece from our first study. Figure 11.2 compares the distribution of Greek EDP-related statistics with the distribution generated by Benford's Law. There is a significant deviation of the debt-related statistics from Benford's Law for all digits.

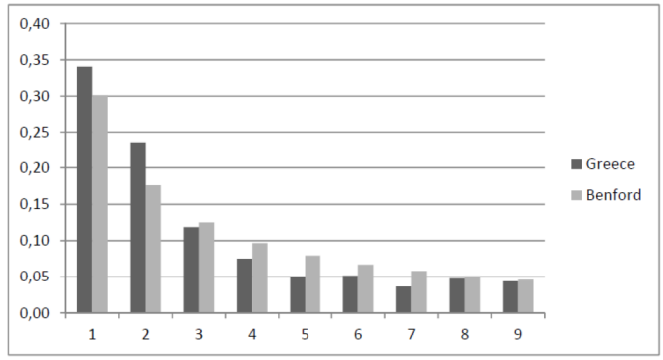

Figure 11.2 First digits of Greek EDP-related statistics.

The results of the second study are presented in Figure 11.3. As shown in Section 11.3.2, we identify a good fit for the social statistics with Benford's Law for all digits.

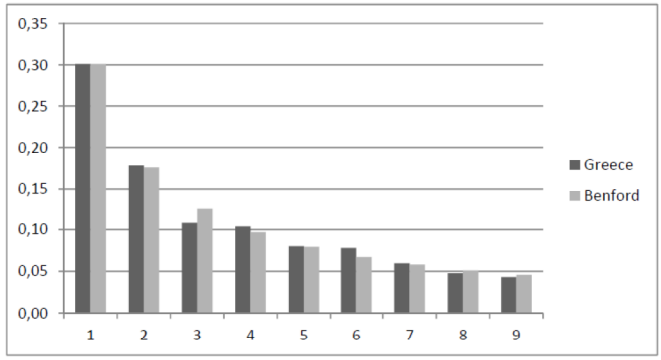

Figure 11.3 First digits of Greek social statistics.

The different results of the two studies are illustrated in Figure 11.4, comparing the χ^2 test statistics for the EDP-related statistics and the social statistics for the period from 1999–2009. The 5 percent significance level for the χ^2 test statistics (with 8 degrees of freedom) is 15.51. We identify significant deviations, for the Greek EDP-related statistics, from Benford's Law for seven of the ten years. In contrast, we find no significant deviations for the social statistics in the same period.

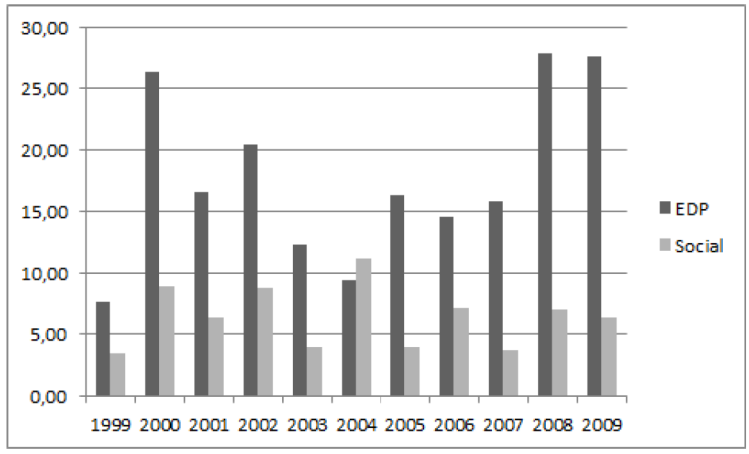

Figure 11.4 χ^2 test statistics for Greece.

Comparing the results of the first study with the results of the second study, we find a lack of data quality for Greek EDP-related statistics, measured by the deviation of the first digit distribution from the distribution generated by Benford's Law. On the contrary, we find evidence that data not related to EDP and debt do not show a significant deviation from Benford's Law. Our results support the

hypothesis that, at least in the case of Greece, data will conform well with Benford's Law if there is no pressure or incentive to falsify statistics (cf. [RauGBK], 2014).

11.4 CONCLUSION

For the euro countries, there is high pressure to comply with the Stability and Growth Pact criteria. The compliance of the member states with the Stability and Growth Pact criteria is monitored by the European Commission through their statistical authority Eurostat. If a country's government deficit spending does not comply with the criteria of the Stability and Growth Pact, the European Commission can apply EDP to this country's government. Therefore, governments have an incentive to falsify statistics related to fiscal monitoring and EDP.

The basis for the fiscal monitoring through Eurostat is the statistics provided by the member states. Particularly during the current euro crisis, the European Commission has raised considerable doubts concerning the data quality of the Greek EDP-related statistics (cf. [EUC3], 2010). In view of Greece's current economic situation, there is a strong incentive for Greece to manipulate the EDP-related statistics.

In a recent study (cf. [RauGBE], 2011) we could show that the first digits distribution of Greek EDP-related statistics show a significant deviation from Benford's Law, indicating low data quality. This result is hardly surprising, considering the current Greek situation.

In this chapter, we analyzed statistics which are not relevant to government deficit spending and fiscal monitoring. Our hypothesis was that countries are more willing to falsify data if they have an incentive to do so, whereas if there is no incentive to manipulate data, the quality of the data will be higher. We used Benford's Law to examine the quality of Greek social statistics, which are not likely to be manipulated, as there is no incentive or pressure for Greece to falsify these statistics.

Our results show that the Greek social statistics data have a good fit with Benford's Law, for the whole sample as well as for the single years. This supports our hypothesis that the quality of statistical data will be higher and will therefore conform well with Benford's Law if there is no incentive for data manipulation.

The results of our two studies can thus be interpreted as a sign for the efficiency of Benford's Law as a measurement method to check the quality of macroeconomic statistics.