BEST PRACTICES IN DATEN VISUALISIERUNG

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APQC®

Agenda

- Einführung
- Displays I: Ranking & Abweichung Charts
- Displays II: Proportions & Anteils Charts
- Displays III: Verteilung & Korrelation Charts
- Analytische Tips
- Analytischer Process

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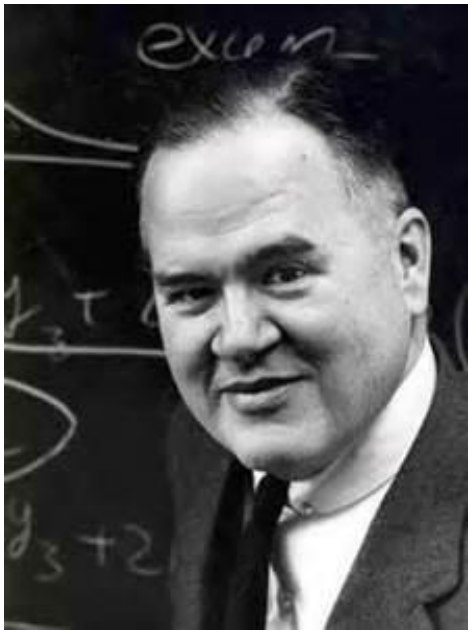
EXPLORATIVE DATEN ANALYSE (TUKEY 1977)

Ein Ansatz oder eine Philosophie für die Daten Analyse umfasst verschiedene graphische Techniken, um:

- den Einblick in den Datensatz zu maximieren;
- entdecken darunterliegender Muster;
- extrahieren wichtiger Variablen;
- erkennen von Ausreißern und Anomalien;
- Vorschlag von Hypothesen bezogen auf die Ursache;
- Test der darunterliegenden Annahmen; und
- beschaffen Basis für weitere Daten.



John W. Tukey
1915-2000

John Tukey: Exploratory Data Analysis (1977)
See Also: Engineering Statistics Handbook
http://itl.nist.gov/div898/handbook/eda/section1/eda11.htm

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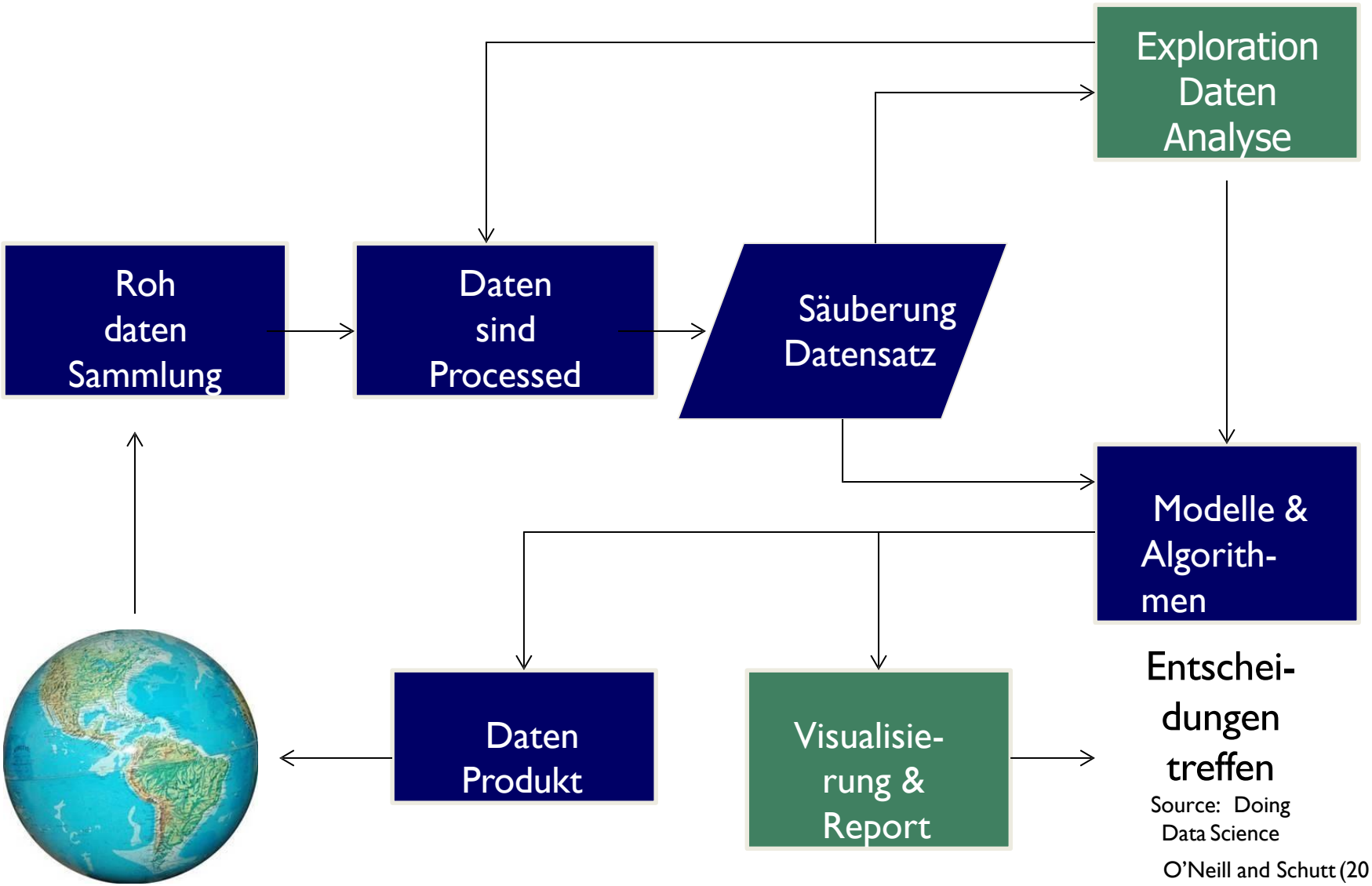
DATEN SCIENCE PROZESS



Source: Doing Data Science

O'Neill and Schutt (2014)

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DATA VISUALIZATIERUNG – ZWECK

- Erzähl die Story / kommuniziere die Botschaft
- Unterstütze das Denken des Lesers / nachdenken über das Thema
- Befähige schnelles Verständnis / Interpretation
- Unterstütze Entscheidungen treffen
- Informiere / sorge für Einblick
- Etabliere Vertrauenswürdigkeit

Source: Edward Tufte Lecture
http://www.youtube.com/watch?v=C6EiZVwESnM

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WAS IST DIE STORY ODER BOTSCHAFT?

Billions of Dollars

	Actual, 2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	Total 2016-2020	Total 2016-2025
Social Security														
Old-Age and Survivors Insurance	703	738	772	817	873	931	994	1,058	1,124	1,195	1,269	1,347	4,387	10,379
Disability Insurance	142	145	149	154	159	165	171	180	189	198	208	216	798	1,788
Subtotal	845	883	921	971	1,032	1,096	1,165	1,237	1,313	1,392	1,476	1,564	5,185	12,167
Major Health Care Programs														
Medicare[a]	600	622	668	681	699	772	826	886	986	1,021	1,052	1,175	3,645	8,765
Medicaid	301	335	360	384	405	428	452	477	503	530	558	588	2,029	4,686
Exchange subsidies and related spending[b]	15	45	71	93	101	106	110	116	122	125	128	131	482	1,104
Children's Health Insurance Program	9	10	11	6	6	6	6	6	6	6	6	6	34	62
Subtotal[a]	926	1,012	1,111	1,163	1,210	1,312	1,394	1,485	1,617	1,682	1,744	1,900	6,190	14,617
Income Security Programs														
Earned income, child, and other tax credits[c]	86	87	89	90	91	75	76	77	78	79	80	82	420	816
Supplemental Nutrition Assistance Program	76	78	78	76	75	74	74	74	73	74	74	75	378	747
Supplemental Security Income	54	55	60	57	54	61	63	64	71	68	65	72	295	636
Unemployment compensation	44	35	36	37	39	42	46	49	51	54	57	60	200	472
Family support and foster care[d]	31	31	32	32	32	33	33	33	34	34	34	35	162	331
Child nutrition	20	21	22	23	24	25	26	27	28	29	31	32	120	268
Subtotal	311	307	317	316	316	310	316	324	336	338	341	355	1,575	3,269

CBO "The Budget and Economic Outlook 2015-2025"
https://www.cbo.gov/publication/49892

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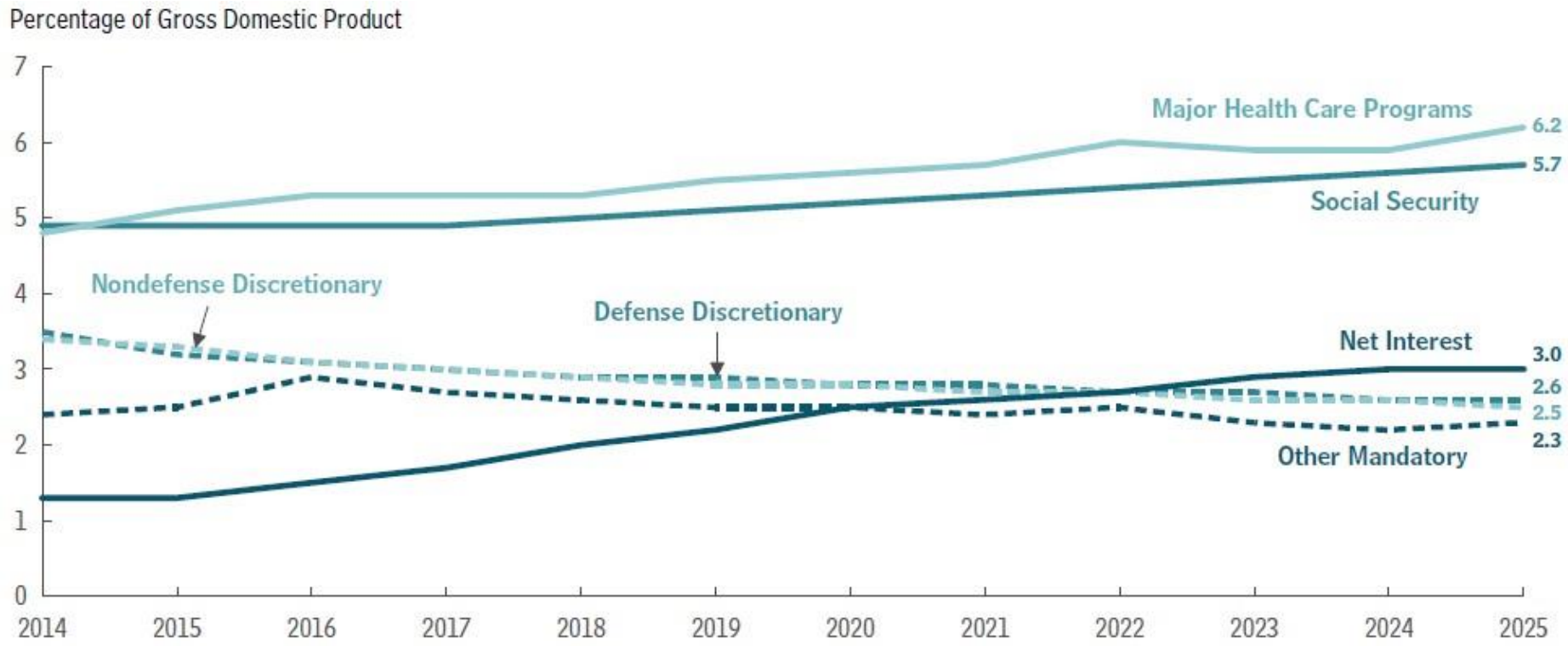
WIE IST DER TREND IM ZEITABLAUF?



Source: Congressional Budget Office.

Note: Major health care programs consist of Medicare, Medicaid, the Children's Health Insurance Program, and subsidies for health insurance purchased through exchanges and related spending. (Medicare spending is net of offsetting receipts.) Other mandatory spending is all mandatory spending other than that for major health care programs and Social Security.

CBO "The Budget and Economic Outlook 2015-2025"
https://www.cbo.gov/publication/49892

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TUFTE – DESIGN PRINZIPIEN

Intellektuelle Logik der Analyse → Design Logik der Display

<u>Intellektuelle Aufgaben</u>

- Vergleich
- Ursache & Wirkung
- Scope der Analyse
- Vertrauens-würdigkeit

<u>Design Prinzipien</u>

- Zeige Vergleiche
- Zeige Ursache & Wirkung
- Einschluß / Ausschluß
- Zeige Quellen

Edward Tufte: Visual Explanations (1997)

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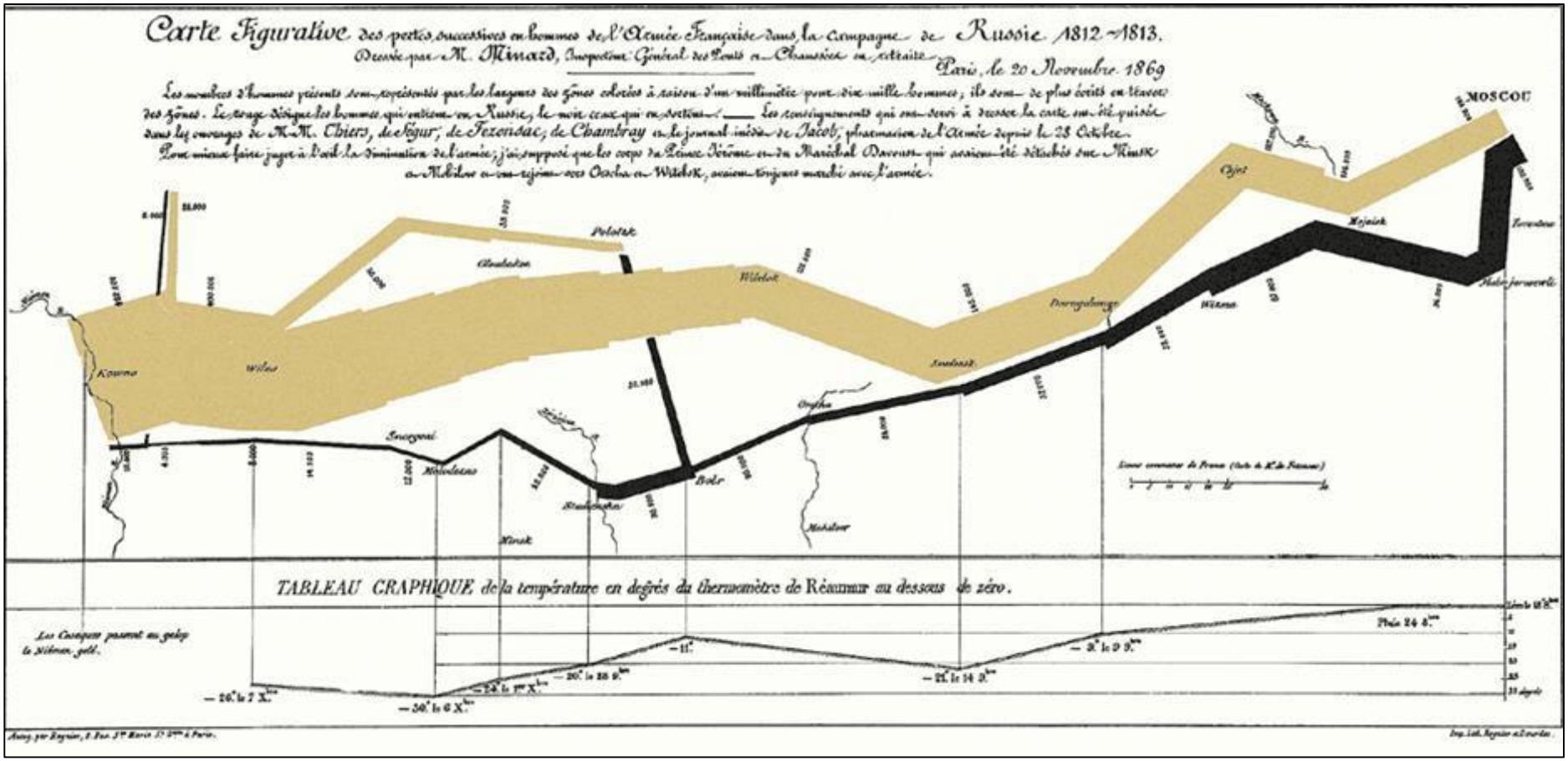
DR. EDWARD TUFTE

Minard: Napoleon's Russia Campaign 1812-13



Variables: Size of army, geography, direction, time, temperature, and distance

Charles Joseph Minard (Drawn 1869)
Source: http://www.edwardtufte.com/tufte/minard

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GRAPHISCHE BEZIEHUNGEN ODER BOTSCHAFTTYPEN

1. Zeitreihen (Variablen im Zeitablauf)
2. Ranking (hoch zu niedrig)
3. Vom Teil-zum-Ganzen (Proportion oder Teil)
4. Deviation (actual vs. plan)
5. Frequenz Verteilung (Beobachtungen über Intervalle)
6. Korrelation (Beziehungen von zwei Variablen)
7. Normalverteilung (nicht quantitativ gerankt)
8. Geodaten (Karte oder Layout)

Stephen Few: "Show me the Numbers" (2012) / Page 101
"Selecting the Right Graph for Your Message" (2004)

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TABELLEN DESIGN

Sales (000's)
2014 YTD September

	Sales			Actual vs. PY		Actual vs. Budget	
	Actual	Prior Yr	Budget	Chg $	% Chg	Chg $	% Chg
Division 1	$ 9,372	$ 8,614	$ 9,411	$ 758	8.8%	$ (39)	-0.4%
Division 2	6,142	5,262	6,121	880	16.7%	21	0.3%
Division 3	3,875	2,997	4,097	878	29.3%	(222)	-5.4%
Division 4	3,329	3,369	3,429	(40)	-1.2%	(100)	-2.9%
Division 5	1,111	1,123	1,211	(12)	-1.1%	(100)	-8.3%
Division 6	787	398	750	389	97.7%	37	4.9%
	$ 24,615	$ 21,763	$ 25,018	$ 2,852	13.1%	$ (403)	-14.1%

- Lasse ausreichend Platz für die Augen um horizontal zu folgen
- Nutze leicht graue Schatten von wechselnden Reihen, wenn keine Patz verfügbar
- Nutze horizontale Linien anstatt Schattierung, wenn weitere Verfolgungsunterstützung benötigt wird

Stephen Few: "Show me the Numbers" (2012) / Page 162

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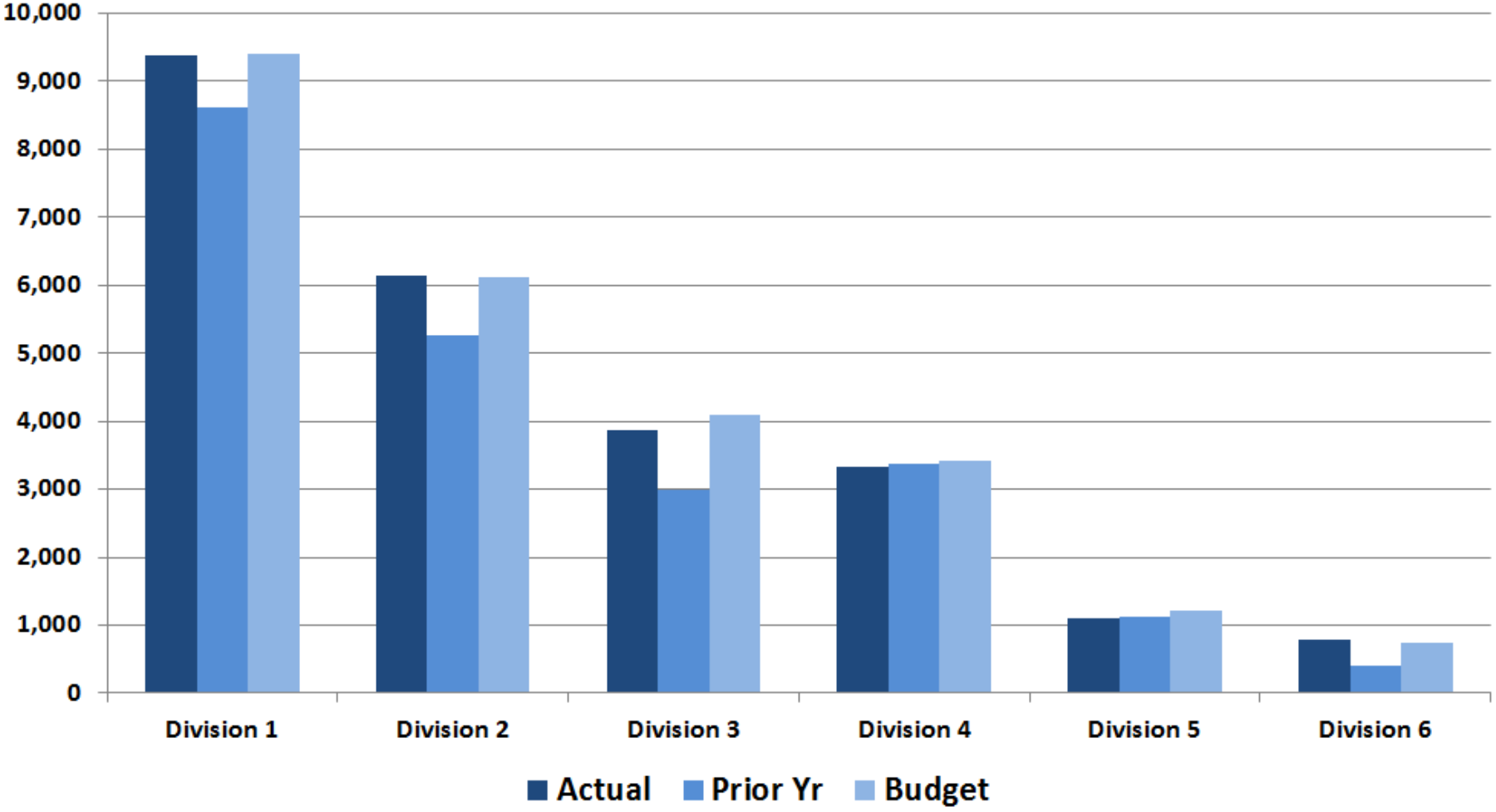
BALKEN CHART (RANKING)

Sales ($ 000's)
2014 SeptemberYTD



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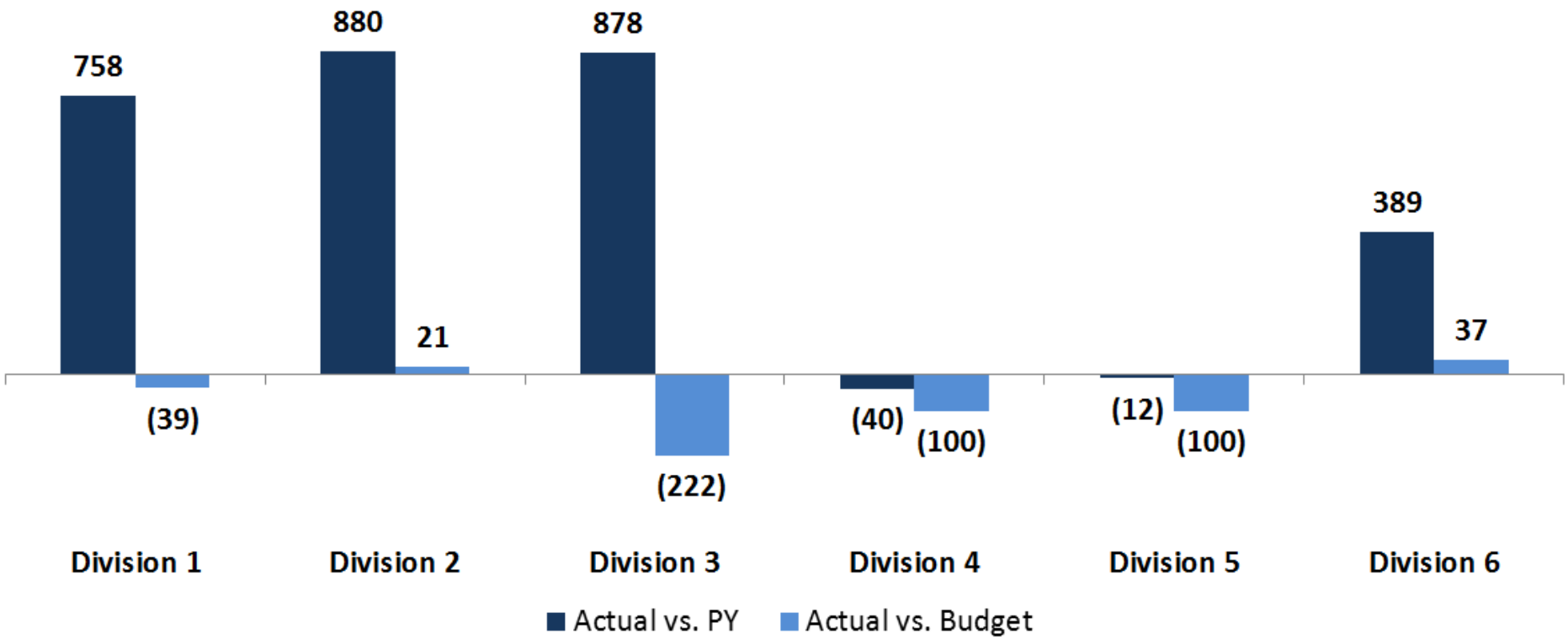
BALKEN CHART (ABWEICHUNG)

Sales Change ($ 000's)
2014 SeptemberYTD



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BALKEN CHART PRINZIPIEN

Do

- Starte Y-Achse bei Null (wichtig!)
  - Längenvergleich ist Schlüsselzweck der Balkendiagramme
- Nutze horizontale Balken, wenn label länglich sind (und alle # sind positiv)
- Nutzung, wenn der Vergleich von diskreten Werten wichtig ist

Don't

- 3-D oder Perspektive
- Angled text on x-axis labels (harder to read & distracting)

Achtung

- Wenn der Fokus auf den trend ist versusder Vergleich von spezifischen Werten, verwende Liniendiagramme

Dona M. Wong
Wall St. Journal Guide to Information Graphics

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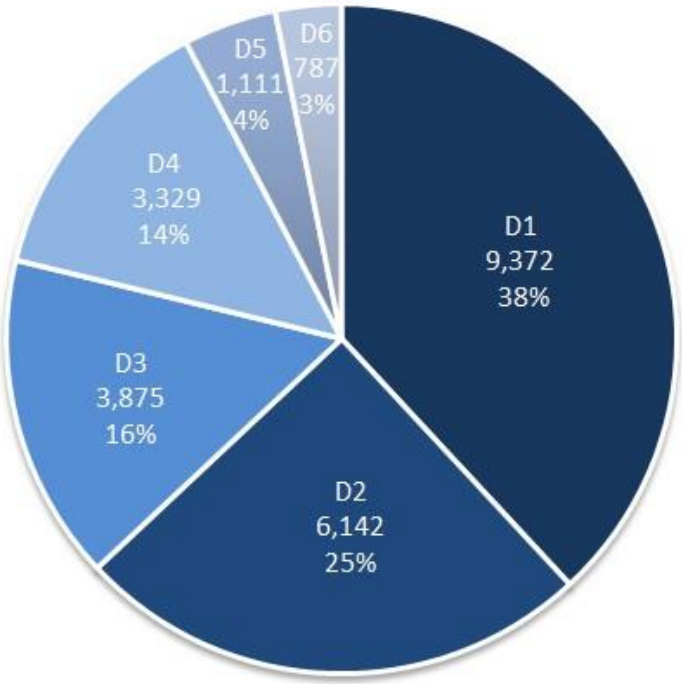
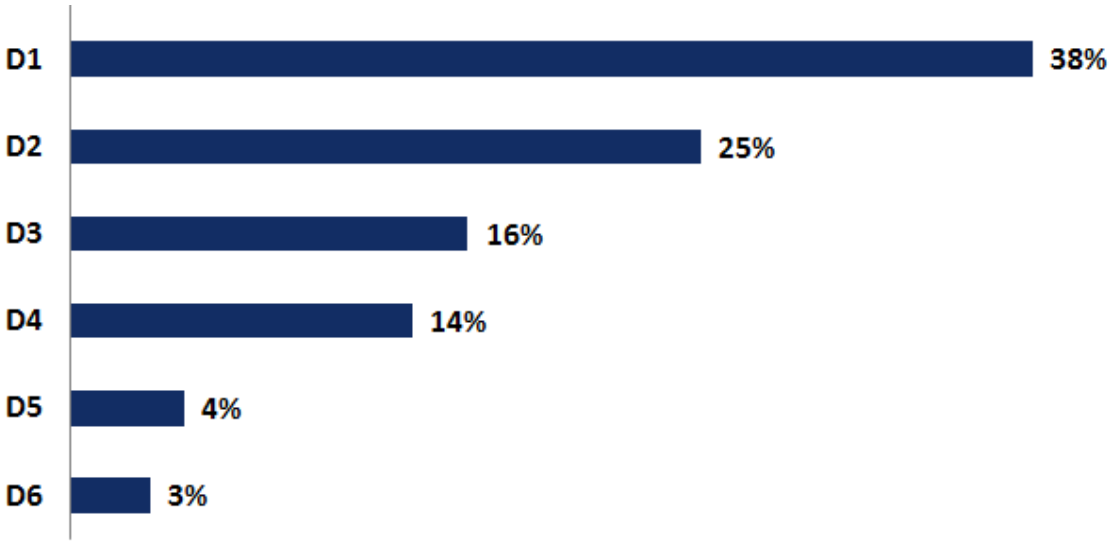
Vom Teil zum Ganzen: Kreis vs. Balken

Revenue by Division



- 5 Stücke Maximum (WSJ)
- Grenzlinien
- Eine Farbe oder Schatten

Revenue by Division



- Das Auge kann die Linienlänge leichter messen als die Größe (Stückfläche)

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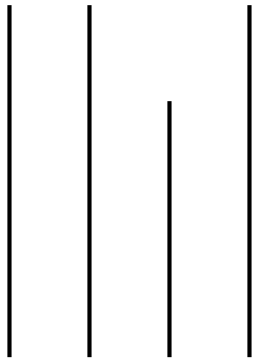
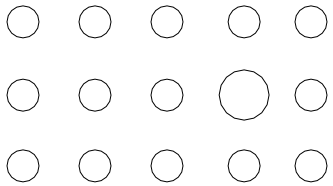
PRE-ATTENTIVE ATTRIBUTES

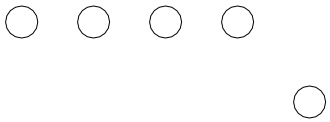
Line Length



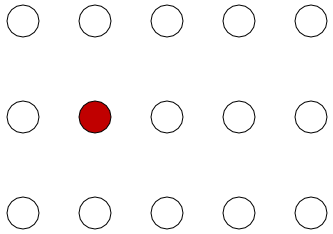
Size



Spatial Position (2D)



Color (Hue)



Other pre-attentive attributes include: Line width, shape, color intensity, curvature,shape rotation, added marks, and enclosure

Source: Stephen Few "Tapping the Power of Visual Perception" (2004)

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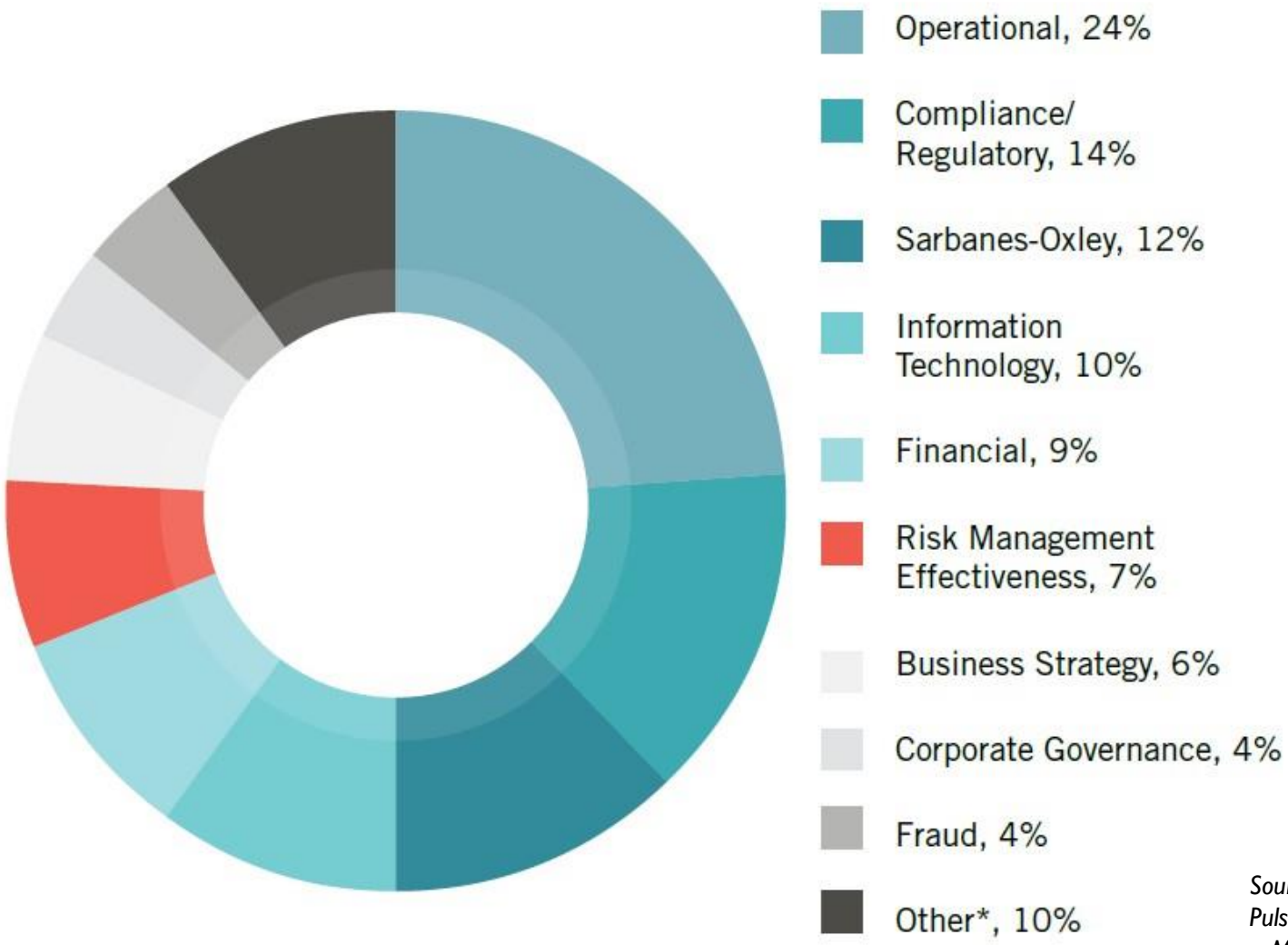
VOM TEIL-ZUM-GANZEN: DONUT (*AVOID*)



Source: IIA North American Pulse of the Profession Survey – March 2014

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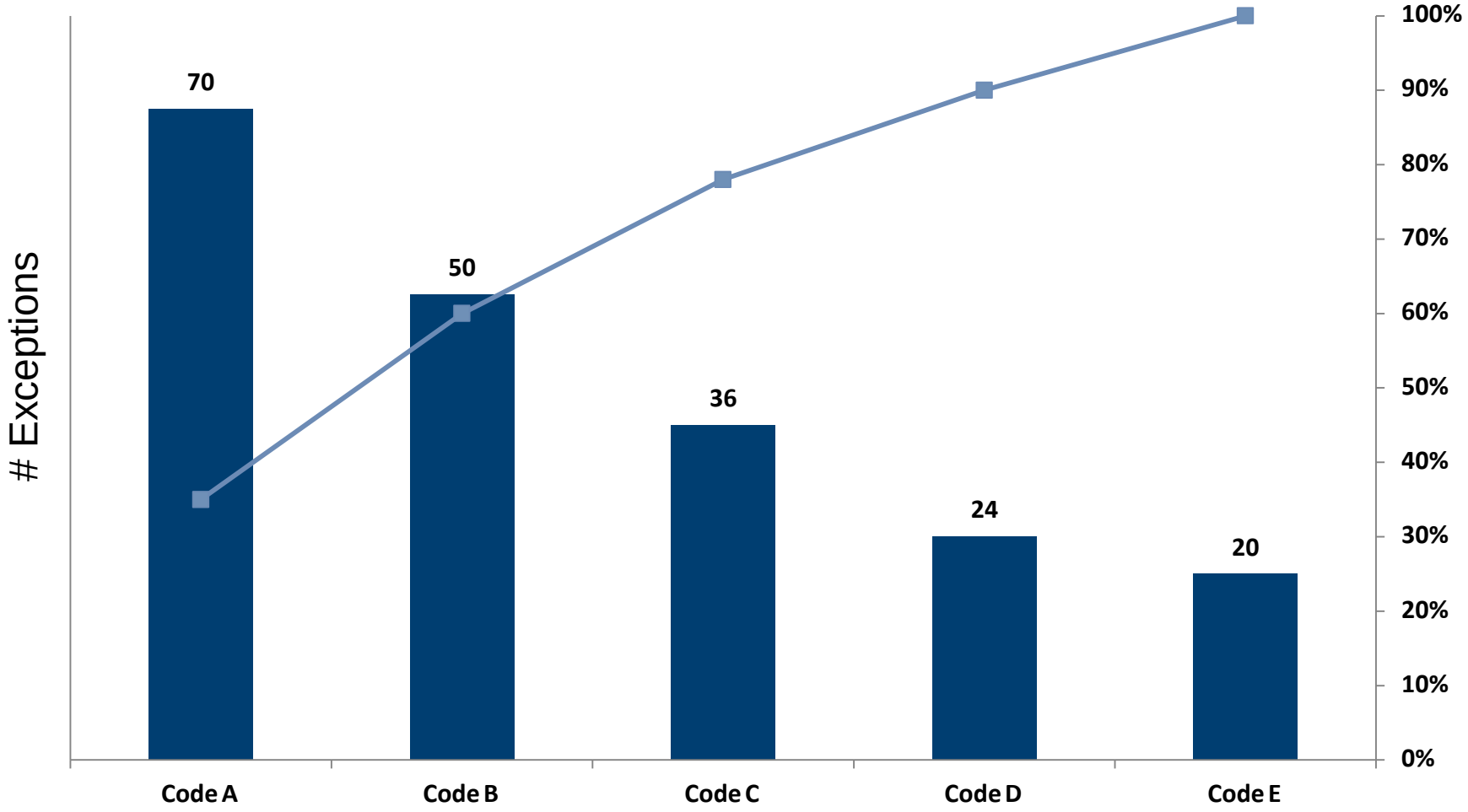
PARETO CHART



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MULTI-PERIODEN FOLIEN

- % Contribution to Change in GDP (Annualized)
- GDP = C+ I + G + NX

Data Download from BEA (Excel)

	Category	2007				2008				2009			
		Q1 07	Q2 07	Q3 07	Q4 07	Q1 08	Q2 08	Q3 08	Q4 08	Q1 09	Q2 09	Q3 09	Q4 09
C	Personal consumption expenditures	1.6	0.9	1.1	0.4	-0.6	0.5	-2.1	-3.1	-0.8	-1.1	1.7	0.1
I	Nonresidential investment	0.9	1.0	0.8	0.9	0.0	-0.3	-1.4	-3.0	-3.6	-1.5	-0.5	-0.4
I	Residential investment	-1.0	-0.8	-1.3	-1.5	-1.3	-0.7	-0.7	-1.3	-1.2	-0.7	0.5	0.0
I	Change in inventories	-0.6	0.8	0.0	-0.8	-1.1	-0.2	0.3	-1.5	-2.3	-1.1	-0.4	4.4
NX	Net exports	-0.5	0.5	1.5	2.2	-0.1	2.1	0.9	-0.1	2.3	2.4	-0.5	-0.1
G	Federal Govt.	-0.4	0.5	0.6	0.2	0.5	0.6	0.9	0.6	-0.2	1.1	0.5	0.0
G	State and Local Govt.	0.2	0.2	0.0	0.2	-0.2	0.1	0.2	0.0	0.4	0.5	0.0	-0.2
GDP	Total	**0.27**	**3.12**	**2.73**	**1.47**	**-2.66**	**1.99**	**-1.97**	**-8.34**	**-5.44**	**-0.41**	**1.28**	**3.87**

Conditional Formatting (Excel)

	Category	2007				2008				2009			
		Q1 07	Q2 07	Q3 07	Q4 07	Q1 08	Q2 08	Q3 08	Q4 08	Q1 09	Q2 09	Q3 09	Q4 09
C	Personal consumption expenditures	1.6	0.9	1.1	0.4	-0.6	0.5	-2.1	-3.1	-0.8	-1.1	1.7	0.1
I	Nonresidential investment	0.9	1.0	0.8	0.9	0.0	-0.3	-1.4	-3.0	-3.6	-1.5	-0.5	-0.4
I	Residential investment	-1.0	-0.8	-1.3	-1.5	-1.3	-0.7	-0.7	-1.3	-1.2	-0.7	0.5	0.0
I	Change in inventories	-0.6	0.8	0.0	-0.8	-1.1	-0.2	0.3	-1.5	-2.3	-1.1	-0.4	4.4
NX	Net exports	-0.5	0.5	1.5	2.2	-0.1	2.1	0.9	-0.1	2.3	2.4	-0.5	-0.1
G	Federal Govt.	-0.4	0.5	0.6	0.2	0.5	0.6	0.9	0.6	-0.2	1.1	0.5	0.0
G	State and Local Govt.	0.2	0.2	0.0	0.2	-0.2	0.1	0.2	0.0	0.4	0.5	0.0	-0.2
GDP	Total	**0.27**	**3.12**	**2.73**	**1.47**	**-2.66**	**1.99**	**-1.97**	**-8.34**	**-5.44**	**-0.41**	**1.28**	**3.87**

Source: BEA Data

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TUFTE: "PANEL" OR "SMALL MULTIPLE" CHARTS

% Beitrag zum Zuwachs zumn BIP (Annualized)

Source: BEA Data

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S&P JAHRES RETURN (EXCL. DIVIDENDS)

Descriptive Statistics: S&P Return %

Variable	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
S&P Return %	34	9.78	16.37	-40.09	1.02	11.49	19.99	35.20

2013	19%
2012	14%
2011	2%
2010	20%
2009	30%
2008	-40%
2007	-4%
2006	12%
2005	8%
2004	4%
2003	32%
2002	-24%
2001	-17%
2000	-2%

1999	9%
1998	31%
1997	25%
1996	24%
1995	35%
1994	-2%
1993	10%
1992	7%
1991	19%
1990	5%

1989	11%
1988	16%
1987	-6%
1986	29%
1985	18%
1984	10%
1983	12%
1982	21%
1981	-7%
1980	13%

Source Data: Yahoo Finance
Author's Computations (Closing Price, First Trading Day of Year)

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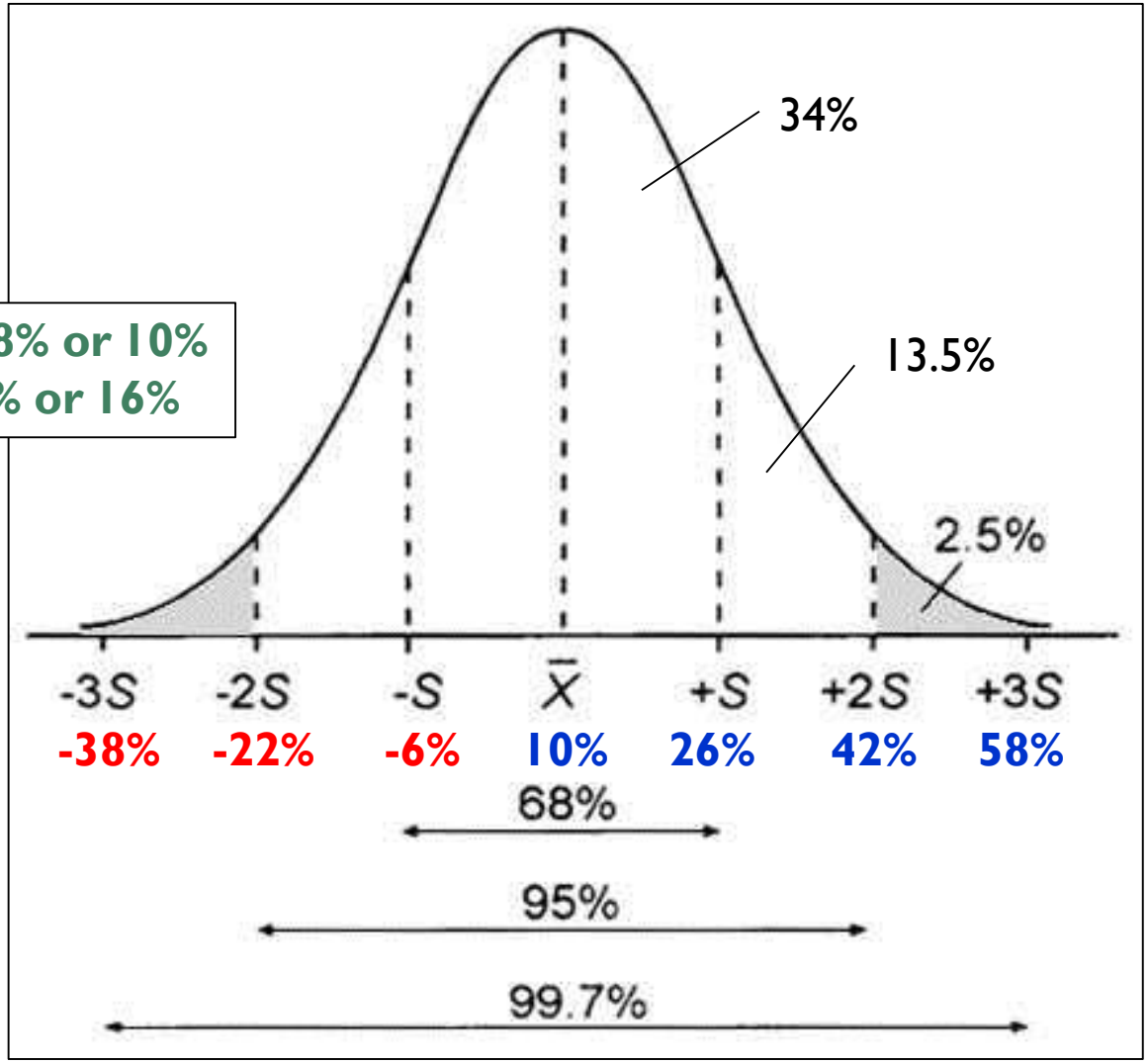
NORMALVERTEILUNG

Mean = 9.78% or 10%
SD = 16.37% or 16%

S&P Return



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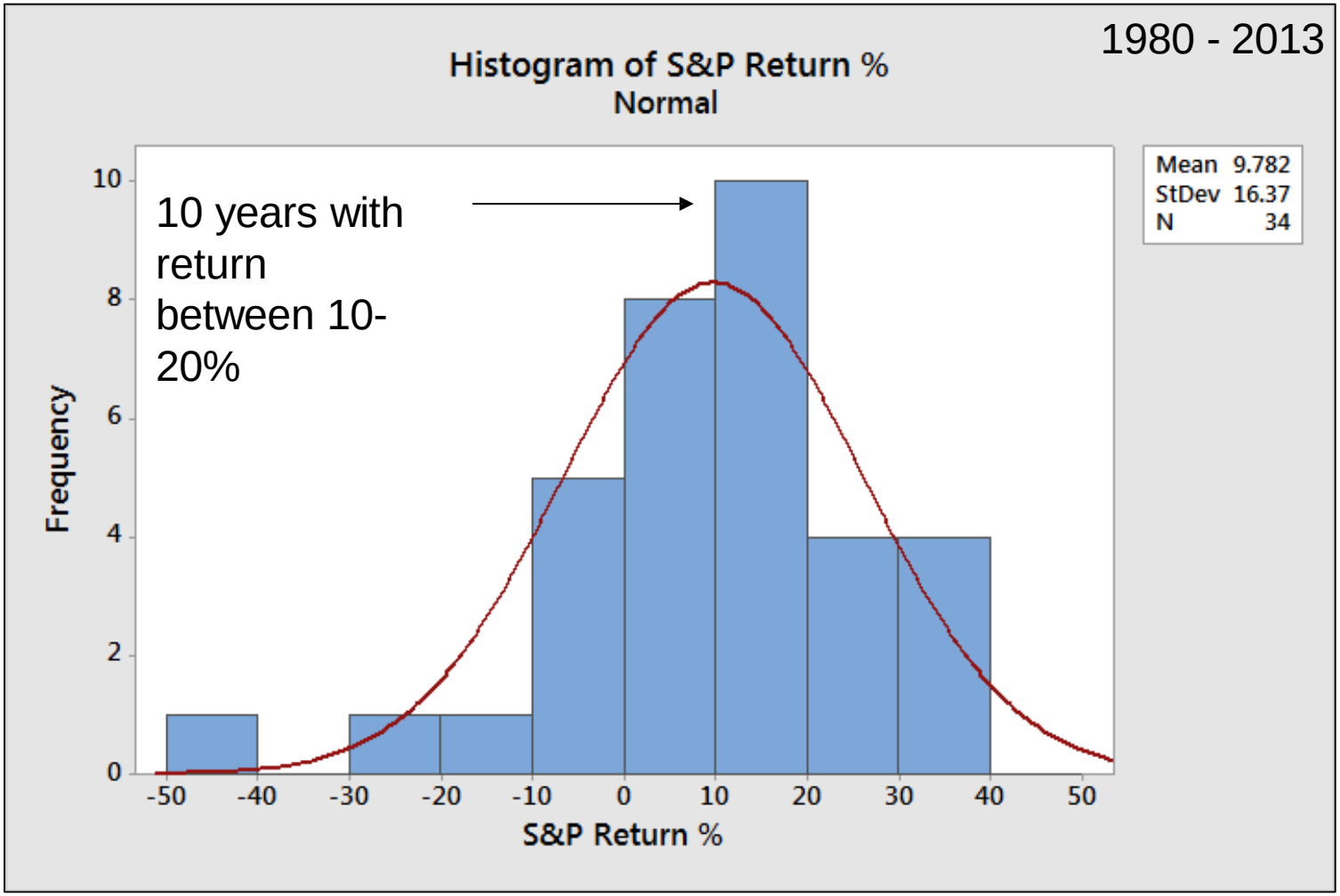
HISTOGRAM (Verteilung)



Each interval is called a "class" or "bin"
Use intervals of the same size to preserve proportions!

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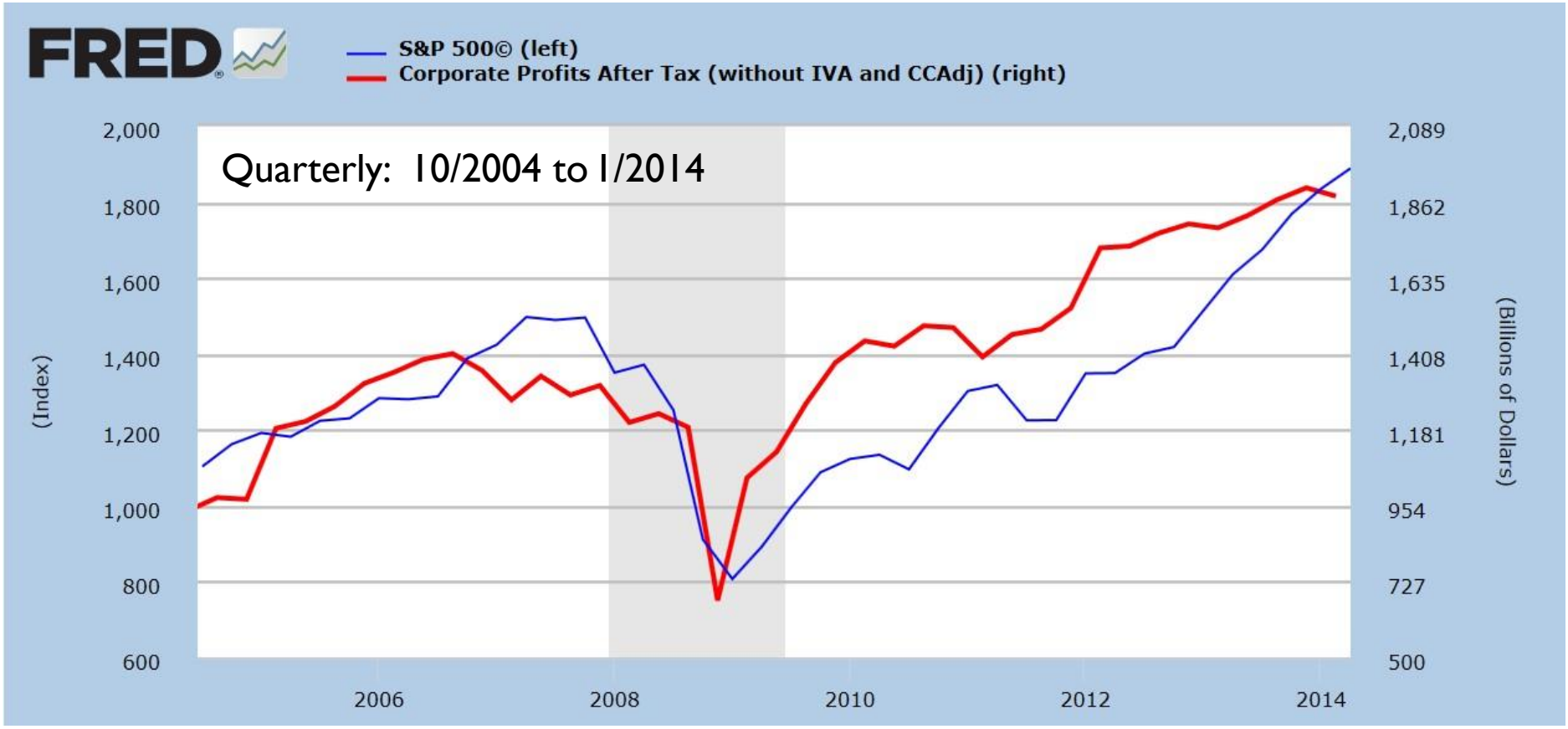
ZWEI VARIABLEN: ARE THEY RELATED?



For each quarter, a measure of CP and SP500
Quarter (X, Y) or
Quarter (CP, SP)

Source Data: FRED Database

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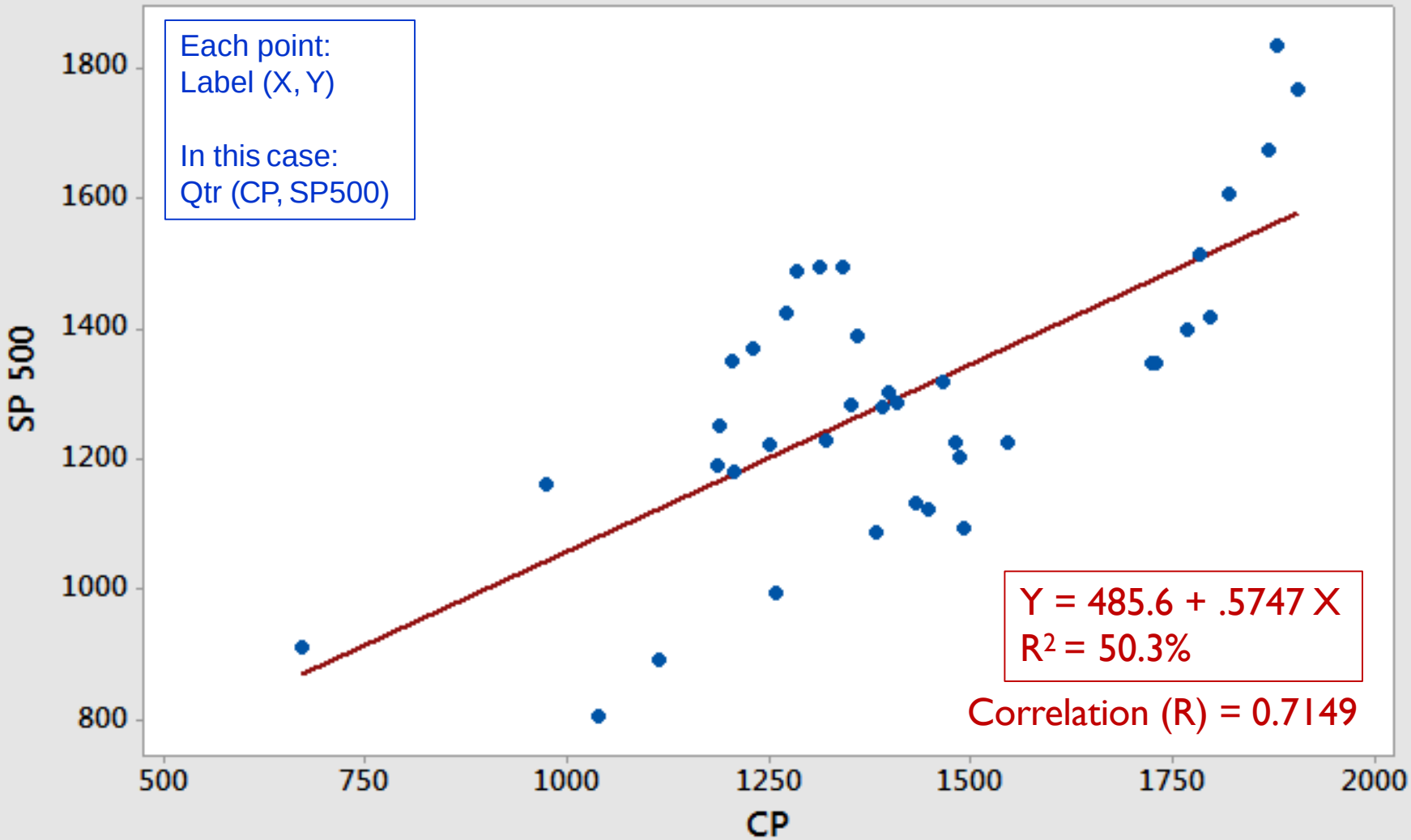
Quarterly data
10/04-1/14



R^2 ~50% means CP (x) explains half the variation in SP 500 index (y) around the y value predicted by the model

R^2 = 100% means a perfect fit; the blue dots would all be on the line

Source Data: FRED Database

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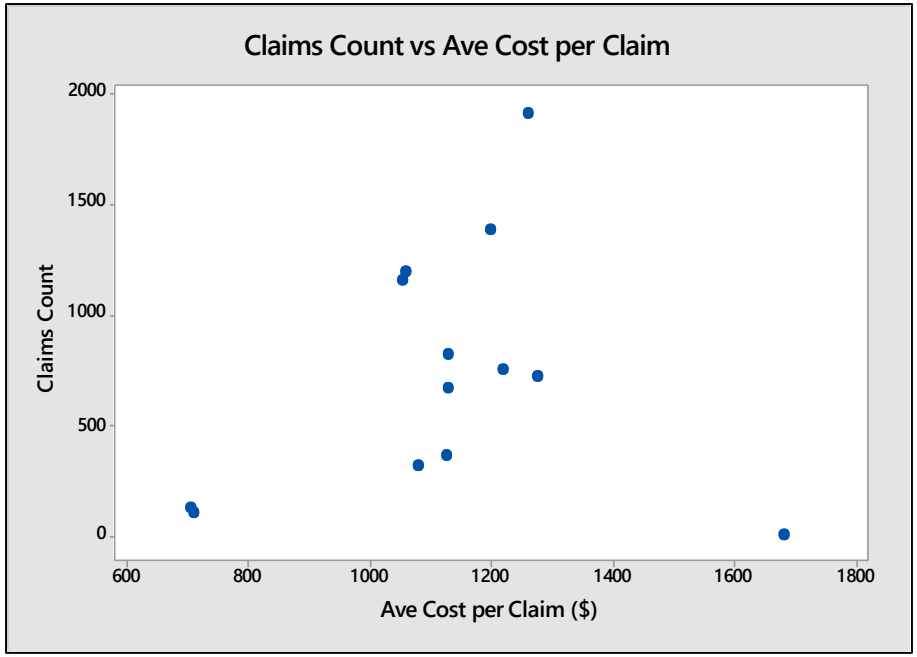
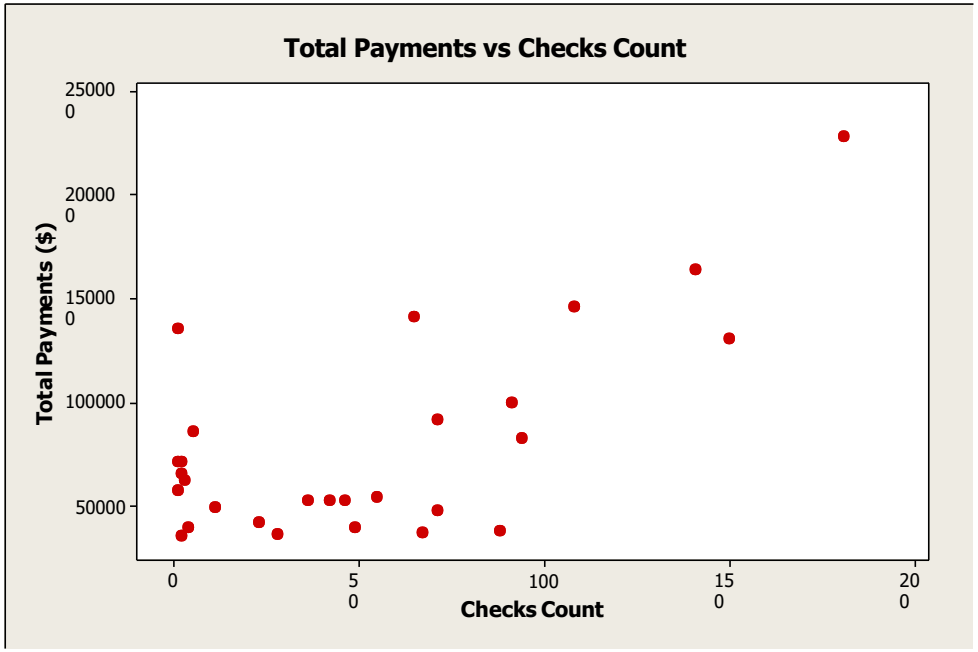
SCATTERPLOT ANWENDUNGEN

Claims Processor Activity



Payments to Vendors



A scatterplot of rate ($) vs. volume (#) can be very effective
Cost per claim: Combine financial & operational metrics

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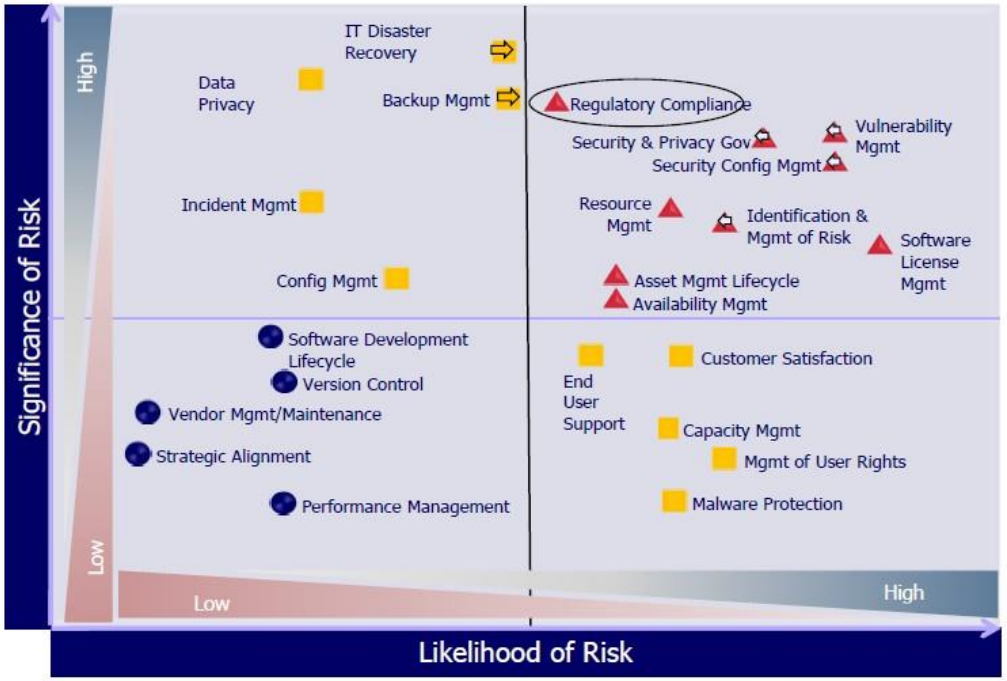
SCATTERPLOT ANWENDUNGEN

Heat Map



Source: Protiviti / Brian Christensen
Presented at MIS SuperStrategies 2014

BCG Growth / Portfolio Matrix

Source: Boston Consulting Group: The Growth-Share Matrix

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VERMEIDUNG VON ANALYTISCHEN FEH

- *Beware the limitations of your own reasoning processes*
  - Confirmation bias: Overweighting evidence that supports pre-conceived notions
- *Beware a point of view vs. emphasizing the pros and cons of alternatives*
  - Overreliance on one statistic to tell the story
  - Not clearly stating assumptions and sources of uncertainty in conclusions
- *"It is difficult to get a man to understand something, when his salary depends on his not understanding it." – Upton Sinclair*
  - Incentives and conflicts of interest

Wie addressieren Sie diese Punkte im analytischen Prozess?

See also: Richards Heuer, Psychology of Intelligence Analysis

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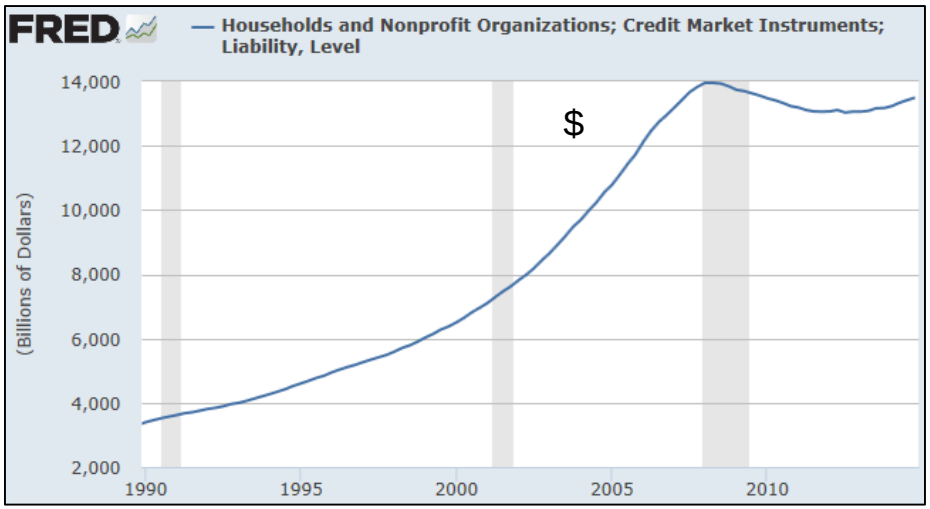
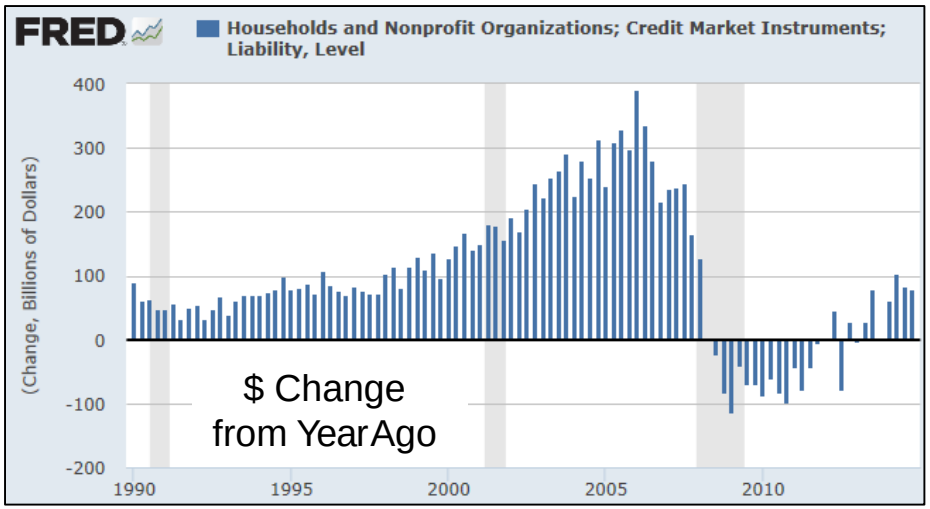
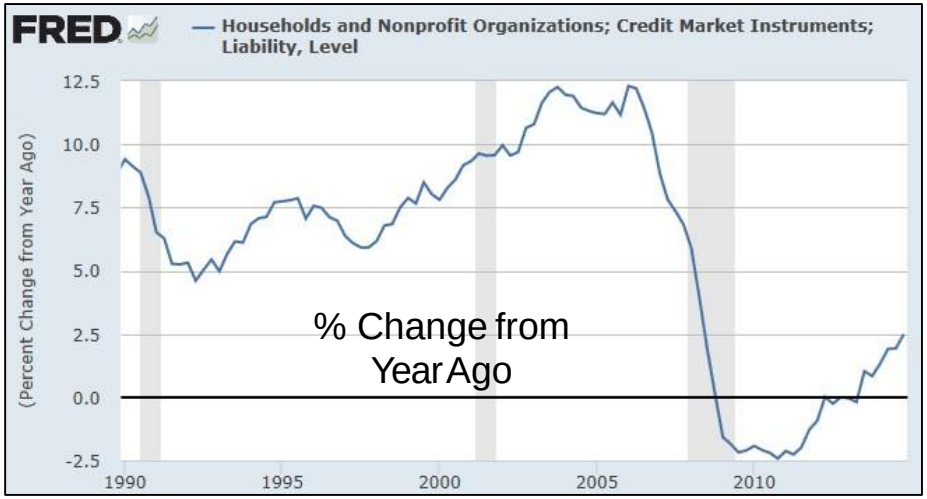
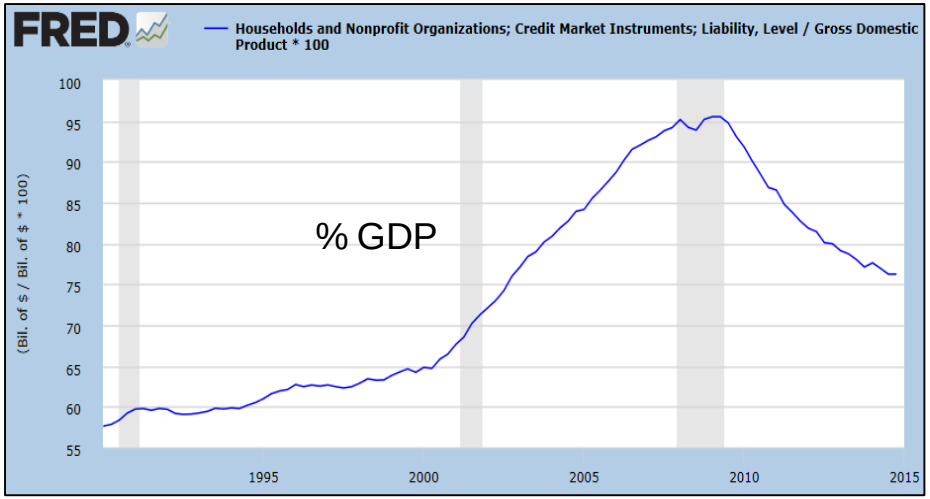
WELCHE DATEN EINHEIT?

Source: FRED Database
Household debt & GDP
Quarterly thru Q1 2015









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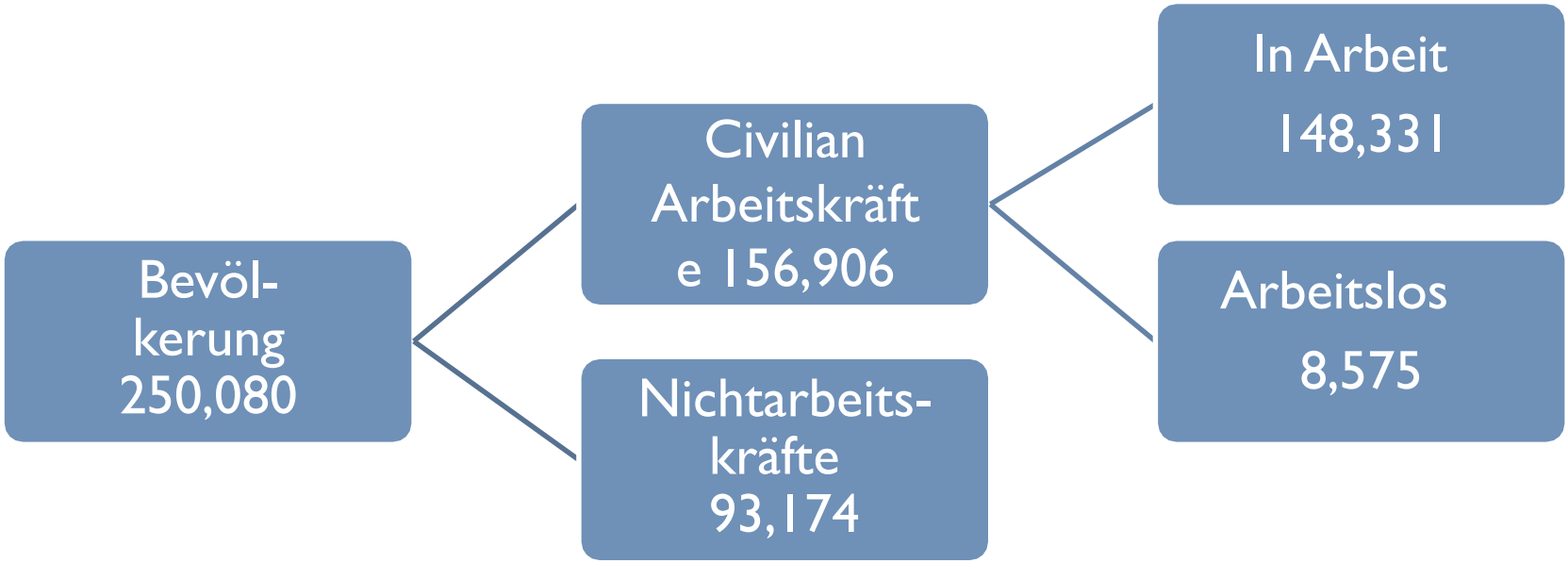
U.S. ARBEITSLOSEN STATISTIK



$$\text{Unemployment Rate} = \frac{\text{Unemployed}}{\text{Civilian Labor Force}} = \frac{8{,}575}{156{,}906} = 5.5\%$$

$$\text{Labor Force Participation Rate} = \frac{\text{Labor Force}}{\text{Civilian Population}} = \frac{156{,}906}{250{,}080} = 62.7\%$$

$$\text{Employment to Population Ratio} = \frac{\text{Employed}}{\text{Civilian Population}} = \frac{148{,}331}{250{,}080} = 59.3\%$$

Illustrates the McKinsey concept of MECE: Mutually Exclusive, Collectively Exhaustive

Source Data: FRED Database; 3/15

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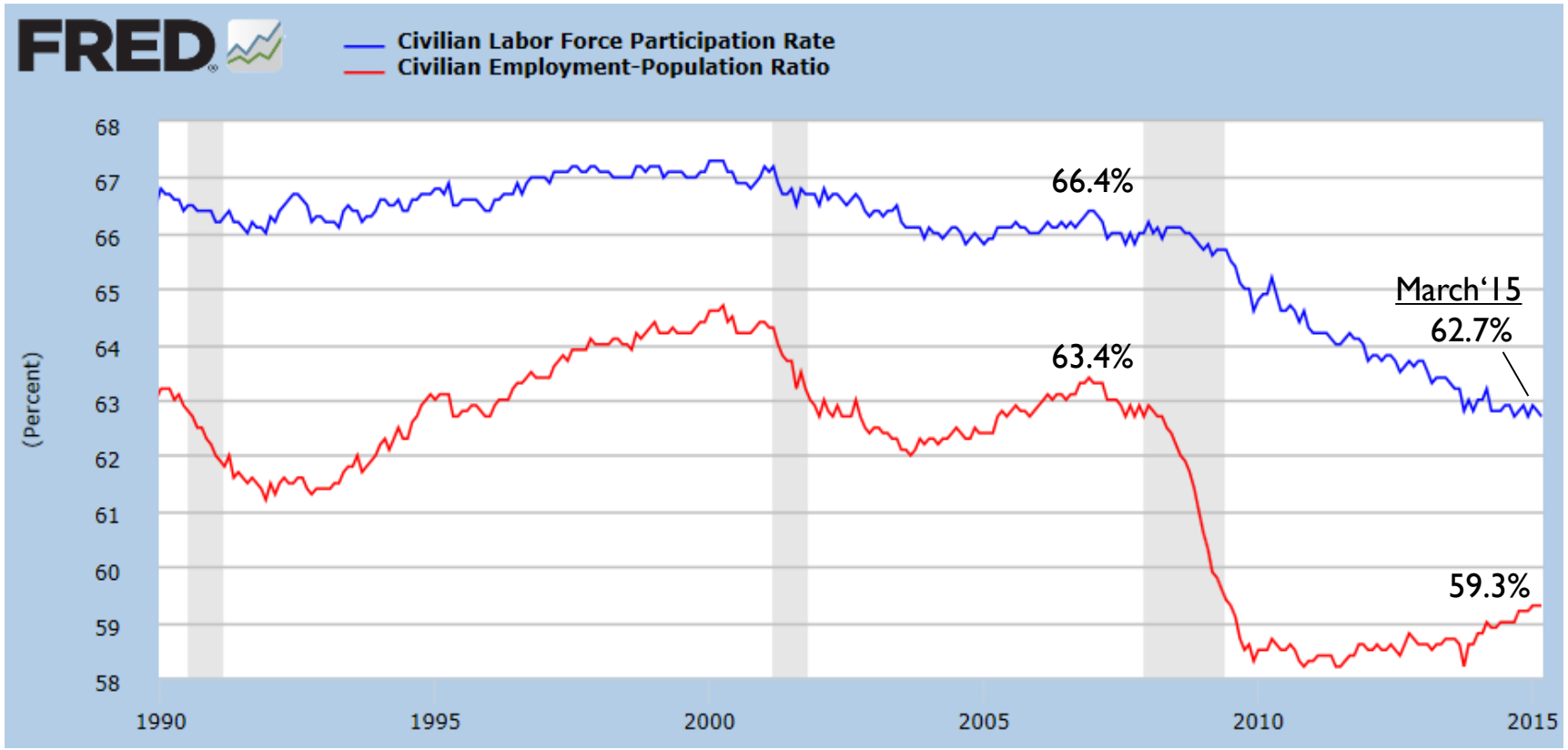
VERHÄLTNIS ANALYSE



- Analysiere das Verhältnis über die Zeit und relativiere diese zueinander
- Ein Verhältnis war deutlich mehr von der Krise als die anderen betroffenen
- Beachten Sie, dass mit Liniendiagramme , die Sie nicht die y-Achse Achse bei Null beginnen müssen
- Doch bei Liniendiagrammen, achten Sie auf Verzerrung aufgrund enger y-Achsenbereiche

Source: FRED Database

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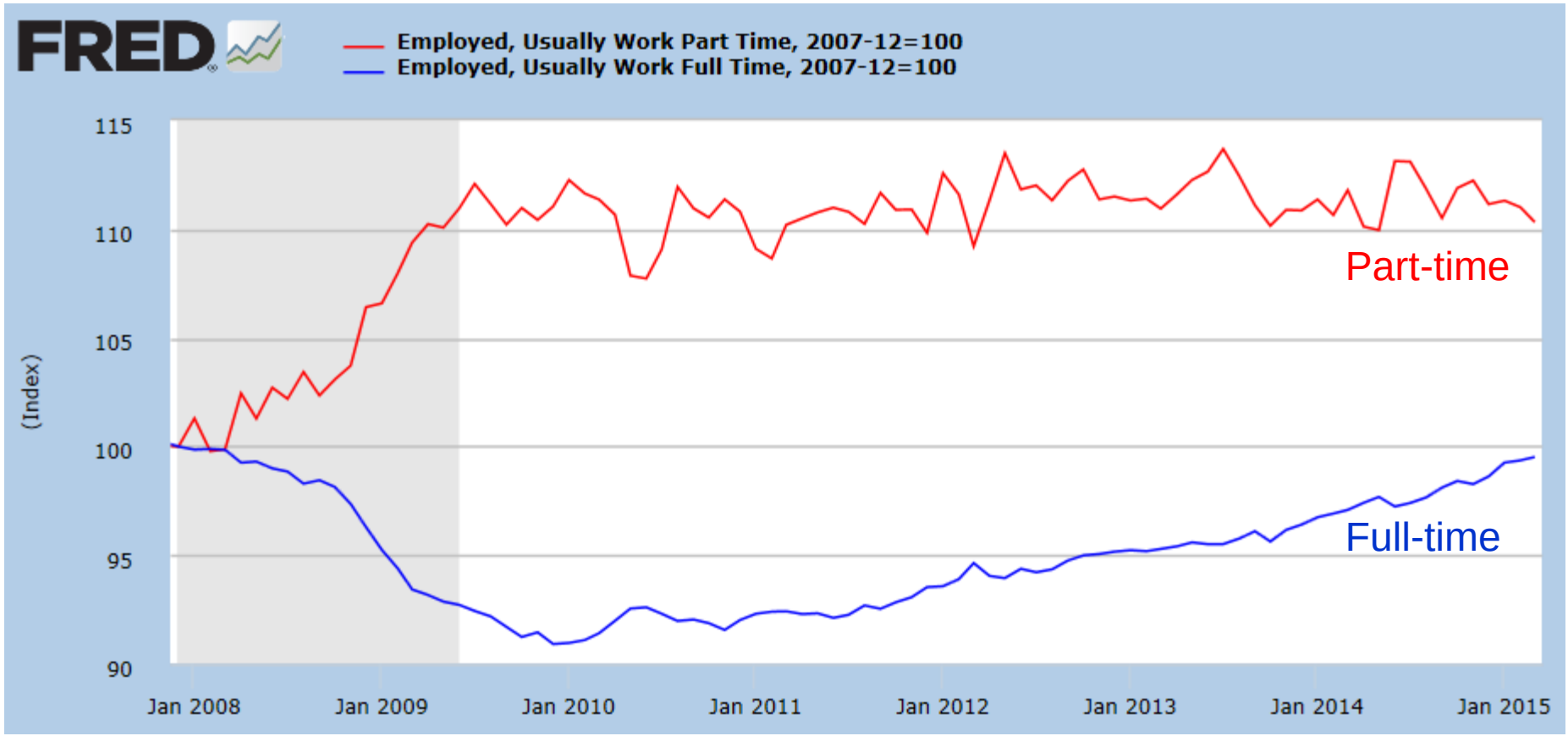
INDEXIERUNG



- Alle nachfolgenden Nummern werden durch den Wert geteilt für 12/2007
- Teilzeitindexwert von 110 bedeutet 10% mehr Teilzeitbeschäftigte als 12/07
- Diese Technik ist hilfreich, wenn die verglichenen Zahlen in der Größe sehr unterschiedlich sind
- Es gibt etwa 120 Millionen Vollzeitbeschäftigte und 30 Millionen Teilzeit (4x) insgesamt

Source: FRED Database

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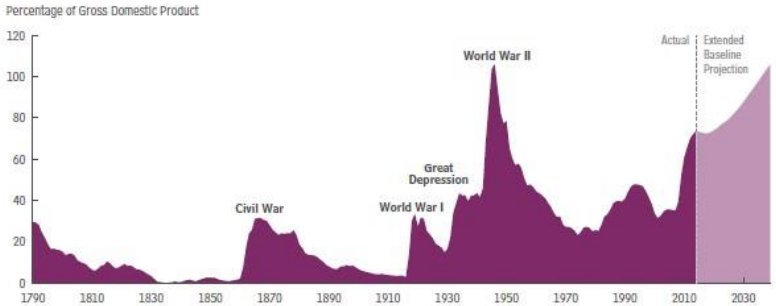
MISCHUNG TEXT UND GRAPHIK

Congressional Budget Office

Figure 1-1.

Federal Debt Held by the Public



Source: Congressional Budget Office. For details about the sources of data used for past debt held by the public, see Congressional Budget Office, *Historical Data on Federal Debt Held by the Public* (July 2010), www.cbo.gov/publication/21728.

Note: The extended baseline generally reflects current law, following CBO's 10-year baseline budget projections through 2024 and then extending the baseline concept for the rest of the long-term projection period. The long-term projections of debt do not reflect the economic effects of the policies underlying the extended baseline. (For an analysis of those effects and their impact on debt, see Chapter 6.)

the preceding several decades. Since then, large deficits have caused debt held by the public to grow sharply—to a projected 74 percent of GDP by the end of 2014. Debt has exceeded 70 percent of GDP during only one other period in U.S. history: from 1944 through 1950, when it spiked because of a surge in federal spending during World War II to a peak of 106 percent of GDP (see Figure 1-1).

CBO projects that, under current law, debt held by the public will exceed its current percentage of GDP after 2020 and continue rising. By 2039, under the extended baseline, federal debt held by the public would reach 106 percent of GDP (see Table 1-1)—equal to the percentage at the end of 1946 and more than two and a half times the average percentage during the past several decades—and would be on an upward path. That trajectory ultimately would be unsustainable. Moreover, the long-term projections of federal debt presented in this chapter and the next few chapters do not incorporate the negative economic effects of higher debt. Projections that account for those effects show debt reaching 111 percent of GDP in 2039 (see Chapter 6).

Projections so far into the future are highly uncertain, of course. Nevertheless, under a wide range of possible expectations for key factors that affect budgetary outcomes, CBO anticipates that if current law generally stayed the same, federal debt in 2039 would be very high by the nation's historical standards (see Chapter 7).

Policy Changes Needed to Meet Various Goals for Federal Debt

An alternative perspective on the long-term fiscal imbalance comes from assessing the changes in revenues or noninterest spending that would be needed to achieve a chosen goal for federal debt. One possible goal would be to make federal debt the same percentage of GDP in some future year as it is today. Another would be to make federal debt the same percentage of GDP in some future year as it has been, on average, during the past several decades. Other goals are possible as well.

The changes in revenues or noninterest spending that are estimated to be necessary to achieve one of those goals are conceptually similar to the estimated actuarial imbalance (that is, a negative actuarial balance) that is commonly reported for the trust funds for Part A of

Wells Fargo Economics Newsletter

Economics Group **U.S. Review** **Wells Fargo Securities, LLC**

U.S. Review

Slack Attack Will Keep the Fed on Hold

Despite a shortened work week in the U.S., economic data and equity markets fired off a few fireworks of their own. Nonfarm payrolls came in much stronger-than-consensus, the ISM manufacturing index remained well within expansion territory, and the Dow Jones Industrial Average and the S&P 500 equity index reached a record high level during the week.

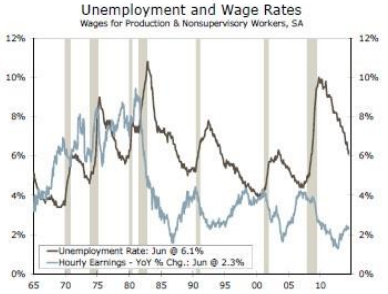
For nonfarm payrolls, the 288,000 gain in June marks the fifth consecutive month over 200k, the longest string of job gains since the late 1990s. Gains were broad-based, including the long depressed government sector. Revisions were also upbeat with April and May increasing on net by 29,000 jobs. Based on the current pace of monthly job gains, the unemployment rate could fall within the Fed's longer-run range by the end of the year. With labor market conditions returning to normal levels and economic activity firming, market participants are confounded by recent comments from Federal Reserve Chair Yellen that there is no need to change current monetary policy. The disconnect between how the Fed views economic conditions and market participants is the amount of slack that is in the economy. More specifically, the Fed is looking at wage pressure, which remains at a low level. Yellen noted in her May news conference that an important sign the labor market is tightening will be an increase in wages.

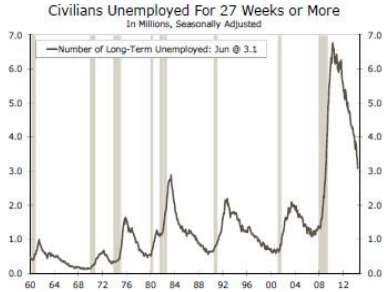
So let's take a look at wages. In today's nonfarm payroll release, average hourly earnings grew just 2.0 percent over the past year and remains below the long-run average of about 3-4 percent. Other indicators of wage pressure including hourly compensation and the employment cost index are also showing a slow pace of wage growth. When you consider real wages, real average hourly earnings are down 0.2 percent over the past year.

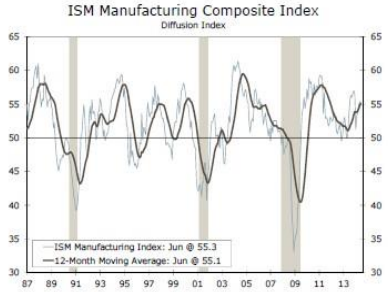
That said, companies have been successful in keeping compensation low, which has allowed them to concentrate on improving profit margins and earnings per share. Some of the recent stock market gains have been driven by company share buy-backs, dividend increases and merger and acquisition activity. So what will push employers to increase wages?

Previous recoveries show that employers will bump up wages when they can no longer fill jobs easily. The short-term unemployment rate is evidence that the labor market is tightening. However, the debate is really about the long-term unemployed and its effect on wages. In June, the long-term unemployed accounted for roughly 32.8 percent of the unemployed at 3.1 million and the U-6 measure, which includes discouraged workers, remained elevated at 12.1 percent. The high level of long-term unemployed shows that the labor market still has room to grow, but some of the pain is really a structural issue.

Another sign economic conditions are improving is the factory sector. U.S. factories registered another strong reading in June with the ISM manufacturing index coming in largely unchanged at 55.3. The headline index was boosted by solid gains in new orders and production. However, the prices paid component remains elevated at 58.0, which is another signal of inflation pressure.







Source: U.S. Department of Labor, Institute of Supply Management and Wells Fargo Securities, LLC

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- Einführung
- Displays I: Ranking & Abweichung Charts
- Displays II: Proportions & Anteils Charts
- Displays III: Verteilung & Korrelation Charts
- Analytische Tips
- Analytischer Process

DATEN ANALYSE PROZESS

Anforderungen / Zweck

- Definiere das Problem
- Scope
- Messen
- Sponsorship
- Budget
- Timeline
- Teilnehmer

Output
Charter

Planung der Analyse

- Verstehen des Prozesses
- Von Fragen zu Antworten
- Schlüsselgrößen
- Schlüsselvariablen

Analye Plan

Sammlung & Scrub Data

- Beschaffe Daten
- Verbindung zu öffentlichen Zahlen
- Ranking/sortieren der Schlüssel-variablen
- Valide Berichte?
- Berichte komplett?
- Schließen von Datenlücken

Data File

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DATEN ANALYSE PROZESS

Visualisiere (EDA) → **Model Data*** → **Analysiere Ursache Wirkung** → **Visualisiere Bericht**

<u>Deskriptive Statistik</u>

- Basis Statistik
- Zeitreihendiagramme
- Ranking: Pivottabellen, Balkendiagramme
- Contributions: Kreis- oder Balkendiagramme
- Ausreißer: Scatterplots
- Verteilung: Histogramme

<u>Inferential Statistics</u>

- Y = f(x)
- Y = ax + b + error
- Regression
- Hypothesentest

- Bestimme Ursache-Wirkung von Fehlern (Nacharbeit/Verspätung)
- Durchfluss Analyse
- Priorisierung Ursache-Wirkung von Nachaerbeit: Pareto Diagramm
- Fishbone-Diagramm
- Failure modes & effects analysis (FMEA)
- Lösungen vorschlagen

Executive summary

- Charter summary
- Statistical summary
- Tabellen
- Graphiken
- Beobachtungen
- Aktionspläne
- Nexte Schritte

<u>Outputs</u>

Tabellen & Graphiken

Model le

Ursache Wirkungs -analyse

Bericht

*Bemerkung: Modellierung and Ursache-Wirkungs- Analyse Schritte sind nicht bei allen Projekten notwendig

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Schlußfolgerung

- Was erzählen und die Daten?
- Wast ist die Story, die wir versuchen zu erzählen?
- Wie können wir die Graphiken in den Berichten/Analysen besser nutzen?
- Wie können wir die Mitarbeiter trainieren Daten zu visualisieren?
- Wie ist unser Datenanalyseprozess?

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