

# On the Correctness of Spreadsheets: *An **Excellent** Problem for PL Researchers*



*Emery Berger*

UMASS**CICS**

COLLEGE OF INFORMATION AND COMPUTER SCIENCES

# On the Correctness of Spreadsheets: *An **Excellent** Problem for PL Researchers*



*Emery Berger*

*Dan Barowy (UMass Amherst)  
& Ben Zorn (Microsoft Research)*

**UMASSCICS**

COLLEGE OF INFORMATION AND COMPUTER SCIENCES

# Reinhart-Rogoff



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*Growth in a Time of Debt*

>90% debt : GDP ratio  $\Rightarrow$  low economic growth



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# Reinhart-Rogoff



*Growth in a Time of Debt*

$>90\%$  debt : GDP ratio  $\Rightarrow$  low economic growth

What Programming Language  
Did *They* Use?

# C++?

```
#include <iostream>
```

```
int main()
```

```
{
```

```
    std::cout << "AUSTERITY!"
```

```
              << std::endl;
```

```
    return 0;
```

```
}
```



# C++?

```
#include <iostream>
```

```
int main()
```

```
{
```

```
    std::cout << "AUSTERITY!"
```

```
              << std::endl;
```

```
    return 0;
```

```
}
```

Nope. ~3.5 million users

# Java?

```
public class HelloWorld {  
    public static void main(String[] args) {  
        System.out.println("AUSTERITY!");  
    }  
}
```

# Java?

```
import static org.junit.Assert.assertEquals;
import java.io.ByteArrayOutputStream;
import java.io.PrintStream;
import org.junit.Test;

public class HelloWorldTest {
    @Test
    public void sayHelloWorld() {
        ByteArrayOutputStream outContent = captureSystemOut();

        HelloWorld.say();

        assertEquals("AUSTERITY!", outContent.toString());
    }

    ByteArrayOutputStream captureSystemOut() {
        ByteArrayOutputStream outContent = new ByteArrayOutputStream();
        System.setOut(new PrintStream(outContent));
        return outContent;
    }
}

public class HelloWorld {
    public static void say() {
        System.out.print("AUSTERITY!");
    }
}
```

# Java?

```
import static org.junit.Assert.assertEquals;
import java.io.ByteArrayOutputStream;
import java.io.PrintStream;
import org.junit.Test;

public class HelloWorldTest {
    @Test
    public void sayHelloWorld() {
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    ByteArrayOutputStream captureSystemOut() {
        ByteArrayOutputStream outContent = new ByteArrayOutputStream();
        System.setOut(new PrintStream(outContent));
        return outContent;
    }
}

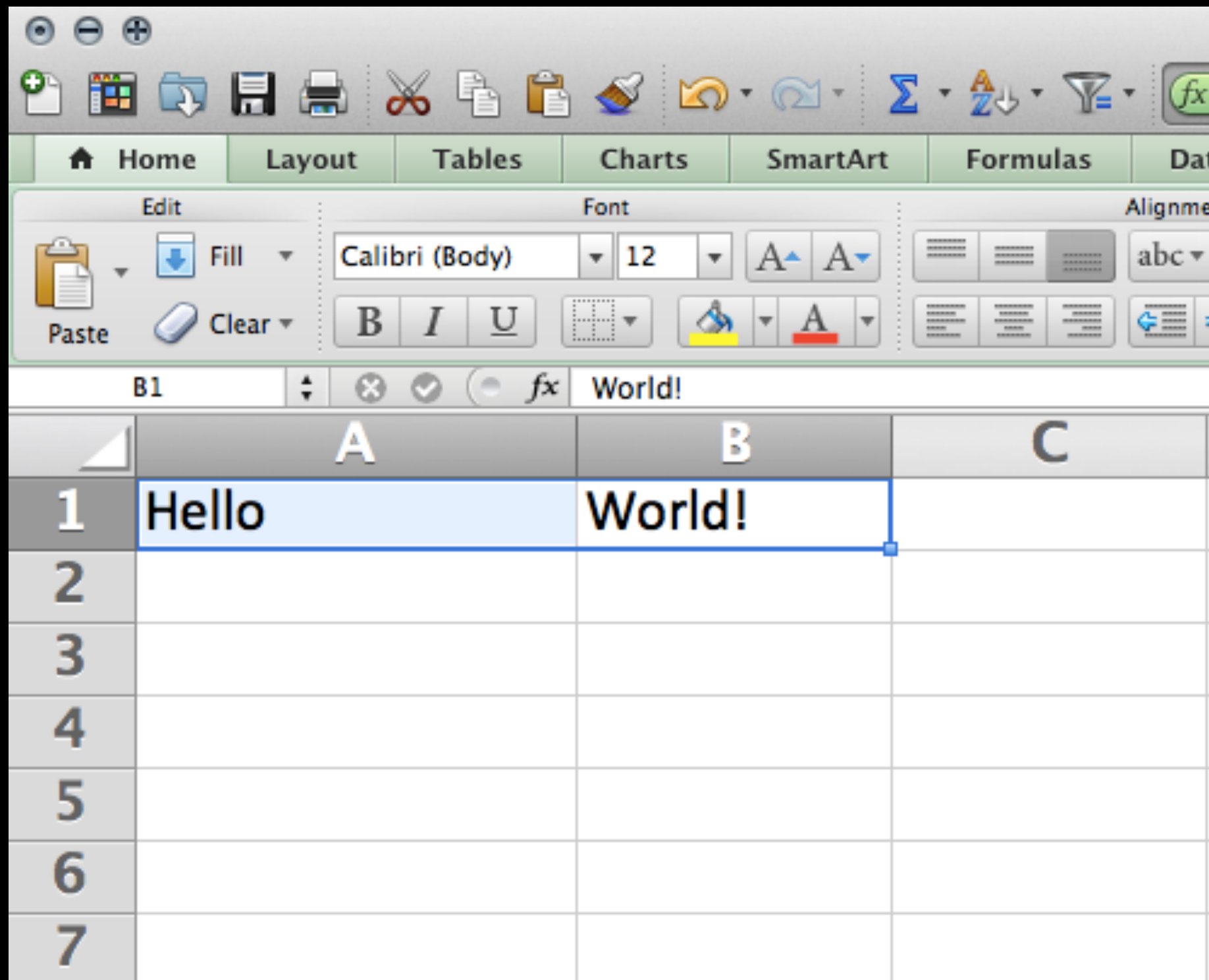
public class HelloWorld {
    public
    :
    }
}
```

Nope. ~9 million users

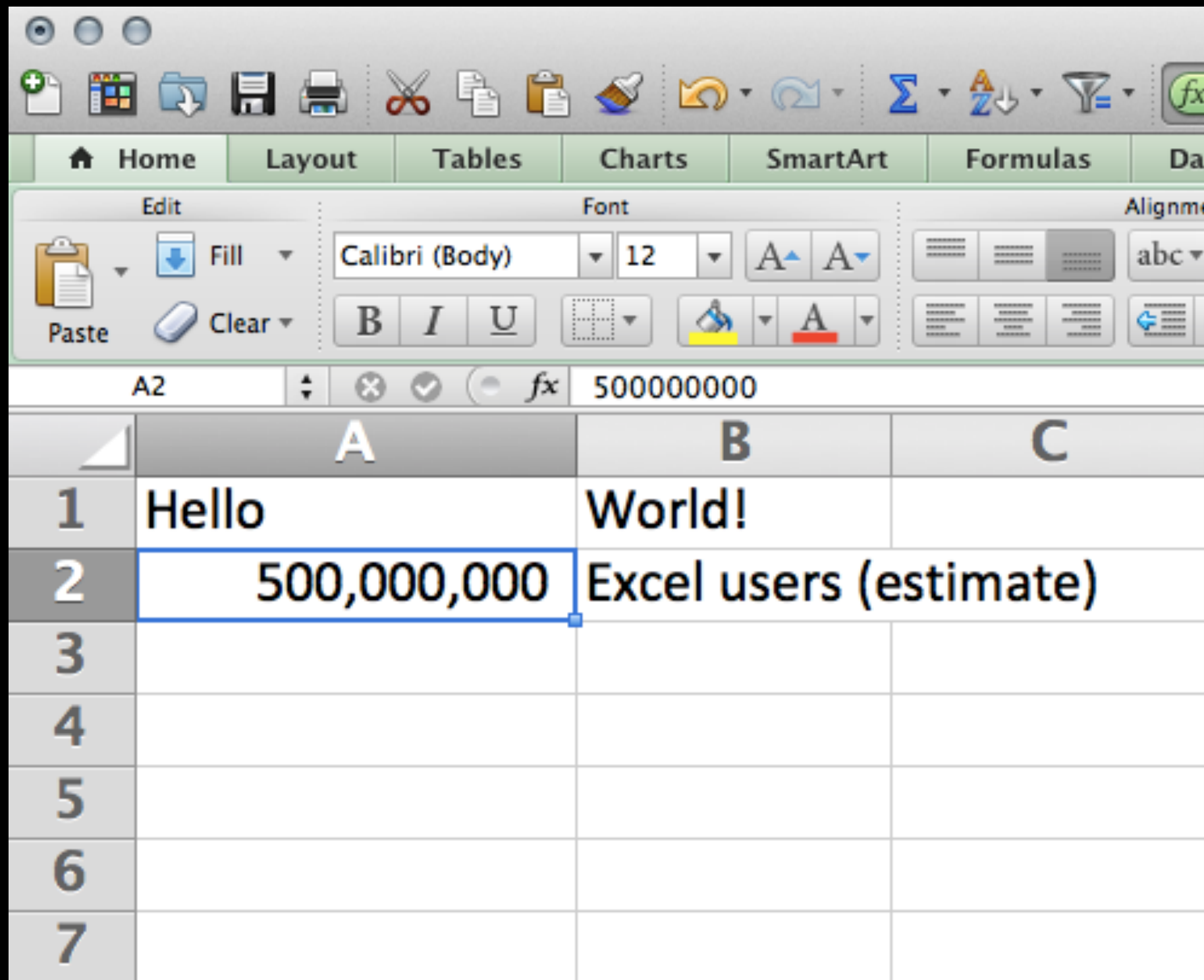
Excel.



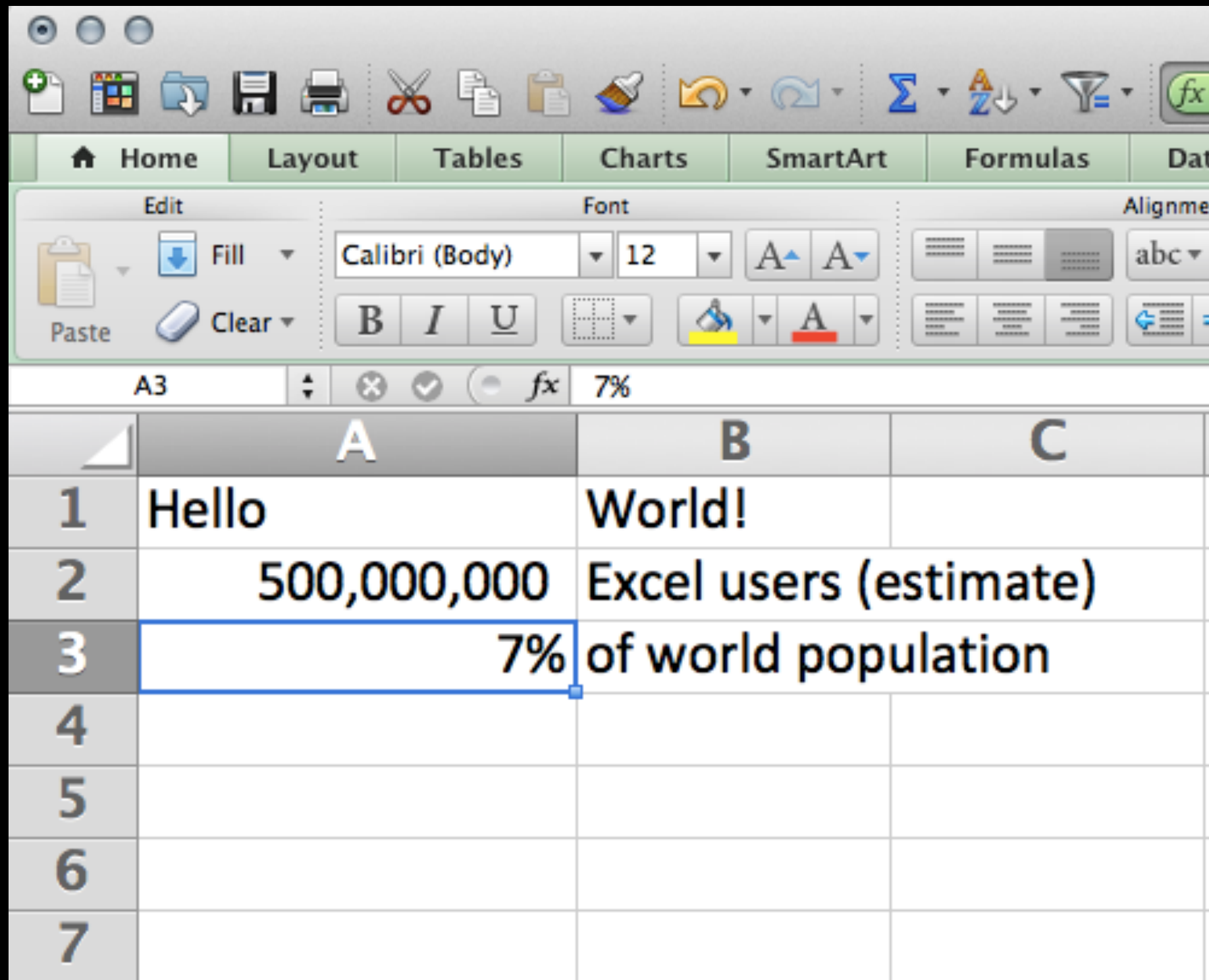
# Excel.



# Excel.



# Excel.



	A	B	C
1	Hello	World!	
2	500,000,000	Excel users (estimate)	
3	7%	of world population	
4			
5			
6			
7			

# Spreadsheets are *Everywhere*



# Spreadsheets are *Everywhere*



500 million users





# Spreadsheets are *Everywhere*



500 million users



Functional, reactive programming language + data



# Spreadsheets are *Everywhere*



500 million users

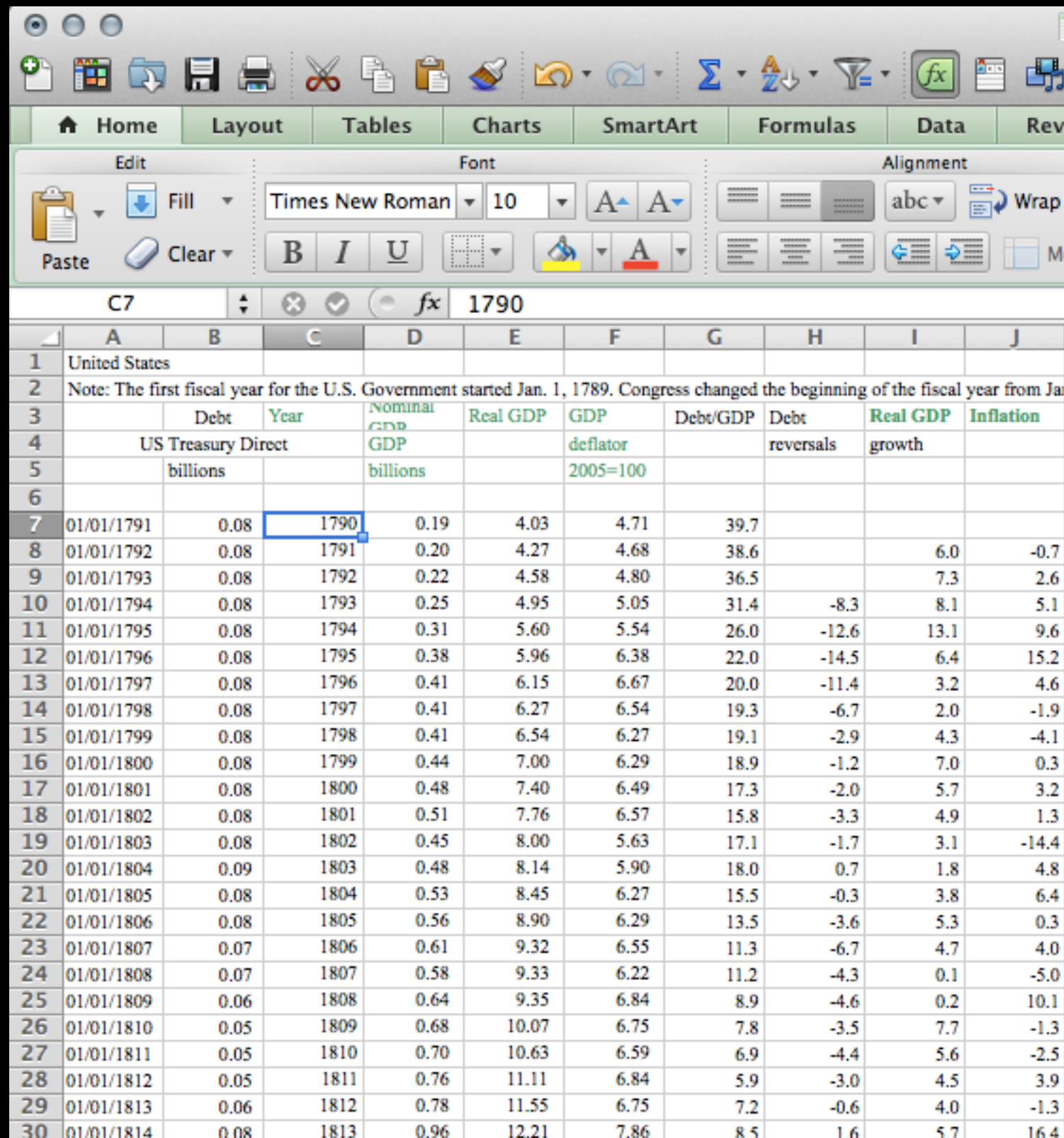


Functional, reactive programming language + data



Hugely important *but* very easy to make mistakes!

# Reinhart-Rogoff Spreadsheet



	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4	US Treasury Direct			GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	01/01/1795	0.08	1794	0.31	5.60	5.54	26.0	-12.6	13.1	9.6
12	01/01/1796	0.08	1795	0.38	5.96	6.38	22.0	-14.5	6.4	15.2
13	01/01/1797	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
14	01/01/1798	0.08	1797	0.41	6.27	6.54	19.3	-6.7	2.0	-1.9
15	01/01/1799	0.08	1798	0.41	6.54	6.27	19.1	-2.9	4.3	-4.1
16	01/01/1800	0.08	1799	0.44	7.00	6.29	18.9	-1.2	7.0	0.3
17	01/01/1801	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	01/01/1802	0.08	1801	0.51	7.76	6.57	15.8	-3.3	4.9	1.3
19	01/01/1803	0.08	1802	0.45	8.00	5.63	17.1	-1.7	3.1	-14.4
20	01/01/1804	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	01/01/1805	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
22	01/01/1806	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
25	01/01/1809	0.06	1808	0.64	9.35	6.84	8.9	-4.6	0.2	10.1
26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4



# The Excel Depression

By PAUL KRUGMAN

Published: April 18, 2013 | 470 Comments

In this age of information, math errors can lead to disaster. NASA's Mars Orbiter crashed because engineers forgot to convert to metric measurements; JPMorgan Chase's "London Whale" venture went bad in part because modelers divided by a sum instead of an average. So, did an Excel coding error destroy the economies of the Western world?

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Fred R. Conrad/The New York Times


Paul Krugman

[Go to Columnist Page »](#)


The story so far: At the beginning of 2010, two Harvard economists, Carmen Reinhart and Kenneth Rogoff, circulated a paper, "Growth in a Time of Debt," that purported to identify a critical "threshold," a tipping point, for government indebtedness. Once debt exceeds 90 percent of gross domestic product, they claimed, economic growth drops off sharply.

Ms. Reinhart and Mr. Rogoff had credibility thanks to a widely admired earlier book on the history of financial crises, and their timing was impeccable. The paper came out just after Greece went into crisis and played right into the desire of many officials to "pivot" from stimulus to austerity. As a result, the paper instantly became famous; it was, and is, surely the most influential economic analysis of recent years.


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# FAQ: Reinhart, Rogoff, and the Excel Error That Changed History

By Peter Coy  | April 18, 2013



SEND TO **kindle**



Photograph by Gregor Schuster



# FAQ: Reinhart, Rogoff, and the Excel Error That Changed History

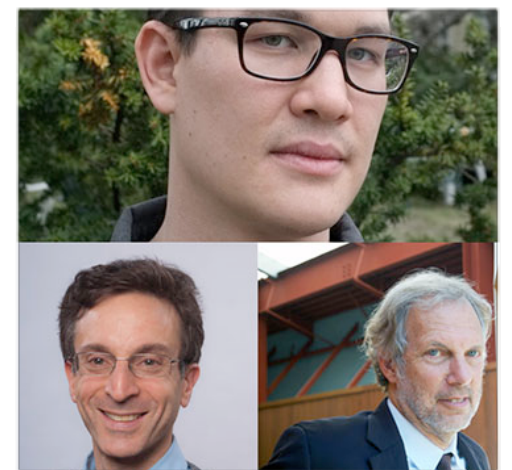
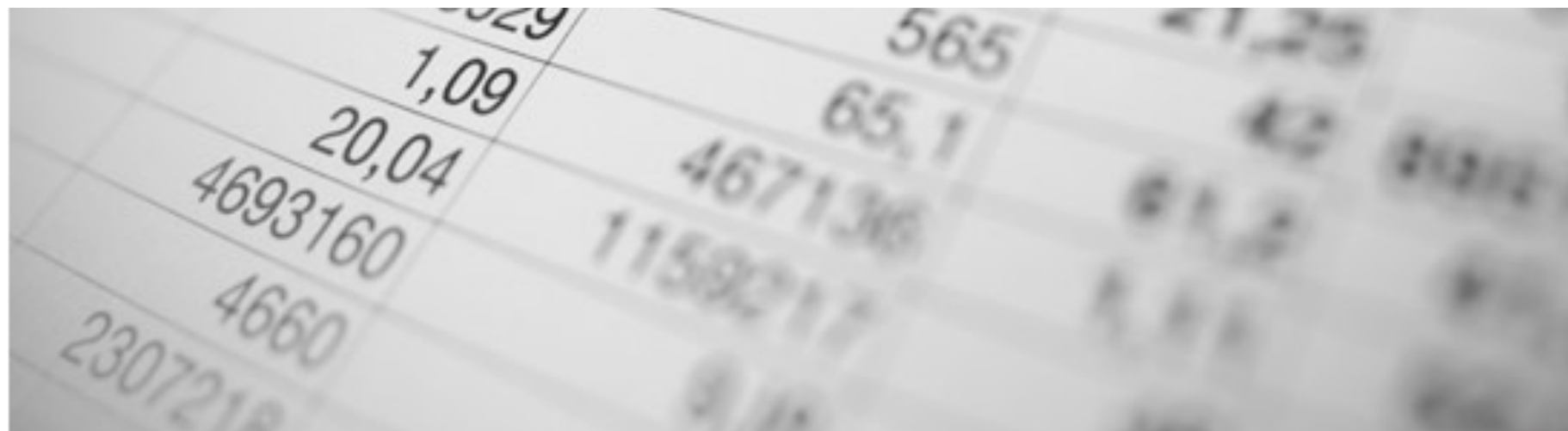
By Peter Coy  | April 18, 2013



SEND TO  kindle

## How big is this mistake?

Reinhart and Rogoff wrote in their 2010 paper that average annual growth was negative 0.1 percent in countries with episodes of gross government debt equal to 90 percent or more of GDP between 1945 and 2009. Liberal economists have been critical of their work for years (just economists being their usual cranky selves), but now three economists at UMass say Reinhart and Rogoff made several mistakes and omissions. According to the UMass scholars, the “corrected” number is positive 2.2 percent—which means GDP still grows, even when debt levels are very high.

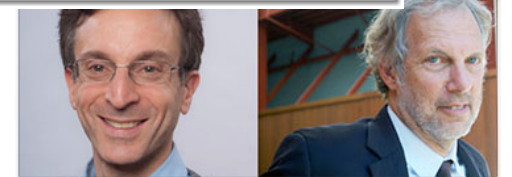
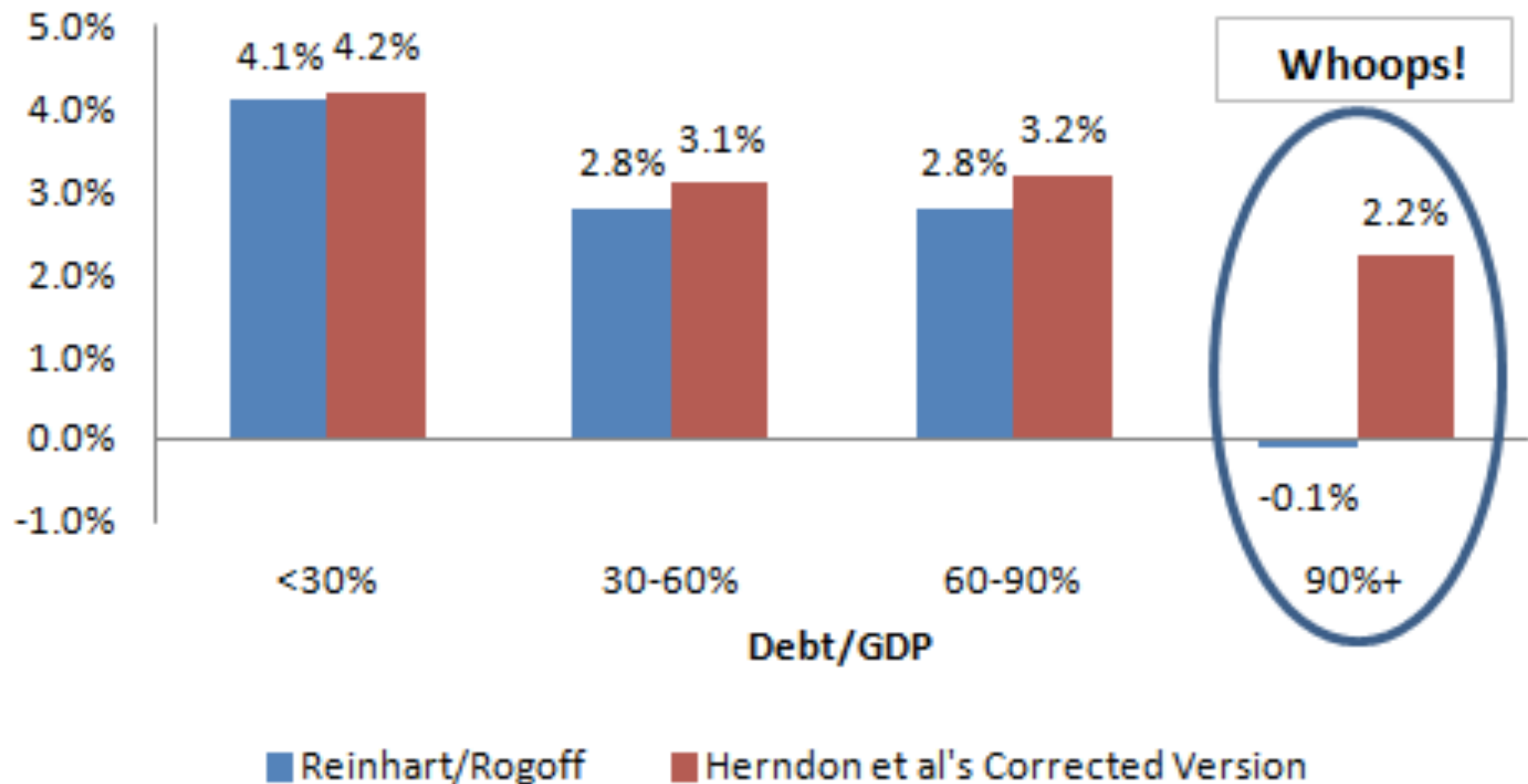


Photograph by Gregor Schuster

# FAQ: Reinhart, Rogoff, and the Excel Error That Changed History

By Peter Coy | April 18, 2013

Real GDP Growth Rates at Different Debt/GDP Levels



Photograph by Gregor Schuster

*Could We Have Prevented This?*



STAND BACK



I'M GOING TO TRY  
SCIENCE

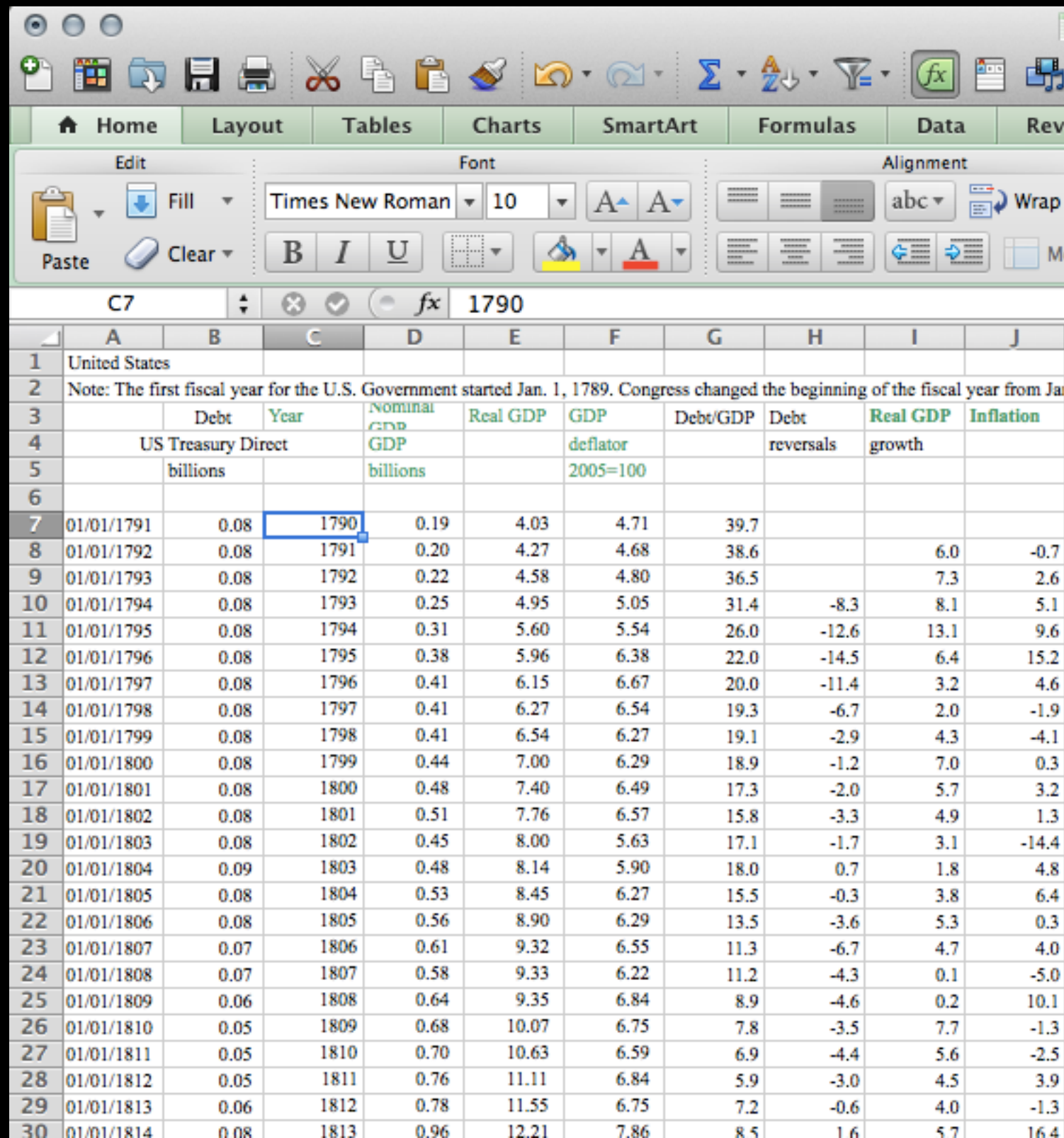


# STAND BACK



# I'M GOING TO TRY PROGRAMMING LANGUAGE TECHNOLOGY

# What's the Problem?




The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4	US Treasury Direct			GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
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17	01/01/1801	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	01/01/1802	0.08	1801	0.51	7.76	6.57	15.8	-3.3	4.9	1.3
19	01/01/1803	0.08	1802	0.45	8.00	5.63	17.1	-1.7	3.1	-14.4
20	01/01/1804	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	01/01/1805	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
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23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
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29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4

# What's the Problem?

People make mistakes.

D'OH!



The image shows a Microsoft Excel spreadsheet with a data table. A cartoon of Homer Simpson is overlaid on the spreadsheet, covering his face with his hands in a gesture of frustration or embarrassment, with the text "D'OH!" written above his head. The spreadsheet has a ribbon with tabs for Home, Layout, Tables, Charts, SmartArt, Formulas, Data, and Review. The Home tab is active, showing options for Paste, Fill, Font (Times New Roman, size 10), Bold (B), Italic (I), Underline (U), and Alignment. The data table has columns for Date, Debt, Year, Nominal GDP, Real GDP growth, and Inflation. The data starts from 1791 and goes up to 1814.

	A	B	C	D	E	F	G	H	I	J
		Debt	Year	Nominal GDP	Real GDP					
		US Treasury Direct		GDP	growth					
		billions		billions						
7	01/01/1791	0.08	1790	0.0						
8	01/01/1792	0.08	1791	0.20	6.0					-0.7
9	01/01/1793	0.08	1792	0.22	7.3					2.6
10	01/01/1794	0.08	1793	0.2	8.1					5.1
11	01/01/1795	0.08	1794		13.1					9.6
12	01/01/1796	0.08	1795		6.4					15.2
13	01/01/1797	0.08	1796		3.2					4.6
14	01/01/1798	0.08			2.0					-1.9
15	01/01/1799	0.08			-2.9					4.3
16	01/01/1800	0.08			-1.2					7.0
17	01/01/1801	0.0			-2.0					5.7
18	01/01/1802	0.0			-3.3					4.9
19	01/01/1803	0.0			-1.7					3.1
20	01/01/1804	0.0			0.7					1.8
21	01/01/1805	0.0			-0.3					3.8
22	01/01/1806	0.0			-3.6					5.3
23	01/01/1807	0.0			-6.7					4.7
24	01/01/1808	0.0			-4.3					0.1
25	01/01/1809	0.0			-4.6					0.2
26	01/01/1810	0.0			-3.5					7.7
27	01/01/1811	0.0			-4.4					5.6
28	01/01/1812	0.0			-3.0					4.5
29	01/01/1813	0.0			-0.6					4.0
30	01/01/1814	0.08	1813	0.29	16.4					16.4

# What's the Problem?

People make mistakes.

D'OH!

I. Program wrong

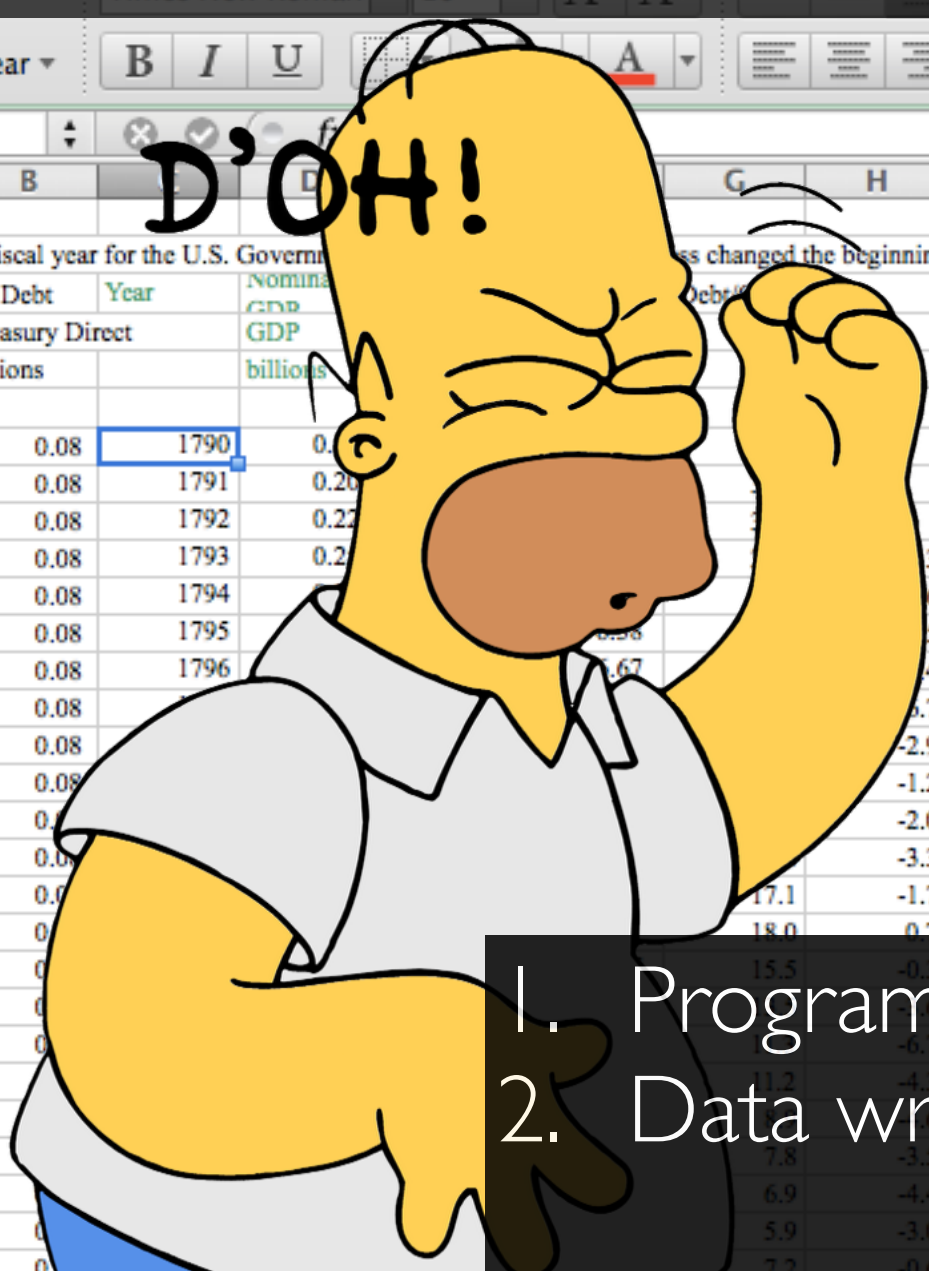
	A	B	C	D	E	F	G	H	I	J
		Debt	Year	Nominal GDP	Real GDP				Real GDP	Inflation
		US Treasury Direct		billions	billions				growth	
7	01/01/1791	0.08	1790	0.0						
8	01/01/1792	0.08	1791	0.20					6.0	-0.7
9	01/01/1793	0.08	1792	0.22					7.3	2.6
10	01/01/1794	0.08	1793	0.2					8.1	5.1
11	01/01/1795	0.08	1794						13.1	9.6
12	01/01/1796	0.08	1795						6.4	15.2
13	01/01/1797	0.08	1796						3.2	4.6
14	01/01/1798	0.08							2.0	-1.9
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29	01/01/1813	0.0							4.0	-1.3
30	01/01/1814	0.08	1813	0.29					5.7	16.4



# What's the Problem?

People make mistakes.

D'OH!



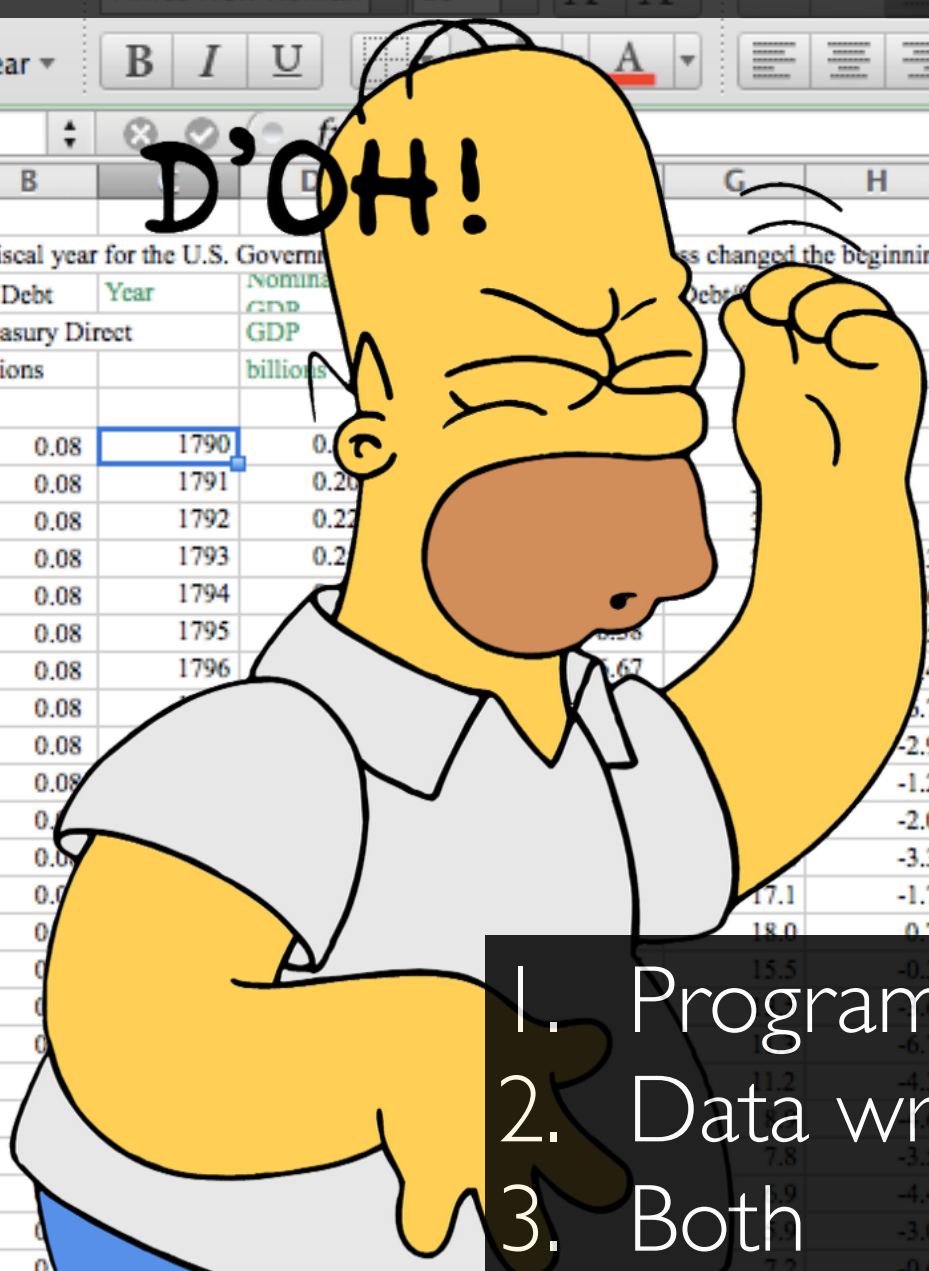
1. Program wrong  
2. Data wrong

	A	B	C	D	E	F	G	H	I	J
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4		US Treasury Direct		billions	billions	growth				
5		billions								
6										
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18	01/01/1802	0.0				4.9			1.3	
19	01/01/1803	0.0				3.1			-14.4	
20	01/01/1804	0.0				1.8			4.8	
21	01/01/1805	0.0				3.8			6.4	
22	01/01/1806	0.0				4.7				
23	01/01/1807	0.0								
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29	01/01/1813	0.0								
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# What's the Problem?

People make mistakes.

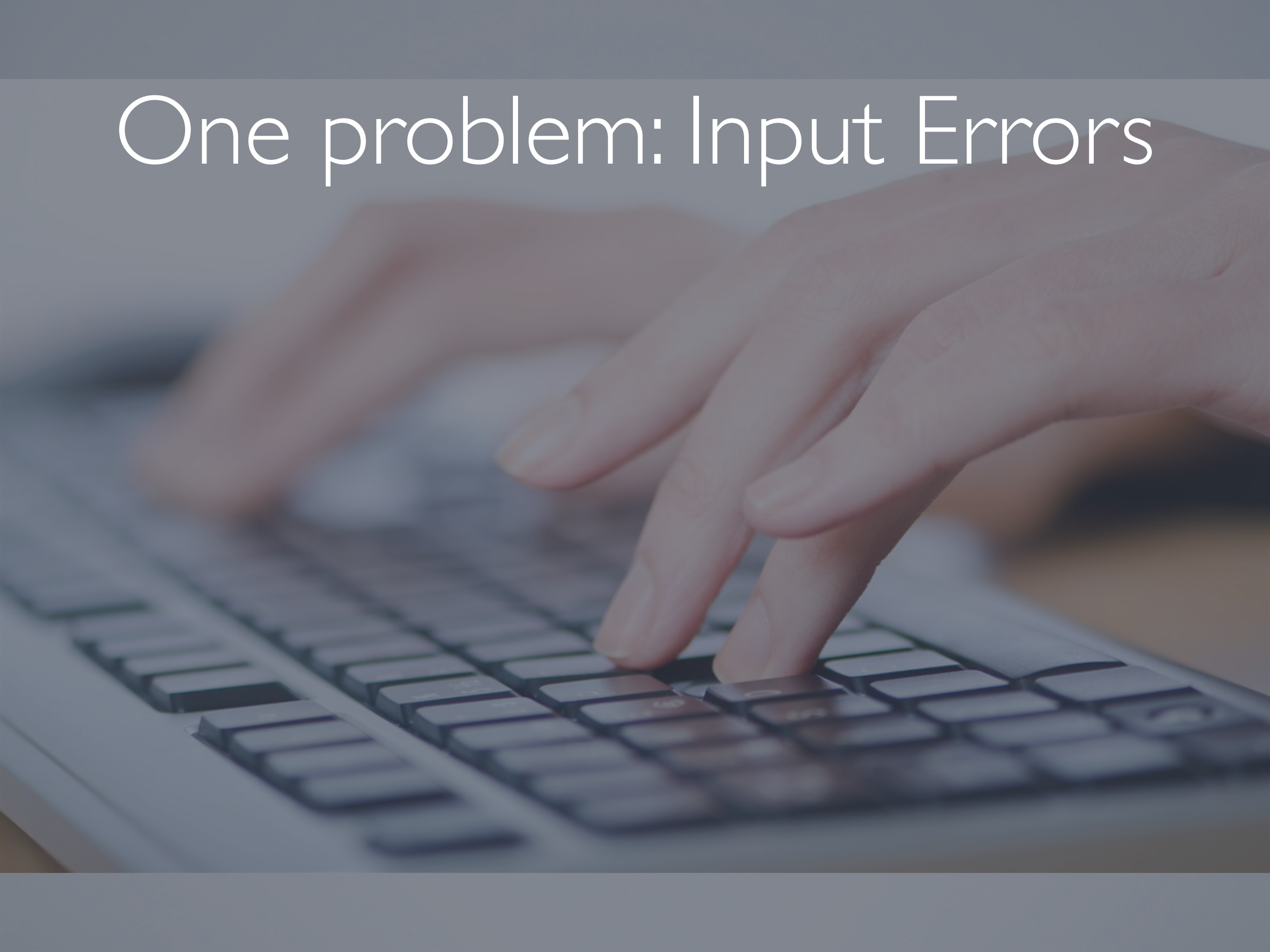
D'OH!



1. Program wrong  
2. Data wrong  
3. Both

	A	B	C	D	E	F	G	H	I	J
1	United States									
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6										
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10	01/01/1794	0.08	1793	0.2		8.1			5.1	
11	01/01/1795	0.08	1794			13.1			9.6	
12	01/01/1796	0.08	1795			6.4			15.2	
13	01/01/1797	0.08	1796			3.2			4.6	
14	01/01/1798	0.08				2.0			-1.9	
15	01/01/1799	0.08				4.3			-4.1	
16	01/01/1800	0.08				7.0			0.3	
17	01/01/1801	0.0				5.7			3.2	
18	01/01/1802	0.0				4.9			1.3	
19	01/01/1803	0.0				3.1			-14.4	
20	01/01/1804	0.0				1.8			4.8	
21	01/01/1805	0.0				3.8			6.4	
22	01/01/1806	0.0				4.7			-5.0	
23	01/01/1807	0.0				4.7			10.1	
24	01/01/1808	0.0				0.1			-1.3	
25	01/01/1809	0.0				5.6			-2.5	
26	01/01/1810	0.0				4.5			3.9	
27	01/01/1811	0.0				4.0			-1.3	
28	01/01/1812	0.0				5.7			16.4	
29	01/01/1813	0.0								
30	01/01/1814	0.08	1813	0.29	16.41	6.89	8.5	1.6		

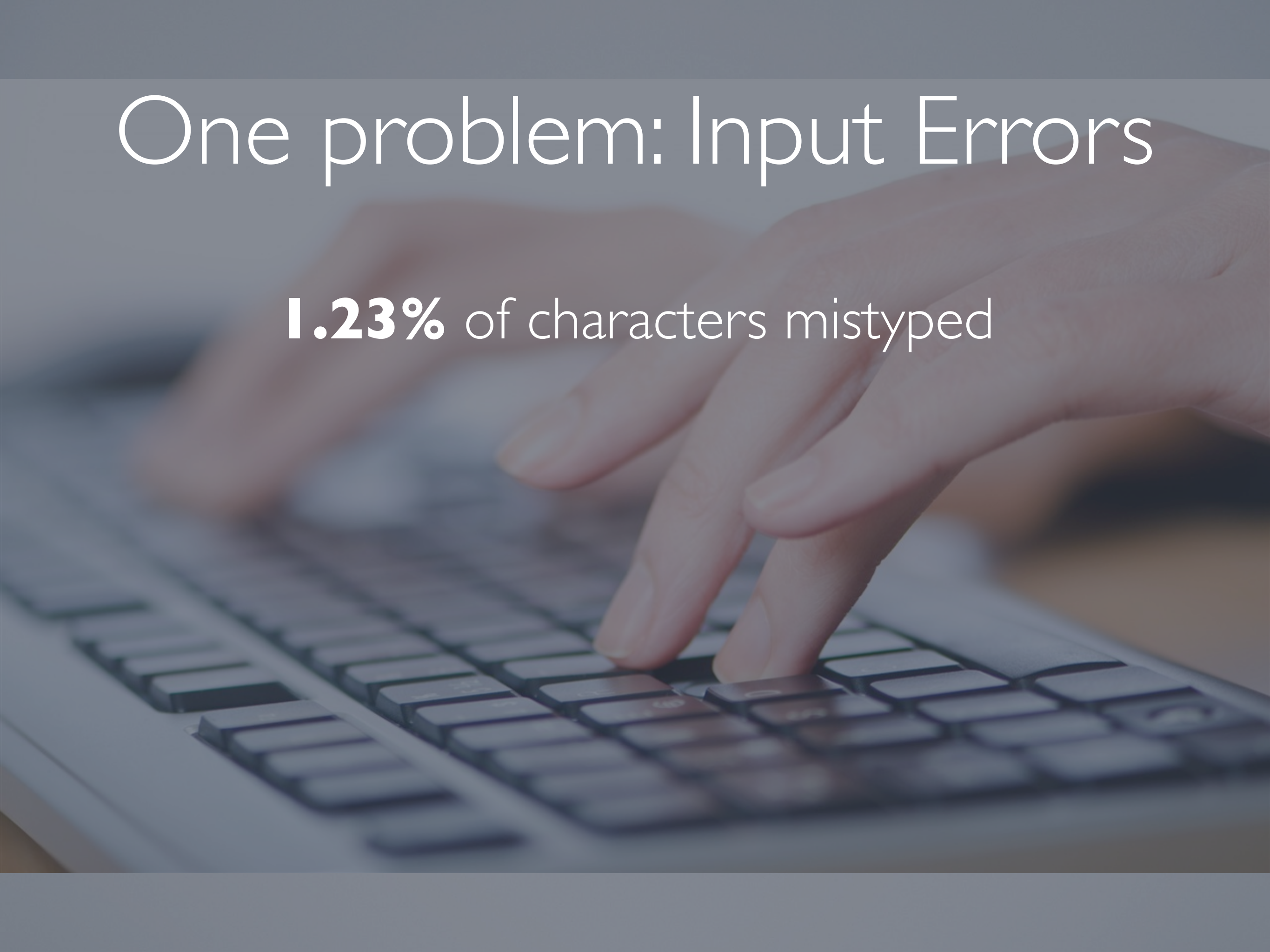
# One problem: Input Errors





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**1.23%** of characters mistyped



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**1.23%** of characters mistyped

**5.26%** of cells mistyped  
[Panko and us]



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**1.23%** of characters mistyped

**5.26%** of cells mistyped  
[Panko and us]

Large spreadsheets:

**at least one typo virtually guaranteed**

# One problem: Input Errors

**1.23%** of characters mistyped

**5.26%** of cells mistyped  
[Panko and us]

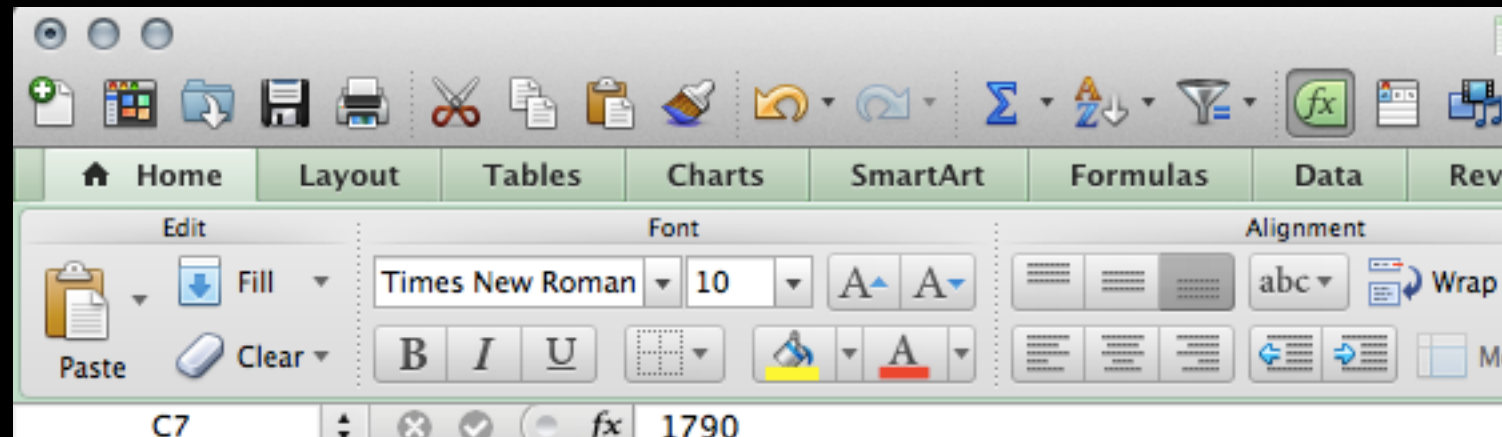
Large spreadsheets:

**at least one typo virtually guaranteed**

(not only source of errors)



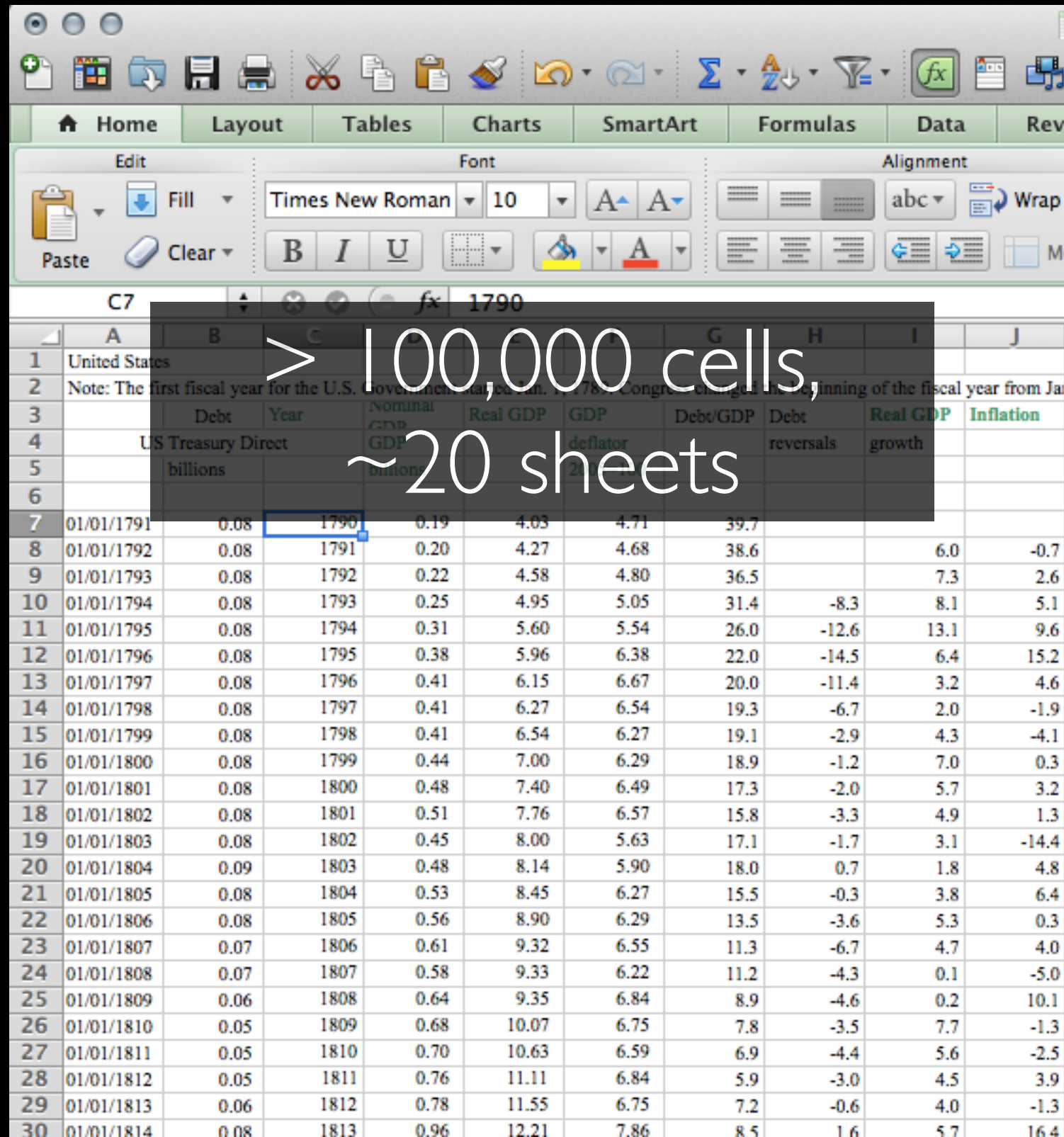
# Data + Formulas



The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4	US Treasury Direct			GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	01/01/1795	0.08	1794	0.31	5.60	5.54	26.0	-12.6	13.1	9.6
12	01/01/1796	0.08	1795	0.38	5.96	6.38	22.0	-14.5	6.4	15.2
13	01/01/1797	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
14	01/01/1798	0.08	1797	0.41	6.27	6.54	19.3	-6.7	2.0	-1.9
15	01/01/1799	0.08	1798	0.41	6.54	6.27	19.1	-2.9	4.3	-4.1
16	01/01/1800	0.08	1799	0.44	7.00	6.29	18.9	-1.2	7.0	0.3
17	01/01/1801	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	01/01/1802	0.08	1801	0.51	7.76	6.57	15.8	-3.3	4.9	1.3
19	01/01/1803	0.08	1802	0.45	8.00	5.63	17.1	-1.7	3.1	-14.4
20	01/01/1804	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	01/01/1805	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
22	01/01/1806	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
25	01/01/1809	0.06	1808	0.64	9.35	6.84	8.9	-4.6	0.2	10.1
26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4

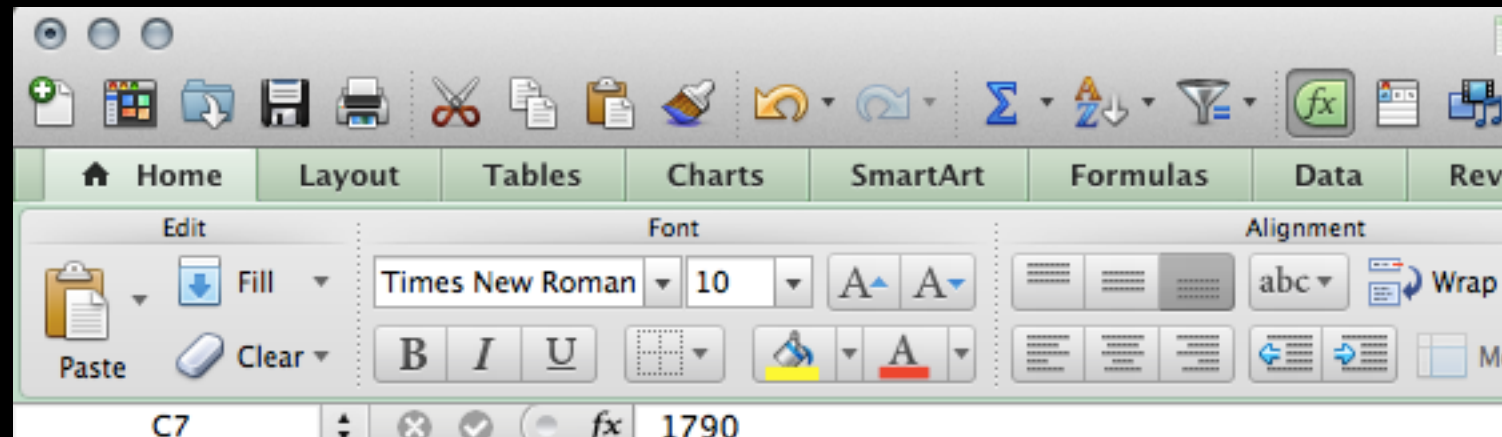
# Data + Formulas



The image shows a screenshot of the Microsoft Excel interface. The ribbon at the top includes tabs for Home, Layout, Tables, Charts, SmartArt, Formulas, Data, and Review. The 'Formulas' tab is active, showing the 'fx' button and various formula-related icons. The formula bar at the top displays '1790'. A large, semi-transparent text box is overlaid on the spreadsheet, containing the text '> 100,000 cells, ~20 sheets'. The spreadsheet itself contains a table with columns for 'United States', 'Debt', 'Year', 'Nominal GDP', 'Real GDP', 'GDP deflator', 'Debt/GDP', 'Debt reversals', 'Real GDP growth', and 'Inflation'. The data spans from the year 1790 to 1814.

	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan. 1 to Oct. 1 in 1800.									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4		US Treasury Direct		GDP	deflator			reversals	growth	
5		billions		billions	2000=100					
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	01/01/1795	0.08	1794	0.31	5.60	5.54	26.0	-12.6	13.1	9.6
12	01/01/1796	0.08	1795	0.38	5.96	6.38	22.0	-14.5	6.4	15.2
13	01/01/1797	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
14	01/01/1798	0.08	1797	0.41	6.27	6.54	19.3	-6.7	2.0	-1.9
15	01/01/1799	0.08	1798	0.41	6.54	6.27	19.1	-2.9	4.3	-4.1
16	01/01/1800	0.08	1799	0.44	7.00	6.29	18.9	-1.2	7.0	0.3
17	01/01/1801	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	01/01/1802	0.08	1801	0.51	7.76	6.57	15.8	-3.3	4.9	1.3
19	01/01/1803	0.08	1802	0.45	8.00	5.63	17.1	-1.7	3.1	-14.4
20	01/01/1804	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
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22	01/01/1806	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
25	01/01/1809	0.06	1808	0.64	9.35	6.84	8.9	-4.6	0.2	10.1
26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4

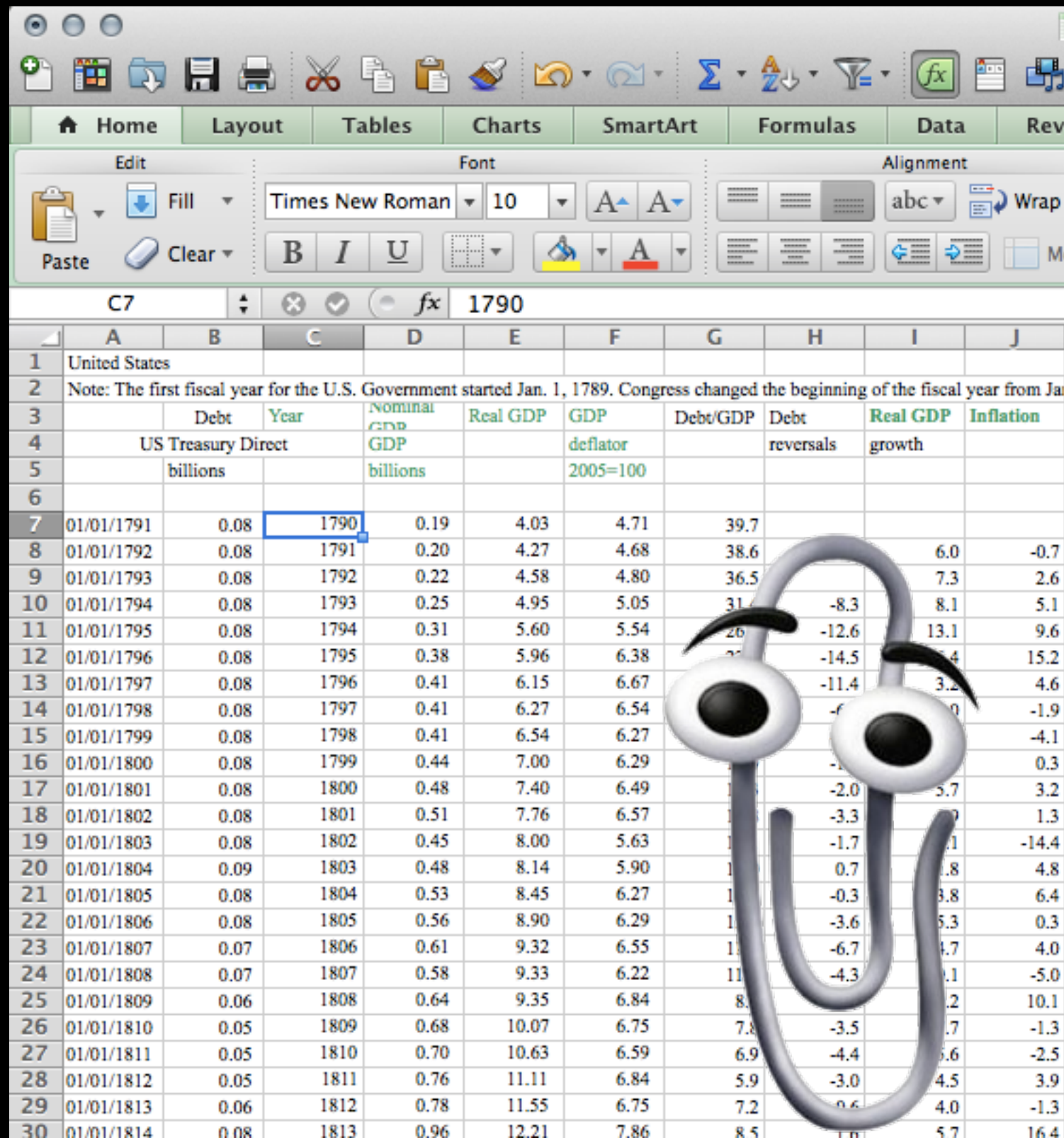
# Data + Formulas



	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4		US Treasury Direct		GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
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13	01/01/1797	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
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20	01/01/1804	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	01/01/1805	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
22	01/01/1806	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
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26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4



# Data + Formulas

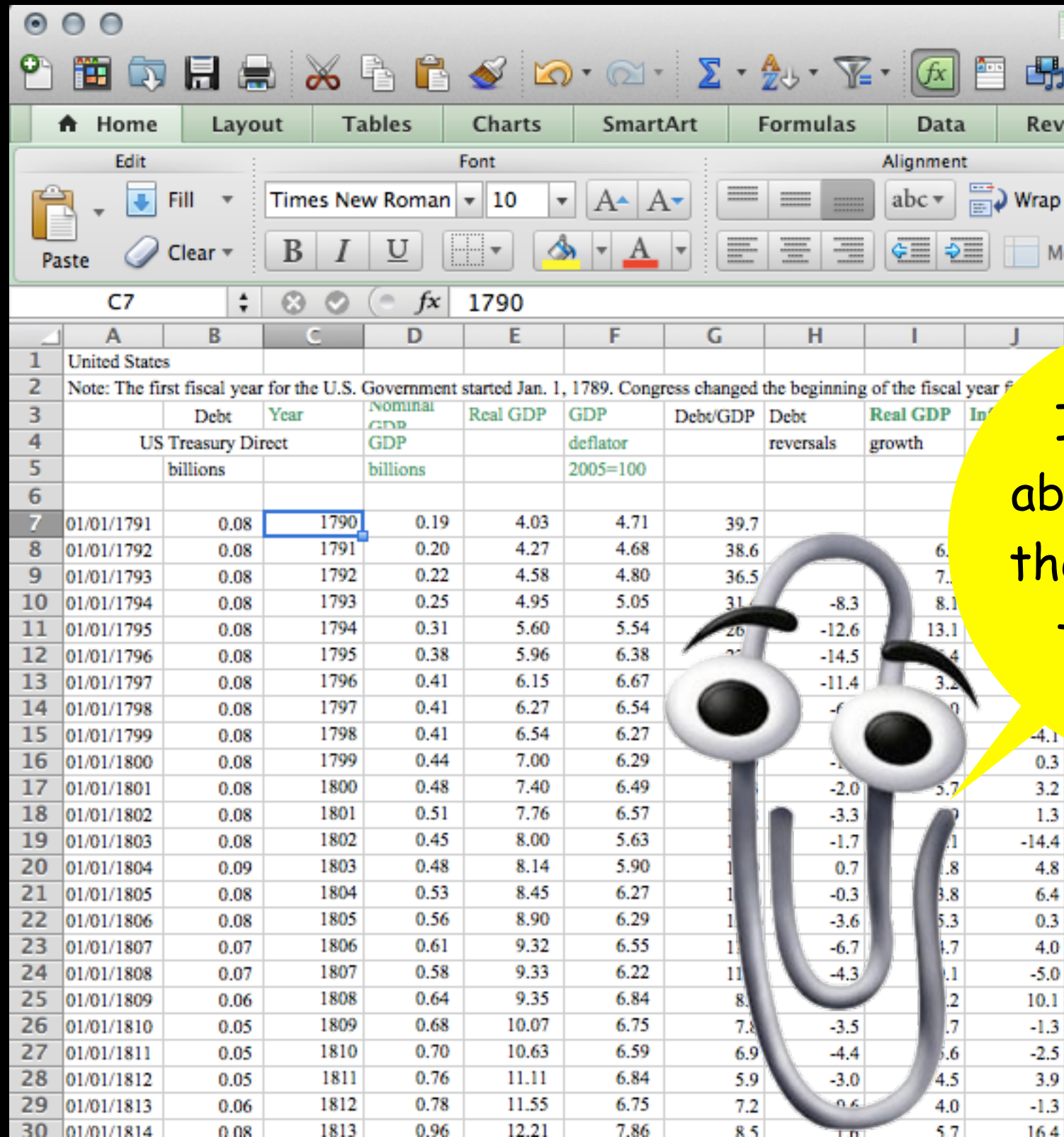


The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
4		US Treasury Direct		GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
6										
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	01/01/1795	0.08	1794	0.31	5.60	5.54	26.1	-12.6	13.1	9.6
12	01/01/1796	0.08	1795	0.38	5.96	6.38	22.1	-14.5	14.4	15.2
13	01/01/1797	0.08	1796	0.41	6.15	6.67	22.1	-11.4	3.2	4.6
14	01/01/1798	0.08	1797	0.41	6.27	6.54	22.1	-6.0	0.0	-1.9
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16	01/01/1800	0.08	1799	0.44	7.00	6.29	22.1	-1.1	0.3	0.3
17	01/01/1801	0.08	1800	0.48	7.40	6.49	11.1	-2.0	5.7	3.2
18	01/01/1802	0.08	1801	0.51	7.76	6.57	11.1	-3.3	0.0	1.3
19	01/01/1803	0.08	1802	0.45	8.00	5.63	11.1	-1.7	1.1	-14.4
20	01/01/1804	0.09	1803	0.48	8.14	5.90	11.1	0.7	1.8	4.8
21	01/01/1805	0.08	1804	0.53	8.45	6.27	11.1	-0.3	3.8	6.4
22	01/01/1806	0.08	1805	0.56	8.90	6.29	11.1	-3.6	5.3	0.3
23	01/01/1807	0.07	1806	0.61	9.32	6.55	11.1	-6.7	4.7	4.0
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.1	-4.3	0.1	-5.0
25	01/01/1809	0.06	1808	0.64	9.35	6.84	8.5	-3.5	1.2	10.1
26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-4.4	1.7	-1.3
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-3.0	1.6	-2.5
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.0	5.7	16.4



# Data + Formulas



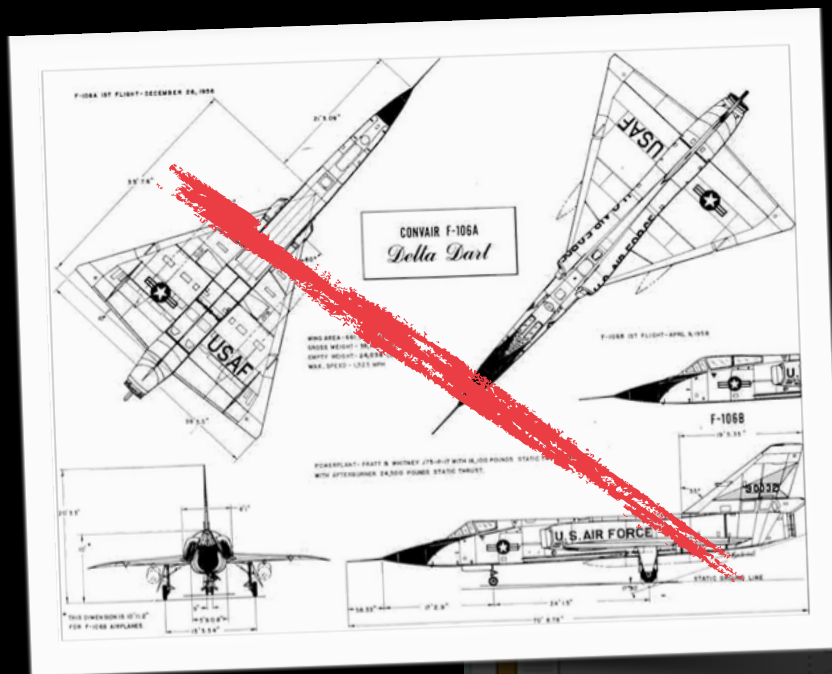
The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J
1	United States									
2	Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year for									
3		Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	In
4		US Treasury Direct		GDP		deflator		reversals	growth	
5		billions		billions		2005=100				
7	01/01/1791	0.08	1790	0.19	4.03	4.71	39.7			
8	01/01/1792	0.08	1791	0.20	4.27	4.68	38.6			
9	01/01/1793	0.08	1792	0.22	4.58	4.80	36.5			
10	01/01/1794	0.08	1793	0.25	4.95	5.05	31.1	-8.3	8.1	
11	01/01/1795	0.08	1794	0.31	5.60	5.54	26.1	-12.6	13.1	
12	01/01/1796	0.08	1795	0.38	5.96	6.38	22.1	-14.5	14.4	
13	01/01/1797	0.08	1796	0.41	6.15	6.67	20.1	-11.4	3.2	
14	01/01/1798	0.08	1797	0.41	6.27	6.54	18.1	-6.1	0.0	
15	01/01/1799	0.08	1798	0.41	6.54	6.27	17.1	-4.1	4.1	
16	01/01/1800	0.08	1799	0.44	7.00	6.29	16.1	-1.1	0.3	
17	01/01/1801	0.08	1800	0.48	7.40	6.49	15.1	-2.0	3.2	
18	01/01/1802	0.08	1801	0.51	7.76	6.57	14.1	-3.3	1.3	
19	01/01/1803	0.08	1802	0.45	8.00	5.63	13.1	-1.7	-14.4	
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23	01/01/1807	0.07	1806	0.61	9.32	6.55	9.1	-6.7	4.0	
24	01/01/1808	0.07	1807	0.58	9.33	6.22	11.1	-4.3	-5.0	
25	01/01/1809	0.06	1808	0.64	9.35	6.84	8.1	-3.5	10.1	
26	01/01/1810	0.05	1809	0.68	10.07	6.75	7.8	-3.5	-1.3	
27	01/01/1811	0.05	1810	0.70	10.63	6.59	6.9	-4.4	-2.5	
28	01/01/1812	0.05	1811	0.76	11.11	6.84	5.9	-3.0	3.9	
29	01/01/1813	0.06	1812	0.78	11.55	6.75	7.2	-0.6	-1.3	
30	01/01/1814	0.08	1813	0.96	12.21	7.86	8.5	1.0	16.4	

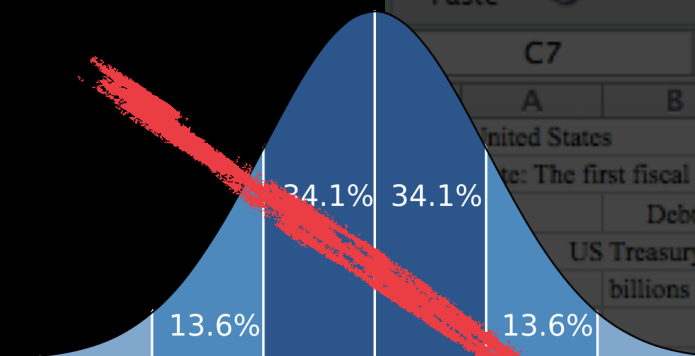
I see you are about to destroy the economies of the Western world...





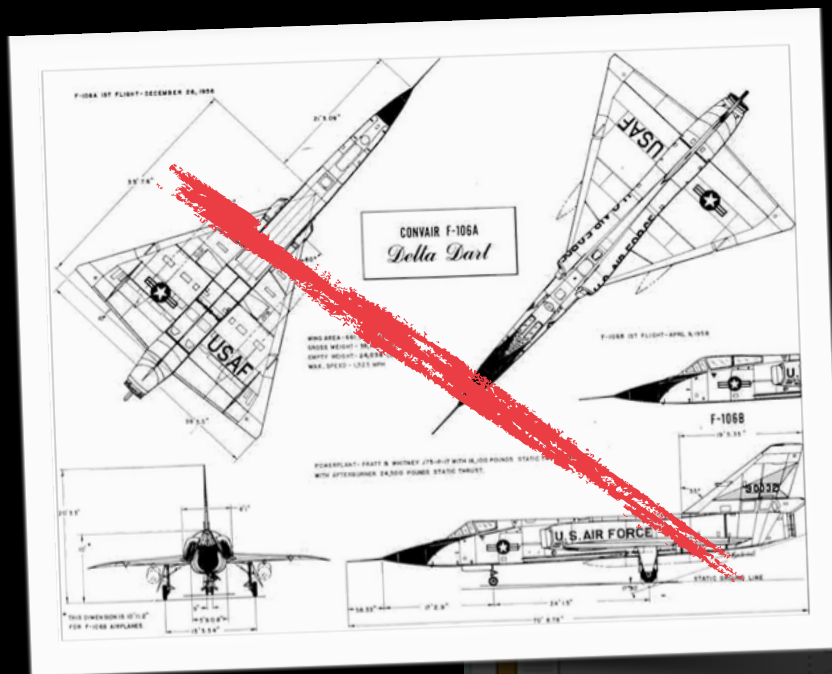
No specifications



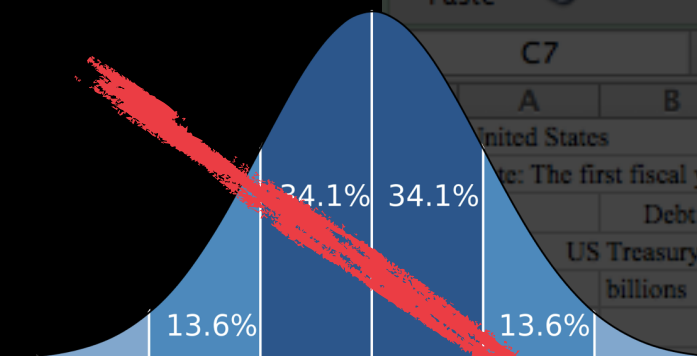
Can't assume distribution on inputs (+ strings!)

United States									
Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan. 1 to Oct. 1 in 1913.									
	Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
	US Treasury Direct		GDP		deflator	reversal	growth		
	billions		billions		2013=100				
7	0.08	1790	0.19	4.03	4.71	39.7			
8	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	0.08	1794	0.31	5.60	5.54	26.0	-12.6	13.1	9.6
12	0.08	1795	0.38	5.96	6.38	22.0	-14.5	6.4	15.2
13	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
14	0.08	1797	0.41	6.27	6.54	19.3	-6.7	2.0	-1.9
15	0.08	1798	0.41	6.54	6.27	19.1	-2.9	4.3	-4.1
16	0.08	1799	0.44	7.00	6.29	18.9	-1.2	7.0	0.3
17	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	0.08	1801	0.51	7.76	6.57	15.8	-3.3	4.9	1.3
19	0.08	1802	0.45	8.00	5.63	17.1	-1.7	3.1	-14.4
20	0.09	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
22	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	0.07	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	0.07	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
25	0.06	1808	0.64	9.35	6.84	8.9	-4.6	0.2	10.1
26	0.05	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4

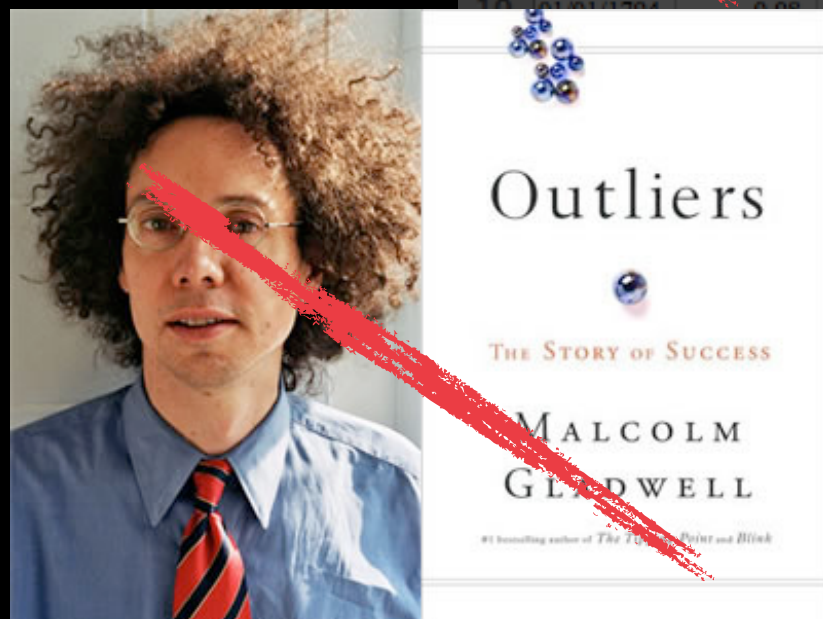




No specifications



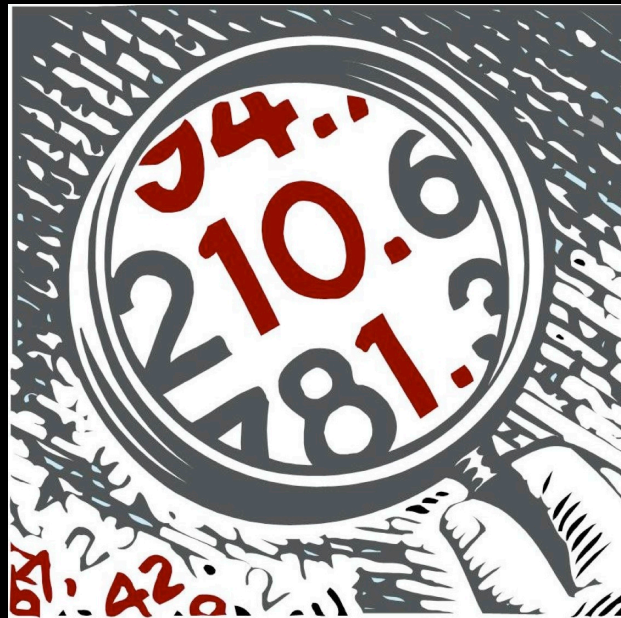
Can't assume distribution on inputs (+ strings!)



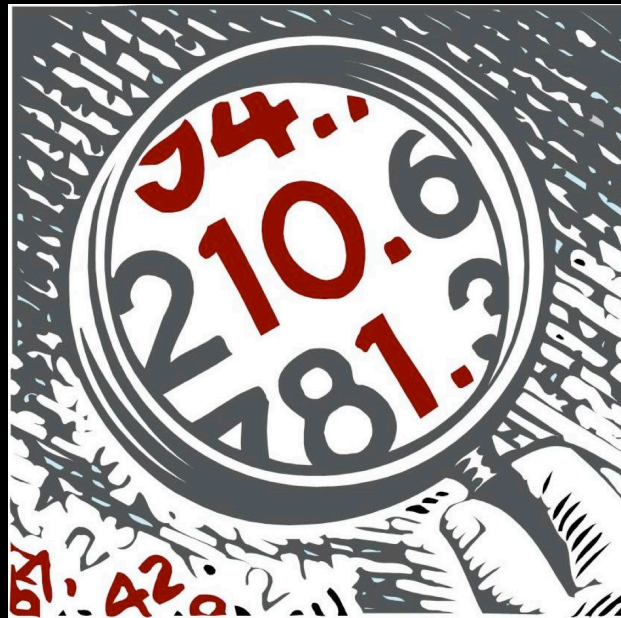
Can't use outlier analysis

United States									
Note: The first fiscal year for the U.S. Government started Jan. 1, 1789. Congress changed the beginning of the fiscal year from Jan. 1 to Oct. 1 in 1800.									
	Debt	Year	Nominal GDP	Real GDP	GDP	Debt/GDP	Debt	Real GDP	Inflation
	US Treasury Direct		GDP	deflator	2000=100	reversal	growth		
billions	billions								
7	0.08	1790	0.19	4.03	4.71	39.7			
8	0.08	1791	0.20	4.27	4.68	38.6		6.0	-0.7
9	0.08	1792	0.22	4.58	4.80	36.5		7.3	2.6
10	0.08	1793	0.25	4.95	5.05	31.4	-8.3	8.1	5.1
11	0.08	1794	0.31	5.60	5.54	26.0	-12.6	13.1	9.6
12	0.08	1795	0.38	5.96	6.38	22.0	-14.5	6.4	15.2
13	0.08	1796	0.41	6.15	6.67	20.0	-11.4	3.2	4.6
14	0.08	1797	0.41	6.27	6.54	19.3	-6.7	2.0	-1.9
15	0.08	1798	0.41	6.54	6.27	19.1	-2.9	4.3	-4.1
16	0.08	1799	0.44	7.00	6.29	18.9	-1.2	7.0	0.3
17	0.08	1800	0.48	7.40	6.49	17.3	-2.0	5.7	3.2
18	0.08	1801	0.51	7.75	6.55	16.8	-3.5	4.1	4.4
19	0.08	1802	0.45	8.00	5.63	17.7	1.7	3.3	4.4
20	0.08	1803	0.48	8.14	5.90	18.0	0.7	1.8	4.8
21	0.08	1804	0.53	8.45	6.27	15.5	-0.3	3.8	6.4
22	0.08	1805	0.56	8.90	6.29	13.5	-3.6	5.3	0.3
23	0.08	1806	0.61	9.32	6.55	11.3	-6.7	4.7	4.0
24	0.08	1807	0.58	9.33	6.22	11.2	-4.3	0.1	-5.0
25	0.08	1808	0.64	9.35	6.84	8.9	-4.6	0.2	10.1
26	0.08	1809	0.68	10.07	6.75	7.8	-3.5	7.7	-1.3
27	0.05	1810	0.70	10.63	6.59	6.9	-4.4	5.6	-2.5
28	0.05	1811	0.76	11.11	6.84	5.9	-3.0	4.5	3.9
29	0.06	1812	0.78	11.55	6.75	7.2	-0.6	4.0	-1.3
30	0.08	1813	0.96	12.21	7.86	8.5	1.6	5.7	16.4

# CheckCell

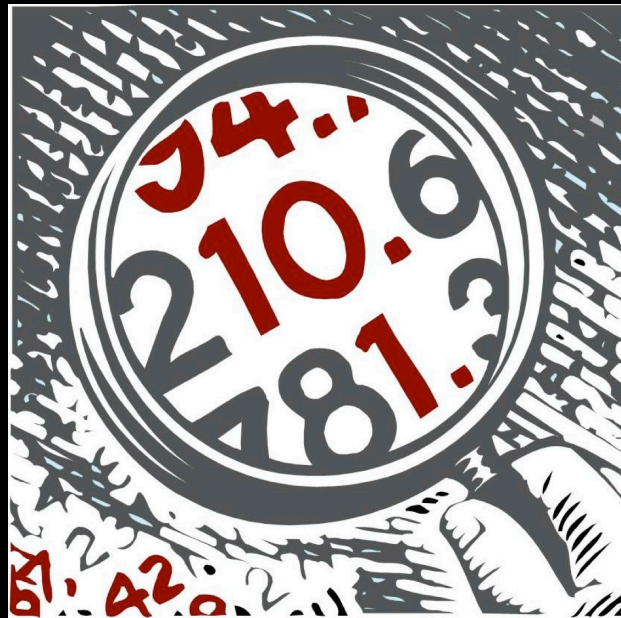


# CheckCell



analyzes *interaction*  
of data & formulas

# CheckCell



analyzes *interaction*  
of data & formulas

identifies cells with

**unusually high impact** on *outputs*



identifies cells with  
**unusually high impact** on *outputs*

identifies cells with  
**unusually high impact** on *outputs*



identifies cells with  
**unusually high impact** on *outputs*



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Masked ID	Ch 2	Ch 3	Ch 6	Ch 4	Ch 5	Ch 8	Ch 9	Hmwk	Lab	Exam I	Exam II	Project	Final	Indiv.	TOTAL	FINAL	Sliding
2		hmwk 1	hmwk 2	hmwk 3	hmwk 4	hmwk 5	hmwk 6	hmwk 7					Total	Exam	Adjust.	SCORE	GRADE	Scale
3	Percent:								15	25	15	15	15	15	(shown only	100.0		Cutoffs
4	MAX:	100	50	135	115	100	50	100	650	100	100	100	100	100	if it had an	100	A:	88.2
5	HI:	100	50	135	115	100	50	100	98	98	100	97	135	96.0	effect on	98.2	B:	79.2
6	AVG:	92	44	131	91	91	46	76	86	90	77	76	92	75	your final	83	C:	67.5
7	LO:	68	21	113	0	15	20	28	12	48	47	39	44	45	grade)	26	D:	58.0
8																		
9	xxxxx0083	97	49	129	90	95	50	75	90	91	69	82	92	87		85.8	B	
10	xxxxx0101	100	50	135	90	98	50	90	94	97	88	82	101	89		92.3	A	
11	xxxxx0178	82	41	124	0	15	50	51	56	85	50	61	78	77		69.5	C	
12	xxxxx0496	93	49	129	95	80	50	33	81	91	88	85	61	70		80.7	B	
13	xxxxx0530	100	48	135	90	98	43	75	91	91	84	76	77	64		81.4	B	
14	xxxxx0766	95	49	129	63	98	50	85	88	92	59	70	67	62		74.9	C	
15	xxxxx0798	78	40	130	110	100	50	100	94	82	63	82	89	68		79.9	B-	
16	xxxxx0840	91	44	133	95	100	50	90	93	95	91	85	103	85		92.3	A	
17	xxxxx0852	91	38		65	80	40	80	61	82	66	64	45	62		65.1	D+	
18	xxxxx0854	98	29	134	113	95	40	78	90	86	88	79	97	85		87.3	B+	
19	xxxxx1471	99	50	129	82	98	50	100	94	93	78	79	104	74		87.4	B+	
20	xxxxx1777	98	48	135	115	100	50	85	97	88	81	55	116	70		84.9	B	
21	xxxxx1842	88	45	134	98	100	38	68	88	84	63	45	88	66		73.4	C	
22	xxxxx1869	100	49	131	115	100	50	91	98	76	78	67	96	64		79.4	B-	
23	xxxxx1909	93	35	135	105	100	50	100	95	95	97	94	106	96		96.9	A+	
24	xxxxx1957	88	45	134	98	100	38	68	88	91	69	79	88	94		85.5	B	
25	xxxxx2061	100	49	131	115	100	50	91	98	86	88	88	96	91		90.7	A	
26	xxxxx2079	75	21	113		85	20	73	60	82	56	58	74	62		66.9	D+	
27	xxxxx2107	95	49	129	63	98	50	85	88	93	81	73	67	81		81.8	B	
28	xxxxx2303	99	29	134	53	85	50	40	75	89	84	76	121	91		89.3	A	
29	xxxxx2371	82	41	124	0	15	50	51	56	90	84	73	78	70	2	78.7	C+	
30	xxxxx2390	90	44	132	93	95	33	68	85	95	88	79	91	77		86.7	B+	
31	xxxxx2431	96	49	125	115	96	50	85	95	91	59	70	99	53		79.2	B-	
32	xxxxx2434	93	46	135	95	100	50	28	84	96	94	97	89	94	3	95.8	A+	
33	xxxxx2685	92	46	135	108	96	35	90	93	95	88	82	135	85		96.2	A+	
34	xxxxx2913	91	38		65	80	40	80	61	91	72	82	45	77		73.3	C	
35	xxxxx3047	96	49	125	115	96	50	85	95	96	66	82	99	77		86.9	B+	
36	xxxxx3227	95	49	129	63	98	50	85	88	92	88	91	67	89		86.4	B+	
37	xxxxx3335	86	48	135	115	100	50	88	96	86	78	61	117	66		84.2	B	
38	xxxxx3360	100	50	135	90	98	50	90	94	97	94	94	101	94		95.8	A+	
39	xxxxx3365	75							12	48	81					26.0	F	
40	xxxxx3459	92	46	135	108	96	35	90	93	93	81	85	135	79		94.1	A	
41	xxxxx3738	91	38		65	80	40	80	61	87	63	76	45	68		68.6	C	
42	xxxxx3817	96	40	130	110	100	50	100	96	93	63	91	89	81		86.3	B+	
43	xxxxx3934	98	29	134	113	95	40	78	90	82	63	58	97	45		73.6	C	
44	xxxxx4228	93	49	129	95	80	50	33	81	96	88	85	61	89		84.6	B	
45	xxxxx4235	100	50	135	90	98	50	90	94	91	78	82	101	72		86.9	B+	
46	xxxxx4236	88	45	134	98	100	38	68	88	85	63	61	88	70		76.7	C	
47	xxxxx4374	98	29	134	113	95	40	78	90	79	72	70	97	72		79.9	B-	
48	xxxxx4382	93	46	135	95	100	50	28	84	90	56	76	89	49		75.6	C	





Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze ☒ Mark as OK ☐ Fix Error ☐ Start Over

% Most Unusual to Show 5.0

CheckCell

K18 fx

	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
5	HW 4	93		<b>Final grade</b>	84.275				
6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
10	Exam 1	84							
11	Exam 2	78							
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Sheet1 Sheet2 Sheet3

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Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

CheckCell

K18 fx

	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
5	HW 4	93		<b>Final grade</b>	84.275				
6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
10	Exam 1	84							
11	Exam 2	78							
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Sheet1 Sheet2 Sheet3

Ready 100%

Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

Looking for errors...

Data Debug

Press F1 for add-in help.

	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
5	HW 4	93		<b>Final grade</b>	84.275				
6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
7	Quiz 2	90							
8	Quiz 3	85							
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Sheet1 Sheet2 Sheet3

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Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

CheckCell

B11 fx 78

	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
5	HW 4	93		<b>Final grade</b>	84.275				
6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
7	Quiz 2	90							
8	Quiz 3	85							
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10	Exam 1	84							
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Sheet1 Sheet2 Sheet3

Ready 100%

Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK **Fix Error** Start Over

% Most Unusual to Show 5.0

CheckCell

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	A	B	C	D	E	F	G	H	I
1	Assignment	Grade		Homework	20%				
2	HW 1	84		Quizzes	30%				
3	HW 2	77		Exams	50%				
4	HW 3	92							
5	HW 4	93		Final grade	84.275				
6	Quiz 1	87		Pass/Fail	Fail				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
10	Exam 1	84							
11	Exam 2	78							
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Sheet1 Sheet2 Sheet3

Ready 100%

Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

**CellFixForm**

Enter the corrected value:

87

Cancel Fix

	A			
1	Assignment			
2	HW 1			
3	HW 2			
4	HW 3			
5	HW 4	93	Final grade	84.275
6	Quiz 1	87	Pass/Fail	Fail
7	Quiz 2	90		
8	Quiz 3	85		
9	Quiz 4	91		
10	Exam 1	84		
11	Exam 2	78		
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Sheet1 Sheet2 Sheet3

Ready 100%

Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

CheckCell

B10 fx 84

	A	B	C	D	E	F	G	H	I
1	Assignment	Grade		Homework	20%				
2	HW 1	84		Quizzes	30%				
3	HW 2	77		Exams	50%				
4	HW 3	92							
5	HW 4	93		Final grade	86.525				
6	Quiz 1	87		Pass/Fail	Pass				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
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11	Exam 2	87							
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Sheet1 Sheet2 Sheet3

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Grades spreadsheet.xlsx - Microsoft Excel

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Analyze Mark as OK Fix Error Start Over

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CheckCell

B10 fx 84

	A	B	C	D	E	F	G	H	I
1	Assignment	Grade		Homework	20%				
2	HW 1	84		Quizzes	30%				
3	HW 2	77		Exams	50%				
4	HW 3	92							
5	HW 4	93		Final grade	86.525				
6	Quiz 1	87		Pass/Fail	Pass				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
10	Exam 1	84							
11	Exam 2	87							
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Sheet1 Sheet2 Sheet3

Ready 100%

Grades spreadsheet.xlsx - Microsoft Excel

File Home Insert Page Layout Formulas Data View Add-Ins

Analyze Mark as OK Fix Error Start Over

% Most Unusual to Show 5.0

CheckCell

B10 84

	A	B	C	D	E	F	G	H	I
1	Assignment	Grade		Homework	20%				
2	HW 1	84		Quizzes	30%				
3	HW 2	77		Exams	50%				
4	HW 3	92							
5	HW 4	93		Final grade	86.525				
6	Quiz 1	87		Pass/Fail	Pass				
7	Quiz 2	90							
8	Quiz 3	85							
9	Quiz 4	91							
10	Exam 1	84							
11	Exam 2	87							
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No bugs remain.

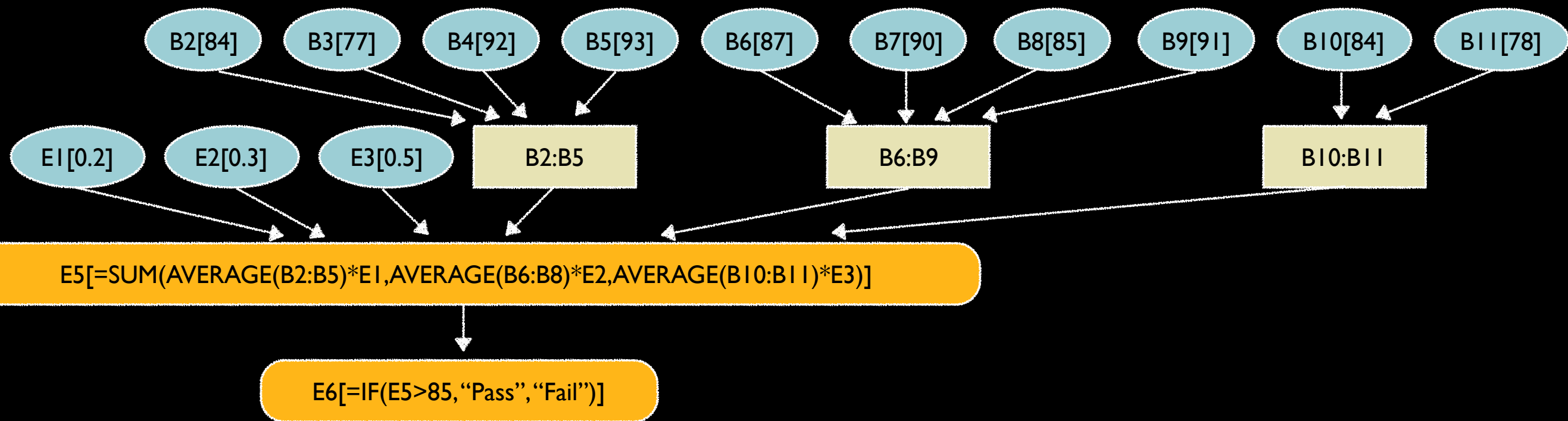
OK

Sheet1 Sheet2 Sheet3

Ready 100%

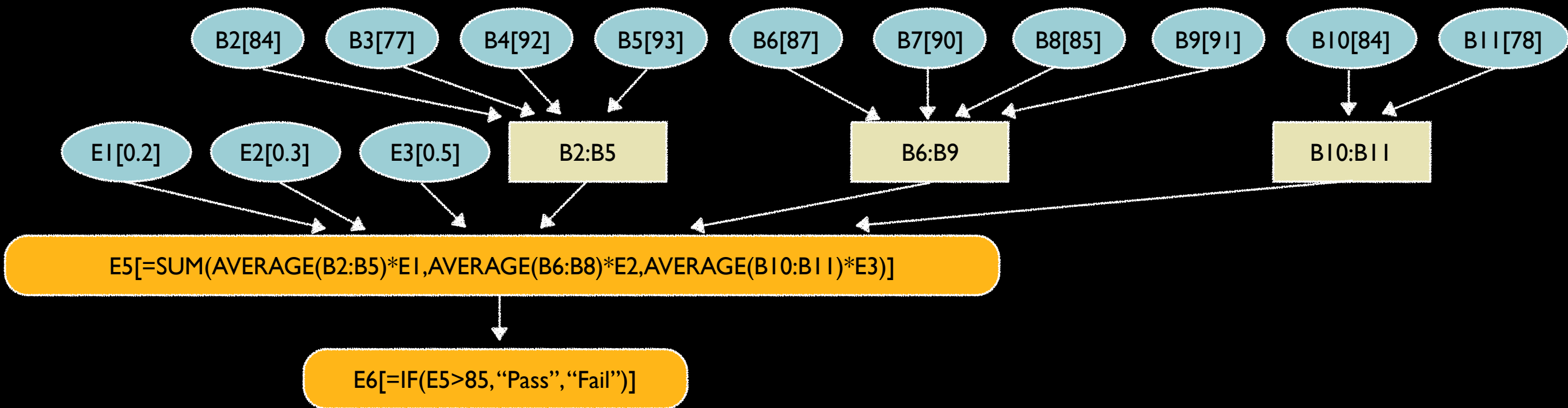
# How CheckCell Works

# How CheckCell Works





# How CheckCell Works



*Dependence Graph:  
Identifies Inputs and Outputs*



[illegible]

	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
5	HW 4	93		<b>Final grade</b>	84.275				
6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
7	Quiz 2	90							
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*not an outlier!*







	A	B	C	D	E	F	G	H	I
1	<u>Assignment</u>	<u>Grade</u>		<i>Homework</i>	20%				
2	HW 1	84		<i>Quizzes</i>	30%				
3	HW 2	77		<i>Exams</i>	50%				
4	HW 3	92							
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6	Quiz 1	87		<b>Pass/Fail</b>	Fail				
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Bootstrap-based Impact Analysis  
*non-parametric technique*  
*samples definitely from population*

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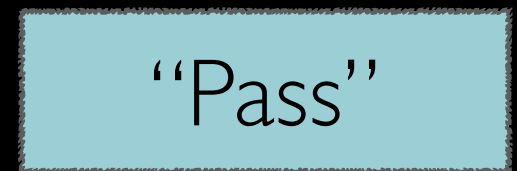
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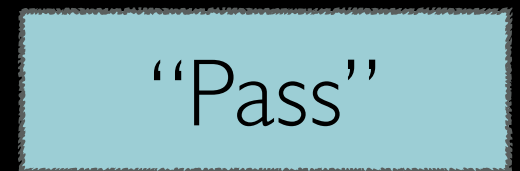
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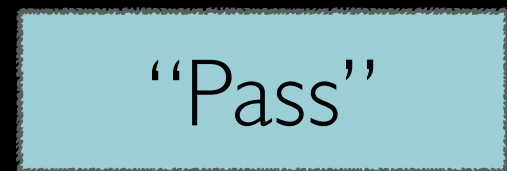
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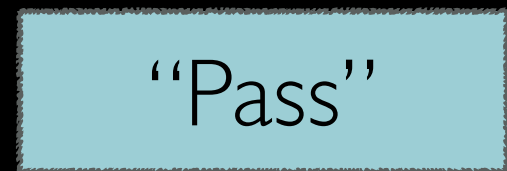
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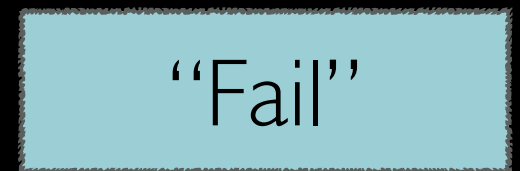


77
90
90
92
87
90
85
93
84
84

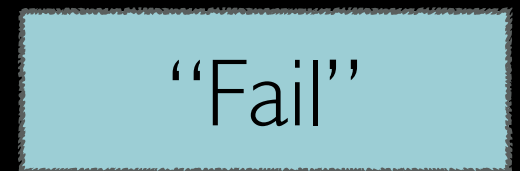




87
90
87
77
87
84
77
93
78
77



87
90
87
77
87
84
77
93
78
77



# Bootstrap Results

# Pass

# Fail

# Pass

# Pass

# Fail

# Fail

# Fail

# Fail

# Fail

# Fail

# Pass

# Pass

# Fail

# Pass

# Pass

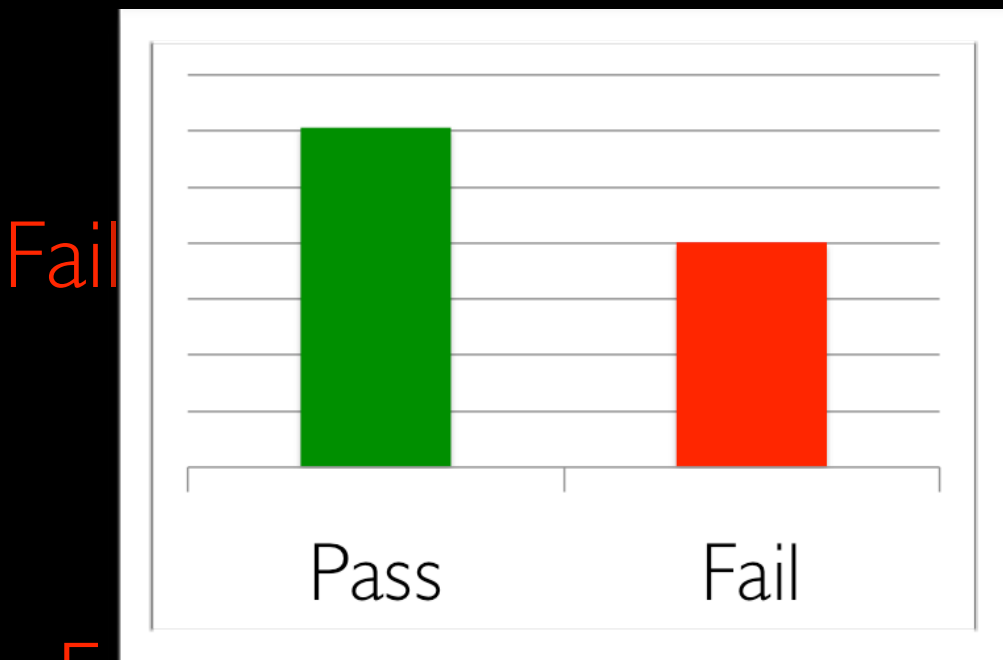
*All outputs*

# Bootstrap Results

# Pass

# Fail

# Pass



# Fail

# Fall

# Pass

# Pass

# Fail

# Pass

# Pass

*All outputs*

# CheckCell

Pass

Fail

Pass

Pass

Fail

Pass

Pass

Pass

Pass



# CheckCell

Pass

Fail

Pass

Pass

Fail

Pass

Pass

Pass

Pass

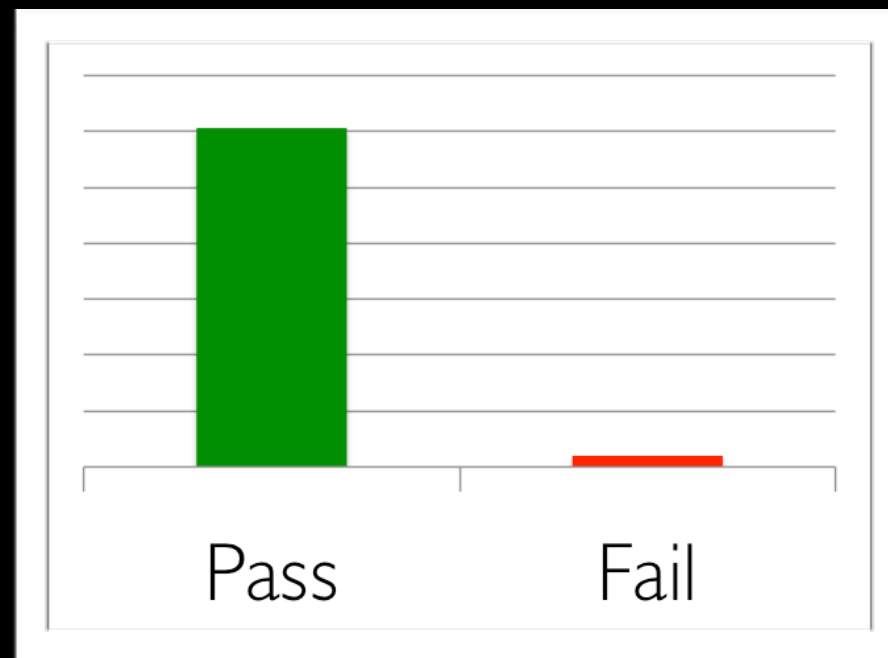
*Isolate outputs that depend on 78*

# CheckCell

Pass

Fail

Pass



Fail

Pass

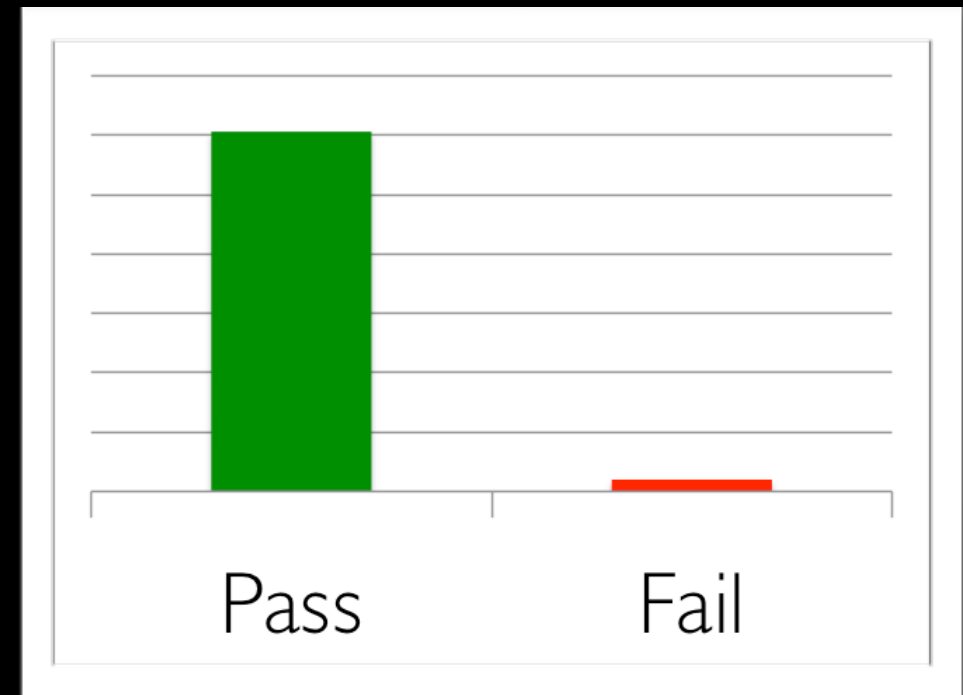
Pass

Pass

Pass

*Isolate outputs that depend on 78*

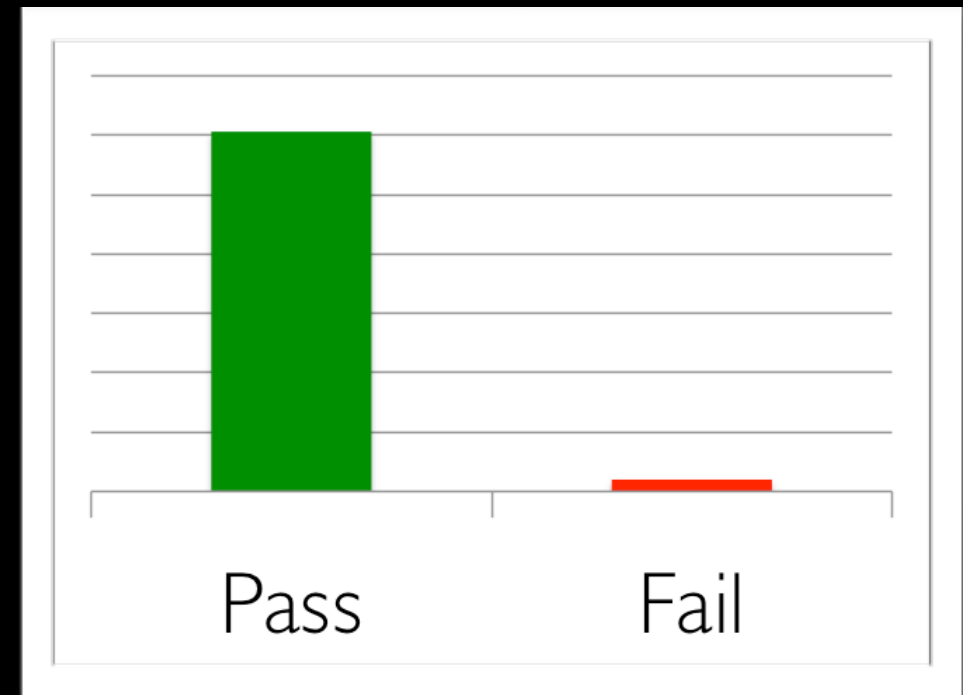
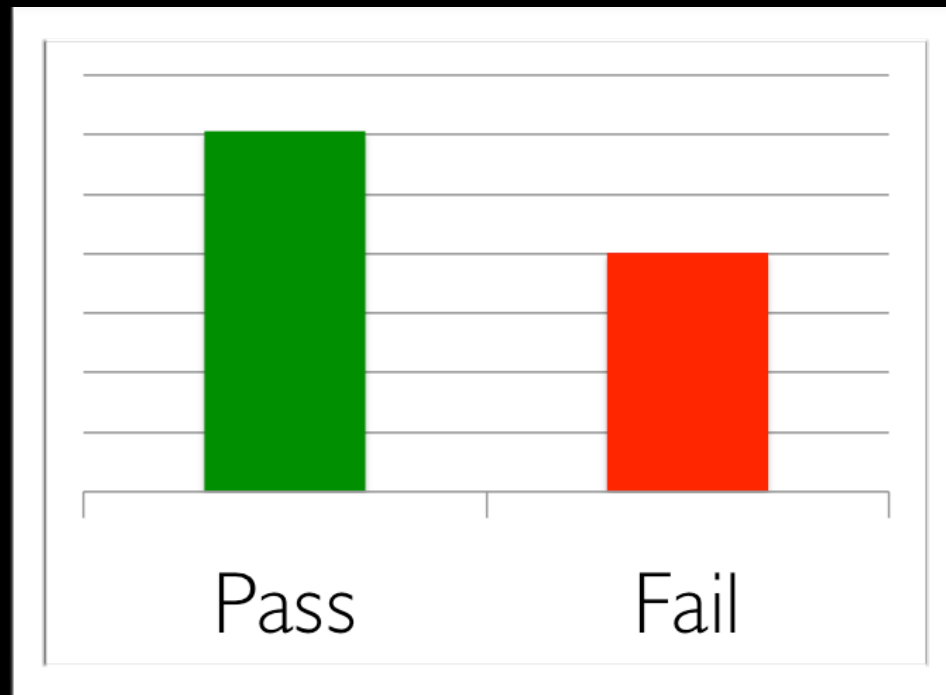
# CheckCell



exclude "78"

...

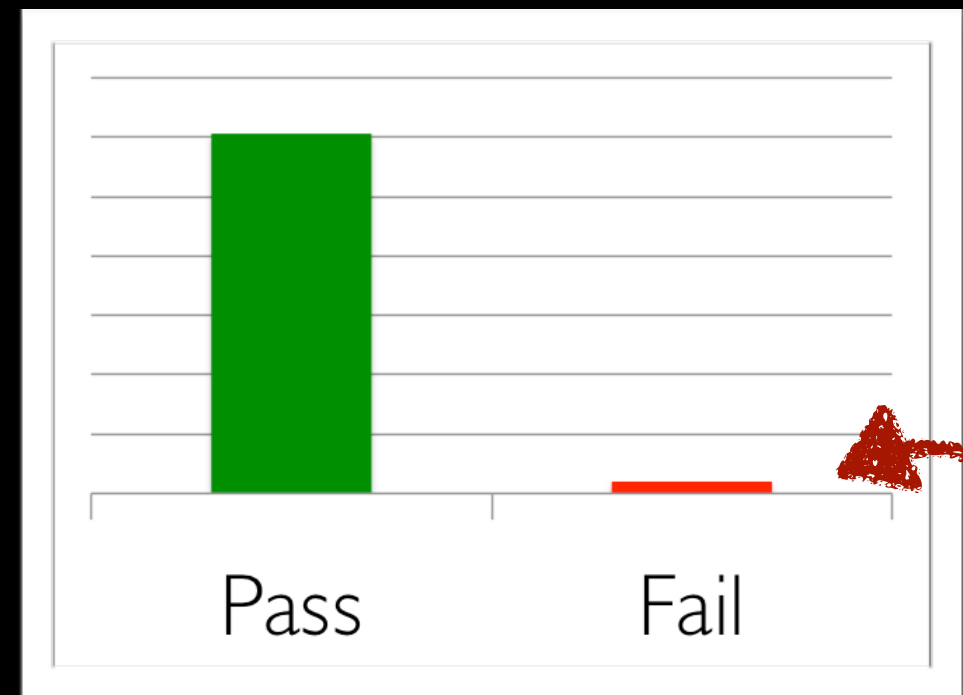
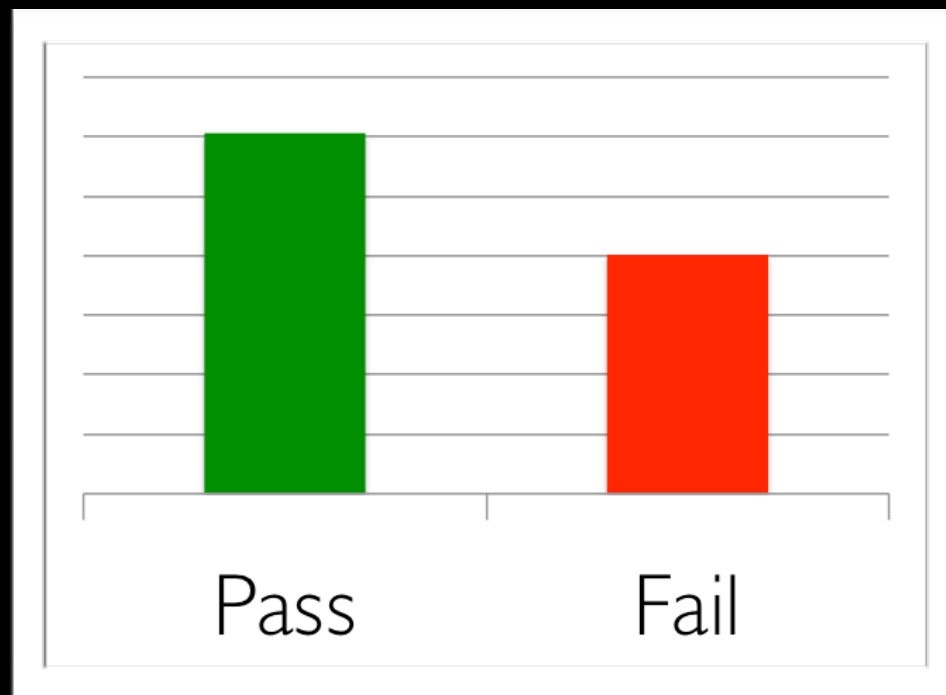
# CheckCell



exclude "78"

...

# CheckCell



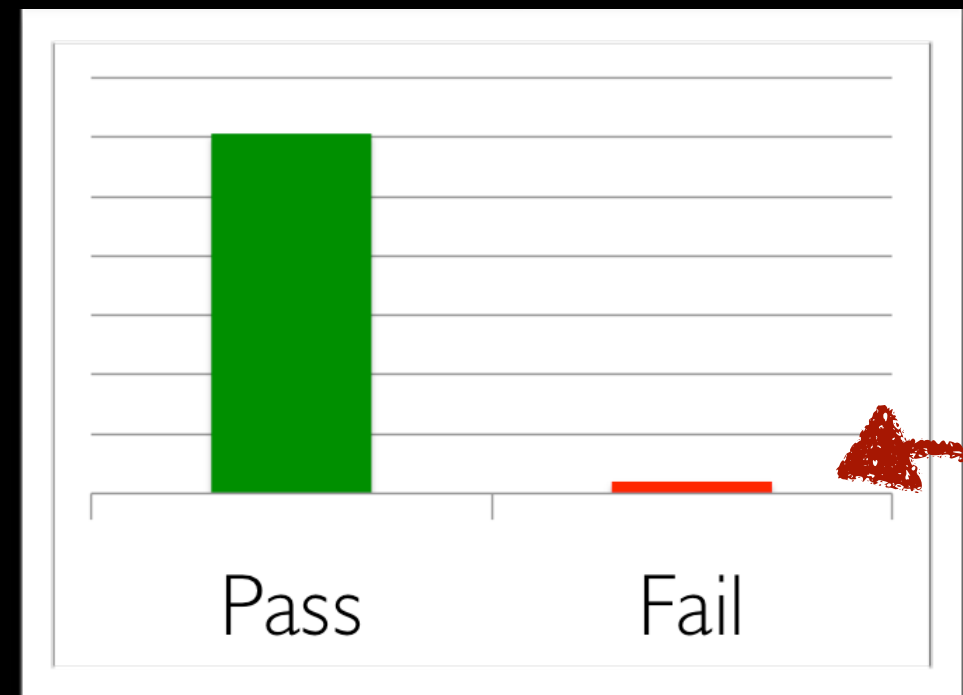
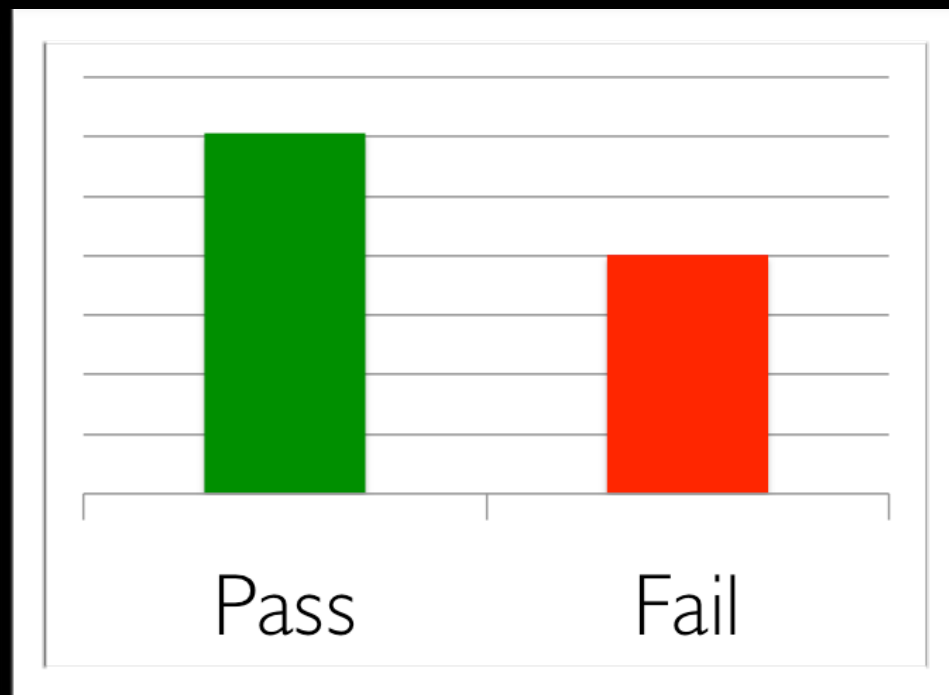
exclude "78"

...

$p < 0.05?$



# CheckCell

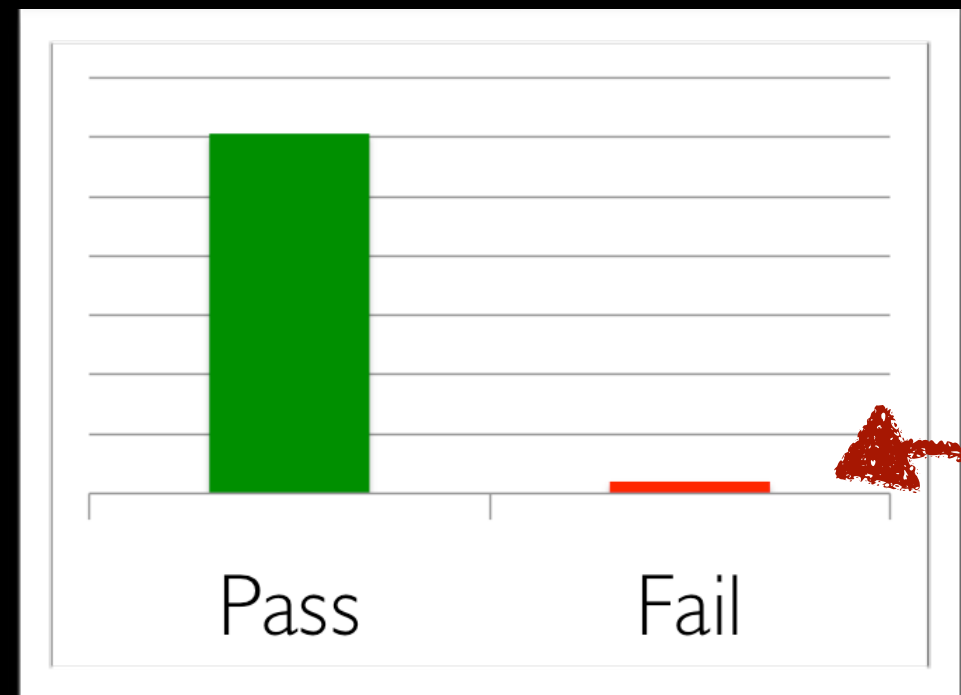
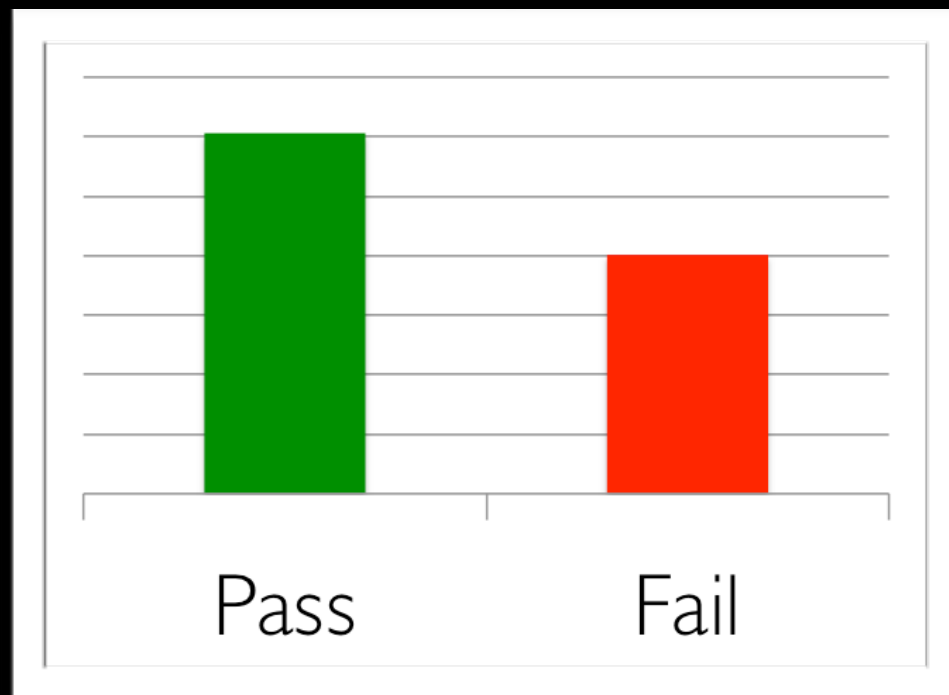


exclude "78"

...

$p < 0.05?$   
**yes!**

# CheckCell

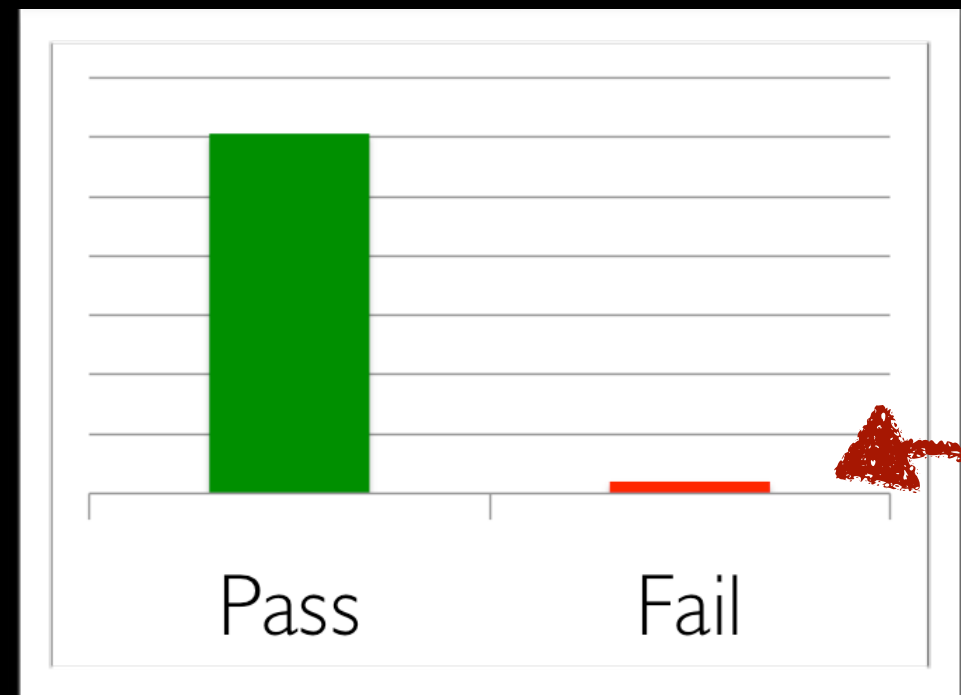
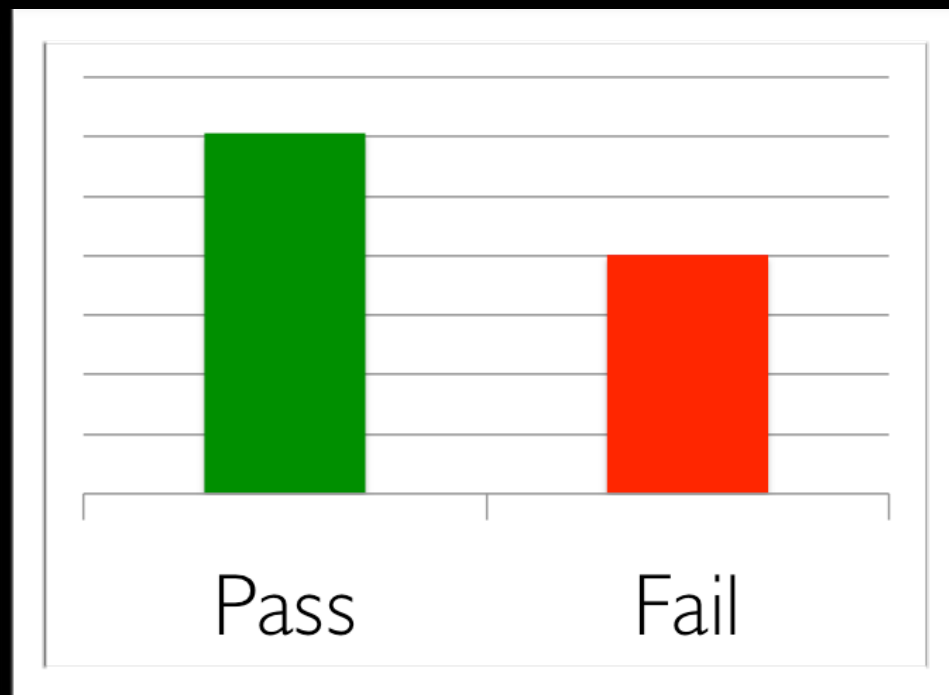


exclude "78"

...

$p < 0.05?$   
**yes!**  
**"unusual!"**

# CheckCell



exclude "78"

...

$p < 0.05?$

**yes!**

**"unusual!"**

*in paper: string outputs, ranking, etc.*

# How Well Does It Work?

# How Well Does It Work?

The image displays three overlapping screenshots of Microsoft Excel, illustrating various spreadsheet features and financial data.

**Top Left Screenshot:** Shows a spreadsheet with columns A through R. The data includes a list of 'Masked ID' (e.g., 1000000001, 1000000002) and corresponding 'Ch 2' values (e.g., 100, 100). The 'Percent' column shows values like 100%, 100%, 92%, and 68%.

**Top Right Screenshot:** Shows the Excel ribbon with the 'Formulas' tab selected. The ribbon includes options for 'Edit', 'Font', 'Alignment', 'Number', 'Format', 'Cells', and 'Themes'. The 'Formulas' tab is active, showing various formula functions like 'SUM', 'AVERAGE', 'COUNT', etc.

**Bottom Screenshot:** Shows a detailed financial statement for 'The Cooper Companies, Inc.' titled 'Financial Highlights'. The statement includes a consolidated profit and loss account and a consolidated financial position statement for the years 2000, 1999, and 1998.

**Consolidated Profit and Loss Account (The Cooper Companies, Inc.):**

	2000	1999	1998
Total turnover	\$151,788	\$135,978	\$119,210
Less share of joint ventures	(45,520)	(29,350)	(27,982)
Less share of associates	(197,317)	(165,328)	(147,192)
Group turnover	\$46,869	\$38,811	\$29,790
Cost of sales	(499)	(395)	(329)
Gross profit	\$47,368	\$39,216	\$30,119
Operating exceptional items	(156)	(164)	(561)
Amortisation of goodwill	(42,127)	(32,712)	(23,087)
Other net operating expenses	(16,711)	(16,711)	(16,711)
Total net operating expenses	(58,994)	(80,297)	(57,359)
Group operating profit	\$2,374	\$1,204	\$1,459
Share of joint ventures' operating profit	(432)	(432)	(432)
Share of associates' operating profit	(129)	(129)	(129)
Total operating profit : Group and share	\$1,813	\$543	\$898
Net loss on disposal of businesses	(6,309)	(9,149)	(8,661)
Net profit on sale of fixed assets	(6,309)	(9,149)	(8,661)
Profit on sale of investments	(6,309)	(9,149)	(8,661)
Exceptional items	(6,309)	(9,149)	(8,661)
Net interest payable and similar charges	(6,309)	(9,149)	(8,661)
Profit on ordinary activities before taxation	(6,309)	(9,149)	(8,661)
Taxation on profit on ordinary activities	(6,309)	(9,149)	(8,661)
Profit on ordinary activities after taxation	(6,309)	(9,149)	(8,661)
Equity minority interests	(6,309)	(9,149)	(8,661)
Profit for the financial year	(6,309)	(9,149)	(8,661)
Dividends - paid and proposed	(6,309)	(9,149)	(8,661)
Retained (loss)/profit for the financial year	(6,309)	(9,149)	(8,661)
Profit for the financial year	(6,309)	(9,149)	(8,661)

**Consolidated Financial Position (The Cooper Companies, Inc.):**

	October 31, 2000	October 31, 1999	October 31, 1998
Assets:			
Cash and cash equivalents	\$14,608	\$20,922	\$7,333
Other current assets	\$98,077	\$79,539	\$108,744
Total current assets	\$112,685	\$100,461	\$116,077
Property, plant and equipment, net	\$47,933	\$40,319	\$42,344
Intangible assets, net	\$110,854	\$80,518	\$84,308
Other assets	\$51,093	\$64,575	\$61,422
Total assets	\$222,569	\$185,873	\$202,151
Liabilities and stockholders' equity (deficit):			
Current liabilities	\$64,838	\$41,896	\$46,701
Long-term debt	\$40,257	\$57,455	\$78,677
Other liabilities	\$18,595	\$22,767	\$25,410
Total liabilities	\$123,690	\$122,120	\$146,788
Stockholders' equity	\$98,879	\$63,753	\$55,363



# How Well Does It Work?

**The Cooper Companies, Inc. - Financial Highlights**  
(In thousands, except per share amounts)

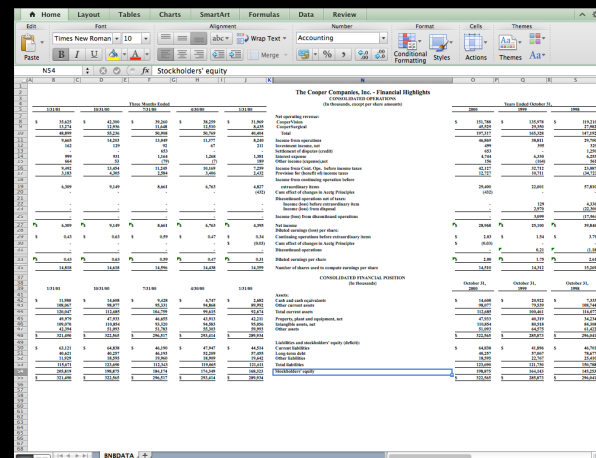
Three Months Ended						Years Ended October 31,		
1/31/01	10/31/00	7/31/00	4/30/00	1/31/00		2000	1999	1998
\$ 35,625	\$ 42,300	\$ 39,260	\$ 38,229	\$ 31,969	Net operating revenue:	\$ 151,788	\$ 135,978	\$ 119,210
13,274	12,936	11,648	12,510	8,435	CooperVision	45,529	29,350	27,982
48,899	55,236	50,908	50,769	40,404	CooperSurgical	197,217	165,328	147,192
9,665	14,203	13,049	11,377	8,240	Total	46,869	38,811	29,700
162	129	92	67	211	Income from operations	499	395	329
-	-	653	-	-	Investment income, net	653	-	1,250
999	931	1,164	1,268	1,381	Settlement of disputes (credit)	4,744	6,330	6,253
664	53	(79)	(7)	189	Interest expense	156	(164)	561
9,492	13,454	11,245	10,169	7,259	Other income (expense), net	42,127	32,712	23,087
3,183	4,305	2,584	3,406	2,432	Income from Cont. Ops. before income taxes	12,727	10,711	(34,723)
6,309	9,149	8,661	6,763	4,827	Provision for (benefit of) income taxes	29,400	22,001	57,810
-	-	-	-	(432)	Income from continuing operation before extraordinary items	(432)	-	-
-	-	-	-	-	Cum effect of changes in Acctg Principles	-	-	-
-	-	-	-	-	Discontinued operations net of taxes:	-	129	4,336
-	-	-	-	-	Income (loss) before extraordinary item	-	2,970	(22,300)
-	-	-	-	-	Income (loss) from disposal	-	3,099	(17,964)
-	-	-	-	-	Income (loss) from discontinued operations	\$ 28,968	\$ 25,100	\$ 39,846
\$ 6,309	\$ 9,149	\$ 8,661	\$ 6,763	\$ 4,395	Net income	\$ 2,03	\$ 1.54	\$ 3.79
\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.34	Diluted earnings (loss) per share:	\$ (0.03)	-	-
-	-	-	-	-	Continuing operations before extraordinary items	-	0.21	(1.18)
-	-	-	-	-	Cum effect of changes in Acctg Principles	\$ 2.00	\$ 1.75	\$ 2.61
-	-	-	-	-	Discontinued operations	14,510	14,312	15,269
\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.31	Diluted earnings per share	-	-	-
14,818	14,618	14,596	14,438	14,359	Number of shares used to compute earnings per share	-	-	-

**CONSOLIDATED FINANCIAL POSITION**  
(In thousands)

						October 31,		
1/31/01	10/31/00	7/31/00	4/30/00	1/31/00		2000	1999	1998
\$ 11,980	\$ 14,608	\$ 9,428	\$ 4,747	\$ 2,082	Assets:	\$ 14,608	\$ 20,922	\$ 7,333
108,067	98,077	95,331	94,868	89,992	Cash and cash equivalents	98,077	79,539	108,744
120,047	112,685	104,759	99,615	92,674	Other current assets	112,685	100,461	116,077
49,979	47,933	46,655	43,913	42,211	Total current assets	47,933	40,319	34,234
109,070	110,854	93,320	94,583	95,056	Property, plant and equipment, net	110,854	80,518	84,308
42,394	51,093	51,783	55,303	59,993	Intangible assets, net	51,093	64,575	61,422
\$ 321,490	\$ 322,565	\$ 296,517	\$ 293,414	\$ 289,934	Other assets	\$ 322,565	\$ 285,873	\$ 296,041
\$ 63,121	\$ 64,838	\$ 46,190	\$ 47,947	\$ 44,514	Liabilities and stockholders' equity (deficit):	\$ 64,838	\$ 41,896	\$ 46,701
40,621	40,257	46,193	52,209	57,455	Current liabilities	40,257	57,067	78,677
11,929	18,595	19,960	18,909	19,642	Long-term debt	18,595	22,767	25,410
115,671	123,690	112,343	119,065	121,611	Other liabilities	123,690	121,730	150,788
205,819	198,875	184,174	174,349	168,323	Total liabilities	198,875	164,143	145,253
\$ 321,490	\$ 322,565	\$ 296,517	\$ 293,414	\$ 289,934	Stockholders' equity	\$ 322,565	\$ 285,873	\$ 296,041

No ground truth...

# Injecting Errors



The Cooper Companies, Inc. - Financial Highlights

	2013	2012	2011	2010
Net operating revenue	1,111,000	1,080,000	1,050,000	1,020,000
Earnings before interest and taxes	1,080,000	1,050,000	1,020,000	990,000
Net income	1,111,000	1,080,000	1,050,000	1,020,000
Net income per share	1.11	1.08	1.05	1.02

# Injecting Errors

Error (



)

Generated errors representative?  
Yes.

The Cooper Companies, Inc. - Financial Highlights  
Consolidated financial statements  
(in thousands, except per share amounts)

	2014	2013	2012	2011	2010
Net operating revenue	\$ 1,045	\$ 1,045	\$ 1,045	\$ 1,045	\$ 1,045
Operating profit	100	100	100	100	100
Net income	100	100	100	100	100
Basic earnings per share	\$ 1.00	\$ 1.00	\$ 1.00	\$ 1.00	\$ 1.00
Diluted earnings per share	\$ 0.99	\$ 0.99	\$ 0.99	\$ 0.99	\$ 0.99
Number of shares outstanding	100,000	100,000	100,000	100,000	100,000

The Cooper Companies, Inc. - Financial Highlights  
Consolidated financial statements  
(in thousands, except per share amounts)

	2014	2013	2012	2011	2010
Net operating revenue	\$ 1,045	\$ 1,045	\$ 1,045	\$ 1,045	\$ 1,045
Operating profit	100	100	100	100	100
Net income	100	100	100	100	100
Basic earnings per share	\$ 1.00	\$ 1.00	\$ 1.00	\$ 1.00	\$ 1.00
Diluted earnings per share	\$ 0.99	\$ 0.99	\$ 0.99	\$ 0.99	\$ 0.99
Number of shares outstanding	100,000	100,000	100,000	100,000	100,000



## Mechanical Turk is a marketplace for work.

We give businesses and developers access to an on-demand, scalable workforce.  
Workers select from thousands of tasks and work whenever it's convenient.

**255,107 HITs** available. [View them now.](#)

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HITs - *Human Intelligence Tasks* - are individual tasks that you work on. [Find HITs now.](#)

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- Can work from home
- Choose your own work hours
- Get paid for doing good work

Find an  
interesting task

Work

Earn  
money



Find HITs Now

## Get Results from Mechanical Turk Workers

Ask workers to complete HITs - *Human Intelligence Tasks* - and get results using Mechanical Turk. [Register Now](#)

### As a Mechanical Turk Requester you:

- Have access to a global, on-demand, 24 x 7 workforce
- Get thousands of HITs completed in minutes
- Pay only when you're satisfied with the results

Fund your  
account

Load your  
tasks

Get  
results



Get Started





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Get  
results



Get Started

<http://mturk.com>

Timer: 00:00:00 of 10 minutes

Want to work on this HIT?

Accept HIT

Want to see other HITs?

Skip HIT

Total Earned: \$0.12  
Total HITs Submitted: 2

Find the Product Name (US-EN)

Requester: Classify AdImages

Reward: \$0.06 per HIT

Qualifications Required: Tax Matters -8589092352025960714 is not less than 100, Product Name (US - EN) - Basic -85890924173507025

Please enter the name of the product being advertised

Complete These Steps

Please enter the name of the product being advertised



- ☐ This is not an ad
- ☐ The image failed to load
- ☐ The Product or Company Name is not known
- ☐ Contains adult content





Find the Product Name (US-EN)

**Requester:** Classify AdImages

**Reward:** \$0.06 per HIT

**Qualifications Required:** Tax Matters -8589092352025960714 is not less than 100, Product Name (US - EN) - Basic -85890924173507025

Please enter the name of the product being advertised

Complete These Steps

Please enter the name of the **product** being advertised

☒

☐ This is not an ad

☐ The image failed to load

☐ The Product or Company Name is not known

☐ Contains adult content



Find the Product Name (US-EN)

**Requester:** Classify AdImages

**Reward:** \$0.06 per HIT

**Qualifications Required:** Tax Matters -8589092352025960714 is not less than 100, Product Name (US - EN) - Basic -85890924173507025

Please enter the name of the product being advertised

Complete These Steps

Please enter the name of the product being advertised



- ☐ This is not an ad
- ☐ The image failed to load
- ☐ The Product or Company Name is not known
- ☐ Contains adult content





**Timer:** 00:00:00 of 10 minutes

Want to work on this HIT?

Accept HIT

Want to see other HITs?

Skip HIT

**Total Earned:** \$0.12  
**Total HITs Submitted:** 2

Find the Product Name (US-EN)

**Requester:** Classify AdImages

**Reward:** \$0.06 per HIT

**Qualifications Required:** Tax Matters -8589092352025960714 is not less than 100, Product Name (US - EN) - Basic -85890924173507025

# Please enter the name of the product being advertised

Complete These Steps

Please enter the name of the **product** being advertised



- ☐ This is not an ad
- ☐ The image failed to load
- ☐ The Product or Company Name is not known
- ☐ Contains adult content



Timer: 00:00:00 of 10 minutes

Want to work on this HIT?

Accept HIT

Want to see other HITs?

Skip HIT

Total Earned: \$0.12  
Total HITs Submitted: 2

Find the Product Name (US-EN)

Requester: Classify AdImages

Reward: \$0.06 per HIT

Qualifications Required: Tax Matters -8589092352025960714 is not less than 100, Product Name (US - EN) - Basic -85890924173507025

Please enter the name of the product being advertised

Complete These Steps

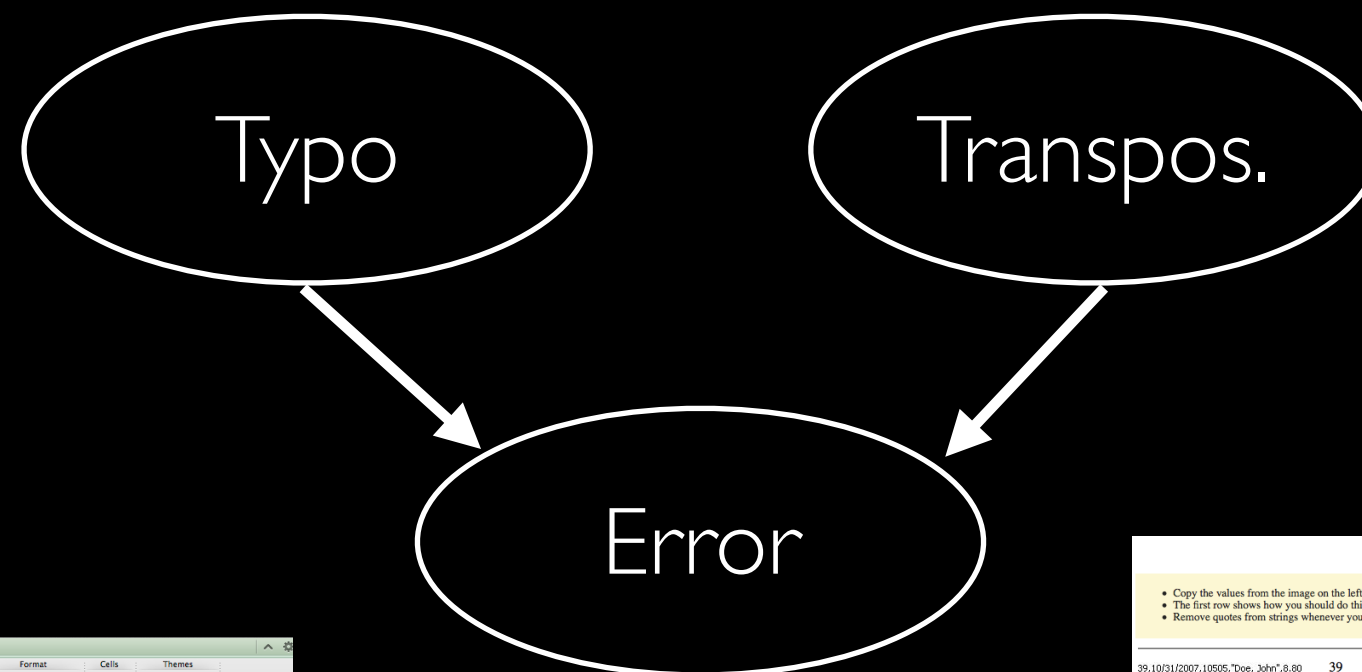
Please enter the name of the product being advertised

☒

- ☐ This is not an ad
- ☐ The image failed to load
- ☐ The Product or Company Name is not known
- ☐ Contains adult content



# Generative typo model

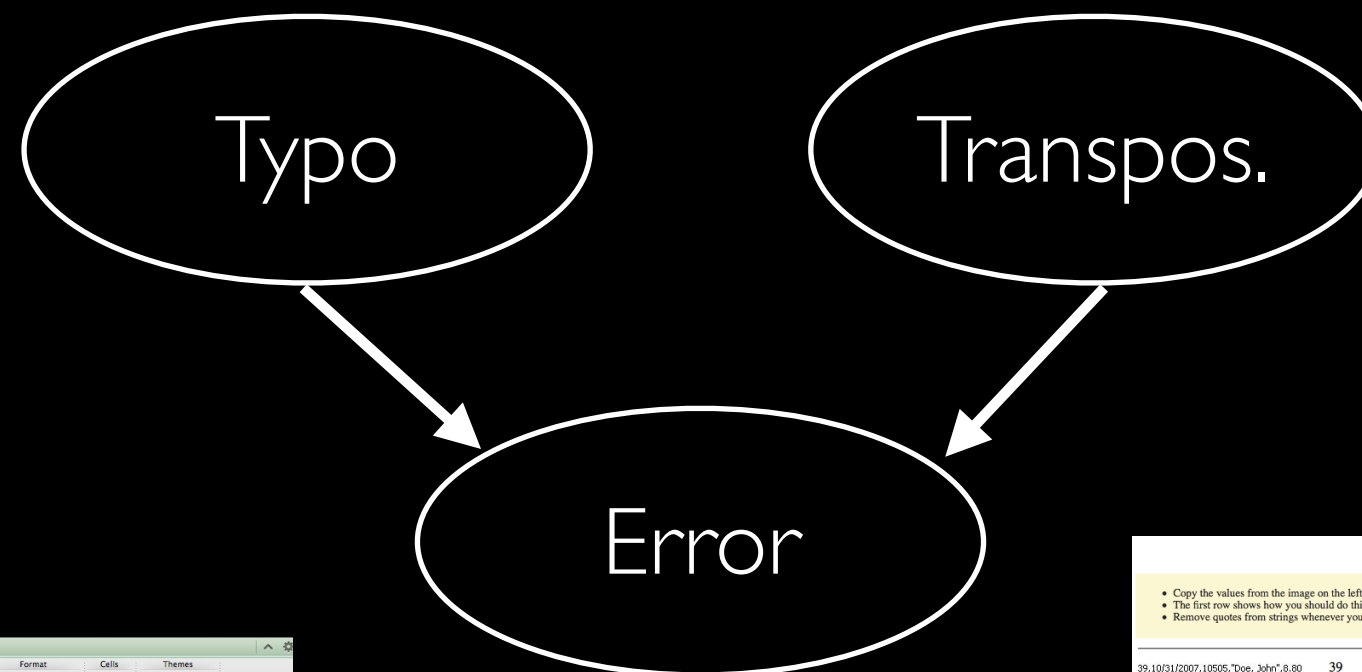


The Cooper Companies, Inc. - Financial Highlights									
CONSOLIDATED OPERATIONS									
(In thousands, except per share amounts)									
	10/31/08	10/31/07	10/31/06	10/31/05	10/31/04		10/31/08	10/31/07	10/31/06
Net operating revenue:									
CooperVision	\$ 35,625	\$ 42,300	\$ 39,240	\$ 38,259	\$ 31,869		\$ 121,788	\$ 125,978	\$ 119,219
CooperHealthcare	13,274	12,526	11,640	12,520	8,457		45,529	26,520	27,962
Total	48,899	54,826	50,880	50,779	40,326		167,317	152,498	147,181
Income from operations	9,665	16,293	13,649	13,777	8,546		16,809	18,811	20,706
Investment income, net	162	129	92	47	211		499	395	329
Net interest expense (income)	999	921	1,144	1,268	1,283		454	639	620
Other income (expense), net	666	52	(79)	(7)	(88)		156	(164)	56
Income from Cont. Ops. before income taxes	9,492	17,445	14,816	15,067	9,952		17,918	19,771	21,671
Provision for (benefit of) income taxes	3,153	4,400	3,484	3,496	2,425		12,122	16,711	16,711
Income from continuing operations before extraordinary items	6,339	13,045	11,332	11,571	7,527		5,796	3,060	4,960
Extraordinary items:									
Gain effect of changes in Acq. Principles	-	-	-	-	-		29,490	22,861	27,819
Discontinued operations net of taxes:									
Income (loss) before extraordinary item	-	-	-	-	-		-	129	4,526
Income (loss) from discontinued operations	-	-	-	-	-		-	2,879	(2,260)
Income (loss) from discontinued operations	-	-	-	-	-		-	3,008	(17,966)
Net income	\$ 6,339	\$ 13,045	\$ 11,332	\$ 11,571	\$ 7,527		\$ 5,796	\$ 3,060	\$ 4,960
Diluted earnings (loss) per share:									
Continuing operations before extraordinary items	\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.34		\$ 2.83	\$ 1.54	\$ 3.79
Gain effect of changes in Acq. Principles	-	-	-	-	-		(8.03)	-	-
Discontinued operations	-	-	-	-	-		-	0.21	(1.32)
Diluted earnings per share	\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.34		\$ 2.83	\$ 1.75	\$ 2.46
Number of shares used to compute earnings per share	14,838	14,838	14,838	14,838	14,838		14,838	14,838	14,838
CONSOLIDATED FINANCIAL POSITION									
(In thousands)									
	10/31/08	10/31/07	10/31/06	10/31/05	10/31/04		10/31/08	10/31/07	10/31/06
Assets:									
Cash and cash equivalents	\$ 11,980	\$ 14,098	\$ 9,428	\$ 4,747	\$ 2,882		\$ 14,098	\$ 28,922	\$ 7,233
Other current assets	398,067	398,067	398,067	398,067	398,067		398,067	398,067	398,067
Total current assets	410,047	412,165	407,495	402,814	400,949		412,165	426,989	405,299
Property, plant and equipment, net	49,979	47,933	46,455	43,313	42,311		49,979	48,319	44,234
Intangible assets, net	118,894	118,894	118,894	118,894	118,894		118,894	118,894	118,894
Other assets	42,094	42,094	42,094	42,094	42,094		42,094	42,094	42,094
Total assets	\$ 621,014	\$ 721,086	\$ 714,938	\$ 687,115	\$ 684,248		\$ 733,130	\$ 736,376	\$ 670,525
Liabilities and stockholders' equity (deficit):									
Current liabilities	\$ 63,121	\$ 64,838	\$ 66,190	\$ 67,847	\$ 69,514		\$ 64,838	\$ 66,190	\$ 67,847
Long-term debt	46,421	46,421	46,421	46,421	46,421		46,421	46,421	46,421
Other liabilities	11,229	18,595	19,809	19,809	19,809		18,595	22,762	22,762
Total liabilities	120,771	129,854	132,420	137,077	135,744		129,854	135,373	137,030
Stockholders' equity	500,243	591,232	582,518	549,998	548,504		603,276	600,983	533,495
Total liabilities and stockholders' equity	\$ 621,014	\$ 721,086	\$ 714,938	\$ 687,115	\$ 684,248		\$ 733,130	\$ 736,376	\$ 670,525

Fill in this spreadsheet					
<ul style="list-style-type: none"><li>Copy the values from the image on the left to the grid on the right.</li><li>The first row shows how you should do this job.</li><li>Remove quotes from strings whenever you encounter them. E.g., "Doe, John" should be entered as Doe, John.</li></ul>					
39,10/31/2007,10505,"Doe, John",8.80	39	10/31/2007	10505	Doe, John	8.80
2779,5799,5726,1152,4132					
6641,840,3643,137,198					



# Generative typo model



The Cooper Companies, Inc. - Financial Highlights

CONSOLIDATED OPERATIONS

(In thousands, except per share amounts)

	10/31/08	10/31/07	10/31/06	10/31/05	10/31/04
Net operating revenue:					
CooperVision	\$ 35,625	\$ 42,300	\$ 39,240	\$ 38,259	\$ 31,869
CooperMedical	13,234	12,506	11,640	12,520	8,457
Total	48,859	54,806	50,880	50,779	40,326
Income from operations	9,665	16,293	13,649	13,777	8,546
Investment income, net	162	129	92	47	211
Net interest expense (income)	999	931	1,144	1,268	1,283
Other income (expense), net	666	52	(79)	(3)	189
Income from Cont. Ops., before income taxes	9,492	17,405	14,786	14,889	9,829
Provision for (benefit of) income taxes	3,183	4,400	2,684	2,496	2,425
Income from continuing operations	6,309	13,005	12,102	12,393	7,404
Extraordinary items:					
Gain effect of changes in Acq. Principles	-	-	-	4,627	(1,572)
Discontinued operations net of taxes:					
Income (loss) before extraordinary item	-	-	-	-	-
Income (loss) from discontinued operations	-	-	-	-	-
Net income	\$ 6,309	\$ 13,005	\$ 12,102	\$ 12,393	\$ 5,832
Earnings per share:					
Continuing operations before extraordinary items	\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.34
Continuing operations net of taxes	-	-	-	-	(0.03)
Discontinued operations	-	-	-	-	-
Earnings per share	\$ 0.43	\$ 0.63	\$ 0.59	\$ 0.47	\$ 0.31
Number of shares used to compute earnings per share	14,838	14,838	14,838	14,838	14,838
CONSOLIDATED FINANCIAL POSITION					
(In thousands)					
Assets:					
Cash and cash equivalents	\$ 11,980	\$ 14,098	\$ 9,428	\$ 7,487	\$ 2,882
Other current assets	398,067	398,067	398,067	398,067	398,067
Long-term assets	13,485	13,485	13,485	13,485	13,485
Property, plant and equipment, net	48,979	47,933	46,658	43,933	42,311
Intangible assets, net	108,894	108,894	108,894	108,894	108,894
Other assets	42,394	42,394	42,394	42,394	42,394
Total assets	\$ 321,490	\$ 321,490	\$ 294,317	\$ 294,317	\$ 284,034
Liabilities and stockholders' equity (deficit):					
Current liabilities	\$ 63,121	\$ 64,838	\$ 46,190	\$ 47,947	\$ 44,814
Long-term debt	46,621	46,727	46,193	42,399	37,685
Other liabilities	11,329	18,595	19,920	19,920	19,920
Total liabilities	121,071	130,160	112,303	110,266	102,419
Stockholders' equity	200,419	191,330	182,014	184,051	181,615
Total stockholders' equity	\$ 200,419	\$ 191,330	\$ 182,014	\$ 184,051	\$ 181,615

169,112  
retyped strings  
from images

Fill in this spreadsheet

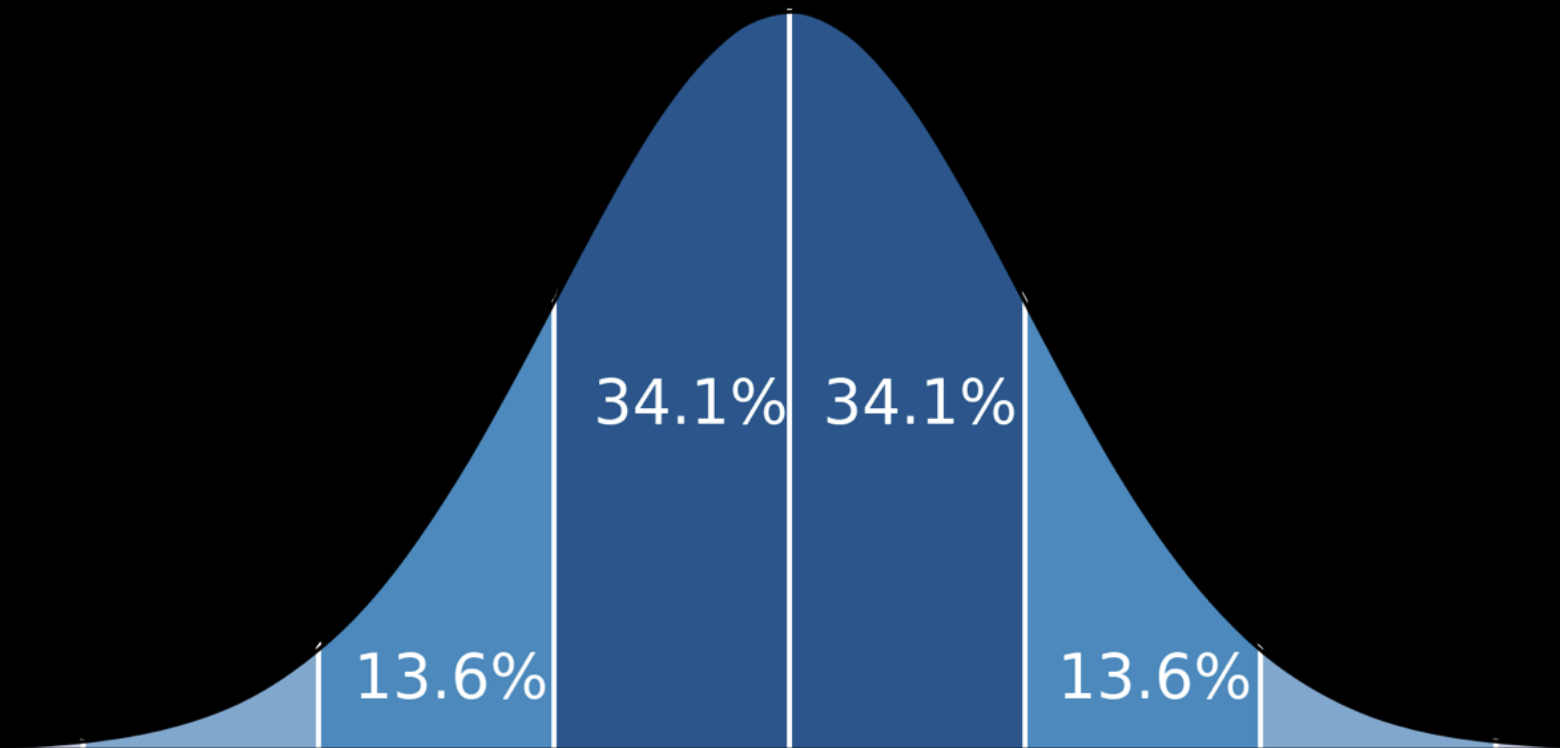
- Copy the values from the image on the left to the grid on the right.
- The first row shows how you should do this job.
- Remove quotes from strings whenever you encounter them. E.g., "Doe, John" should be entered as Doe, John.

39,10/31/2007,10505,"Doe, John",8.80	39	10/31/2007	10505	Doe, John	8.80
2779,5799,5726,1152,4132					
6641,840,3643,137,198					

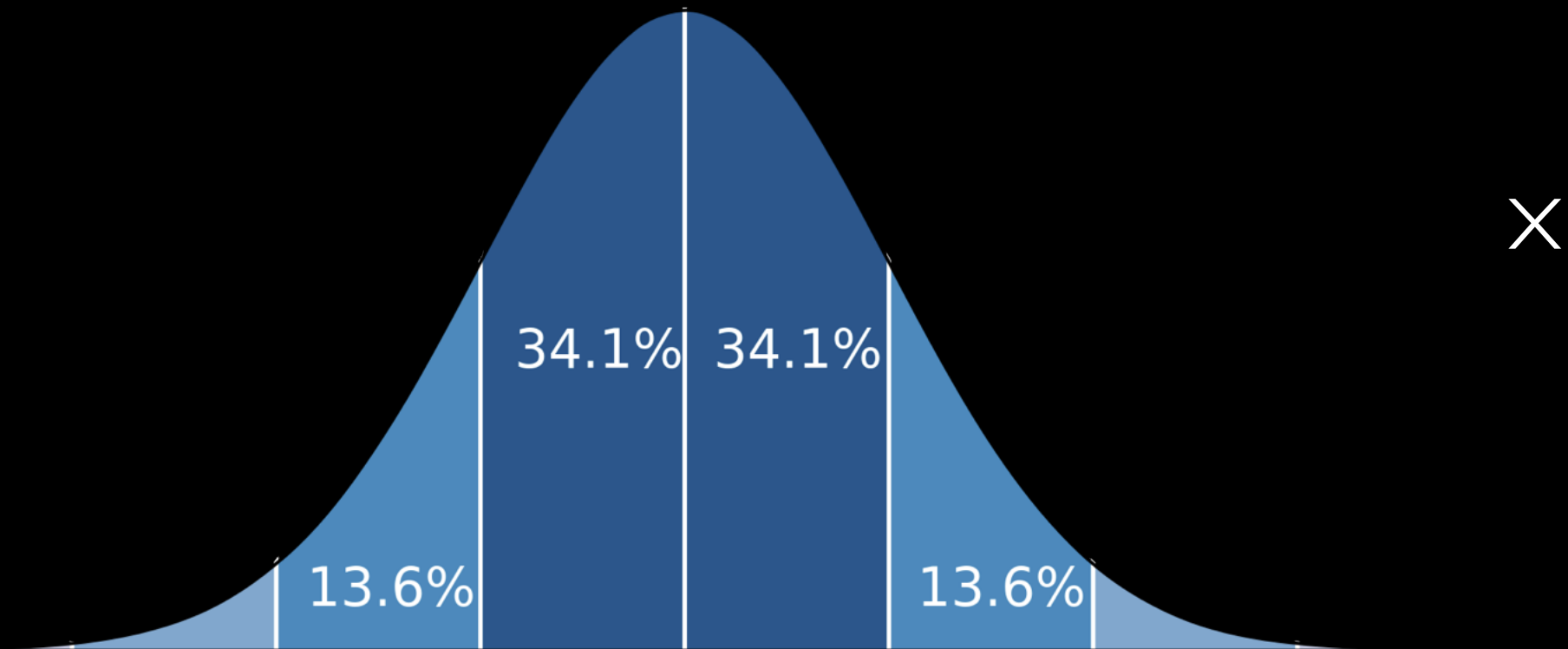


Gaussian “strawman”  
*(only compared against numeric inputs)*

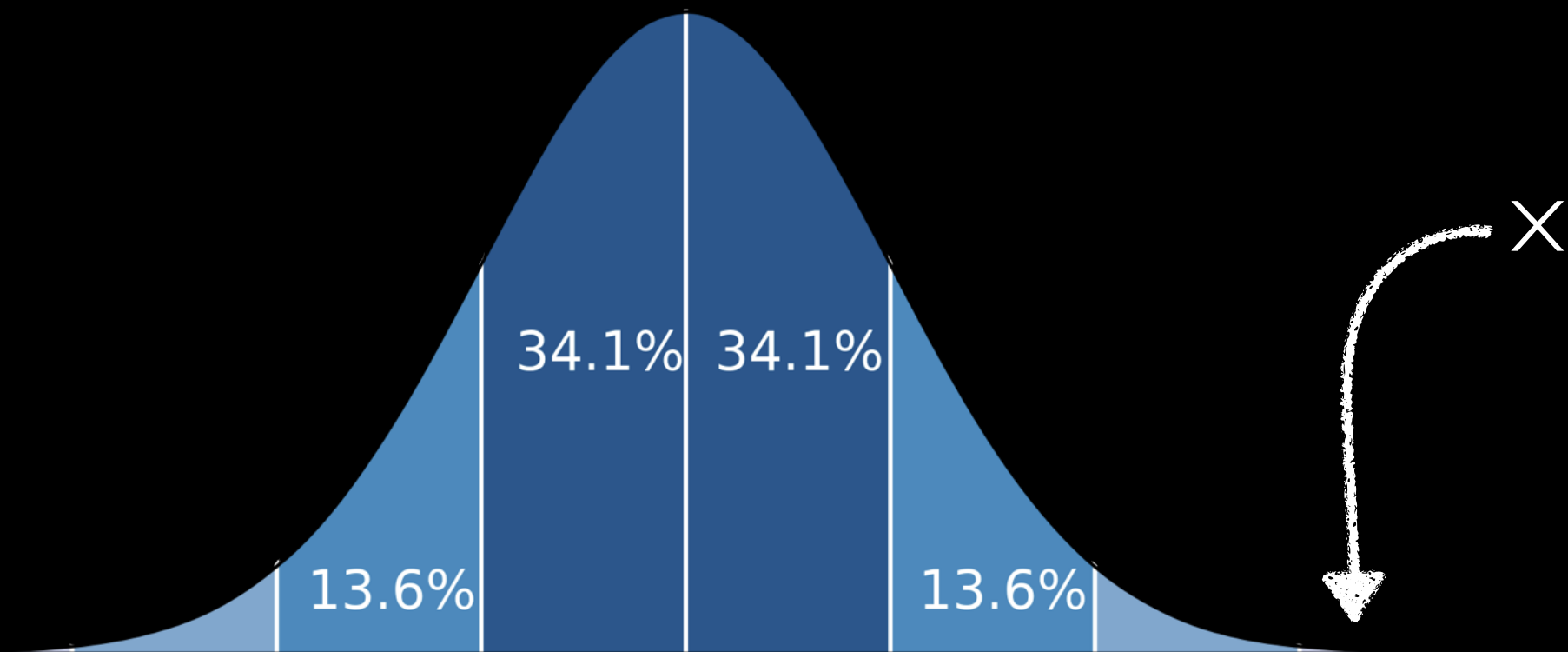




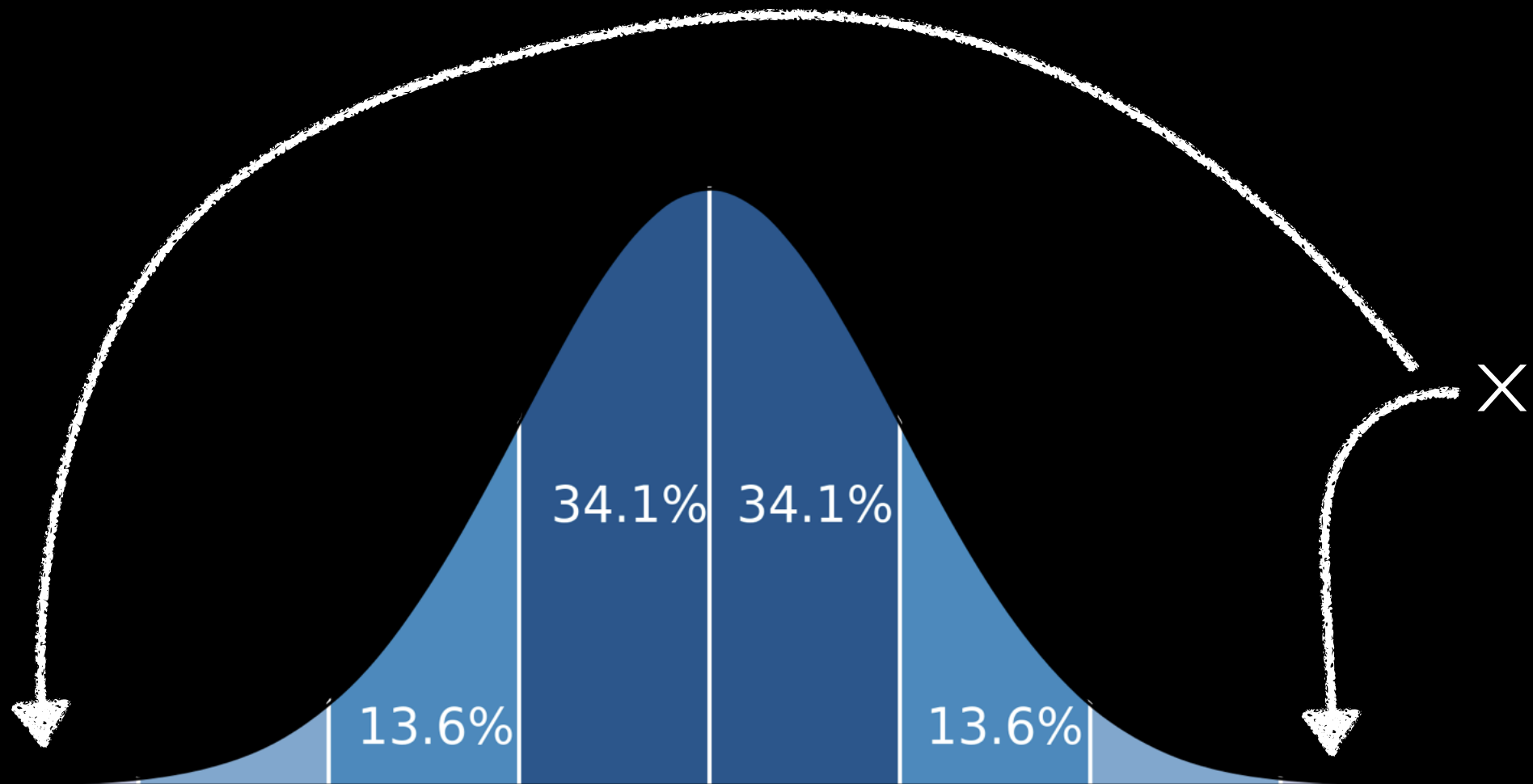
Gaussian “strawman”  
*(only compared against numeric inputs)*



Gaussian “strawman”  
*(only compared against numeric inputs)*



Gaussian “strawman”  
*(only compared against numeric inputs)*



Gaussian “strawman”  
*(only compared against numeric inputs)*

input data



Gaussian



outliers in input data



input data



Gaussian



outliers in input data

input data & outputs

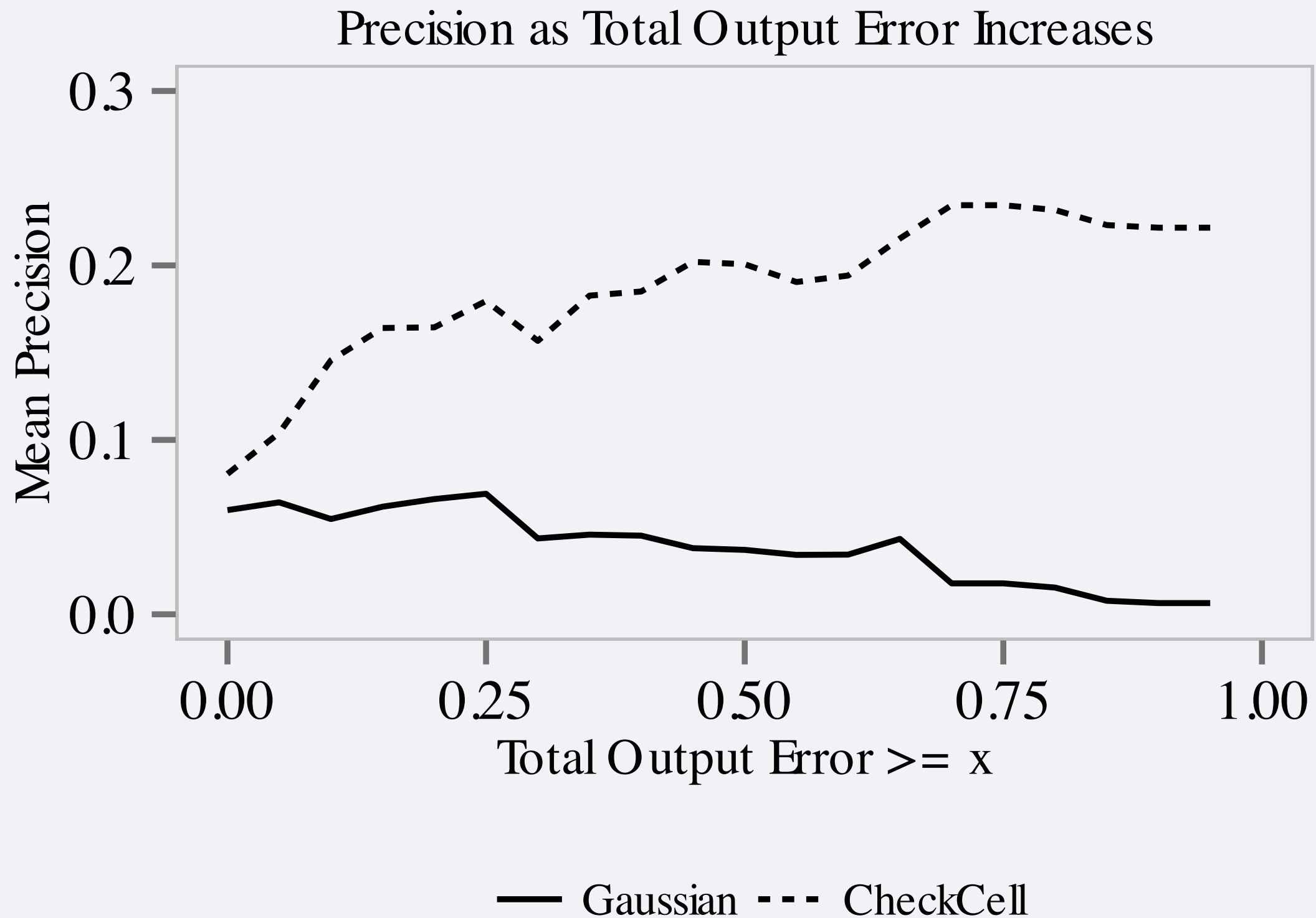


CheckCell

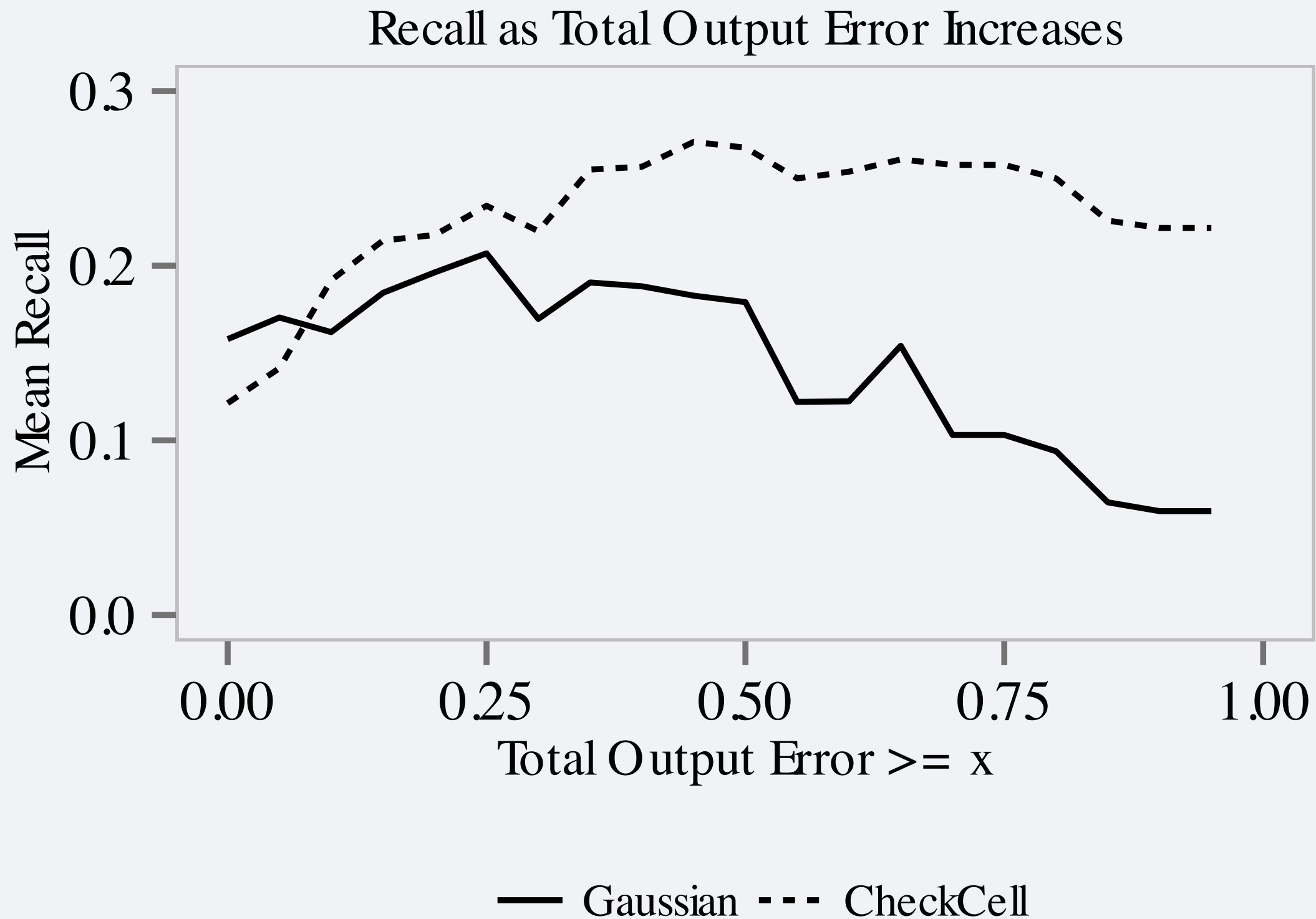


data with unusual impact

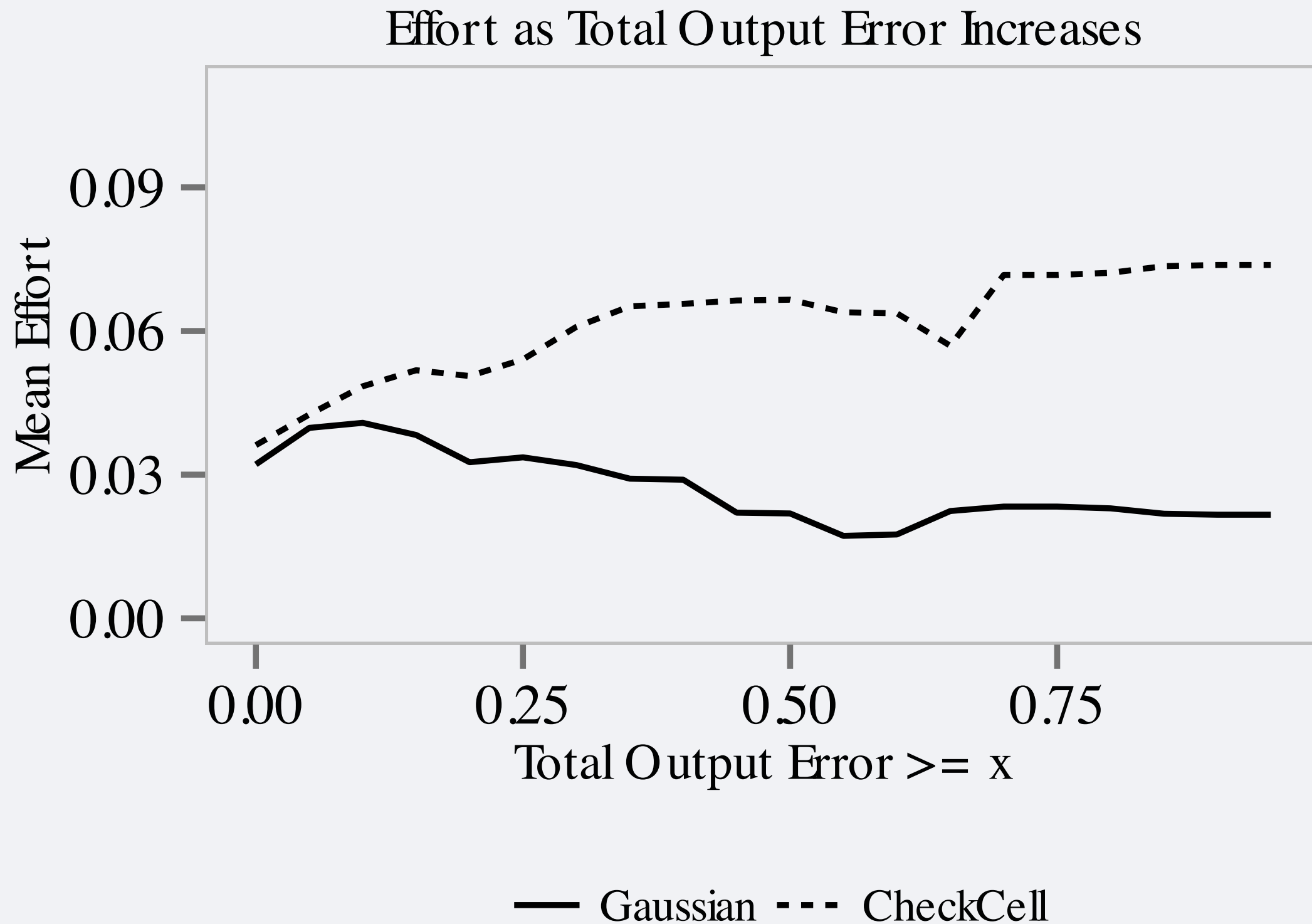
# CheckCell: *correct more often*



# CheckCell *finds more errors*

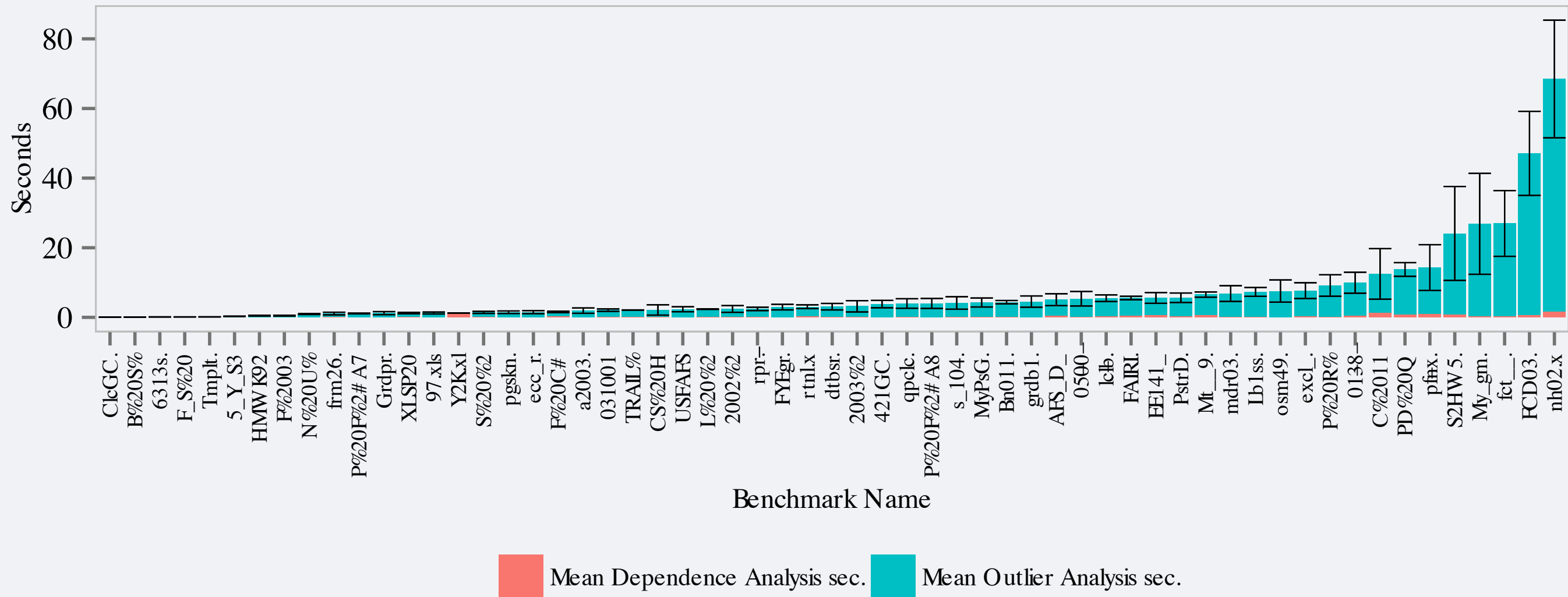


# CheckCell *requires little effort*



# CheckCell is *fast*

Mean CheckCell Execution Times





# Case Study: Reinhart-Rogoff

Date: December 5, 2009		Number of observations					Average												M
Country	Coverage	Total	Debt/GDP				Real GDP growth Debt/GDP				Inflation Debt/GDP				Real GDP growth Debt/GDP				
			30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	
US	1791-2009		129	59	23	5	4.0	3.4	3.3	-1.8	1.1	1.8	2.3	6.1	4.0	3.7	3.4	-0.1	
UK	1830-2009		3	68	27	82	2.5	2.2	2.1	1.8	0.8	4.2	1.4	2.0	2.0	2.6	1.8	2.1	
Sweden	1880-2009		79	40	11	0	2.9	2.9	2.7	n.a.	2.8	4.6	4.2	n.a.	3.3	3.0	2.9	n.a.	
Spain	1850-2009		26	53	47	30	1.6	3.2	1.3	2.8	9.9	5.5	2.3	0.5	1.7	3.3	0.8	2.1	
Portugal	1880-2009		42	10	39	0	4.8	2.5	1.4	n.a.	8.8	3.3	0.9	n.a.	5.4	2.4	1.4	n.a.	
Norway	1880-2009		98	25	1	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.	
New Zealand	1932-2009		9	33	17	19	2.5	2.9	3.9	3.6	2.6	7.4	5.0	2.8	2.8	3.0	2.9	4.1	
Netherlands	1880-2009		17	50	32	8	4.1	2.8	2.4	2.0	6.4	1.5	0.0	-2.2	4.2	3.1	2.0	1.1	
Japan	1885-2009		47	42	11	11	4.9	3.7	3.9	0.7	6.0	2.1	3.2	-1.1	6.2	3.5	1.9	1.1	
Italy	1880-2009		26	12	39	49	5.4	4.9	1.9	0.7	5.6	11.1	10.6	13.1	5.8	3.1	1.6	1.1	
Ireland	1949-2009		8	14	32	7	4.4	4.5	4.0	2.4	2.9	4.8	7.3	5.3	5.3	4.1	3.7	3.1	
Greece	1884-2009		13	5	11	55	4.0	0.3	4.8	2.5	13.3	19.4	12.3	2.8	3.9	0.5	3.8	3.1	
Germany	1880-2009		96	11	0	0	3.6	0.9	n.a.	n.a.	1.8	1.5	n.a.	n.a.	3.6	1.2	n.a.	n.a.	
France	1880-2009		26	21	19	37	4.9	2.7	2.8	2.3	5.2	5.0	1.5	1.2	5.4	2.7	2.8	1.1	
Finland	1914-2009		69	18	6	3	3.2	3.0	4.3	1.9	10.3	5.4	13.2	32.7	3.3	3.2	3.8	0.1	
Denmark	1880-2009		57	16	17	0	3.1	1.7	2.4	n.a.	2.5	4.7	3.3	n.a.	2.8	0.8	2.6	n.a.	
Canada	1925-2009		3	52	23	7	1.9	4.5	3.0	2.2	2.2	4.1	0.6	6.0	2.5	4.2	4.1	2.1	
Belgium	1835-2009		37	60	32	31	3.0	2.6	2.1	3.3	1.0	2.0	3.0	3.2	2.8	2.8	2.6	2.1	
Austria	1880-2009		43	32	35	0	4.3	3.0	2.3	n.a.	5.3	2.4	0.7	n.a.	4.6	2.3	2.1	n.a.	
Australia	1902-2009		38	33	23	8	3.1	4.1	2.3	4.6	5.9	2.9	5.2	3.7	3.5	4.7	3.4	6.1	
		2317	866	654	445	352	3.7	3.0	3.5	1.7	5.5	5.2	4.6	5.7	3.9	3.1	2.8	1.1	
Minimum							1.6	0.3	1.3	-1.8	0.8	-0.1	0.0	-2.2	1.7	0.5	0.8	-0.1	
Maximum							5.4	4.9	10.2	3.6	13.3	19.4	13.2	32.7	6.2	4.4	10.2	4.1	

# Case Study: Reinhart-Rogoff

“This one extraordinary growth experience (Norway) contributes fully 5.3 percent (1/19) of the weight [...] even though it constitutes only 0.2 percent (1/445) of the country-years in this category.”  
— Herndon et al. (2013)

Date: December 5, 2009		Number of observations					Average												M
		Coverage	Total	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above
US	1791-2009	129	59	22	33	3	0	2.9	2.9	2.7	n.a.	2.8	4.6	4.2	n.a.	3.3	3.0	2.9	n.a.
UK	1830-2009	68	17	8	2	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Sweden	1880-2009	79	40	11	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Spain	1850-2009	26	53	47	30	1	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Portugal	1880-2009	49	10	0	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Norway	1880-2009	98	25	1	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
New Zealand	1932-2009	9	33	17	19	2	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Netherlands	1880-2009	17	60	32	18	8	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Japan	1885-2009	47	42	11	11	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Italy	1880-2009	26	12	39	49	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Ireland	1949-2009	8	14	32	7	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Greece	1884-2009	13	5	11	55	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Germany	1880-2009	96	11	0	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
France	1880-2009	16	1	0	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Finland	1914-2009	69	18	6	3	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Denmark	1880-2009	57	16	17	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Canada	1925-2009	3	52	23	7	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Belgium	1835-2009	37	60	32	31	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Austria	1880-2009	43	32	35	0	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
Australia	1902-2009	38	33	23	8	0	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
			2317	866	654	445	352	3.7	3.0	3.5	1.7	5.5	5.2	4.6	5.7	3.9	3.1	2.8	1.7
Minimum								1.6	0.3	1.3	-1.8	0.8	-0.1	0.0	-2.2	1.7	0.5	0.8	-0.1
Maximum								5.4	4.9	10.2	3.6	13.3	19.4	13.2	32.7	6.2	4.4	10.2	4.9

# Case Study: Reinhart-Rogoff

e: December 5, 2009		Number of observations				Average				Inflation				Real GDP growth				
		Total	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above
Country	Coverage																	
US	1791-2009	129	59	23	23	14	3.3	1.1	1.8	2.3	3.1	4.0	3.7	3.4	-0.1	2.0	2.6	2.0
UK	1830-2009	68	17	17	17	17	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Sweden	1880-2009	79	40	11	11	0	2.9	2.9	2.7	n.a.	2.8	4.6	4.2	n.a.	3.3	3.0	2.9	n.a.
Spain	1850-2009	26	53	47	30	1	1.6	1.3	1.3	2.8	9.9	5.5	1.3	0.5	1.7	3.3	0.8	2.0
Portugal	1880-2009	10	10	10	10	10	2.5	2.5	2.5	n.a.	8.2	3.2	3.2	3.2	2.4	1.4	n.a.	n.a.
Norway	1880-2009	98	25	1	1	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.
New Zealand	1932-2009	9	33	17	19	1	2.5	2.9	3.9	3.6	2.1	7.4	5.0	2.8	3.0	2.9	4.0	4.0
Netherlands	1880-2009	17	160	32	18	8	4.1	1.8	1.1	6.0	1.5	-2.1	-2.1	3.1	2.0	1.0	1.0	1.0
Japan	1885-2009	47	42	11	11	11	4.9	3.7	3.9	0.7	6.0	2.1	3.2	-1.1	6.2	3.5	1.9	1.0
Italy	1880-2009	26	12	39	49	5.4	4.9	1.9	0.7	5.6	11.1	10.6	13.1	5.8	3.1	1.6	1.0	1.0
Ireland	1949-2009	8	14	32	7	4.4	4.5	4.0	2.4	2.9	4.8	7.3	5.3	5.3	4.1	3.7	3.0	3.0
Greece	1884-2009	13	5	11	55	4.0	0.3	4.8	2.5	13.3	19.4	12.3	2.8	3.9	0.5	3.8	3.0	3.0
Germany	1880-2009	96	11	0	0	3.1	0.9	n.a.	n.a.	1.8	1.5	n.a.	n.a.	3.6	1.2	n.a.	n.a.	n.a.
France	1880-2009	16	11	11	11	2.8	2.7	2.8	2.3	5.2	5.0	1.5	1.2	5.4	2.7	2.8	1.0	1.0
Finland	1914-2009	69	18	6	3	3.2	3.0	4.3	1.9	10.3	5.4	13.2	32.7	3.3	3.2	3.8	0.0	0.0
Denmark	1880-2009	57	16	17	0	3.1	1.7	2.4	n.a.	2.5	4.7	3.3	n.a.	2.8	0.8	2.6	n.a.	n.a.

“This one extraordinary growth experience (Norway) contributes fully 5.3 percent (1/19) of the weight [...] even though it constitutes only 0.2 percent (1/445) of the country-years in this category.”

— Herndon et al. (2013)

“This one extraordinary growth experience (Norway) contributes fully 5.3 percent (1/19) of the weight [...] even though it constitutes only 0.2 percent (1/445) of the country-years in this category.”

— Herndon et al. (2013)

CheckCell reports 10 errors  
(all typos & methodological errors)



# Case Study: Reinhart-Rogoff

e: December 5, 2009		Number of observations				Average				Average				Average				M
		Total	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above	30 or less	30 to 60	60 to 90	90 or above
Country	Coverage																	
US	1791-2009	129	59	22	33	3	1.0	2.0	3.3	-1.8	1.1	1.8	2.3	3.1	3.7	3.4	-0.1	2.0
UK	1830-2009	68	17	17	21	13	2.1	2.1	2.1	1.4	2.0	2.0	2.0	2.0	2.6	1.8	2.0	2.0
Sweden	1880-2009	79	40	11	0	2.9	2.9	2.7	n.a.	2.8	4.6	4.2	n.a.	3.3	3.0	2.9	n.a.	n.a.
Spain	1850-2009	26	53	47	30	1.6	1.6	1.3	2.8	9.9	5.5	1.3	0.5	1.7	3.3	0.8	2.0	2.0
Portugal	1880-2009	10	10	10	10	1.8	1.8	1.8	n.a.	8.9	3.2	3.2	3.2	3.2	2.4	1.4	n.a.	n.a.
Norway	1880-2009	98	25	1	0	2.9	4.4	10.2	n.a.	4.4	-0.1	0.0	n.a.	3.0	4.4	10.2	n.a.	n.a.
New Zealand	1932-2009	9	33	17	19	2.5	2.5	3.9	3.6	2.1	7.4	5.0	2.8	3.0	2.9	2.9	4.0	4.0
Netherlands	1880-2009	17	160	32	18	4.1	1.8	1.8	1.8	6.0	1.5	-2.1	-2.1	3.1	2.0	2.0	1.0	1.0
Japan	1885-2009	47	42	11	11	4.9	3.7	3.9	0.7	6.0	2.1	3.2	-1.1	6.2	3.5	1.9	1.0	1.0
Italy	1880-2009	26	12	39	49	5.4	4.9	1.9	0.7	5.6	11.1	10.6	13.1	5.8	3.1	1.6	1.0	1.0
Ireland	1949-2009	8	14	32	7	4.4	4.5	4.0	2.4	2.9	4.8	7.3	5.3	5.3	4.1	3.7	3.0	3.0
Greece	1884-2009	13	5	11	55	4.0	0.3	4.8	2.5	13.3	19.4	12.3	2.8	3.9	0.5	3.8	3.0	3.0
Germany	1880-2009	96	11	0	0	3.0	0.9	n.a.	n.a.	1.8	1.5	n.a.	n.a.	3.6	1.2	n.a.	n.a.	n.a.
France	1880-2009	16	11	11	11	2.7	2.7	2.8	2.3	5.2	5.0	1.5	1.2	5.4	2.7	2.8	1.0	1.0
Finland	1914-2009	69	18	6	3	3.2	3.0	4.3	1.9	10.3	5.4	13.2	32.7	3.3	3.2	3.8	0.0	0.0
Denmark	1880-2009	57	16	17	0	3.1	1.7	2.4	n.a.	2.5	4.7	3.3	n.a.	2.8	0.8	2.6	n.a.	n.a.

“This one extraordinary growth experience (Norway) contributes fully 5.3 percent (1/19) of the weight [...] even though it constitutes only 0.2 percent (1/445) of the country-years in this category.”

— Herndon et al. (2013)

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— Herndon et al. (2013)

CheckCell reports 10 errors  
(all typos & methodological errors)

CheckCell.org

# Formula Errors

PROPOSED FINANCIAL OUTLOOK STATEMENT			
TOBACCO SETTLEMENT TRUST FUND			
FY 2003-04 and FY 2004-05			
(Dollars in Millions)			
2003-04	Total	Recurring Funds	Nonrecurring Funds
<b>Funds Available:</b>			
Balance forward from 2002-03	4.9	0.0	4.9
Initial settlement estimate	364.0	364.0	0.0
Profit adjustment	0.0	0.0	0.0
December 31, 2003 Reversions	3.7	0.0	3.7
Transfer from LCETF - Regular	37.5	37.5	0.0
Transfer from LCETF - BioMedical	3.5	3.5	0.0
Transfer from General Revenue	23.1	0.0	23.1
Interest earnings	1.0	1.0	0.0
<b>Total 2003-04 Funds Available</b>	<b>437.7</b>	<b>406.0</b>	<b>31.7</b>
<b>EFFECTIVE APPROPRIATIONS 2003-04</b>			
Agency for Health Care Administration	183.4	183.4	0.0
Department of Children and Family Services	163.4	163.4	0.0
Department of Elder Affairs	24.8	24.8	0.0
Department of Health	52.4	52.4	0.0
Transfer to General Revenue (Sec 39, 2002 GAA)	10.2	0.0	10.2
Transfer to Biomedical Research TF (Sec. 215.5601)	3.5	3.5	0.0
<b>Total 2003-04 Appropriations</b>	<b>437.7</b>	<b>427.5</b>	<b>10.2</b>
<b>Unencumbered Reserves</b>	<b>(0.0)</b>	<b>(21.5)</b>	<b>21.5</b>



# Formula Errors

CheckCell finds *data* errors:  
what about formulas?

5			
6	<b>2003-04</b>	<b>Total</b>	<b>Recurring Funds      Nonrecurring Funds</b>
7	<b>Funds Available:</b>		
8	Balance forward from 2002-03	4.9	0.0      4.9
9	Initial settlement estimate	364.0	364.0      0.0
10	Profit adjustment	0.0	0.0      0.0
11	December 31, 2003 Reversions	3.7	0.0      3.7
12	Transfer from LCETF - Regular	37.5	37.5      0.0
13	Transfer from LCETF - BioMedical	3.5	3.5      0.0
14	Transfer from General Revenue	23.1	0.0      23.1
15	Interest earnings	1.0	1.0      0.0
16			
17	<b>Total 2003-04 Funds Available</b>	<b>437.7</b>	<b>406.0      31.7</b>
18			
19	<b>EFFECTIVE APPROPRIATIONS 2003-04</b>		
20	Agency for Health Care Administration	183.4	183.4      0.0
21	Department of Children and Family Services	163.4	163.4      0.0
22	Department of Elder Affairs	24.8	24.8      0.0
23	Department of Health	52.4	52.4      0.0
24	Transfer to General Revenue (Sec 39, 2002 GAA)	10.2	0.0      10.2
25	Transfer to Biomedical Research TF (Sec. 215.5601)	3.5	3.5      0.0
26			
27	<b>Total 2003-04 Appropriations</b>	<b>437.7</b>	<b>427.5      10.2</b>
28			
29	<b>Unencumbered Reserves</b>	<b>(0.0)</b>	<b>(21.5)      21.5</b>
30			

# Formula Errors

CheckCell finds *data* errors:  
what about formulas?

5			
6	2003-04	Total	Recurring Funds Nonrecurring Funds
7	Funds Available:		
8	Balance forward from 2002-03	4.9	0.0 4.9
9	Initial settlement estimate	364.0	364.0 0.0
10	Profit adjustment	0.0	0.0 0.0
11	December 31, 2003 Reversions	3.7	0.0 3.7
12	Transfer from LCETF - Regular	37.5	37.5 0.0
13	Transfer from LCETF - BioMedical	3.5	3.5 0.0
14	Transfer from General Revenue	23.1	0.0 23.1
15	Interest earnings	1.0	1.0 0.0
16			
17	Total 2003-04 Funds Available	437.7	406.0 31.7
18			
19	EFFECTIVE APPROPRIATIONS 2003-04		
20	Agency for Health Care Administration	183.4	183.4 0.0
21	Department of Children and Family Services	163.4	163.4 0.0
22	Department of Elder Affairs	24.8	24.8 0.0
23	Department of Health	52.4	52.4 0.0
24	Transfer to General Revenue (Sec 39, 2002 GAA)	10.2	0.0 10.2
25	Transfer to Biomedical Research TF (Sec. 215.5601)	3.5	3.5 0.0
26			
27	Total 2003-04 Appropriations	437.7	427.5 10.2
28			
29	Unencumbered Reserves	(0.0)	(21.5) 21.5
30			

Problem:  
*how do we  
know a  
formula is  
wrong?*

# ExcelLint

Identifies locally-anomalous formula *shapes* and indicates likely fixes

5				
6	2003-04		Total	Nonrecurring Funds
7	Funds Available	ExcelLint thinks that =SUM(D6:D16) should look more like address: \$B\$17, formula: =SUM(B7:B16) or address: \$E\$17, formula: =SUM(E7:E16)		
8	Balance forward		4.9	0.0
9	Initial settlement		364.0	364.0
10	Profit adjustment		0.0	0.0
11	December 31, 2003		3.7	0.0
12	Transfer from LC		37.5	37.5
13	Transfer from LC		3.5	3.5
14	Transfer from G		23.1	0.0
15	Interest earnings		1.0	1.0
16				
17	Total 2003-04 Funds Available		437.7	406.0
18				
19	EFFECTIVE APPROPRIATIONS 2003-04			
20	Agency for Health Care Administration		183.4	183.4
21	Department of Children and Family Services		163.4	163.4
22	Department of Elder Affairs		24.8	24.8
23	Department of Health		52.4	52.4
24	Transfer to General Revenue (Sec 39, 2002 GAA)		10.2	0.0
25	Transfer to Biomedical Research TF (Sec. 215.5601)		3.5	3.5
26				
27	Total 2003-04 Appropriations		437.7	427.5
28				
29	Unencumbered Reserves		(0.0)	(21.5)
30				

# Excelint

Identifies locally-anomalous formula *shapes* and indicates likely fixes

Total		Recurring Funds	Nonrecurring Fun
6			
7			
8	4.9	=B8-E8	=B8
9	363.98	=B9-E9	0
10	0	=B10-E10	0
11	3.7	0	3.7
12	37.5	=B12-E12	0
13	3.5	=+B13	0
14	23.1	0	=+B14
15	1	=B15-E15	0
16			
17	=SUM(B7:B16)	=SUM(D6:D16)	=SUM(E7:E16)
18			
19			
20	183.4	=B20-E20	0
21	163.4	=B21-E21	0
22	24.8	=B22-E22	0
23	52.4	=B23-E23	0
24	10.2	=B24-E24	=B24
25	3.5	3.5	0
26			
27	=SUM(B19:B26)	=SUM(D19:D26)	=SUM(E19:E26)
28			
29	=B17-B27	=D17-D27	=E17-E27

# Excelint

Identifies locally-anomalous formula *shapes* and indicates likely fixes

6	Total	Recurring Funds	Nonrecurring Fun
7			
8	4.9	=B8-E8	=B8
9	363.98	=B9-E9	0
10	0	=B10-E10	0
11	3.7	0	3.7
12	37.5	=B12-E12	0
13	3.5	=+B13	0
14	23.1	0	=+B14
15	1	=B15-E15	0
16			
17	=SUM(B7:B16)	=SUM(D6:D16)	=SUM(E7:E16)
18			
19			
20	183.4	=B20-E20	0
21	163.4	=B21-E21	0
22	24.8	=B22-E22	0
23	52.4	=B23-E23	0
24	10.2	=B24-E24	=B24
25	3.5	3.5	0
26			
27	=SUM(B19:B26)	=SUM(D19:D26)	=SUM(E19:E26)
28			
29	=B17-B27	=D17-D27	=E17-E27



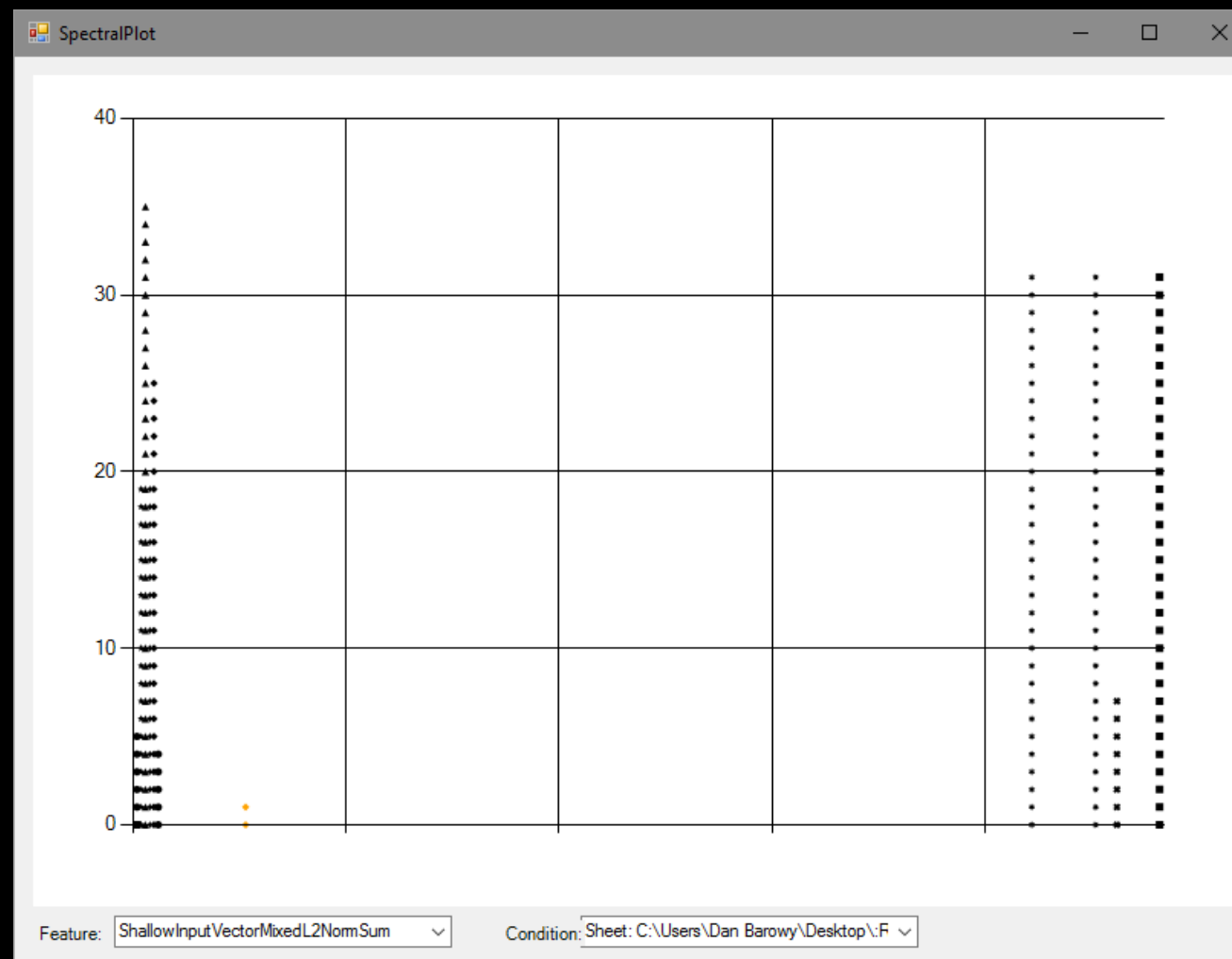
# ExcelLint

Identifies locally-anomalous formula *shapes* and indicates likely fixes

6	Total	Recurring Funds	Nonrecurring Fun
7			
8	4.9	=B8-E8	=B8
9	363.98	=B9-E9	0
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11	3.7	0	3.7
12	37.5	=B12-E12	0
13	3.5	=+B13	0
14	23.1	0	=+B14
15	1	=B15-E15	0
16			
17	=SUM(B7:B16)	=SUM(D6:D16)	=SUM(E7:E16)
18			
19			
20	183.4	=B20-E20	0
21	163.4	=B21-E21	0
22	24.8	=B22-E22	0
23	52.4	=B23-E23	0
24	10.2	=B24-E24	=B24
25	3.5	0	0
26			
27	=SUM(B19:B26)	=SUM(D19:D26)	=SUM(E19:E26)
28			
29	=B17-B27	=D17-D27	=E17-E27

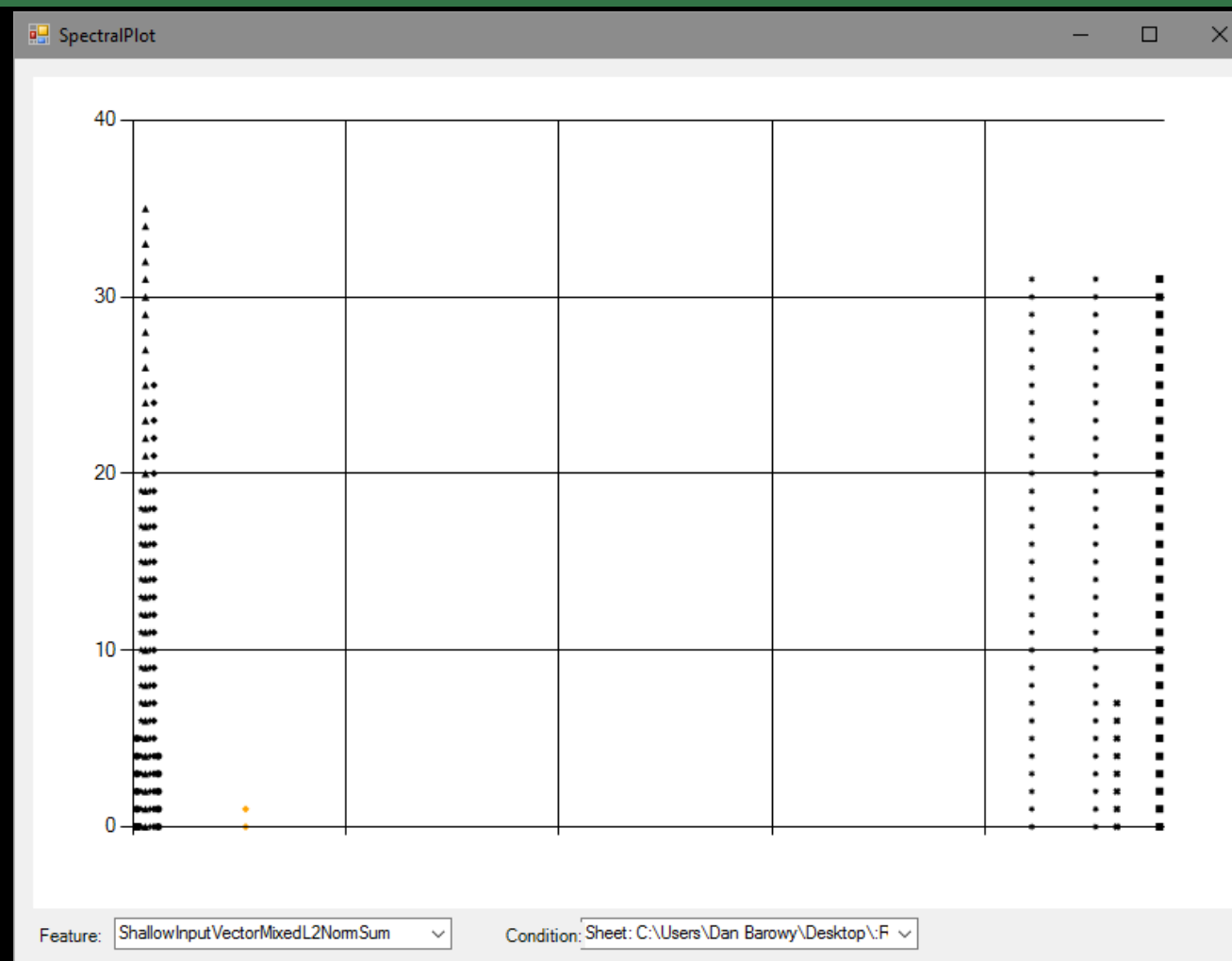
No hard-coded rules:  
purely statistical analysis  
over structures & locations

# ExcelLint Spectral Analysis



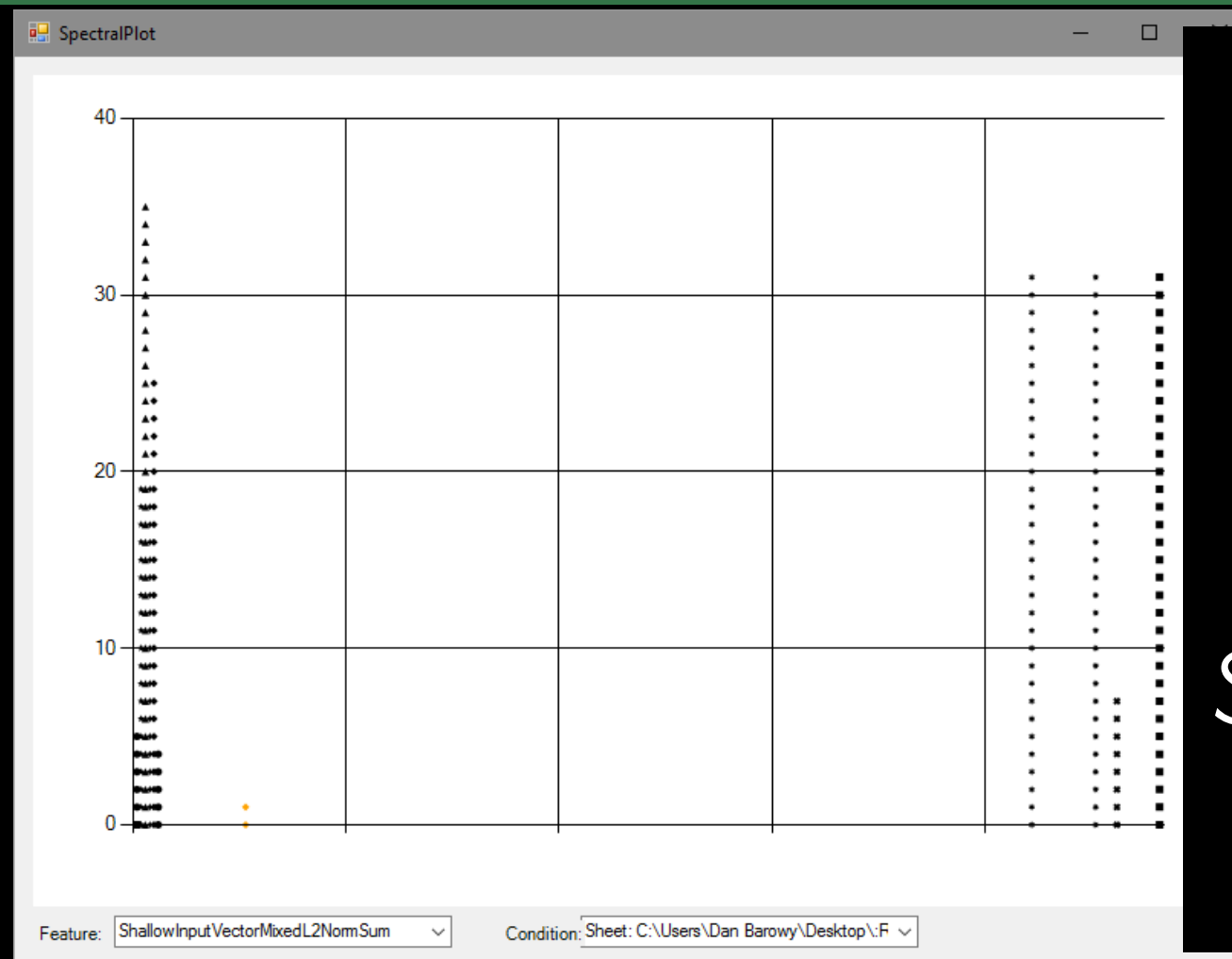
# ExceLint Spectral Analysis

Finds nearest transformation  
over vector encoding –  
fixes that maximally reduce entropy



# ExcelLint Spectral Analysis

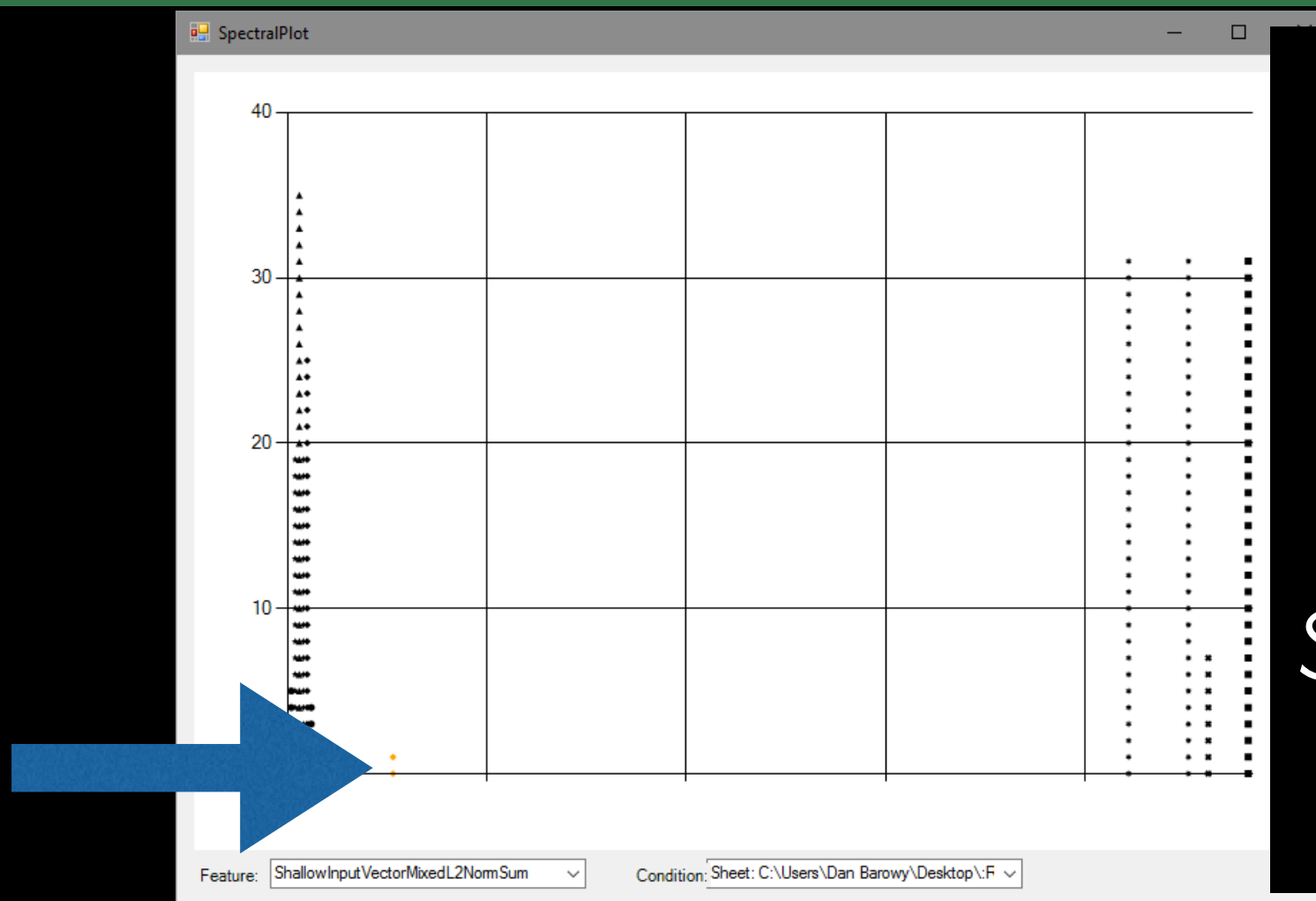
Finds nearest transformation  
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*vector  
encoding  
captures  
structure &  
locality*

# ExcelLint Spectral Analysis

Finds nearest transformation  
over vector encoding –  
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*vector  
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# Infrastructure



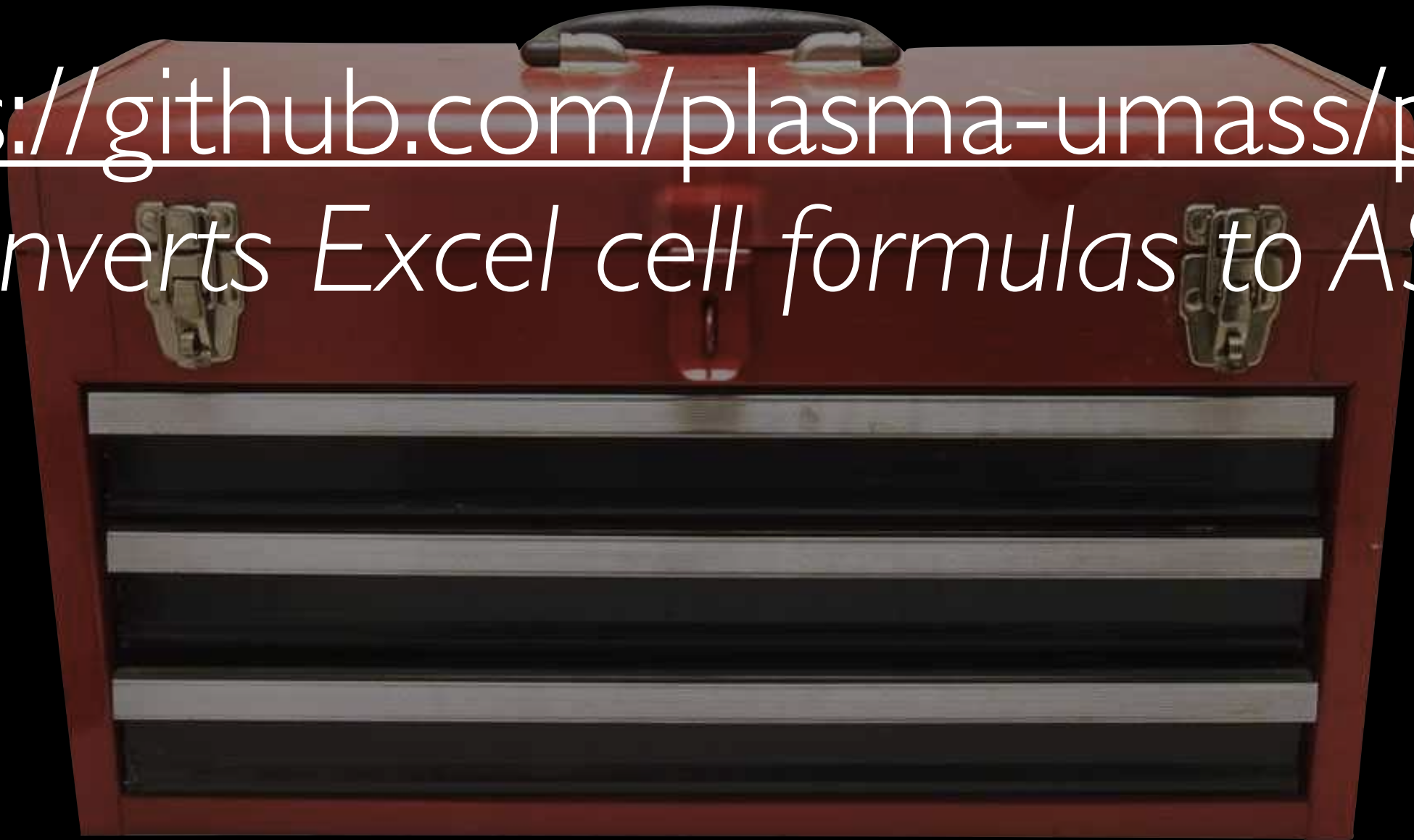
# Infrastructure

<https://github.com/plasma-umass/parcel>



# Infrastructure

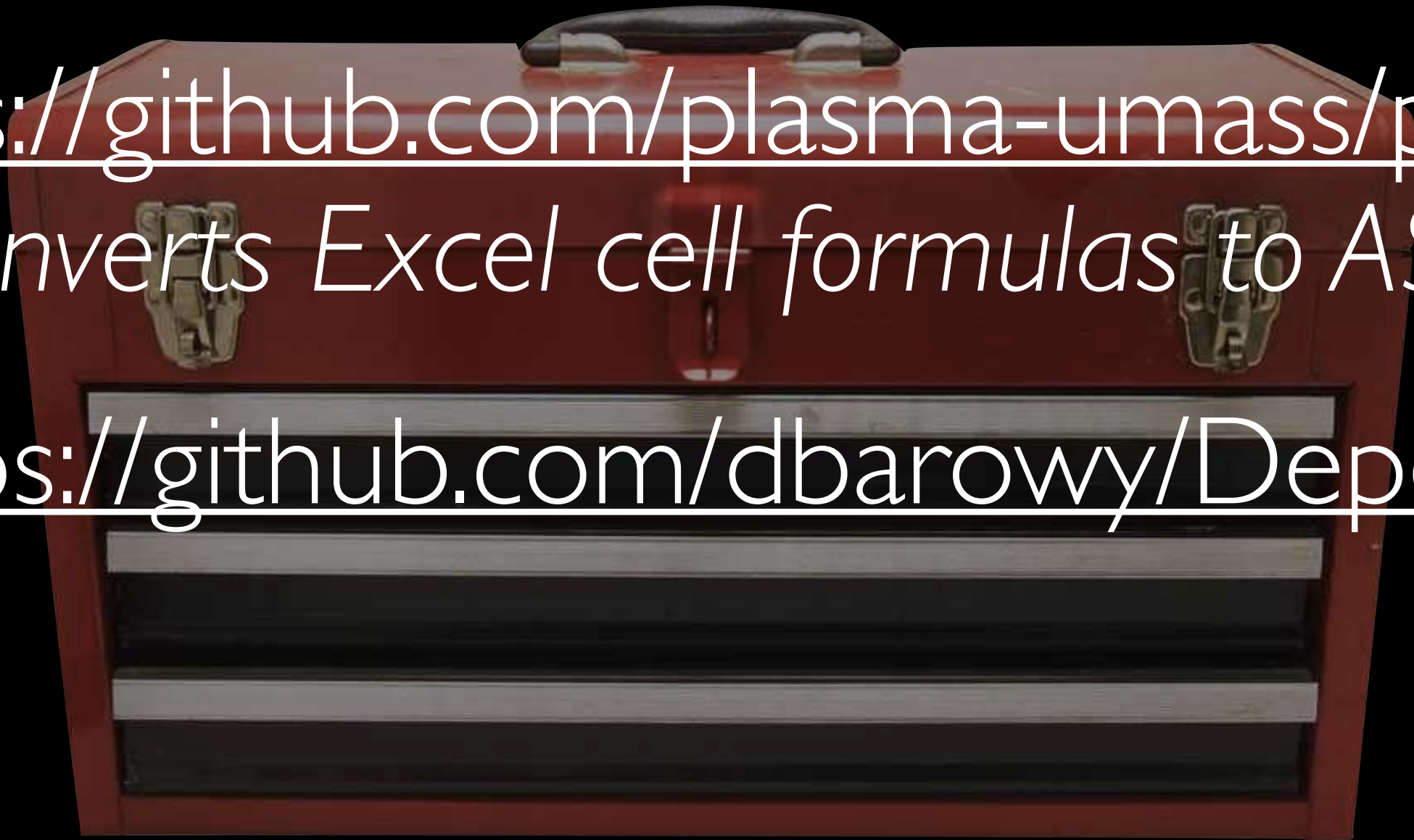
<https://github.com/plasma-umass/parcel>  
*converts Excel cell formulas to ASTs*



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<https://github.com/plasma-umass/DataDebug>  
*CheckCell codebase*



**programming languages and systems at massachusetts**

# **PLASMA**

**<http://plasma.cs.umass.edu>**