Dynamic Visualization of Economic Indicators

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Abstract

Data visualization tools can take existing statistics and re-express them in ways that facilitate interpretation by a variety of audiences ranging from the sophisticated "power user" to the novice. Because these tools can expand a program's audience dramatically, it is vital to develop tools that "tell the complete story," for example, including measures of reliability along with point estimates. This report presents the ongoing efforts at the U.S. Census Bureau to develop and implement a standard set of data visualization tools for usage with its e monthly and quarterly economic indicators. We present two different types of data visualization tools: one that presents a "snapshot" of all indicators at a given point in time and another that presents dynamic interpretations of the time-series data for a specified indicator (totals and change estimates).

Key Words: economic indicator, graph, sparkline, error bars

1. Introduction

Data visualization tools can take existing statistics and re-express them in ways that facilitate interpretation by a variety of audiences ranging from the sophisticated "power user" to the novice. Responding to emerging data user demands, the Census Bureau has moved deliberately in recent years to increase the ratio of graphics to tables and text in our publications and to increase the public's awareness of our measures by prominently displaying these graphics in different forms of dissemination. Examples of this include a fully redesigned web page, the release of several mobile applications ("mobile apps") for Apple and Android products, and the expansion of the Economic Time Series Database to include interactively specified time series and trend charts.

Because visualization tools can expand a program's audience dramatically, it is vital to develop tools that "tell the complete story." For example, it is far easier to detect trends in an economic indicator's time series from a line chart, a bar chart, or a dot plot than from a table displaying hundreds of level and percent change statistics. However, if there is sampling variability associated with these estimates, then it is equally important to include measures of reliability in the graphics along with point estimates to avoid misrepresentation. Similarly, seasonally adjusted series are often quite different from their unadjusted counterparts, and studying the unadjusted series could lead to very different conclusions from the official releases.

This report presents the ongoing efforts at the U.S. Census Bureau to develop and implement data visualization tools for usage with its monthly and quarterly economic.

The Census Bureau's economic indicators – monthly or quarterly reports covering construction, foreign trade, manufacturing, retail, wholesale, services, and housing are key inputs to the Gross Domestic Product estimates, prepared by the Census Bureau's sister agency in the Department of Commerce, the Bureau of Economic Analysis. These statistics also are important to monetary and budgetary decision makers, economists, business analysts, and economic researchers in assessing the health of the economy, and in making corporate investment decisions. Moreover, they are vital to corporate boardrooms looking for guidance on investment and expansion decisions.

The development and implementation of these tools *began* on two parallel paths, each originating from a different department from within the same agency, each with different motivations. The Communications Directorate effort was part of an agency-wide initiative to increase the public's awareness of Census Bureau measures besides those produced by the Decennial Census. The Economic Directorate's effort was largely in response to user requests, but was also motivated by comparisons to features of other economic database tools, such as the "Create Your Own Graphs" feature of the *FRED* tool provided by the Federal Reserve Bank of St. Louis (http://research.stlouisfed.org/fred2/). Ultimately, the paths have intersected – as would be expected – and the tools described in the paper are the outcome of ongoing collaboration.

We present two different types of data visualization tools: one that presents a "snapshot" of all indicators at a given point in time and another that presents dynamic interpretations of the time-series data for a specified indicator (totals and change estimates). Both use *currently published statistics*, with the objective of making the existing and available statistics "accessible" to a different audience. These prototypes tell the **same** story as displayed on the U.S. Census Bureau's Economic Indicators Page (http://www.census.gov/cgi-bin/briefroom/BriefRm). Thus, no revisions to existing methodology are necessary, and no additional training is required for subject matter experts to inform the public about the displayed information.

2. Background/Motivation

The data used in this paper are available from the Economic Indicators Database, a repository of indicator time series data that provides highly granular data to external and internal users, available at http://www.census.gov/econ/currentdata. The indicator programs release data to the database as part of the release process, so the series are timely and up-to-date. The duration of the time series can be quite extensive, depending on the program. For example, housing starts measures are available from 1959 onward. Wallace et al (2012) describes the motivation and development process for the Economic Indicators Database. Since its introduction, the tool has provided extraction capabilities for text files or EXCEL spreadsheets of indicator time series data. More recently, in response to users' requests to import large amounts of data in "flat" files in comma separated value (.csv) format, the Census Bureau has augmented the Database Search Tool with a facility allowing users to get the complete dataset for a given survey in one download. Each survey is represented by a zipped file containing a Readme.txt file and a .csv file that contains both the metadata and the actual data values. When a new release is published, the files for each particular survey are updated (monthly for most, quarterly for some).

The Economic Database Search Tool provides information on *individual* programs. However, the indicators provide a much more complete view of the state of the economy when viewed collectively. There would be numerous advantages of having the Census Bureau develop combined indicator displays instead of outside users or agencies. Developing combined indicator displays are inherently challenging. There are different sampling designs: some are census programs, whereas others are probability or non-probability samples. Key statistics from each have different units of measure (e.g., nominal billions of dollars, annualized thousands of housing units). In addition, each indicator has a different release schedule and its own seasonal adjustment and revision timing. Finally, each indicator program is administered by subject matter experts, whose expertise is extensive but often limited to their own program area. Thus, it would be quite easy for an uninformed user to inadvertently create a misleading graphic. Indeed, given the diversity of the indicators, it is quite easy for the informed user to do so as well.

In February 2011, the Economic Directorate assembled a team of subject matter experts (analysts and mathematical statisticians), IT specialists, and marketing specialists to develop requirements for data visualization tools that combine statistics from different programs to allow analysis, while maintaining strict compliance with the Census Bureau's Statistical Standards. This team developed the written requirements for combined displays of indicator data and illustrated how to use these requirements with (hard copy) prototypes. The team examined several different sources of information:

- Anecdotal requests from data users (team member experience)
- Census Bureau Standards
    - Quality Standards (U.S. Census Bureau , 2012)
    - Statistical Graphics Standards (U.S. Census Bureau, 2005)
- Internet searches (good and bad examples)
- Literature searches

The working environment for the indicators moves quickly, leaves little time for error, and requires quick turnaround for user inquiries. Consequently, there was a strong interest in developing self-explanatory formats for all visualizations that could be applied to the existing published measures. Likewise, the majority of subject matter experts on the team were considerably less comfortable with re-expressing the measures to put them on a common scale, i.e. indexing, which they believed would lead to increased user inquiries and require additional training for the subject matter experts.

In the meantime, the Communications Directorate began its contract to develop a "dashboard" of economic indicators for display on the Census Bureau's home page. Although the Economic Directorate team did include one representative from the Communications Directorate, the two efforts were initially independent. The team issued its requirements documentation in October 2011, and the "Indicators Dashboard" was added to the Census Bureau homepage in December 2011. In July 2012, the Economic Indicators Database began providing interactive graphical capabilities. In August 2012, the "America's Economy" mobile application became available; this mobile app includes time series plots of individual indicators as well.

3.“Telling the Story” of a Single Indicator

The data visualization tools developed for the economic indicators re-express the official information as a story about the economy. The overarching principle for developing each individual tool was to “maintain the appropriate visual metaphor,” i.e., create a display that presents the information without perturbing it. In this section, we use the complete set of available visualization tools to “tell the story” of one particular indicator release from the perspective of a “non power” user, interjecting information about the development process along the way.

3.1. The Dashboard (Part I)

On December 6, 2012, the Quarterly Services Survey (QSS) released its third quarter 2012 report. Figure 1 presents excerpts from the press release.

> Information The U.S. Census Bureau announced today that the estimate of U.S. information sector revenue for the third calendar quarter of 2012, adjusted for seasonal variation but not for price changes, was $295.3 billion, an increase of 0.3 percent (± 0.8%)* from the second quarter of 2012 and up 2.1 percent (± 1.1%) from the third quarter of 2011.
>
> * The 90 percent confidence interval includes zero. The Census Bureau does not have sufficient statistical evidence to conclude that the actual change is different from zero.

Figure 1: Extracted Text from Quarterly Services Survey Press Release

These few lines provide quite a bit of subtly conveyed but important information about the indicator:

- This indicator is an estimate (not a population total) from a probability sample.
- The significance level of the hypothesis test for change is 0.10 (the U.S. Census Bureau Standard).
- There is evidence that the total level of revenue has increased since the previous year, but not since the previous quarter.
- There are seasonal effects in the original time series.
- Estimates are not adjusted for inflation.

The Census Bureau provides this information to the public in several different ways. For example, the “power user” subscribes to the RSS feed, so the information is automatically added to their computer. The “America’s Economy” mobile app updates the launching page with the indicator highlights within one hour of the press release; detailed information and links are also available. Finally, a visitor to the U.S. Census Bureau’s home page at www.census.gov would notice it at the top of the U.S. Census Bureau Indicators Dashboard, located at the top right-hand side of the page.

The first entry in the Economic Indicators Dashboard shown in Figure 2 provides a visual summary of the press release text. The first column provides the “short name” over the indicator, along with the statistical period and release date. More detailed information on the statistic is provided in hover annotation, which reads “Information Sector revenue (seasonally adjusted).” The second column contains the current quarter’s estimate. The

blue up arrow displays the current-to-prior quarter; the asterisk denotes "non-significance."[2] The QSS computes percentage change (the ratio of the current to prior estimate) to measure differences; the percentage change value is directly below the arrow and includes a %-age sign.

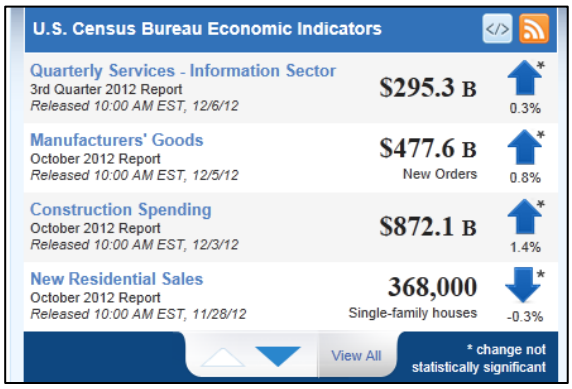

Figure 2: Economic Indicator Dashboard (at www.census.gov)

Obviously, the dashboard does not provide all of the information contained in the press release. For each indicator, the dashboard provides a simple and accurate depiction, but it lacks depth of information. For example, the margin of error for the estimated total is missing, so there is no information about the sampling variability effects. The displayed period-to-period change is with respect to the most recent release; longer-term effects are not provided. The launching page of the "America's Economy" mobile app mimics this format; the individual program page repeats the same information, but contains the first line of the press release (including the margin of error, as applicable).

This visualization is an appetizer, intended to be the first step in a data discovery process. Appetite duly whetted, the user clicks on the "Quarterly Services" text, and the dashboard provides access directly to the Economic Indicator Briefing Room (Figure 3). The Briefing Room provides a consolidated summary of the indicator releases, expanding on the dashboard and providing access to the historic series stored in the Economic Database. Looking at the Briefing Room summary, our user notices that the levels of total revenue for the Information Sector have not increased significantly in the past two quarters. Intrigued, she decides to examine a longer series and does so by clicking on the "Time Series/Trend Charts" link in the second column.

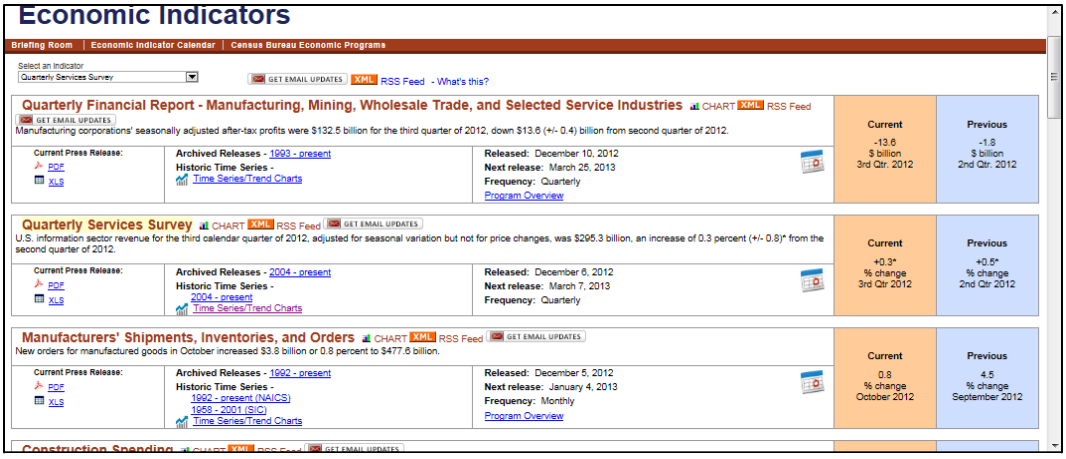

Figure 3: Economic Indicator Briefing Room

[2] In the statistical literature, an asterisk usually denotes significance. The indicator press releases have used it to express the converse for decades. To maintain consistent annotation, the asterisk always conveys *non-significance* in the indicator visualization tools.

3.2. Time Series/Trend Charts

3.2.1. Economic Indicators Database

In addition to providing data set extract capabilities, the Economic Indicators Database provides customizable dynamic charts for all of the thirteen indicators produced by the U.S. Census Bureau that can be exported as .pdf,.jpeg, or .png files.[3] The user can create charts for either seasonally adjusted or not seasonally adjusted data (where applicable). Error lines depicting 90% confidence interval limits are included on bar or line chart for totals and dot plots for change estimates when Database Search selects "Show estimates of Sampling Variability." Table 1 summarizes the chart options for the Database Search Tool.

These charts were developed in full compliance with the requirements developed by the Data Visualization Team. The specific types of graphs were culled from data user and program manager requests. Complete instructions for developing these charts are available at http://www.census.gov/econ/currentdata/ChartInstructions.pdf; technical documentation is available at http://www.census.gov/econ/currentdata/TechnicalDocumentation.pdf. The charts are data driven, so not all options are available for each program. For example, the Foreign Trade charts do not include error bars since the program is a census as opposed to a survey, and the Quarterly Financial Report Retail Trade profits measures are not seasonally adjusted.

Table 1: Time Series/Trend Chart Options in the Economic Indicators Database

Chart Type	Data Totals No Error Data	Data Totals Error Data	Coefficient of Variation	Percentage Change No Error Data	Percentage Change Error Data
Bar	X		X		
Bar With Whiskers		X			
Line*	X				
Line With Whiskers		X			
Dot plot				X	
Dot plot With Whiskers					X

*Line charts are only available for time series with sixteen or more statistical periods

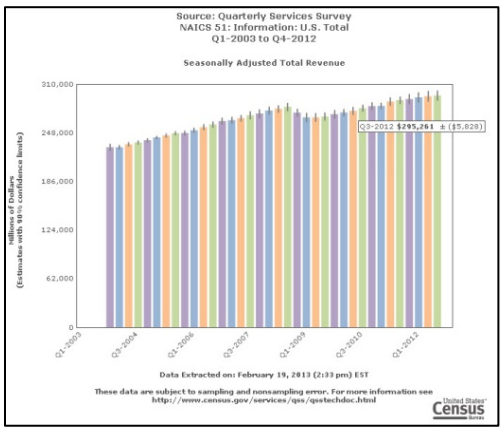

Figure 4: Bar Chart with Error Bars (Confidence Bands) and Annotation

Because the majority of indicators are estimates, it is important to convey the sampling variability of each measure **directly** on the graph. The literature provides several options such as making the physical size of a data point proportional to the corresponding variability in the estimate (Wainer, 2009, pp. 135-136) or providing confidence interval bands (Cleveland, 1994, pp. 216-219). The first option adds layers of complexity to both the design of the graphs and to the accompanying technical documentation. The second option is immediately appealing. Confidence bands can be easily incorporated into the graphs as error bars, making

[3]Until the next release of this tool, the charts are not embeddable, saving the chart as images disables the live links, and the charts are not displayable on Apple devices due to software limitations.

implementation relatively simple. More important, including the confidence bars in the graphs is consistent with the press releases, which report margins of error (MOE) as applicable or available. However, implementation of confidence bands as error bars required compromise from all of the programs. The 90% confidence intervals (error bars) displayed on the charts are obtained under standard normality assumptions and may be rounded to the nearest unit. Consequently, they usually differ somewhat from the program's published margins of error, which make use of their survey's design and estimation procedures and may employ finer degrees of precision.

Returning to our QSS example, our intrigued data user wants to examine the complete time series and extracts the data set containing all seasonally adjusted quarterly estimates of revenue from Sector 51, along with estimates of sampling variability. First, she requests the bar chart depicted in Figure 4.

The indicator program, indicator level (e.g., industry or geographic region), and statistical periods covered are provided in the title, and the indicator name is presented immediately about the graph (including information on seasonal adjustment). The X-axis starts with first month/quarter of the selected date range and ends with last month/quarter of selected date range; there may be empty spaces at the beginning or end of the chart, depending on the earliest available statistical periods stored and the number of remaining statistical periods for data collection in the calendar year, respectively. Since previously released indicator values have planned revisions that include new data and updates to existing data as available, the footnote includes the date/time stamp of the data extraction, along with the source and accuracy statements and program-specific links. The Y-axis label includes the units of measure and indicates whether 90% confidence limits are included. Flyover annotations display time period and data value for all points on the chart and display the absolute value of the MOE for the 90% confidence interval if error bands are included on the graph. Note that the annotation is available on *all* charts.

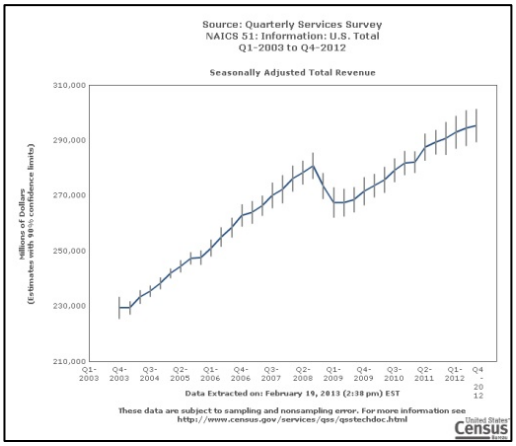

Figure 5: Line Chart with Error Bars (Annotation Not Displayed)

The bar chart design follows the tenets outlined in Few (2004) for matching relationship type (time-series) with value encoding methods. The categorical subdivisions (quarter in this example) are displayed on the X-axis and the quantitative values (seasonally adjusted revenue) are on the Y-axis. The colors encode differences in category. In Figure 4, the four colors of the bars each correspond to a specific quarter, with a repeating pattern. A bar chart for a monthly indicator uses a variation on the same color scheme but uses different intensity levels of color within the same quarter to distinguish between the months. Thus, the color palette follows the recommendations provided in Few (2004, pp. 106). The design does reflect some compromise between the literature “ideal” and reality. Ware (2000) reports that we cannot distinguish between eight different hues in the same graph; the monthly data bar charts *technically* contain twelve. Few (2004, p.106) recommends including blank space between each bar; spacing is, however, lost when

more than 12 months or quarters of data are plotted. In presenting the Economic Time Series Data, however, the individual points are less important than the overall annual trends, coupled with the ability to distinguish significant differences in current to prior period changes by visual inspection. The error bars on the Q3-2012 and Q2-2012 bars overlap, as do the error bars corresponding to Q3-2012 and Q3-2011.

Time-series plots are a powerful analytic tool for examining statistical trends, providing "the sense of continuity that is required for displays over time"; see Cleveland (1993, pp.152) and Few (2004, pp.71). Figure 5 presents the QSS line chart with error bars for the same time period. The point estimates are marked by the error bars, demonstrating both the discontinuity of the series and the effects of sampling errors. The individual point estimates are connected by a single line to convey trend. When confidence bands are included, the line charts emphasize the overall pattern and the individual values simultaneously. When the confidence bands are not displayed, the line chart simply provides a visualization of the trend over the studied time period. The line graph presented in Figure 5 subtly restates the key information conveyed in the press release, although the differences in point estimates may in some cases be visually exaggerated. Presently, the Y-axis is truncated. In the next release, the Y-axis for the time-series plots will start at 0.

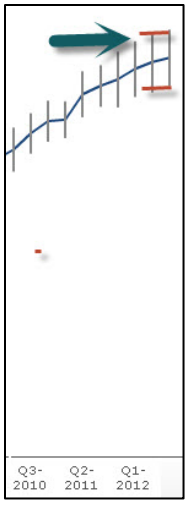

Figure 6: Extract from QSS Time Series Plot

Figure 6 hones in on the most recent measures from the QSS. By drawing horizontal red lines from the Q3-2012 error bars to the Q1-2012 X-axis, we see that the confidence intervals overlap for both the Q3 to Q2 estimates as the Q3 to Q1 estimates (i.e., then differences are not significant), visually reiterating the information. However, the error bars from all the earlier statistical periods do not overlap, providing visual evidence of an overall increase over time.

The bar charts and time-series plots present information on totals. Producing the charts without the error bars provides a clearer (less cluttered) visual of the overall trend. Neither bar charts nor line charts present information on the magnitude or the significance of the percentage change. With the exception of the Quarterly Financial Report, which reports real-valued profits and loss, the percentage change represents the "bottom line" for the indicator and this trend statistic is the number of most immediate interest to the public.

Graphing the percentage change accurately presents a different set of challenges. Scale is generally not an issue. Discontinuity is. Percentage change compares discrete intervals and does not represent a continuous series. Consequently, the primary purpose of the visualization is to show how the percentage change values vary with time, not to try to observe a relationship between percentage change and time. For this, we use dot plots.

The percentage change estimates fall into three separate categories: significant, not significant, and not testable (no standard errors available). Marker shape and color delineate between categories. For the indicators that are estimates, we want to convey information about the MOE, although the interpretation is different. With the bar and line charts, the error bars allow us to draw conclusions about the trend. With the dot plot, the error bars show the variability in the change estimates. Changes in error bar length are therefore informative about sampling and nonsampling error effects. Table 2 provides the

specifications for each dot plot symbol. The color choices, shapes, and spacing along the x-axis follow from Few's "Gestalt Principles of Visual Perception" (2004, pp. 116):

- Proximity – equal spacing between points to present "independence" between measurements
- Similarly – use the same color and shape to delineate between categories
- Enclosure – the dot plot has a visible boundary, so that the set of plotted changes is perceived as a group
- Closure–markers are to have a clear boundary, so each estimate is distinct
- Continuity – see proximity
- Connection – error bars are connected to the point estimates

Table 2: Specifications for Dot Plot Symbol

Symbol	Category	Definition
Purple circle	Significant	90% confidence interval does not include zero 0 < (Estimate - 1.645 x standard error) or 0 > (Estimate + 1.645 x standard error)
Orange diamond	Not significant	90% confidence interval includes zero (Estimate - 1.645 x standard error) < 0< (Estimate + 1.645 x standard error)
Blue Triangle	Not testable	Standard errors are not provided/available and program is not a census

Figure 7 presents the dot plot (with confidence limits) from our QSS example. Notice that the error bars for the non-significant (orange diamonds) change estimates cross the horizontal (Y = 0) asymptote.

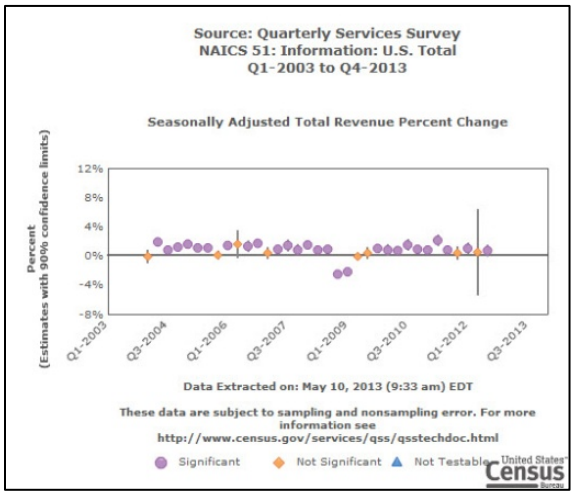

Figure 7: Dot Plot for Percentage Change in QSS Series

The margin of error for the Q3-2012 estimate provided in the annotation is different from the value provided in the press release (0.7% versus 0.8%). This demonstrates the effect of the compromise usage of normal theory confidence intervals. The QSS estimates variances by the method of random groups, constructing confidence intervals using a *t*-statistic with 7 d.f. (8 random groups -1). The critical value for a 90% confidence interval for QSS is 1.895, which yields a larger margin **of error than the corresponding limits** developed with the normal theory critical value of 1.645. The text that precedes the graph in the Economic Indicators Database cautions about this potential discrepancy.

3.2.2. The America's Economy Mobile App

Instead of exploring the internet, our fictional user may be one of the thousands of owners of the "America's Economy" mobile app. If so, she could obtain less detailed but similar information from her smartphone or tablet, provided either device is an Apple or Android product. As a mobile app user, she would obtain dashboard-like information on the QSS release from the launching page shown in Figure 8. From this page, she would proceed to the program's "Details" page, which repeats the dashboard information, along with the applicable text from the press release (Figure 9). Scrolling down, she sees the

sparkline of the QSS NAICS Sector 51 revenue time-series for the past four quarters shown in Figure 10' [Note: "Sparklines are datawords: data-intense, design-simple, word-sized graphics" (Tufte, 2006, pp. 47)]. Intrigued, she touches the sparkline to see the larger graph on a separate screen (Figure 11). This graph is the simplest possible time-series plot, containing a maximum of two years of estimates. Again, the y-axis is truncated to prevent flattening. Hash marks (//) on the axis explicitly indicate the truncation, saving valuable space on the smartphone's limited real estate [Note: Hash marks will be included in the next release of the Economic Data Base Search Visualization Tool..

Figure 8: Launching Page of America's Economy Mobile App

The America's Economy app is itself a data visualization. The graphs present a much more simplified story (set of information) than those provided by the Economic Indicators Database. Much of the design work for the graphs was dictated by the size of the smallest device (smartphone).

Figure 9: Detail Page from America's Economy app

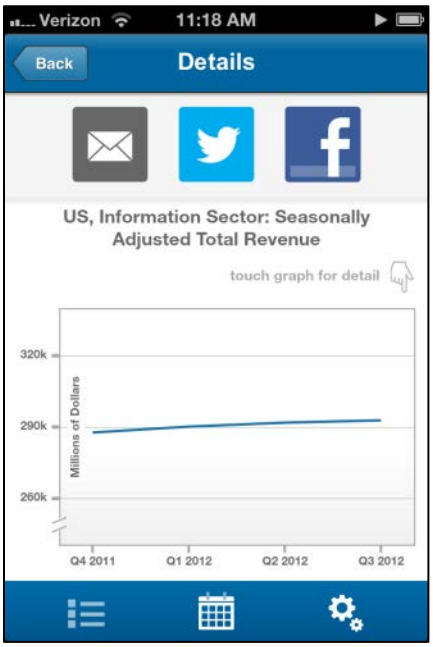

Figure 10: Detail Page (Continued) Containing Sparkline

Since the America's Economy app is a Census Bureau product, the graphs in the app are also subject to the same official standards, limiting presentations. Titles are required to be informative and to contain information on source, products must link directly to source and accuracy statements, and the x- and y-axes must remain constant. Equally important, the America's Economy app was not allowed to combine series whose estimates are not statistically different without providing a visual means of conveying this information. In the original design, for example, the graphs would have contained multiple series by

region or industry as requested. However, the graphs that contained sufficient disclaimers were too cluttered for interpretation, and the statistics stored in the Economic Database did not always facilitate computations. Instead, the app provides a direct link to the Economic Database, from which the user can obtain the more informative graphs.

Figure 11: Sparkline (America's Economy Mobile App)

We believe that data users are frequently following the link from the app to the Economic Database, as the number of visits to the Economic Indicators Database increased by a factor of approximately twenty-three since the America's Economy app's release in August 2012 (this factor does not exclude multiple visits from the same user). Certainly, there has been great popularity of the America's Economy app since its release. See "Census Mobile App a Hit" – Washington Post, September 7, 2012; and "Apps Aim to Help Citizens Sort Through Complex Economic Data" – Nextgov Today, December 6, 2012.

4. Telling the Story of the Combined Set of Indicators

By design, each indicator provides **unique** information about a sector of the economy. Combining presentations of indicators can as easily misrepresent the state of economy as it can provide a more comprehensive picture. For example, some indicators are leading (precede a change in an economic trend), whereas others are lagging. Uninformed users might draw erroneous conclusions about the utility of a lagging indicator when combined with a leading indicator on the same display. There are other, more tangible, distinctions that need to be made. It makes sense to use percentage changes to describe movement in totals for positive valued indicators such as Retail Sales, Business Inventories, Manufactured Durable Goods, or Housing Starts. However, it does not make sense to use percentage changes with real-valued indicators such as Profit/Loss or for rates such as the Homeownership rate. In the former case, direction and magnitude of absolute change are meaningful (as Wall Street recognized years ago); in the latter case, the direction and magnitude of absolute change in percentage points describe the change.

The dashboard is a combined indicator display that sidesteps many of these challenges. It provides up-to-date collective information, but only allows the user to further investigate one indicator at a time. It avoids the challenge of interpretability by using a single color arrow or line to display change. The proposed initial design used green up arrows and red down arrows. Such color coding is directly misleading for the unemployment rate and for the trade deficit. It introduced ambiguity with business inventories, as an increase can indicate an improvement in the economy if business sales are increasing at the same rate or faster, but can also indicate a decline if the inventories to sales ratios are actually increasing.

Now that the combined indicator datasets described in Section 2 are available, a user can create their own displays. When developing our data visualization requirements, the Economic Directorate team proposed two prototypes for presenting combined indicator

visualizations. The first assembles the indicators' time-series as a set of adjacent sparklines as show in Figure 12.

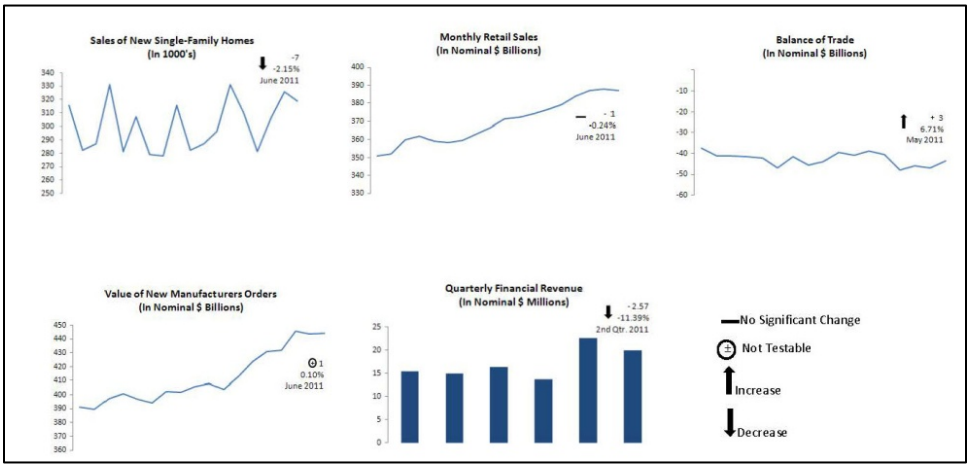

Figure 12: Sparkline Presentation of Combined Indicator Data (Fictional Values)

In Figure 12, each sparkline presents an 18-month series, with the last entry annotated by the change in the total, the percentage change (if applicable), and the statistical period. The proposed symbols are subtly different from those used in the dashboard: arrows represent significant changes, a flat line represents a not-significant change, and a circled +/- indicates the change cannot be tested because the program is a non-probability sample [Note: this symbol was proposed for the Economic Indicator Dashboard, but was not included in the final design. The developers believed that having four symbols made it more difficult to interpret; the Communications Directorate did not want to highlight a design deficiency of an indicator on the Census Bureau's home page, especially when the disclaimers were available from the program's internet page and publications]. These symbols provide the same information, but are a bit easier to see in a small graphic. The use of bar charts instead of line graphs distinguishes the quarterly data from the monthly data in the display. Access to the program-level data would be accessible either via live links provided immediately below the sparkline or by directly clicking on the graph of interest.

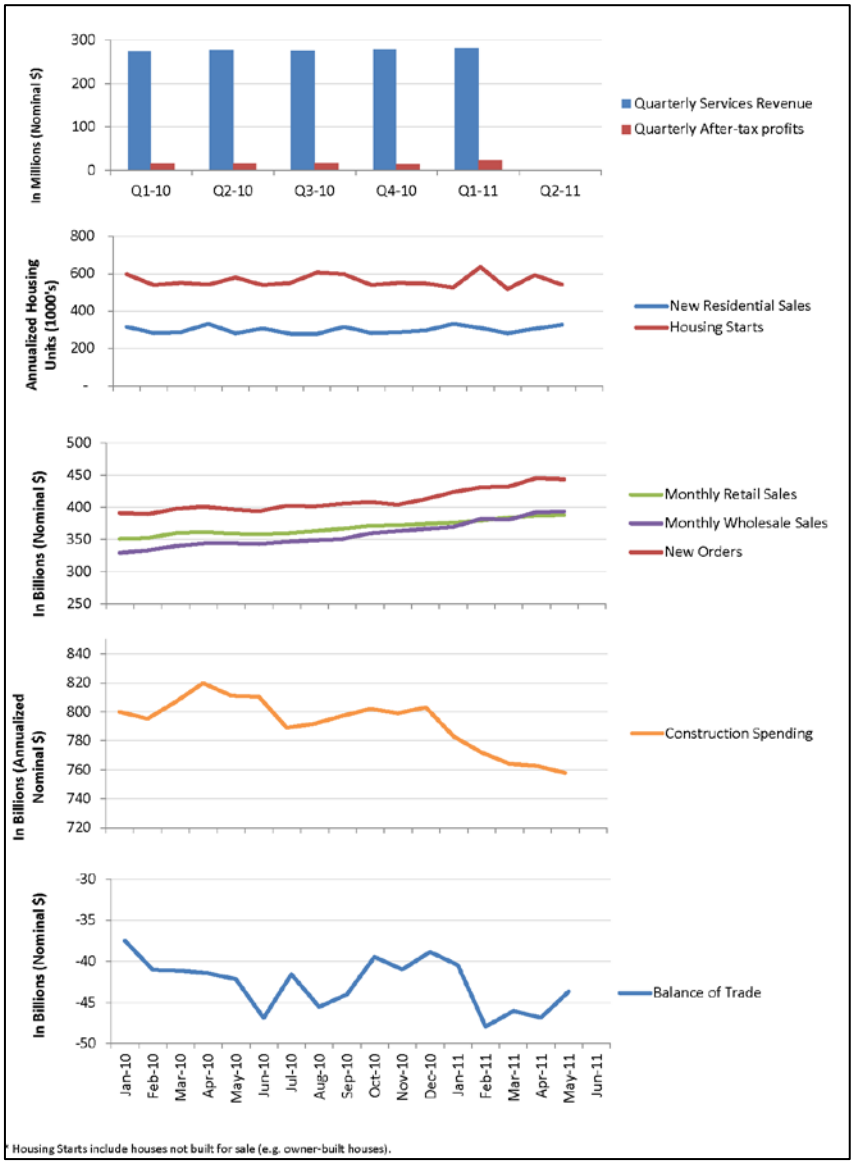

Figure 13: Stacked Combined Indicator Display (Fictional Data)

Figure 13 presents another prototype data visualization for combining indicator program statistics, again using fictional data. The second proposed prototype stacks separate time-series plots across the same x-axis (time), combining series that have the same units of size and periodicity.

Future applications could consider indexed displays such as moving averages, but only after conducting extensive research to determine an optimal method for all indicators **and** the subject matter experts are provided with training in the indexing methodology.

5. Conclusion/The Future?

In this age of information overload and the 30-second attention span, it is now more important than ever to incorporate data visualization techniques to tell the story behind

the numbers. In doing so, however, a statistical agency must be absolutely certain that the story that the displays show is consistent with other products using the same data and does not distort the information or extrapolate beyond what can be verified (at least internally). This is particularly important for the economic indicators, since they are so widely used and have so much impact on policy, programs, and the market. A visualization that contradicts the press release is an erroneous data release and is a serious violation of the public trust.

In this paper, we present data visualization tools for economic indicators that present a "snapshot" of all indicators at a given point in time and that present dynamic interpretations of the time-series data for a specified indicator (totals and change estimates). For us, the presentation process in the paper is backwards. We were originally motivated by the business need to develop logical displays of the combined indicators, but had to work backwards to learn how best to display the individual series. Every tool that has been developed and released is the product of an extensive team effort. We firmly believe that this is the correct procedure. To avoid any potential misrepresentation to the public, subject matter experts *must* be involved in the development of official visualizations and should approve all final displays.

In Beautiful Evidence (2006), Edward Tufte provides six fundamental principles of analytic design:

1. Show comparisons, contrasts, differences
2. Show causality, mechanism, explanation, systematic structure
3. Show multivariate data: that is, show more than 1 or 2 variables
4. Completely integrate words, images, numbers, diagrams
5. Thoroughly describe the evidence. Provide a detailed title, indicate the authors and sponsors, document the data sources, show complete measurement scales, point out relevant issues
6. Analytic presentations ultimately stand or fall depending on the quality, relevance, or integrity of their content

The data visualization tools that we present in this paper are firmly grounded in these principles, with the exception of showing causality. As for the sixth principle, the quality, relevance, and integrity of the economic indicators produced by the U.S. Census Bureau has been proven repeatedly.

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References

Cleveland, W.S. (1994). The Elements of Graphing Data. Summit, NJ: Hobart Press.

Cleveland, W.S. (1993). Visualizing Data. Summit, NJ: Hobart Press.

Few, S. (2004). Show Me the Numbers: Designing Tables and Graphs to Enlighten. Oakland, CA: Analytics Press.

Tufte, E.R. (2006). Beautiful Evidence. Cheshire, CT: Graphics Press LLC.

U.S. Census Bureau (2005). Presentation of Statistical Graphics. *Internal documentation, available upon request.*

U.S. Census Bureau (2012). The U.S. Census Bureau Statistical Quality Standards. *Internal documentation, available upon request.*

Wainer, H. (2009). Picturing the Uncertain World: How to Understand, Communicate, and Control Uncertainty through Graphical Display. Princeton, NJ: Princeton Analytics Press.

Wallace,M.E., Poisson, J.G., Thompson, K.J., Marske, R.A. (2012). Improved Access to U.S. Economic Indicators: Implementation, Outreach, and Future Development. *Proceedings of the Fourth International Conference on Establishment Survey,* American Statistical Association.

Ware, C. (2000). Information Visualization: Perception for Design. San Francisco: Morgan Kaufman Publishers, p. 167.