# RESEARCH NOTE:
# SCRAPING FINANCIAL DATA FROM THE WEB USING THE R LANGUAGE

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## I. ABSTRACT

The main goal of this research note is to educate business researchers on how to automatically scrape financial data from the World Wide Web using the R programming language. This paper is organized into the following main parts. The first part provides a conceptual overview of the web scraping process. The second part educates the reader about the Rvest package – a popular tool for browsing and downloading web data in R. The third part educates the reader about the main functions of the XBRL package. The XBRL package was developed specifically for working with financial data distributed using the XBRL format in the R environment. The fourth part of this paper presents an example of a relatively complex web scraping task implemented using the R language. This complex web scraping task involves using both Rvest and XBRL packages for the purposes of retrieving, pre-processing, and organizing financial and non-financial data related to a company from various source and using different data forms. The paper ends with some concluding remarks on how the web scraping approach presented in this paper can be useful in other research projects involving financial and non-financial data.

**Keywords:** Web Scraping, HTML, CSS, XML, XBRL, R, RStudio

## II. INRODUCTION

Financial data is increasingly distributed over the World Wide Web (the web) using HTML, CSS, XML, XBRL, and other digital formats. For example, the United States Securities and Exchange Commission (SEC) has been mandating filing of financial statements in plain text or HTML formats and publishing this data via the Electronic Data Gathering, Analysis, and Retrieval System (EDGAR) database since 1993 (Shin 2003). In 2009 the SEC mandated all publicly listed companies to start filing certain financial reports in XBRL format by 2011 (Rashty 2013). Other countries have followed the suit in mandating companies to make their financial reports accessible to the public via the web. All these regulations together with growing use of Information and Communication Technologies (ICTs) to power business operations have resulted an exponential growth in the volume of financial data available on the web. This financial data, when combined with other relevant qualitative and quantitative data on the web, can be used by academic and industry researchers to answer a number of old and new research questions with more rigor, precision, and timeliness.

Harnessing these vast volumes of financial data requires a variety of skills (Munzert et al. 2015). Besides vast volume, there are three other common issues associated with using financial and other types data available on the web: variety, velocity, and veracity (Goes 2014). First, web data comes in a variety of formats and relies on various technological and regulatory standards (Basoglu and White 2015). Second, this data is characterized by extreme velocity: it is generated in real time and is continuously updated and modified. Third, this data is also characterized by veracity. Due to the voluntary, democratic, and often anonymous patterns of interactions on the web, there is an inherent uncertainty associated with availability and quality of web data. A researcher can never be completely sure whether the needed data is available on the web and

whether it will be available in the future. Moreover, quality and completeness of this data is usually uncertain too.

Given these challenges associated with using this "big financial data" from the web, harnessing this data requires a highly customizable and programmatic approach. Unfortunately, ready-made tools for accessing web data do not always work. Because of that, many research projects relying on big datasets from the web require creating custom tools for automatically retrieving this data.

One popular and easily-customizable platform for accessing and analyzing web data is R, which is one of the most widely-used programming languages in data science (Lander 2014). R can be used not only to collect financial and other data from the web, but also to subject the collected data to a myriad of analysis techniques once the data is collected (or "scraped"). Thus, the main goal of this research note is to educate researchers and practitioners about the basic web scraping infrastructure in R and how this infrastructure can be used for extracting financial and non-financial data from the web. This research note contains enough information so that a reader with a basic understanding of programming and a familiarity with a few fundamental web technologies (e.g. HTML, CSS, and XML) can start using R for developing tools for automated collection of financial and non-financial data from various web sources.

## III. WEB SCRAPING IN R: AN OVERVIEW

Web scraping is defined here as programmatic extraction, pre-processing, and organization of data from the web for further quantitative or qualitative analysis of this data. Web scraping consists of two intertwined phases: website analysis and web scraping (see Figure 1). Due to the velocity, variety, and veracity of web data, both phases cannot be fully automated and require at least some degree of human involvement.

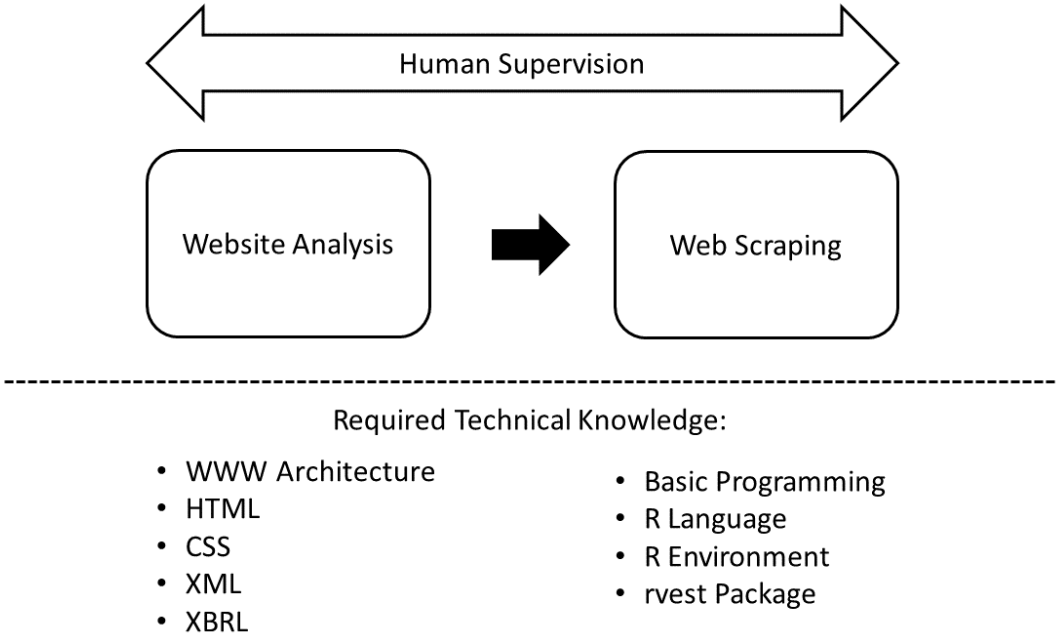



Figure 1. Web Scraping in R: An Overview

During the website analysis phase, a researcher should analyze the structure of a website (or several websites – depending how complex the data collection task is) and inspect its underlying code. The main goal of the analysis phase is to determine which webpage elements contain the needed data. This analysis requires a basic understanding the World Wide Web (WWW) architecture and some of the most commonly used technologies for storing, displaying and transmitting information on the web: HTML, CSS, XML, and XBRL. A basic understanding of HTML and XBRL mark-up languages is especially important since the EDGAR database distributes financial data of publically-listed corporations in these formats. Knowledge of CSS is also useful in cases where financial data is retrieved from a company's website directly (as opposed to going to EDGAR) or from another web resource used to supplement financial data (e.g. letters to shareholders or news reports). The reason for that is that companies often use HTML and CSS

to format their financial statements or other data that they distribute through their corporate websites. One can use specialized website analysis tools (e.g. the SelectorGadget add-on or extension for Chrome Browser) to determine which CSS elements contain the needed data. A good knowledge of XML and XML-related technologies is useful for understanding XBRL, since XBRL uses XML as its meta-language.

Once a website is analyzed and the location of the needed data in the underlying code of a webpage is determined, one can proceed to the second phase: web scraping. On the technical level, web scraping consists of a variety of tasks related to downloading, cleaning, organizing, and preprocessing data from the web for the purposes of obtaining a clean data set. Web scraping can be done using a variety of programming languages (e.g. R, Python, Java, etc.) and ready-made software tools (e.g. Web Scraper extension for Google Chrome or import.io web tool). This research note discusses web scraping using the R language for several reasons. The main reason is that R language is increasingly becoming a de facto standard in data science (Lander 2014). With thousands of free analysis packages available in R, R can be used for carrying virtually all known forms of basic and advanced analysis of quantitative and qualitative data (CRAN 2017). Moreover, R can be used to formally describe every step of data collection and analysis. This contributes to reproducibility of research – one of the hallmarks of science (Peng 2011). Finally, the R environment already contains several useful, stable and highly-customizable packages that can be used for retrieving data from the web in various formats (e.g., HTML, CSS, XML, and XBRL). A reader wishing to learn more about any of the technologies used in web scraping (including R language) should refer to Appendix A where we list the recommended resources.

Web scraping using R requires a basic understanding of programming in general, R syntax, the RStudio environment as well the basic functions of the Rvest and XBRL packages. The Rvest

package was developed for haRvesting HTML, CSS, and XML data from the web (Wickham 2016). XBRL is specialized package for retrieving and analyzing financial data in XBRL format (Bertolusso and Kimmel 2016). The functionalities of the two packages are covered in detail in the subsequent two sections.

## IV. RVEST PACKAGE

This section is devoted to the functionality of the Rvest package – a popular R package used for accessing and parsing web data in various formats. The first part provides an overview of the package. The second part provides a simple illustration of how the package can be used for retrieving financial data from the web.

### Package Overview

Rvest is a popular web scraping package developed by Hadley Wickham (2016). Rvest contains functions that can be used for simulating sessions of a web browser or web crawler (comes in handy when one needs to browse through many webpages one at a time), as well as numerous functions for retrieving data from documents that use HTML, XML, CSS, and JSON formats. Some of the most essential functions are listed in Table 1 below. Many other functions are available as a part of Rvest package (see Wickham 2016).

Table 1. Some Functions of Rvest Package (Wickham 2016)

| **Function Usage and Purpose** | **Arguments** |
|---|---|
| Usage: read_html(x, ..., encoding = "")<br><br>Purpose: This function reads HTML code of a web page from which data is to be retrieved. | • x: A url, a local path, or a string containing HTML code that needs to be read<br>• …: Additional arguments can be passed to a URL using the GET() metod<br>• encoding: specify encoding of the web page being read |
| Usage: html_nodes(x, css, xpath)<br><br>Purpose: This function is used to select specific elements of a web document. To select these specific elements one can use CSS elements which contain the needed data or use XPath language to specify the "address" of an element of a web page | • x: A document, a node, or a set of nodes from which data is selected<br>• css, xpath: a name of a CSS element or an XPath 1.0 link can be used to select a node |
| Usage: html_session(url, ...)<br><br>Purpose: This function allows to start a web browsing session to browse HTML pages for the purpose of collecting data from them. | • url: address of a web page where browsing starts<br>• …: Any additional httr config commands to use throughout session |
| Usage: html_table(x, header = NA, trim = TRUE, fill = FALSE, dec = ".")<br><br>Purpose: This function can be used to read HTML tables into data frames (a commonly used data structure in R). Can be especially useful for reading HTML tables containing financial data. | • x: A node, node set or document<br>• header: if NA, then the first row contains data and not column labels.<br>• trim: if TRUE, the function will remove leading and trailing whitespace within each cell?<br>• fill: If TRUE, automatically fill rows with fewer than the maximum number of columns with NAs.<br>• dec: The character used as decimal mark for numbers |

**Rvest Usage Example**

The R script below (see Figure 2) provides a simple example of how Rvest package can be used for accessing financial data. The script uses a third quarter 10-Q statement by Berkshire Hathaway available from EDGAR. Balance sheet data is retrieved from the HTML page available through EDGAR that contains the Form 10-Q report for the third quarter.

```
#This script requires Rvest package to be installed and activated
library(Rvest)

#The variable url contains a URL to the 10-Q document published via EDGAR
url <- "https://www.sec.gov/Archives/edgar/data/1067983/000119312516760194/d268144d10q.htm"

#read_html() function from Rvest package used to read HTML code from page
tenqreport_html <- read_html(url)

#xpath used to retreive HTML code specifically for balance sheet table
balance_sheet_html <- html_nodes(tenqreport_html, xpath='/html/body/document/type/sequence/filename/description/text/table[7]')

#HTML code related to the balance sheet table is removed so that only balance sheet data is obtained
balance_sheet_list <- html_table(balance_sheet_html)

#Balance sheet data is saved from a list (a data structure that html_table function returns) into a data frame structure
balance_sheet_table <- balance_sheet_list[[1]]
```

Figure 2. A Simple Example of Using Rvest Package

Once balance sheet data is saved into a data frame (named “balance_sheet_table” in this example), individual values from the balance sheet can be accessed and used in calculations. For example, certain accounting ratios can be calculated. Alternatively, one can match the balance sheet with other data related to the company and available on the web. The Rvest package can be used in a similar fashion to obtain quantitative and qualitative data from the same HTML document or other sources on the web.

## V. XBRL PACKAGE

This section is devoted to the functionality of the XBRL package – an R package developed specifically for accessing financial information in XBRL format. Just like the section devoted to Rvest, it consists of two main parts. The first part provides an overview of the XBRL package. The second part provides a simple illustration of how the package can be used for retrieving financial data from the web.

### XBRL Package Overview

XBRL is a free package developed by Roberto Bertolusso and Marek Kimmel – two statisticians from Rice University (Bertolusso and Kimmel 2016). The package contains a number of functions that can be used for extracting financial information from an XBRL instance file and the associated taxonomies. Extracting and processing XBRL files can take some time. For example, an XBRL instance file for a large corporation can contain several megabytes worth of data – and this does not include related taxonomies. To save time and computing resources, the XBRL package can be used in a "piecemeal" fashion, where each element of an XBRL instance file is extracted and processed separately, depending on the needs of a researcher. For that, one needs to use a variety of low-level functions described in the manual supplied with the XBRL package (see Bertolusso and Kimmel 2016). Each of the low-level functions uses one of the arguments described in Table 2. The functions themselves are described in Table 3.

Table 2. Arguments Used by XBRL Package Functions (Bertolusso and Kimmel 2016)

| **Argument** | **Description** |
|---|---|
| file | A local file name or a URL for an XBRL document |
| doc | A pointer to an external memory source where XBRL data is stored. This pointer is returned by the xbrlParse function. |
| arcType | Represents type of XBRL data. Can be "presentation", "calculation", or "definition" |

Table 3. Low-Level Functions in XBRL Package

| **Function** | **Used on** | **Purpose** | **Returns** |
|---|---|---|---|
| xbrlParse(file) | Any XBRL file | XBRL file | A pointer to external memory used by the low-level functions. This can be thought of as making a local copy of the file for further analysis |
| xbrlFree(doc) | Any XBRL file | Releases the external memory used for storing the contents of an XBRL file locally | NULL |
| xbrlGetSchemaName(doc) | XBRL instance document | Extracts the name of the XBRL schema associated with a file | A character vector |
| xbrlGetLinkbaseNames(doc)<br>xbrlGetImportNames(doc) | XBRL taxonomy document | Extract the names of documents linked to the taxonomy during the process of discovery. | A character vector |
| xbrlProcessContexts(doc)<br>xbrlProcessFacts(doc)<br>xbrlProcessUnits(doc)<br>xbrlProcessFootnotes(doc) | XBRL instance documents or taxonomies | Extract information from taxonomy and instance files in the form of data frames | A data frame |



The comprehensive function xbrlDoAll() combines all of the functionality of the low-level functions into one single function. This function performs all the steps necessary to extract a

collection of various data frames, starting with an XBRL instance file (Bertolusso and Kimmel 2016). These data frames, together with relationships among them, are visualized in Figure 3.

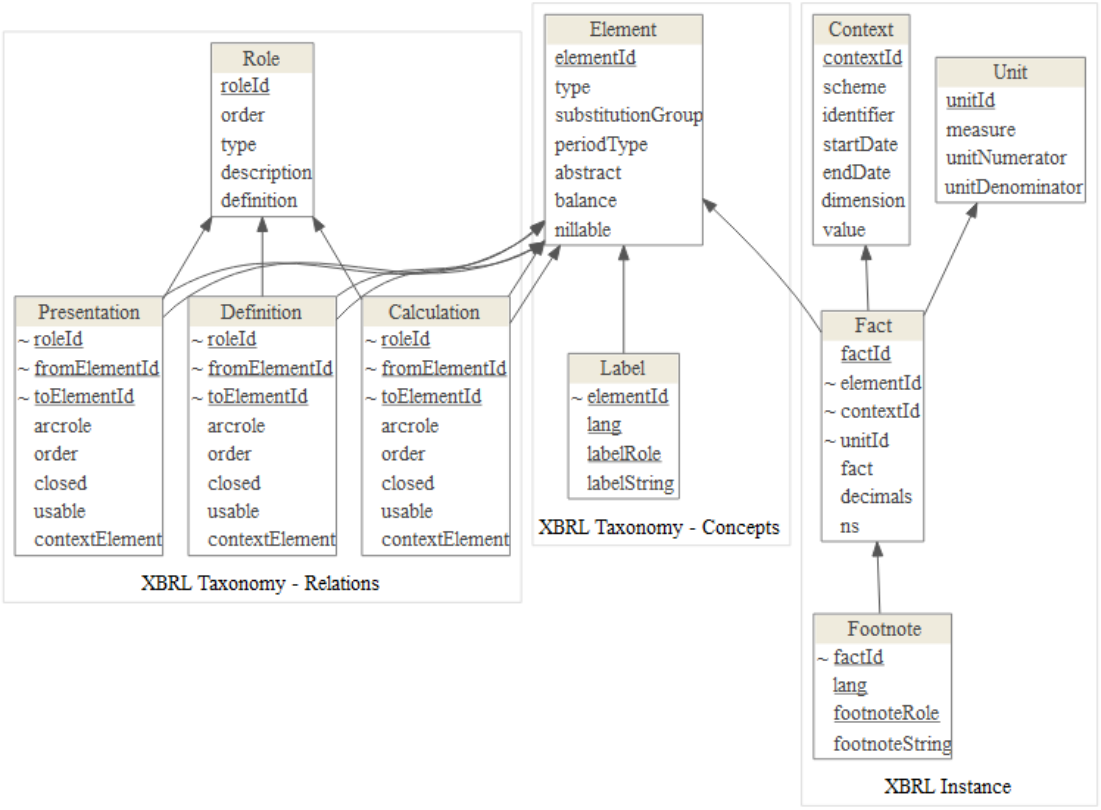



Figure 3. XBRL Data Frames and Their Relationships (Reprinted from Bergant 2015)

The function xbrlDoAll() is used as follows (Bertolusso and Kimmel 2016) :

```
xbrlDoAll(file.inst, cache.dir = "xbrl.Cache", prefix.out = NULL, verbose = FALSE,
delete.cached.inst = TRUE)
```

The arguments used by xbrlDoAll() the function are explained in Table 4.

Table 4. Arguments of xbrlDoAll Function

| Argument | Description |
|---|---|
| file.inst | XBRL instance file name. Can be a URL or a path to a local file. |
| cache.dir | The name of a local directory that should be used for storing discovered taxonomies. If nothing is supplied (i.e. the value of the parameter is NULL), no caching (or storing) of discovered taxonomies is done. |
| prefix.out | Prefix to be used for creating CSV files with the content of the data frames produced. |
| verbose | Should be set to TRUE if one wants to see the details of the process used for discovery and analysis of XBRL documents. |
| delete.cached.inst | Should be set to TRUE if one wants to delete downloaded XBRL instance, schema and linkbase files. |

**XBRL Usage Example**

The simple example provided here uses a holistic approach to XBRL instance document discovery. All the information related to an XBRL instance file is extracted with the help of the xbrlDoAll() function. Just like the previous example involving Rvest, the script below uses a third quarter form 10-Q statement submitted by Berkshire Hathaway. The difference is that the data is now retrieved from an XBRL report submitted in XMRL format, which is also retrieved through the EDGAR web database.

```
# Setting stringsAsFactors = FALSE forces R to treat string or text data as t
ext and not as values or levels of a particular variable (something that is d
one by dafault in R)
options(stringsAsFactors = FALSE)

# XBRL package library is loaded
library(XBRL)

# The variable url contains the link to the XBRL instance file (3d Quarter Fo
rm 10-Q filed by Berkshire Hathaway via EDGAR) to be analyzed
url <- "https://www.sec.gov/Archives/edgar/data/1067983/000119312516760194/br
ka-20160930.xml"

# xbrlDoAll() function creates a list of data frames (the list is named "xbrl
.vars") containing all the information extracted from the instance file.
xbrl.vars <- xbrlDoAll(url, verbose=TRUE)
```

Figure 4. A Simple Example of Using XBRL Package

Note that the resulting list named "xbrl.vars" contains ten data frames with information related to the elements read from the instance document (one data frame for each entity shown in Figure 3). The data frame related to facts (that is specific financial data being distributed via the instance document) is of particular interest, since researchers may want to do calculations with actual financial data. Thus, this data frame contains a complete set of attribute values for each fact together with its numeric value stored in the data frame's column with the name "fact".

## VI. A COMPLEX WEB SCRAPING EXAMPLE

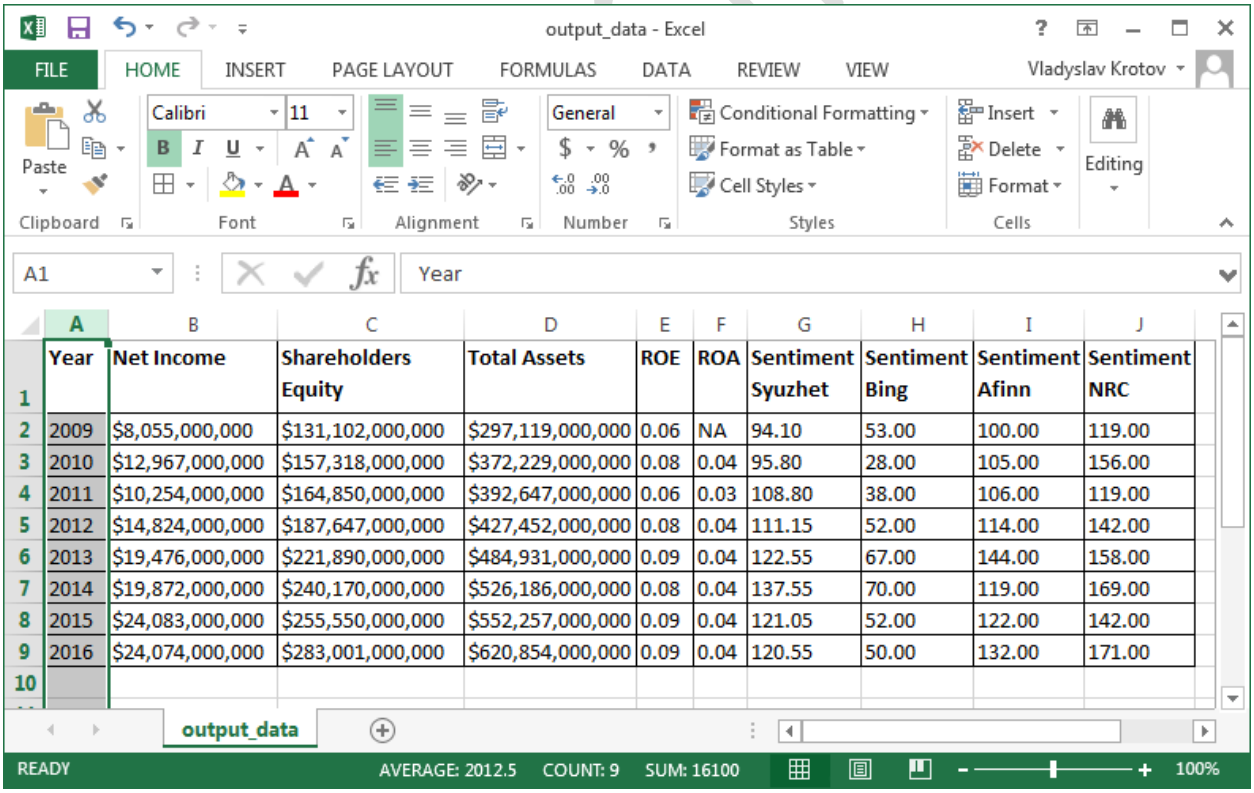
This section contains an integrated example of using both the Rvest and XBRL packages to automate a relatively complex web scraping task. The first part of this section provides an overview of the web scraping task. The second part provides an annotated R script used for automating the data collection task.

### Web Scraping Task Overview

The web scraping task is initiated to collect data that can potentially answer the following research question: Is there a relationship between annual performance of a company and the sentiment expressed in an annual report? Among other things, the web scraping task involves the following:

- Retrieving financial data for Berkshire Hathaway from two different Web sources: (1) EDGAR and (2) the company's corporate website (http://www.berkshirehathaway.com).
- The two data sources provide two different units of observation. In the case of EDGAR, financial data is retrieved in the form of XBRL instance documents (10-K Reports). Berkshire's website is used to retrieve annual reports in PDF format for the period corresponding to the instance documents.

- Simple calculations (ROE and ROA) involving basic logic (e.g. whether data from the previous period is available) are performed based on the data obtained from 10-K reports.
- Annual reports are subjected to sentiment analysis to calculate a sentiment score for each of the annual reports using four different scoring algorithms: Syuzhet, Bing, Afinn, and NRC. These algorithms are implemented as a part of the Syuzhet R package (see Jockerts, 2017).
- All the data is saved into an Excel table (see Figure 5 below). Excel format is quite popular among researchers; it can be used for both programmatic and manual data manipulation and analysis.




| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Year | Net Income | Shareholders Equity | Total Assets | ROE | ROA | Sentiment Syuzhet | Sentiment Bing | Sentiment Afinn | Sentiment NRC |
| 2 | 2009 | $8,055,000,000 | $131,102,000,000 | $297,119,000,000 | 0.06 | NA | 94.10 | 53.00 | 100.00 | 119.00 |
| 3 | 2010 | $12,967,000,000 | $157,318,000,000 | $372,229,000,000 | 0.08 | 0.04 | 95.80 | 28.00 | 105.00 | 156.00 |
| 4 | 2011 | $10,254,000,000 | $164,850,000,000 | $392,647,000,000 | 0.06 | 0.03 | 108.80 | 38.00 | 106.00 | 119.00 |
| 5 | 2012 | $14,824,000,000 | $187,647,000,000 | $427,452,000,000 | 0.08 | 0.04 | 111.15 | 52.00 | 114.00 | 142.00 |
| 6 | 2013 | $19,476,000,000 | $221,890,000,000 | $484,931,000,000 | 0.09 | 0.04 | 122.55 | 67.00 | 144.00 | 158.00 |
| 7 | 2014 | $19,872,000,000 | $240,170,000,000 | $526,186,000,000 | 0.08 | 0.04 | 137.55 | 70.00 | 119.00 | 169.00 |
| 8 | 2015 | $24,083,000,000 | $255,550,000,000 | $552,257,000,000 | 0.09 | 0.04 | 121.05 | 52.00 | 122.00 | 142.00 |
| 9 | 2016 | $24,074,000,000 | $283,001,000,000 | $620,854,000,000 | 0.09 | 0.04 | 120.55 | 50.00 | 132.00 | 171.00 |
| 10 | | | | | | | | | | |

Figure 5. Collected Data after Formatting

The data collection task is deliberately small. The final data set contains only 8 observations for one single company, which is Berkshire Hathaway (see Figure 5). A small data collection task is selected to minimize the execution time of the script. Still, even a short example like this one will run for almost one minute on an average office computer. Naturally, this example can be extended to collect additional data from other companies to produce a large data set. The fact that this small data collection task takes almost one minute for a computer to complete shows how much time will be saved by automating this task with the help of the R language.

**Annotated R Code Used for Web Scraping**

The annotated R code used for collecting the data shown in Figure 5 is provided in Figure 6 below. The code is also available in the form of an R script file from one of the author's GitHub account: [link removed]

```
#Load required packages
require(Rvest)
require(XBRL)
require(pdftools)
require(syuzhet)

#Set working directory
setwd("C:/Users/[name removed]/Google Drive/Research/JETA/Code")

#Store strings as strings, rather than factors, inside data frames
options(stringsAsFactors=FALSE)

#Set filters
type <- "10-K"    #read annual statements
numStmts <- 8     #number of statements to be read (the most-recent statement
s will be read)

#Build the URL to get the list of reports
baseQueryUrl <- "https://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&C
IK=0001067983&type="
queryUrl <- paste(baseQueryUrl, type, sep="")

#Get and parse the HTML for the list of reports
```

```
reportListHtml <- read_html(html_session(queryUrl))
documentLinks <- html_nodes(reportListHtml, "a[id=\"documentsbutton\"]")
documentLinkUrls <- data.frame(xml_attrs(documentLinks))

#Create frame in which data results will be stored
all_data <- data.frame(Year=character(0),
                       NetIncome=character(0),
                       ShareholdersEquity=character(0),
                       TotalAssets=character(0),
                       ROE=character(0),
                       ROA=character(0),
                       SentimentSyuzhet=character(0),
                       SentimentBing=character(0),
                       SentimentAfinn=character(0),
                       SentimentNRC=character(0))

#Create columns for the data frame
colnames(all_data) <- c("Year",
                        "NetIncome",
                        "ShareholdersEquity",
                        "TotalAssets",
                        "ROE",
                        "ROA",
                        "SentimentSyuzhet",
                        "SentimentBing",
                        "SentimentAfinn",
                        "SentimentNRC")

#This will store the "Total Assets" value for the previous year (used in ROA
calculation)
prevTA <- -1

#Read each statement one at a time
for(stmt in numStmts:1)
{
  #Read HTML for the current statement
  filingDetails <- toString(documentLinkUrls[1,stmt])
  filingDetailsUrl <- paste("https://www.sec.gov", filingDetails, sep="")
  filingDetailsHtml <- read_html(html_session(filingDetailsUrl))

  #Read the Data Files html table which should contain the XBRL document
  dataFilesTable <- html_nodes(filingDetailsHtml, "table[summary=\"Data Files
      \"]")
  tableRows <- html_nodes(dataFilesTable, "tr")

  for(row in 1:length(tableRows))
  {
    #Specifically find the XBRL document from among the Data Files
    if(grepl("XBRL INSTANCE DOCUMENT", tableRows[row]))
    {
```

```
    #Get the URL of the XBRL document itself
    link <- html_node(tableRows[row], "a")
    linkUrl <- paste("https://www.sec.gov", xml_attr(link, "href"), sep="")
    writeLines(linkUrl) #print the url of the XBRL document

    #Read the data from the XBRL instance file
    xbrl.vars <- xbrlDoAll(linkUrl, cache.dir="XBRLcache", prefix.out="out"
    , verbose=FALSE)

    #Determine the date of the annual statement based on the name of the XB
    RL file
    year  <- substr(linkUrl, nchar(linkUrl)-11, nchar(linkUrl)-8)
    month <- substr(linkUrl, nchar(linkUrl)-7,  nchar(linkUrl)-6)
    day   <- substr(linkUrl, nchar(linkUrl)-5,  nchar(linkUrl)-4)

    #Retreve the "facts" from the XBRL
    values <- xbrl.vars$fact

    #Find the positions of Net Income (NI), Shareholders Equity (SE), and
    Total Assets (TA) in the facts data frame
    regex <- paste(year,"-?",month,"-?",day,"(_0)?","$",sep="")
    indexNI <- which(values$elementId=="us-gaap_NetIncomeLoss" & grepl(rege
    x,values$contextId))
    indexSE <- which(values$elementId=="us-gaap_StockholdersEquity" & grepl
    (regex,values$contextId))
    indexTA <- which(values$elementId=="us-gaap_Assets" & grepl(regex,value
    s$contextId))

    #Obtaining NI, SE, and TA values
    NI <- as.numeric(values$fact[indexNI]) #NI contains income for both the
    year & the 4th quarter (we only use the annual value)
    SE <- as.numeric(values$fact[indexSE])
    TA <- as.numeric(values$fact[indexTA])

    #print key values to output
    writeLines(paste("Net Income: ", NI[1]))
    writeLines(paste("Shareholders Equity: ", SE))
    writeLines(paste("Total Assets: ", TA))
    writeLines("")

    #Download a corresponding Letter to Shareholders and read into a charve
    ctor
    txt <- pdf_text(paste("http://www.berkshirehathaway.com/letters/",year,
    "ltr.pdf",sep=""))
    all_txt <- paste(txt, sep="", collapse="")

    #Calculate sentiment score using four different methods
    sentimentSyuzhet <- get_sentiment(all_txt, method="syuzhet")
    sentimentBing <- get_sentiment(all_txt, method="bing")
    sentimentAfinn <- get_sentiment(all_txt, method="afinn")
```

```
      sentimentNRC <- get_sentiment(all_txt, method="nrc")

      #If available, use the previous Total Assets to calculate ROA
      if(prevTA!=-1)
        ROA <- 2*NI[1]/(TA+prevTA)
      else
        ROA <- "NA"

      #Consolidate all the information about this statement into a single fra
      me
      stmt_info <- data.frame("Year"=year,
                              "NetIncome"=NI[1],
                              "ShareholdersEquity"=SE,
                              "TotalAssets"=TA,
                              "ROE"=NI[1]/SE,
                              "ROA"=ROA,
                              "SentimentSyuzhet"=sentimentSyuzhet,
                              "SentimentBing"=sentimentBing,
                              "SentimentAfinn"=sentimentAfinn,
                              "SentimentNRC"=sentimentNRC)

      #Write the current statement info to the frame where all data is stored
      all_data <- rbind(all_data, stmt_info)

      #this year's TA is stored as the previous year's TA to use in the next
      loop iteration
      prevTA <- TA
    }
  }
}

#Finally, write all the collected data to an output file
write.table(all_data, file="output_data.csv", sep=",", col.names=TRUE, row.na
mes=FALSE)
```

Figure 6. An Integrated Example of Using Rvest and XBRL for Automating a Complex Web Scraping Task in R

## VII. IMPLICATIONS FOR RESARCHERS

There is nothing new about obtaining financial data from the web. Numerous web databases (e.g. EDGAR) have been available for years (Debreceny et al. 2005). Researchers have been downloading structured datasets containing financial data and analyzing them using computer tools for years. The real value of the web scraping toolset presented in this paper comes from

several areas. First, in the era of Big Data, even simple manipulations with accounting numbers can be very tedious and time consuming if done manually. The R environment can be used to automate a number of simple and also complex data collection and data transformation processes and techniques involving complex heuristic. Second, the approach outlined in this paper allows researchers to go beyond accounting data (which is already available in structured format from the numerous databases containing accounting data). Accounting facts can be combined with other sources of quantitative and even qualitative data for better understanding of a particular phenomenon. Third, using R for web scraping and subsequent analysis ensures reproducibility of accounting research (Peng 2011). Any manual manipulation of data may involve subjective choices and interpretations in relation to how data is retrieved, saved, cleaned, formatted, etc. Oftentimes, even research involving simple data manipulations cannot be replicated by other researchers due to the errors committed at various stages of data gathering and analysis (Dennis and Valacich 2014). Fourth, once financial and non-financial data is retrieved using R, it can subjected to a virtually all known forms of analysis implemented via thousands of user-generated packages available from CRAN.

## VIII. CONCLUSION

The World Wide Web is a vast repository of data. Many old and new research questions can be addressed by retrieving and analyzing this data. Unfortunately, web data is often unstructured or semi-structured, based on somewhat loose standards, and generated or updated in real time. As demonstrated in this research note, the R environment can be used as a platform for creating and modifying an automated tool for retrieving financial and non-financial data from the web. A "one size fits all" web scraping solution can hardly work due to the diverse nature of business research and the constantly and rapidly evolving World Wide Web. We are confident that

the approach to web scraping outlined in this research note should serve as a good starting point for any accounting or general business research requiring web scraping.

## Appendix A – Additional Resources

### Web Architecture

The following brief online tutorials can be recommended for those who want to learn more about the Word Wide Web Architecture:

- Dynamic Web Solutions. 2017. *A Conceptual Explanation of the World Wide Web*. Available at: http://www.dynamicwebs.com.au/tutorials/explain-web.htm
- Tutorials Point. 2017. *HTTP Tutorial*. Available at: http://www.tutorialspoint.com/http/

World Wide Web Consortium is the ultimate source on the technologies and specifications related to the Web:

- World Wide Web Consortium (W3C). 2017. Available at: https://www.w3.org/

### HTML

A free online tutorial from w3schools.com on various aspects of HTML:

- http://www.w3schools.com/html/default.asp

### CSS

A free online tutorial from w3schools.com on CSS:

- http://www.w3schools.com/css/default.asp

### XML

A free online tutorial from w3schools.com on XML and a number of related technologies:

- http://www.w3schools.com/xml/xml_exam.asp

In addition to providing a rather thorough treatment of XML, the tutorial also has sections devoted to related technologies, such as XML Namespaces, XML Schema, XPath and XLink

**XBRL**

A comprehensive collection of various articles and technical specifications documents describing XBRL and related issues is available from XBRL International website:

- https://www.xbrl.org/

A good starting point for learning technical aspects of XBRL is XBRL's International "how to" page for developers:

- https://www.xbrl.org/the-standard/how/getting-started-for-developers/

**R and RStudio**

We recommend the following book to people with basic understanding of computer programming but no previous knowledge of R:

- Lander, J. P. 2014. *R for Everyone: Advanced Analytics and Graphics*. Boston, MA: Addison-Wesley.

The book contains an excellent introduction into various aspects of R language and contains a manual on installing and using RStudio. Much of the examples found in this note are based on this book.

For those already familiar with R, the following advanced text on R can be recommended:

- Wickham, H. 2014. *Advanced R*. Boca Raton, FL: CRC Press.

Alternatively, one can access various articles and tutorials on R online:

- https://www.r-bloggers.com/how-to-learn-r-2/

Those wishing to get a practical introduction to data science in R and learn various related technologies and statistical techniques, the following online specialization from John Hopkins University is available in Coursera:

- https://www.coursera.org/specializations/jhu-data-science

Those who already have some knowledge of R and wish to get straight into web scraping using R, should read the documentation for the following two R packages:

- Rvest: https://cran.r-project.org/web/packages/Rvest/Rvest.pdf
- XBRL: https://cran.r-project.org/web/packages/XBRL/XBRL.pdf

The following online tutorial by Darko Bergnant contains a good overview and a practical demonstration on using XBRL package:

- https://github.com/bergant/XBRLFiles

The package "finreportr" can be used for retrieving financial statements from SEC using R:

- https://cran.r-project.org/web/packages/finreportr/finreportr.pdf

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Bertolusso, R., and M. Kimmel. 2016. *Package 'XBRL'*. Available at: https://cran.r-project.org/web/packages/XBRL/XBRL.pdf

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