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Cashless Economies, Data Analysis, and Research-Based Teaching: The Versatility of the Velocity of Money for Teaching Macroeconomics

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Abstract: Simple concepts such as the velocity of money can be powerful tools to stimulate classroom discussions about complex issues in macroeconomics classes. For example, are cashless societies likely or is monetary policy likely to be effective? Such concepts are also ideal for in-class data analysis and for research-based teaching. The velocity of money for example only requires values from three commonly available variables, a simple calculation, and can be analysed by plotting it on a graph. In this paper we provide a summary of the velocity of money, what affects it, and illustrate these with two fascinating cases. We also provide two assignments, including how to create data sets, along with grading rubrics. Finally, we discuss experiences from an assignment we set our class.

Keywords: Teaching Macroeconomics, Velocity of Money, Cashless Society, Data Analysis, FRED, Undergraduate Research

JEL Classifications: A22, B22, E41, E42, E51

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1. Introduction

The velocity of money is a macroeconomic concept that is all too often neglected or mistreated in the macroeconomics curriculum. Many introduce an aggregate relationship involving money holdings and the price level and then quickly consign the velocity of money to the bin labelled "stays constant" or ignored. For example, Mankiw (2019) in his popular intermediate macroeconomics textbook, *Macroeconomics*, introduces the transactions velocity of money (usually denoted as V) as part of the quantity equation. He then moves to V as meaning the income velocity of money which then leads on to the money demand equation in his chapter on inflation. But all this is really only to get to assuming V is constant to get the quantity equation, and thus link money to the price level. After this, the transactions velocity of money or the income velocity of money play no part in his textbook, even in subsequent chapters investigating monetary policy. This is not an unusual treatment of the velocity of money (see for example Mishkin 2015). There are some, such as Abel, Bernanke, and Coushore (2017) and Dornbsuch, Fisher and Startz (2018), who do show movements in the velocity of money in a graph and may even briefly discuss the graph. But mostly it is as a curiosity or an aside on the way to looking at inflation and the money supply.

This is a shame because simple concepts such as the velocity of money can be powerful tools to stimulate classroom discussions about complex issues in introductory and intermediate macroeconomics classes. In the case of the velocity of money, it can be used to introduce and discuss a range of topics including why the demand for money may rise or fall, is monetary policy likely to be effective in a given country, and topically, are we likely to see the emergence of cashless societies. Simple concepts such as the velocity of money are also ideal for in-class data analysis and for research based teaching, or as the basis of a flipped-classroom lecture,

even at the introductory level. The velocity of money for example only requires values from three variables in a simple calculation and can be analysed by plotting on a graph.

There are many practical ways of using the velocity of money in teaching introductory or intermediate macroeconomics. As V is easy to calculate then a course lecturer can set a data centric student assignment that focuses on the key skills of sourcing, selecting and presenting data. The FRED database is an excellent resource for such an assignment. Second, most students find the concept of V relatively straightforward given its natural link with money and spending resulting. This makes any changes in it readily amenable to being analysed by students, importantly what a rising or falling V means in terms of people demanding money. Third, since students find V easy to calculate and relatively easy to analyse, velocity can be used to teach students methodological skills such as proposing plausible theories that use economics to explain what is observed. This could range from "testing" the constancy assumption or whether or not we are moving to a world effectively without cash. Finally, students can examine how changes in V can potentially affect a government's use of monetary policy to achieve different economic objectives. One example of this is the effectiveness of the interventions by central banks as they reacted to the global financial crisis as discussed by Anderson, Bordo, and Duca (2017), Gros, Alcidi, and De Groen (2015), Kuttner (2018), Martin and Milas (2012), and Price (2013). These authors argue that the large increase in the monetary base did not stimulate aggregate demand or result in inflation. Students could calculate what happened to V during this period (it declined), use their results to analyse what most likely happened to money demand, and then use this analysis to assess the merits of the arguments for the likely ineffectiveness of monetary expansion.

In this paper we focus on the velocities of currency and narrow money as they are most relevant to considering transactions behaviour, especially the "cashless society" question. We first discuss what is meant by velocity and then what affects it. Next we use two cases to show what has happened to V and to illustrate the potential utility of velocity as a pedagogical topic. Then we provide instructions students could use to create data sets to calculate and study velocity for different countries, as well as providing the outlines of two types of assessment for instructors. Finally, we present some feedback from an assessment item based on velocity we used in an intermediate macroeconomics course.

2. What is *V*?

The transactions velocity of money is most easily thought of as the speed at which money circulates around the economy over a given period of time.[1] That is, for a given nominal value of expenditure, how many times does a unit of money change hands in the process of payments between economic agents for the transactions that make up the expenditure? If economic agents wish to hold a large amount of money relative to their expenditures then velocity will be slow and the converse is true for smaller desired holdings. This idea is captured in the definitional equation of $V = P \cdot Y / M$, where the "price level" (P) in combination with real GDP (Y) indicate nominal expenditure, and one or other of the measures of monetary aggregates (M) indicates how much money is used as a means of payment for the transactions making up that expenditure.

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[1] For the really interested there are usually two concepts of the velocity of money. One is called the transactions velocity of money where the number of transactions (T) is the quantity variable, i.e. $V = PT/M$. The income velocity usually takes the quantity variable as real GDP hence the right hand side has nominal GDP, i.e. $V = PY/M$. In practice the number of transactions (T) is not observable so it is the income velocity that is being referred to. These measures can be quite different. For example, an economy with a large number of transactions for second hand goods will have a different transactions velocity than another economy with a smaller number of such transactions. However, both may have the same income velocity of money.

From there this identity is usually re-arranged to the familiar "equation of exchange" or $M \cdot V = P \cdot Y$. As indicated in table 1, the purpose of the equation of exchange for most modern texts is to explain the relationship between M and P. Hence at this point, it is usually assumed that V is constant and that Y is determined by things other than M or P. As Blaug et al (1995) explains:

> "...the quantity theory of money really consists of three interrelated propositions: (a) the causal arrow runs from money M to prices P...; (b) there is a stable demand for nominal money-balances-to-hold, sometimes known as the velocity of circulation of money V...; and (c) the volume of transactions T or the volume of output Y... is determined independently of the quantity of money or the level of prices but rather by real variables such as endowments, preferences and technology." (29)

From these propositions and the equation of exchange, the crude quantity theory of money can be derived from rearranging the equation of exchange to put it in terms of M, or $M = kP$ where $k = Y / V$. In other words, the price level will always be some constant multiple of the money supply determined by the ratio of Y to V. All of this serves to get to the end point which is to show that changes in the price level are brought about by (exogenous) changes in the money supply.

To make this relationship more explicit, sometimes the equation of exchange can be converted into a dynamic (approximation) form written in terms of percentage changes (indicated by the caret symbol),[2]

$$\hat{M} + \hat{V} = \hat{Y} + \hat{P}.$$

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[2] A more mathematically accurate method is to take logs and then totally differentiate. However, this method is beyond most principles courses so the percentage change approximation can be used instead.

Writing the quantity theory of money in terms of percentage changes highlights that if the percentage change in velocity ($\hat{V}$) is assumed to be constant (usually equal to zero) and output is assumed to grow at a constant rate then there exists a clear relationship between money growth and inflation. This is equivalent to taking the Classical Dichotomy (the distinction between real and nominal variables and that money affects nominal but nor real variables) as a reasonable starting position to take.

The quantity theory of money is one of the "oldest surviving theories in economics" (Blaug et al 1995, 27). Blaug et al (1995) credit John Locke with the earliest coherent statement of the quantity theory in 1692. However, the early economists did not simply assume the velocity of money away or see it of little analytical use. Laidler (1991, 16) notes how early monetary economists (for example Mill and Hume) were well aware that assuming a constant velocity of money was convenient but did not hold in the real world. Laidler (1991, 127) lays out the work of Knut Wicksell who saw the availability of credit as a major influence on changes in V and hence on changes to the price level. He also notes the work of Fisher in setting out some determinants of the velocity of money (72) including both speculative and precautionary types of motives. Bordono and Jonung (1987, 19) note that Irving Fisher stresses the transaction motive for money and so expected V to continue to rise as financial innovation reduced the need for money balances to settle transactions. Blaug et al (1995) note that the three interrelated propositions that underlay the quantity theory of money (see above) "…are highly controversial and by no means truisms" (29).

Another way to think about V is that it is "…the inverse of the percentage of income that people keep in the form of money. … Velocity is therefore essentially a measure of income-adjusted money demanded" (Caplan 2009). This turns out to be a very useful pedagogical way to think

about *V*, as if *V* is rising, then money demand is falling in real terms and vice versa. Goldfeld and Sichel (1990) give a comprehensive survey of the demand for money.

3. What affects *V* in theory?

As discussed, most modern texts pay less attention to the velocity of money (for the rest of the paper velocity will mean the income velocity of money) than older ones and are more likely to assume (explicitly or implicitly) that *V* is constant to concentrate on the link between the money supply and the price level. Clearly, as shown in Figure 1, *V* is not constant, and is itself a function of deeper parameters. As these change, *V* will also change.

Figure 1. Notes and coins velocity of circulation for New Zealand, Australia, the United Kingdom and the United States (Index 1980=100).
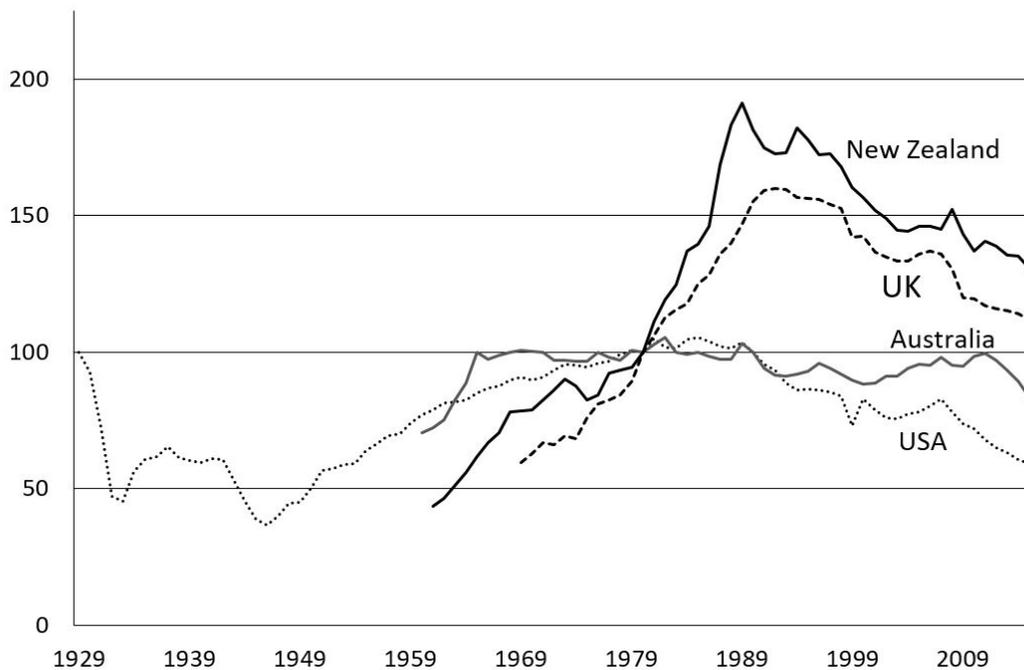
Note: Data is from Bordo and Jonung (1987).

These changes ultimately stem from factors related to the three motives for holding money as summarised in the general surveys of Barro and Fischer (1976), Goldfield and Sichel (1990), and Friedman (2008). The first is the transactions motive which arises from the primary

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function of money as a medium of exchange (Baumol, 1952; Walsh, 2010, ch.3). The purchasers pay money to sellers in exchange for goods or services or assets. In nominal terms this implies that real income and the price level will both positively affect the demand for money as they result in a higher total value of transactions. If real incomes and the price level collectively grow faster than the money supply then velocity would rise as each unit of money would on average be used in more transactions in nominal terms (Friedman and Schwartz, 1963).

Changes in any factor related to the transactions motive could affect V. One such factor is the form of payments method (Bordo and Jonung, 1987). If households shift towards money and away from other payment methods (e.g. barter) and from consuming their own household production, then demand for money rises and V falls. Another factor arises from financial innovation and what constitutes money suitable as a medium of exchange. A noticeable feature of financial markets is the rising availability of credit instruments and money substitutes, such as the development of credit and debit cards and online payments systems, or automated teller machines from technology improvements. This has reduced the need for cash holdings (Teles and Zhou, 2005; Alvarez and Lippi, 2009). These lower transactions cost of accessing and using money to pay for transactions causing the demand for money to fall and V to rise. Quinn and Roberds (2008) provide a detailed and very accessible history of the evolution of the cheque as a payments technology from the thirteenth century onwards and how it reduced the demand for currency. Stix (2004) documents an example of debit cards causing a reduction in the demand for currency.

The transactions motive for holding money naturally lends itself to answering a longstanding and topical question, are we moving towards a cashless society? This issue has been around

since at least the 1950s and 60s (Reistad 1967; Lee 1967) with regular claims that a cashless society is imminent (Wright 1982, April; Ramo et al 1998, April; Acton and O'Grady 2008, October 15). Changes in V, such as it falling for the first half of the twentieth century as demand for cash holdings was rising (Keeley, 1988; Drehman, Goodhart, and Kreuger, 2002; Bagnall et al 2016; Bech et al, 2018), and then rising for the next 40 years and falling since then, can be used to infer what is happening to the demand for cash as a means of paying for transactions in answering this question.

An important cost of holding money and thus a determinant of its demand is the difference between the real return on money versus other assets (Friedman, 2008). Higher real interest rates tends to increase this opportunity cost of holding money, reducing the demand for it, resulting in an increase the velocity of money. Expected inflation also reduces the return on money since money is a nominal asset and higher inflation erodes its purchasing power. Higher rates of expected inflation will thus increase the velocity of money. However, this is unlikely to explain long term, secular changes in V. In this vein, one significant event which can be studied is the high inflation rates of the 1970s and 1980s and their effect on the demand for money (Blejer, 1979; Smirlock, 1982; Goldfield and Sichel, 1990).

A second motive for demanding money is the precautionary motive. Traditionally this has been posited as arising from penalties from money balances being below some minimum level when flows of income and expenditures are uncertain (Patinkin, 1965; Whalen, 1966). The implication is a person or business should hold some amount of money to avoid these penalties. Improvements in cash management technology and lower costs of transferring between broader forms of financial wealth and money would result in less money demanded and a higher velocity. Precautionary demand for money can also increase with economic instability due to

money having a high degree of liquidity over other forms of assets. For example, higher average inflation is usually accompanied by more variable and uncertain inflation, introducing uncertainty about the expected future values of nominal variables being decided upon today (Blejer, 1979; Smirlock, 1982). Higher inflation would thus be associated with a higher precautionary demand for money, causing V to fall. The demand for velocity is affected by other forms uncertainty such as the state of confidence in the finance system. Financial crises due to stock market crashes and banking crises, such as happened with the Global Financial Crisis, increases the demand for more liquid forms of assets, such as money and particularly currency, reducing the velocity of money (Anderson, Bordo, and Duca, 2017; European Central Bank, 2012).

Classroom discussion could encompass how velocity might change if there is a lack of confidence in the financial system due to financial crises (Stix 2013) which consequently can make monetary policy substantially more difficult. Some authors suggest this might have occurred when central banks tried stimulate economies following the Global Financial Crisis (GFC) with their attempts partially neutralised by a slowing velocity of money. Martin and Milas (2012) and Gros, Alcidi, and De Groen (2015) provide evidence for the United States, United Kingdom and Europe. Berkmen (2012) finds this for Japan and Cusbert and Rohling (2013) document how the demand for currency rose substantially in Australia after the global financial crisis.

Lastly, Tobin (1958) argues that people hold money resulting from it being an asset. In determining the optimal portfolio of assets to hold, a risk averse person will choose low risk but low return money along with higher risk but higher return assets. The more risk averse a person, the more money they will hold in their portfolio, the lower will be V. The greater the

difference in return between money and higher risk assets, the less money will be demanded in a person's portfolio, and the higher will be *V*.

4. Two Case Studies of *V* – Sweden and Mexico

We will now present two illustrative and interesting examples of how velocity of money can change and the factors affecting it. Sweden is interesting since it is the most common example given of a country claimed to be moving to a cashless economy. Mexico is interesting since there are claims about pervasive corruption and the stability of banking system, as well as the country having experienced periods of high inflation.

4.1 Sweden

Sweden is a highly developed Western economy with a long established and well functioning financial system, including the world's oldest central bank, the Sveriges Riksbank, founded in 1668. As such, it has centuries of readily available economic data which is a great asset when teaching and studying broad historical changes. For example, Edvinsson (2014, chs 4,7) contains data on Swedish GDP and financial variables, including the monetary base and broad money supply, going back to the 1600s. Figure 2 shows the velocities for the monetary base and for the broad money supply since the middle of 1800 using the Riksbank data. The sizeable falls in the velocities of money until the 1920s illustrates what Jonung (1983) describes as a monetisation process whereby the economy moves to money as part of the growth of commercial banking and the decline of barter as a means of paying for transactions. This is reflected in the large growth in bank offices, bank accounts per capita, and bank deposits. The period from the early 1960s until the mid 1980s saw increases in both 3-month Treasury and long-term government bond yields which can be found at the Fred database. This increases the

opportunity cost of holding assets as lower earning money and, as would expected from theory, its velocity increases.

Studying changes in *V* from 2007/08 onwards is very instructive and can be used to illustrate both macroeconomic relationships and the importance of taking care in analysing data. We know that interest rates fell significantly in response to the GFC, which would normally result in a lower opportunity cost of holding money as an asset, with resulting falls in its velocity. Both narrow and broad money supply velocities decrease as would be consistent with falling

Figure 2. Income Velocity of Money for Sweden for the Monetary Base (M0), the Narrow
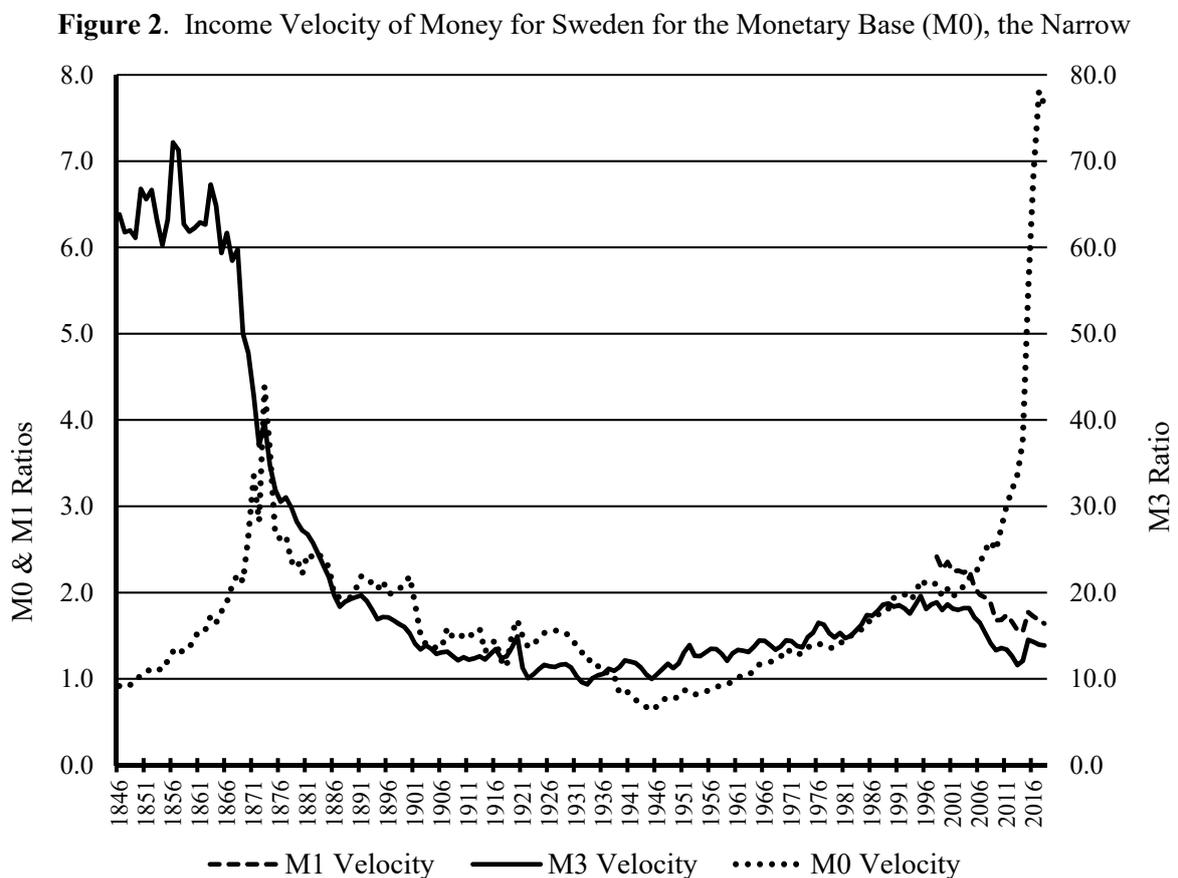
Money Supply (M1), and Broad Money Supply (M3).
Note: Monetary base, broad money and GDP data are from Rodney Edvinsson and Anders Ögren (2014) updated using the Federal Reserve Bank of St. Louis' Fred database. Narrow money supply is from the Federal Reserve Bank of St. Louis' Fred database.

interest rates. But currency related velocity rises substantially over this period from 25 to 77. This would seem at first a puzzle, but it is not when knowing that M0 fell from over SEK 100

billion just under 58 billion by 2017, a 42 percent decrease.[3] These changes reflect Sweden moving towards a cashless society with electronic payments becoming the overwhelmingly dominant form of payments mechanism (Ingves, 2018; Sveriges Riksbank, 2019). An interesting resulting question to assign students is to explain what economic and non-economic factors are causing Sweden to move so strongly away from cash to electronic payments compared to other countries (Ardvisson, 2019).

4.2 Mexico

Mexico has a much younger banking system than Sweden with the Mexican central bank, the Banco de México, founded in 1925. Like Sweden, during the latter half of the nineteenth century Mexico experienced the rise of money as a means of payment relative to barter and such like. But unlike Sweden, Mexico has experienced banking system crises at times, in the early 1900s, the early 1980s, and the mid 1990s (Marichal, 2008; Graf, 1999; Del Angel, 2016). Mexico has also experienced large changes in inflation and nominal interest rates. There have been periods of rising and high inflation (with correspondingly high nominal interest rates) from the 1970s to a peak of 131 percent in 1987, and a brief spurt of inflation in the mid-1990s. There have also been periods of substantial falls such as between the late 1980s through to the mid 1990s, and after the brief spurt of inflation in mid-1990s onwards. Finally, Mexico unlike Sweden is widely seen as having a pervasive problem with corruption as shown by the Corruption Perceptions Index produced by Transparency International. [4] With higher rankings being better, Mexico's best was 72nd out of 180 countries in 2007 and worst was 138th out of 180 countries in 2018 (with Sweden being at worst seventh out of roughly 170 countries). This

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[3] Data retrieved from Sweden's Riksbank: https://www.riksbank.se/en-gb/notes-and-coins/statistics/.

[4] Details about the Corruptions Perception Index, including historical values, can be found at https://www.transparency.org/. The first year of the Index was 1995 when 41 countries were assessed with the number of countries assessed increasing to 180 by 2018.

among other things has led to Mexico having a relatively large shadow economy as a percentage of GDP of 31.7 percent on average between 1991 and 2015 (as compared to Sweden of 20 percent) as estimated by Medina and Schneider (2017).

These all result in a rich story to tell about changes in the Mexican velocity of money shown in Figure 3 and allow for incorporating and explaining the importance of institutional factors in macroeconomics. The fall in velocity from 1989 through to 1992 can be explained by falling inflation. Equally the rise in velocity from 1992 to 1995 can be explained by the increase in inflation. What is interesting to point out to students is the period from 1994 through to 1998.

Figure 3. Income Velocity of Money for Mexico for the Monetary Base (M0) and for the Narrow Money Supply (M1).
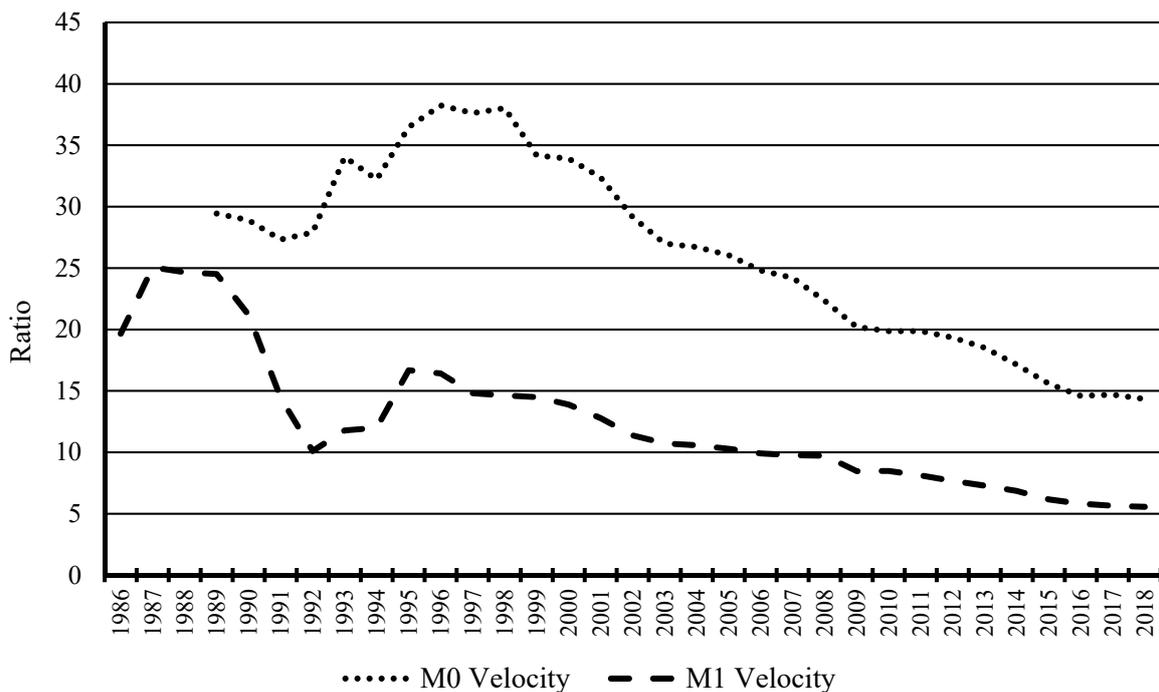
Note: Monetary base data is from Banco de México's monetary aggregates and domestic financial assets. Narrow money supply and GDP are from the Federal Reserve Bank of St. Louis' Fred database.

A banking crisis occurred in 1994 with 20 percent of the banking sector insolvent and supported by the Mexican government. Normally this would see people flee to cash, but the velocity of both currency and wider monetary aggregates rose as people fled both. The explanation being that the Peso experienced a large devaluation and people shifted to other currencies and real

assets. Another interesting period is from the GFC onwards. Interest rates did fall in Mexico and as a result people's demand for money rose and the velocity of money fell. But the velocity of currency fell noticeably more than broader monetary aggregates. An institutional based explanation is that corruption grew, and as a consequence, the black market and grey economy also grew, and transactions in these parts of the economy are usually conducted in cash (Schneider and Enste 2000; Organisation for Economic Co-operation and Development 2017; Europol 2015). Repeated banking crises along with high levels of corruption is also consistent with Mexico having not moved towards becoming a cashless economy as has Sweden.

5. Bringing velocity into the classroom

As is evident from the data, a constant V, while useful and acceptable in the short run, isn't a tenable assumption over all time periods. But rather than being a problem, it provides an learning opportunity for students as illustrated by the case studies of Sweden and Mexico.

Instructors can use any significant periods of change in V to stimulate discussions about how people pay for transactions (Schreft 2006), the demand for money (Goldfield and Sichel 1990), and financial innovation (Quinn and Roberds 2008). For example, V slows down for many countries for the first part of the twentieth century. A natural question to ask students is what does a fall in V mean in terms of the demand for money?

To begin a class first introduce the concept of money and it's function with historical examples, for which there are many online resources including podcasts, (e.g. Federal Reserve Bank of St Louis), slide shows (e.g. British Museum), and website articles (e.g. Federal Reserve Bank

of Atlanta).[5] This can then be used to introduce the demand for money by asking the class who has any notes and coins with them, and then asking those who have and don't have any notes and coins why or why not. Since some students will have demand deposits rather than cash, the answers can be used to lead into a discussion about the different measures of money and which measures are likely to be bigger than others and why. Then the different official measures of money can be introduced contrasting currency with (liquid) narrow money with (less liquid) broader money. Appendix A contains the definitions used by the International Monetary Fund as a good starting point.

5.1 Creating a Money Velocity Dataset

Once the class is aware that there are different forms of money and thus different measures of money, then students are in a position to use the Federal Reserve Bank of St Louis' FRED database. The next steps are to create the data lists to allow students to calculate velocities for different countries. Detailed instructions students can use to create a database are provided next.

You will need to register and create a Data List:

- Go to https://fred.stlouisfed.org/
- Click on "My Account" at top right-hand of the page.
- Click on "Create a New Account" and follow the instructions.

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[5] https://www.stlouisfed.org/education/economic-lowdown-podcast-series/episode-9-functions-of-money (https://www.stlouisfed.org/education/economic-lowdown-podcast-series/episode-9-functions-of-money), slide shows (https://www.britishmuseum.org/explore/themes/money/the_beginnings_of_coinage.aspx), website articles (https://www.frbatlanta.org/about/tours/story-of-money.aspx)

Money Data List:

1. Once registered click on "My Account" and then the "+ Add New" tab. Click on "Data List" and give it an appropriate name e.g. "Money". Once the Data List is created, you can begin to populate it with money stock data series.

2. Search "M1"; filter by *Geographies* (select United States) and *Frequencies* (select Annual); select "National Currency" for "M1 for the United States" (FRED series code: MANMM101USA189S). Add to your Data List.

3. Follow the same steps but choose different countries for the filter *Geographies*: Australia (MANMM101AUA189N), Canada (CANGDPNADSMEI), Chile (MANMM101CLA189S), Euro Area (MANMM101EZA189S), Japan (MANMM101JPA189S), Mexico (MANMM101MXA189N), Sweden (MANMM101SEA189S), and the United Kingdom (MANMM101GBA189S).

Income Data List:

1. Create a new Data List called "Income". Search "GDP"; filter by *Geography Type*, (select Nation), *Geographies* (select United States), and *Frequencies* (select Annual); select "Gross Domestic Product" Billions of Dollars (FRED series code: GDPA). Add to your Data List.

2. Follow the same steps but choose different countries for the filter *Geographies*: Australia (AUSGDPNADSMEI), Canada (CANGDPNADSMEI), Chile (MKTGDPCLA646NWDB), Euro Area (NYGDPMKTPCDEMU), Japan (MKTGDPJPA646NWDB), Mexico (MKTGDPMXA646NWDB), Sweden (MKTGDPSEA646NWDB), United Kingdom (GBRGDPNADSMEI).

Exchange Rate Data List:

1. Create a new Data List called "Exchange Rates". Some of the GDP series are in US$ and not the countries' national currencies. You will need the exchanges for these countries to convert them back to their national currencies.

2. Search "Exchange rate"; filter by Geography Type, (select Nation) and Frequencies (select Annual); Add the following to your Data List: "National Currency to US Dollar Spot Exchange Rate for Chile" (CCUSSP02CLA650N); "National Currency to US Dollar Exchange Rate: Average of Daily Rates for the Euro Area" (CCUSMA02EZA618N); "US Dollar to National Currency Spot Exchange Rate for Japan" (CCUSSP01JPA650N); "National Currency to US Dollar Exchange Rate: Average of Daily Rates for Mexico" (CCUSMA02MXA618N); "US Dollar to National Currency Spot Exchange Rate for Sweden" (CCUSSP01SEA650N).

Downloading Data Lists:

1. Once done, click on "My Account", select "Data Lists" from All Content, select the three data lists you have created, and then click on "Download". You will be given two formatting options, choose the "Excel" option.

2. Once downloaded, unzip the contents and you will have three Excel files titled "Money", "Income", and "Exchange Rates". Create a blank master Excel file, give it a relevant name (e.g. "Velocity"), and create four worksheets labelled "Money", "Income", "Exchange Rates", and "Velocity".

3. Copy and paste the contents from the "Annual" sheet in each of the three downloaded Excel files into their respective worksheets into your master Excel file. Add a row to each sheet and give each series the name of the respective country of each column. Insert a column next to the Date column of each sheet, and give it a heading of "Year". Make the column has the "General" format.

4. Extract the year from the date column by typing "=Year(A2)" for cell B2, and copy and paste this formula for the Year column to the last row with any data in it.

Exchange Rate Conversions:

1. The M1 series are all in national currencies. But the GDP series for Chile, the Euro Area, Japan, Mexico, and Sweden are all in US\$. These will need to be converted into national currencies

using data from the "Exchange Rates" sheet to use with the M1 data to calculate values for the income velocity of money.

2. You will need to make sure the values used in the "Income" sheet create extra columns for each of these countries with the name of each column heading being the country name and "GDP in National Currency".

3. For the blank columns for Chile, Japan, and Sweden, divide each year's value of GDP in the "Income" sheet by each respective year's exchange rate from the "Exchange Rate" sheet to convert GDP into the national currencies.

4. For the Euro Area and Mexico, multiple each year's value of GDP in the "Income" sheet by each respective year's exchange rate from the "Exchange Rate" sheet to convert GDP into the national currencies.

The Fred database has data on the quantity of M1 for many countries. But it lacks good coverage on the quantity of currency. If an instructor wants students to study some types of issues such whether countries are moving to cashless economies or what happens if people do not trust a banking system then students will need data on currency. This means collecting data outside of the FRED database typically from central banks. Steps are given below to help instructors with this.

Creating a Dataset on Currency:

1. Monthly currency in circulation for the US is available from the FRED database (CURRSL) using the same process as for other data series already downloaded. You will need to extract the December values.

2. European Central Bank: http://sdw.ecb.europa.eu/browse.do?node=9691106. Select "M1 and components" series. Select BSI.M.U2.Y.V.L10.X.1.U2.2300.Z01.E and click the "Download Data" tab. Download as an "Excel (csv)" file.

3. Bank of Japan: https://www.stat-search.boj.or.jp/index_en.html. Select "Money and Deposits" then "Currency in Circulation" followed by "Currency in Circulation by Denomination". Select series MD05'MACCV1, and input 1956 to 2019 in "Output Year Range" and select "Calendar Year" in the frequency option. The click "Graph". Once the graph appears then select "View Data". This leads to a new window and you can download and save it as an annual series in a csv file format. Select the "Header" option as it gives more information about the series.

4. Bank of Canada: https://www.bankofcanada.ca/rates/banking-and-financial-statistics/. Click on "Selected monetary aggregates and their components". Scroll down to "Monthly Series" and click on "CSV". Delete all but the first two columns of "date" and "V37173" and save the file. It is a monthly series and you will need to extract the December values.

5. Banco de Mexico: https://www.banxico.org.mx/SieInternet/defaultEnglish.do. Select "Monetary aggregates and domestic financial assets". Choose "Monetary Base" under "Information Structures", then "Monetary Base", "Monthly", and click on "Monetary Base". Select only "Currency held by the public" series, and then export the series as a vertical "xlsx" file. It is a monthly series and you will need to extract the December values.

6. Bank of England: http://www.bankofengland.co.uk/boeapps/iadb/. Select "Search" and type "LPMAVAA" and enter. Choose the series with options "all available dates" and "Columnar with titles", then click on the "CSV" tab. It is a monthly series and you will need to extract the December values.

7. Banco Central de Chile: https://si3.bcentral.cl/Siete/secure/cuadros/home.aspx?Idioma=en-US. Select "Money and Banking. Next select "currency in circulation" for "Aggregates Balances", with the options of 1985 to 2020 as the date range, annual frequency, and original series. Then click on the Excel icon, and download as an Excel file choosing the vertical option.

8. Reserve Bank of Australia: https://www.rba.gov.au/statistics/tables/. Select series D3, "Monetary Aggregates" and click on "Data". Delete all the but the first two columns in the saved table. It is a monthly series and you will need to extract the December values.

9. Sweden: http://sdw.ecb.europa.eu/home.do. Enter BKN.M.SE.NC10.B.50P2.C0.S.N as an "SDW Search". Click on the "Sweden - Net Circulation" data series and download as an Excel

file from the Data Download. It is a monthly series and you will need to extract the December values.

The task of extracting just the December value of monthly data also provides an opportunity to teach students features in Excel such as the use of Pivot Tables. Once students create their data sets then they are in a position to use them to attempt any assessment items assigned to them. We give two examples below, one about how to present the data graphically in an informative way and the other to address the issue of economies becoming cashless. Grading rubrics for the two assignments are contained in Appendix B and Appendix C.

5.2 Assignment 1: Graphing Velocity

In the "Velocity" sheet, label the first column "Year" with the starting year being the earliest year of all data series from all the sheets. Label each of columns 2 to 12 with a country name. Calculate the velocity of a country for a year by a formula using the country's GDP value for that year in its national currency from the "Income" sheet divided by the country's M1 value for that year from the "Money" sheet. You cannot do this for all years for all countries as each country's data series will cover differ ranges of years. You should calculate the velocity only for those years for a country where you have values of both GDP and M1. Make sure that GDP and M1 are in the same currency. If not, use the exchange rates you downloaded to convert them to the same currencies. Plot the values of "Velocity" and "Year" for each country for which there are values to create a line chart showing how velocity changes over time for each country. *Question:* Discuss your findings. Pay attention to upward and downward trends in the income velocity of money. Think about what economic variables might be needed to explain those trends. Submit your Excel file along with your report.

The velocity figures use M1 since the FRED database has little data on the currency. It is possible to add a second part and extend this project by getting students to search for and download data on currency from the central banks of different countries. This could be made less structured if the intention is to extend students or if a class is comprised of particularly able students or if the instructor wants a more demanding research assessment item.

5.3 Assignment 2: Cashless Societies

Use your datasets to calculate the narrow money income velocity and the currency income velocity for each country using the formula taught in class. You cannot do this for all years for all countries as each country's data series will cover differ ranges of years. You should calculate the income velocity only for those years for a country where you have values of GDP, M1, and currency. Make sure that GDP, M1, and currency are in the same currency. Create a graph for each country displaying their two income velocities.

Question: Use your calculated and graph income velocities of money to explain if there is any evidence that countries are becoming cashless societies. Discuss your findings. Pay attention to where the trends in the two income velocities of money diverge and if they are consistent with a country moving to a cashless society. Think about what economic variables might be needed to explain those trends. For extra marks you could download the populations of each country from the Fred database and calculate and graph currency per capita to add to your analysis.

6. Our experience from a cashless society assignment

We created a highly open-ended student research assignment about the topic of a cashless society for a standard intermediate macroeconomics university course taught in 2017 in the

Department of Economics and Finance at the University of Canterbury in New Zealand. Henderson (2016) argues that such undergraduate research exercises are important in students learning and development of higher-order skills. The statement students had to address was "Countries will eventually become cashless societies." The motivation for the topic arose from a lecture about the demand for currency, how this was related to the income velocity of money, and that a fall in the demand for currency should see a rise in the income velocity of currency. The aim of the essay was to build several useful skills in the process of learning more about the velocity of money and how it could be used to gain an understanding of the monetary system (Méndez-Carbajo 2015).

6.1 Description of the Class

The course is a semester long and enrolment was 142 in 2017. The textbook is *Macroeconomics* by Mankiw, a standard North American text. The pre-requisites for the course and introductory microeconomics and macroeconomics. The composition of students by sex was 106 (74.6 percent) male and 36 (35.4 percent) female. Most students (92.9 percent) were between 19 and 22 years old. The first degree of students was the Bachelor of Arts (16 or 11.3 percent), Bachelor of Commerce (97 or 68.3 percent), or Bachelor of Science (20 or 14.1 percent). The other nine students were scattered over other types of qualifications. Some students (14 or 9.9 percent) were double-degree students with almost all of these being one of the above degrees with the Bachelor of Laws. Relatively more males were science students than the composition of the class, but the difference was not large. Over 71 percent (102) of the class was of European ethnicity, 16.2 percent (23) were East-Asian, 7 percent (10) were indigenous Maori, with other ethnicities making up the remainder of the class. Just over 83 percent of the students were New Zealand citizens. Before starting the course, 2.1 percent of the students had a failing Grade Point Average (GPA), 38 percent had a GPA in the C range, and 45.8 percent had a GPA in

the B range and 14.1 percent had an A range GPA.[6] Overall, there are no statistically significant differences at the 5% or 1% levels by sexes across the different qualifications or across different letter grade ranges, or by ethnicities across different qualifications or across different letter grade ranges.

Table 1. Summary Statistics of Students Enrolled in the Course

	No.	%		No.	%
Sex			*Age*		
Female	36	35.4			92.9
			19-22		
Male	106	74.6	<19 or >22		7.1
Ethnicity			*GPA (before course)*		
European	102	71.0	A		2.1
East-Asian	23	16.2	B		45.8
Maori (Indigenous)	10	7.0	C		38.0
Other	7	5.8	< C		2.1
Degree (all Bachelors)			*Citizenship*		
Arts	16	11.3	New Zealand	118	83.1
Commerce	97	68.3	International	24	16.9
Science	20	14.1			
Other	9	6.3			

6.2 Assessment Exercise and Purpose

The assessment item given to the students as shown in Figure 2 had three primary objectives. The first was for students to learn more about the concepts and theories to do with the velocity of money, the quantity theory, the demand for money, and innovation in payments technologies. At the same time students would learn how to propose plausible theories that are grounded in economics. The second objective was to improve students' knowledge about the

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[6] The University of Canterbury has a grade scale from -1 for the lowest (and failing grade) of E to 9 for the highest grade of A+. The full scale range and associated grades are: A+ (9), A (8), A- (7), B+ (6), B (5), B- (4), C+ (3), C (2), C- (1), D-Fail (0), E-Fail (-1).

sources and characteristics of economic data, and the organisations that collect and use it. The final major objective was to enhance students' data analysis and spreadsheet skills, including how to design spreadsheets. Barreto (2015) explains how Excel offers an excellent option for improving learning outcomes in the classroom. The column by Bishop (2016, May 11) who reports that spreadsheet errors cost United Kingdom businesses billions of pounds from their making poor decisions also highlights why developing student's spreadsheet skills is potentially attractive to prospective employers of students.

6.3 Performance of the Class

The reaction of students to the essay topic was generally enthusiastic. The subject is highly topical and widely discussed in the media, and it is one they could easily relate to since it was about how they personally paid for transactions. The higher interest from students resulted in higher effort that other assessment items and only a couple of students actually failed the essay compared to just under ten percent for the class as a whole.

A voluntary survey about students' experiences of the assessment exercise was held after the assessment had been graded and returned as suggested by Staveley-O'Carroll (2018). Since it was voluntary then of course it was subject to self-selection issues. That said, the survey respondents had very similar average and distributional characteristics to the class as a whole. The exceptions being that those who responded to the survey had a mildly better entry GPAs (5.1 average versus 4.6) and did better in the course (4.9 average versus 3.9). Over three-quarters of those surveyed said it improved their ability to use Excel and also their data handling skills. This was despite most students in the course having passed the first year Excel heavy university statistics course, STAT101 – 113 (79.6 percent) passed it, 5 (3.5 percent) failed it,

Table 2. Student Responses from Survey of Experiences of the Research Exercise

Student Survey Questions	Responses	
	No.	%
Q1: How would you describe your excel expertise prior to doing this report?		
I had no skills in excel at all.	4	10.0
I was a novice user who could do basic functions such as inputting data and doing basic formula (e.g. addition, multiplication).	9	22.5
I had a few skills that went beyond basic (e.g. creating graphs, linking cells with data to other formula cells, more complex formula).	22	55.0
I was a competent excel user and was confident I could learn new skills as I needed them.	5	12.5
Q2: Did the exercise improve your ability to use excel?		
No, not at all.	10	25.0
Yes, I learned a couple of new things but they were minor.	24	60.0
Yes, I learned some very useful skills that I did not previously have.	6	15.0
Q3: Did your data search skills improve?		
No, not at all.	4	10.0
Yes, in minor but useful ways.	30	75.0
Yes, significantly (e.g. much more confident at finding data, have much greater knowledge on data sources.	6	15.0
Q4: Did your data handling skills improve?		
No, not at all.	10	25.0
Yes, in minor but useful ways.	23	57.5
Yes, significantly (e.g. much more confident at finding data, have much greater knowledge on data sources.	7	17.5
Q5: Did the assignment improve you knowledge and understanding of the money market and money more broadly?		
No, not at all.	2	5.0
Yes, in minor but useful ways.	24	60.0
Yes, significantly (e.g. much more confident at finding data, have much greater knowledge on data sources.	14	35.0
Q6: Was the level of feedback provided sufficient to help you improve your skills for the future?		
No, not at all.	5	12.5
Yes, in minor but useful ways.	20	50.0
Yes, significantly (e.g. much more confident at finding data, have much greater knowledge on data sources.	15	37.5

and 24 (16.9 percent) had not taken it by the time the students were enrolled in ECON206.[7]

Over 90 percent of the students surveyed said it improved their skills in finding economic information and also their knowledge of and understanding about money and the money market, including the velocity of money. The experiences of the students were independent of their having taken STAT101, how well they did in that course, and even their overall GPA.[8] Overall, our experience from using a simple concept such as the income velocity to create a learning opportunity has been highly positive. Furthermore, it is an opportunity which students respond well to and many seem to have learnt much from doing. One observation we did make is based on informal discussions with students after the assignment. The general and we have to emphasise unscientific feedback was that weaker and less confident students would have preferred a more structured assignment than the more capable students (of the form of the two examples of assignments provided earlier), and felt they would have learned more from this format. This suggests that a consideration instructors have to make in using a research assignment as encouraged by Henderson (2016) is whether to make it a structured assignment or a more open-ended one. This will depend on the capability and experience of the class.

7. Conclusion

The assumption that the velocity of money is constant is sometimes a useful one in Principles of Macroeconomics and Intermediate Macroeconomics courses. It allows instructors to draw

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[7] The course description for STAT101 is: "An introduction to the ideas, techniques and applications of statistics and probability. The emphasis is on applying statistics to problems, selecting sensible techniques, following the methodology and interpreting the results. Understanding the concepts and computer-based solutions are emphasised and applications to commerce, the social sciences, the humanities, science and engineering are considered. Particular topics include data analysis, summary statistics, probability, statistical distributions, estimation and inference (including confidence intervals, hypothesis tests and modelling)." The main software used in the course is Excel.

[8] We created contingency tables and calculated chi-square tests of association and could not reject any null hypotheses of independence. We don't report these as a noticeable number of the cells in each case have fewer than five counts which is usually taken as necessary for the chi-square test to be valid.

the link between money and prices which is a key concept underlying monetary policy. However, this assumption prevents instructors using a generally easily understood and calculated economic variable as a teaching tool of beginning and intermediate university students, and a very versatile one at that. The income velocity of money can easily be used to underpin an assignment focusing on teaching skills related to searching for data, using Excel (or other programs) to analyse data, and how to present data using graphs and such like. It can readily be used to teach beginning university students the general scientific method skills of formulating hypotheses and testing them without needing sophisticated theories and statistical programs. The income velocity of money also lends itself to studying monetary policy, and under what conditions it might or might not be effective.

Apart from showing that the assumption of a constant income velocity of money is shaky at best, we provide a succinct summary of the theory behind the income velocity of money, provide two interesting cases of what has happened to velocity, and provide two assignments including grading rubrics centred on the income velocity of money. We also provide a summary of our experiences using an assignment based on the income velocity of money, including student feedback about it. As we show, it can be a useful learning device, although as we also find, a careful consideration instructors has to make in using velocity as the basis of an assignment is whether to make it a more structured assignment or a more open-ended one. This will depend on the nature of the course and the characteristics of the specific class. In the end, whatever approach is taken by an instructor, we firmly believe that students will learn much by studying the income velocity of money in more depth than it is currently given in many of the textbooks we use in our courses.

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Appendix A. Monetary aggregates definitions

The International Monetary Fund in its 2016 *Monetary and Financial Statistics Manual and Compilation Guide* categorises monetary aggregates by how liquid different types of financial instruments are in fulfilling their medium of exchange function as shown in table 2 (page numbers are after each aggregate). The *medium of exchange* function is defined (179) as "...a means for acquiring nonfinancial assets (goods, merchandises, equipment, etc.), services, and financial assets without resorting to barter."

Table A.1 International Monetary Fund Definitions of Main Monetary Aggregates

Monetary Aggregate	IMF Definition
Currency (58)	Notes and coins that are of fixed nominal values and are issued or authorized by central banks or governments.
Monetary Base (197)	Currency in circulation, ODCs' [other depository corporations] deposit holdings at the central bank, and those deposits of money-holding sectors at the central bank that are also included in broad money.
M1 (322)	Currency in circulation plus transferable deposits held by all money-holding sectors.
Broad Money (180)	The sum of all liquid financial instruments held by money-holding sectors that are widely accepted in an economy as a medium of exchange, plus those that can be converted into a medium of exchange at short notice at, or close to, their full nominal value.

The measures of monetary aggregates for each country satisfy these definitions although the specific financial instruments included the measures can differ from country to country. This means that instructors might require students to specify the sources and definitions of their data.

Appendix B. Graphing Assignment Grading Rubric

Category	Exceptional (A)	Competent (B)	Basic (C)	Unsatisfactory (D/F)
Excel Workbook Structure	Worksheets, tables and charts logically grouped. Input values logically grouped by worksheet. Content grouped within worksheets. Separation of calculations and inputs. Cell references used in formulas. Simple formulas using multiple cells for complex calculations.	Worksheets, tables and charts grouped by function, but input values spread throughout the spreadsheet. Most content is grouped within worksheets. Uses cell references in formulas. Most formulas easy to follow.	Worksheets, tables and charts grouped by function, but input values in multiple worksheets. Content spread out within worksheets. Uses a mix of cell references and embedded parameter values in formulas. Some formulas difficult to follow.	Little if any clear functional grouping of worksheets, tables, charts, and input values. Most content is messily placed within a worksheet. Uses embedded parameter values in formulas. Some formulas difficult to follow.
Excel Workbook Documentation	Descriptions of spreadsheet and each worksheet on a contents page. Descriptive labels for different worksheets. Descriptive labels for rows and columns of tables. Units included. Documentation of sources, definitions, and units of data. Informative labelling.	Descriptions of some aspects of the spreadsheet exist. Descriptive labels for different worksheets. Descriptive labels for rows and columns of tables, but some units are missing. Documentation of sources of the data. Informative labelling of most chart elements.	Descriptive labels for worksheets rows and columns of tables. Data units are mostly missing. Documentation of some data sources but might be incomplete making it difficult to find the exact location of the data. Only labels some chart elements.	Typically uninformative labels for different worksheets, and rows and columns of tables. Units are missing. Documentation of sources of the data is missing or unhelpful in locating the data used. Might not contain charts and chart elements are missing.
Excel Workbook Formatting	Consistent fonts throughout spreadsheet. Consistent and simple table layouts making it easy to read them. Cell heights and widths allow all values to appear. Valid number of decimal points. No trailing zeros.	Consistent fonts throughout spreadsheet. Most table layouts are easy to follow, but are not uniform. Occasionally cell heights and widths are too small resulting in obscured or truncated values. No trailing zeros.	Variety of fonts and table layouts used. Some table layouts are messy and take effort to follow. Some cell heights and widths result in obscured or truncated values. Some series have an excessive number of trailing zeros.	A variety of fonts and table layouts are used. Table layouts are usually messy. Some cell heights and widths are too small resulting in obscured or truncated values. Excessive trailing zeros frequently exist.
Assignment Report	Defines income velocity and states how to calculate it. Lists different measures of money and states which measure is used to calculate velocity. Includes well formatted and informative graphs. Details notable trends in velocity. In-depth correct analysis of trends using relevant economic theory and linking to changes in the demand for money. Reaches appropriate conclusions. Writes using good English.	Defines income velocity and how to calculate it. Mentions there is more than measure of money and states which type of money is used to calculate velocity. Informative graphs in report, but some weaknesses in formatting. Details notable trends in velocity. Correctly uses relevant economic theory to analyse trends. Reaches appropriate conclusions. Most writing using good English.	Defines income velocity. States velocity formula only. States the measure of money used to calculate velocity. Includes graphs but effort required to understand them. Describes some trends in velocity. Uses relevant economic theory to analyse trends but with gaps. Mentions demand for money but doesn't link it to trends. Reaches appropriate conclusions. Good written English although with periodic errors.	Mentions income velocity. Doesn't describe how to calculate it. Mentions which type of money is used to calculate velocity. Doesn't include student created graphs. Literally repeats graphs in words. Superficial and incomplete analysis of graphs with some mistakes. Mentions demand for money incorrectly or without linking to data. Superficial conclusions with some errors. Writing contains frequent errors.

Appendix C. Cashless Society Assignment Grading Rubric

Category	Exceptional (A)	Competent (B)	Basic (C)	Unsatisfactory (D/F)
Money	Defines concept of money and explains its functions. Describes official measures of money, including currency and M1. Details and explains trends in different money measures.	Defines concept of money and explains its functions. Lists official measures of money, including currency and M1. Details trends with limited discussion of currency and M1.	Superficial discussion of what money is and its functions. Lists currency and M1. Details trends in currency and M1. Any discussion is a verbatim description of the graphs.	Neglects defining concept of money. Lists some functions of money. Mentions currency and M1. Lacks empirical evidence about measures of the money supply.
Income velocity of money	States and explains quantity theory and its components. Discusses the background of it and its economic implications. Explains how to calculate income velocity of money.	States and explains quantity theory and its components. Some discussion of its economic implications. Explains how to calculate income velocity of money.	States quantity theory and its components. Superficial discussion about its economic implications.	States quantity theory and its components. No discussion of it.
Demand for money	Defines the demand for money and explains how it arises from the transaction, precautionary, and asset motives. Lists the economic variables representing each motive. Correctly explains how the demand for money is affected by these variables.	Defines the demand for money and explains how it arises from the transaction, precautionary, and asset motives. Lists some of the economic variables representing each motive. Correctly explains how the demand for money is affected by these variables.	Defines the demand for money. Superficial explanation of the transaction, precautionary, and asset motives. Lists some economic variables representing each motive. Limited explanation of how the demand for money is affected by these variables.	Defines the demand for money. Superficial mention of some or all of the transaction, precautionary, and asset motives. Lists one or two economic variables affecting the demand for money. No or incorrect explanation of how the demand for money is affected by these variables.
Data and graphs	Contains student created graphs. Gives graphs appropriate titles, labels axes, and includes units. Defines data used, and includes units and sources. Incorporates graphs. Describes key trends in velocities. In-depth and correct analysis of trends using relevant economic theory and linking to changes in the demand for money.	Contains student created graphs. Most titles, axis labels, and units included with graphs. Defines most data used and includes sources. Refers to graphs in analysis but not always persuasively. Describes key trends in velocity. Limited but mostly correct analysis of trends using relevant economic theory and linking to changes in the demand for money.	Contains student created graphs. Graphs are missing some of the titles, axes labels, or units. Literally describes graphs in words. Limited use of graphs in analysis with clear mistakes.	Contains uninformative and badly formatted graphs or uses graphs from other sources. Either ignores graphs in analysis or incorrect interpretation of them.

Cashless Society Assignment Grading Rubric (continued)

Category	Exceptional (A)	Competent (B)	Basic (C)	Unsatisfactory (D/F)
Cashless society	Explains what is meant by cashless society. Knows cashless society still uses a form of money. Explains benefits and costs of digital payments system. Details trends in the two velocities with correct linkage to changes in the use of and demand for currency and digital payments.	Explains what is meant by cashless society. Knows cashless society still uses a form of money. Mentions one or two benefits and costs of digital payments system. Details trends in the two velocities with limited linkage to changes in the use of and demand for currency and digital payments.	Explains what is meant by cashless society. Knows cashless society still uses a form of money. States trends in velocities of money. Superficial linkage to the use of currency and digital payments. Mostly relies on data on currency to infer changes in the use of it.	Explains what is meant by cashless society. Doesn't mention that a cashless society still uses a form of money. Ignores income velocities and any graphs and relies solely on data on currency to infer changes in it.
Exposition	Writes in a professional style in formal English. Uses correct punctuation, spelling, and grammar. Logically orders and groups topics and employs section headings. Properly references all sources (e.g. APA).	Writes in a professional style in formal English. Most punctuation, spelling, and grammar are correct. Sections logically ordered but topic order within section could be improved. Properly references all sources (e.g. APA).	Majority of writing is in a formal style but does contains some causal writing. Periodic errors in punctuation, spelling, and grammar. Some stream of consciousness writing. Includes references for all sources but some inconsistency in formatting.	Writes in a casual and stream of consciousness style. Writing contains many mistakes in punctuation, spelling, and grammar. Missing some references for some sources and included references are formatted inconsistently.