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WORKING PAPER

What do the Different Measures of GDP Tell Us?

Faced with the prospect that slow growth could continue for years, economists are focusing more on the determinants of growth over the long run. As a result, supply-driven measures of understanding the economy are growing in importance at the expense of the traditional focus on aggregate demand.

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Working Paper
December 2016
Business Cycle; Fiscal and Tax Policy

Daniel Schwanen
Vice President, Research

$12.00
ISBN 978-1-987983-08-1
ISSN 0824-8001 (print);
ISSN 1703-0765 (online)

The Study In Brief

GDP is key to macroeconomics, yet different ways of defining and measuring GDP have particular purposes. This paper examines how total GDP can be conceptualized, dissected and studied and how these improve our analysis and understanding of the sources of economic growth.

While each approach is useful, macroeconomic analysis is shifting from a short-term, recession-driven focus on managing aggregate demand to a long-term, supply-side perspective on the determinants of economic growth. This shift is likely to accelerate in the current environment of concerns about a "new normal" of slow growth, with the debate framed by supply determinants such as an aging labour force and whether technological innovations have been mostly exhausted.

How one views GDP has important implications for policymaking. If today's chronic slow growth is due to deficiency of demand, stimulative fiscal policies might be the proper response, depending on a country's fiscal capacity to take on more debt. However, if the shortfall in growth is due to a lack of productivity growth, different policies might be appropriate that increase the efficiency of resource use or the rate of innovation. The point is that a more detailed understanding of each measure of GDP leads to better comprehension of why it behaves in a particular way in response to different economic circumstances. This knowledge will allow policymakers to make more informed decisions.

The author reviews each of the different ways of looking at GDP and how they evolved in response to the needs of analysts. He summarizes the strengths and weaknesses of each and what can be learned by contrasting and combining them in analysis. In order the six are:

- GDP by industry;
- GDP by expenditure;
- GDP by income;
- The quantity equation;
- GDP by input/output; and
- GDP by factor input.

For economists, the different optics for viewing economic activity lead to a more profound understanding of the process of economic growth. Good analysis and policy prescription often depend on finding the right optic to understand a particular problem.

Michael Benedict and James Fleming edited the manuscript; Yang Zhao prepared it for publication. As with all Institute publications, the views expressed here are those of the authors and do not necessarily reflect the opinions of the Institute's members or Board of Directors. Quotation with appropriate credit is permissible.

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Paul Samuelson, one of the 20th century's leading economists, said in his classic economics textbook that Gross Domestic Product (GDP) is the single most important concept in macroeconomics.

Richard Lipsey, author of the counterpart Canadian textbook on economics, quickly added the important proviso that there are various concepts and measures of national income, each appropriate for a particular purpose.

This paper assumes the veracity of the first statement that GDP is key to macroeconomics, and explores the implications of the second claim that the different ways of defining and measuring GDP have particular purposes. It examines how total GDP can be conceptualized, dissected and studied and how these improve our analysis and understanding of the sources of economic growth. While each approach is useful, macroeconomic analysis is shifting from a short-term, recession-driven focus on managing aggregate demand to a long-term, supply-side perspective on the determinants of economic growth. This shift is likely to accelerate in the current environment of concerns about a "new normal" of slow growth, with the debate framed by supply determinants such as an aging labour force and whether technological innovations have been mostly exhausted, as claimed most famously by Robert Gordon.[1]

How one views GDP has important implications for policymaking. If today's chronic slow growth is due to deficiency of demand, stimulative fiscal policies might be the proper response, depending on a country's fiscal capacity to take on more debt. However, if the shortfall in growth is due to a lack of productivity growth, different policies might be appropriate that increase the efficiency of resource use or the rate of innovation. The point is that a more-detailed understanding of each measure of GDP leads to better comprehension of why it behaves in a particular way in response to different economic circumstances. This knowledge will allow policymakers to make more informed decisions.

To fully understand a concept, one has to know its origins and evolution. It is fundamental to appreciate that economists invented GDP as a tool to better understand changes in the macroeconomy. The term GDP was coined in 1934 to describe an analytical tool to help policymakers understand and end the Great Depression. In fact, there is no such entity as GDP in the real world waiting to be measured by economists. Like most statistics, GDP cannot be measured by holding up a statistical mirror to the economy. Instead, it is a contrivance of carefully and deliberately designed concepts. Echoing what Friedman and Schwartz (1970) said about defining money, GDP "is not something in existence to be discovered, like the American continent; it is a tentative scientific construct to be invented, like 'length' or 'temperature' or 'force' in physics."

Beyond demonstrating theoretical soundness and internal consistency, GDP must serve the practical needs of analysts while being subject to the limitations imposed by data. Because it is a nebulous concept, both GDP's definition and measurement have evolved over time as economies have changed. For example, the growing economic

The author thanks Jeremy Kronick, Steven Ambler, W.E. Diewert and Eric Lascelles, as well as anonymous reviewers, for comments on an earlier draft. The author retains responsibility for any errors and the views expressed here.

1 See *The Rise and Fall of American Growth*. Princeton University Press. 2016.

importance of computers and human capital were reflected in the recognition of computer software as part of fixed investment in 1999, followed by research and development expenditure. However, the malleability of the very concept of GDP over time also poses problems when studying long-term trends in growth, since what is included in GDP and how it is measured changes over the decades.

There are three basic ways of measuring GDP (Moyer et al. 2006). These are the sum of all expenditures, total incomes and industry production. Expenditure is the best known, since it is based on the famous equation Hicks introduced in 1940 that is still taught in basic economics courses – GDP equals the sum of personal consumption, investment,[2] government purchases and exports minus imports.[3] Under the income approach, incomes consist of all income earned by labour and capital, mostly labour income and profits, plus a mixture of the two earned by farmers, small businesses and renters. Finally, industry GDP is the sum of the value added by goods-and-services producing industries, broken down into 21 major industry groups such as manufacturing, construction, finance, retail trade and so on (value-added is the gross output of an industry minus the inputs it purchased from other industries).

These three conventional approaches to GDP developed over time in response to the changing needs of economists and policymakers. Work on GDP was formalized during the Great Depression under the supervision of Nobelist Simon Kuznets, with the first set of accounts based on production by industry. The sum of incomes was finalized soon after. As economies moved from peacetime to wartime production in the 1940s, the emphasis shifted from industry output to production and spending by type of product and purchaser, resulting in the expenditure-based approach to GDP.

Wartime planning increased the focus on how to efficiently plan and organize inputs to produce the combination of military and consumer goods needed during the war. By the early 1950s, the development of formal input-output accounts provided the basis for a new method of measuring and analyzing industry GDP, allowing economists to better understand the role of productivity in long-term growth. Rather than just studying industry output, the input-output accounts broke down that output into the inputs required in the production process, adding a fourth dimension to studying GDP.

Beyond these four ways of measuring and analyzing GDP, there are two other means of assessing GDP. However, they are not independent measures of GDP; given an estimate of GDP, they provide a different way of analyzing the how and why of changes in GDP. The most famous is Irving Fisher's quantity equation, $MV=PQ$, where M is the money supply, V is the velocity of money (that is, the number of times each dollar on average is used to make a transaction per unit of time), and P and Q are the price and quantity of GDP (or the prices received for the volume of production of goods and services). Since the velocity of money cannot be observed directly, it is inferred by dividing GDP by the money supply ($V=PQ/M$). Of course, since there are so many definitions of money supply, velocity estimates will vary.

Finally, in long-term growth theory GDP is determined by the inputs of labour and capital and the productivity in combining them to generate

2 Investment includes plant and equipment, software, housing and inventories.

3 Or as people with an undergraduate course in economics will recognize, this is the famous equation, $GDP=C+I+G+X-M$. In the second quarter of 2016, Canadian consumption was the largest part of GDP at $1,043 billion, followed by investment at $381 billion, government spending of $352 billion, exports of $563 billion and imports of $567 billion. (Imports are subtracted because they are embedded in the various components of domestic spending).

income. This productivity approach differs from the input-output decomposition, which measures the inputs of labour and material purchased by each industry as part of its production process. Instead of painstakingly tracking every purchased input, Solow (1956) looked at broad categories of capital and labour inputs and how efficiently they were combined with, and amplified by, technology. Over time, growth theory evolved to the study of multifactor productivity, a more sophisticated way of analyzing inputs and productivity.

So, there are actually six ways of looking at GDP. Additionally, this paper briefly mentions a few other forms of evaluating the strengths and weaknesses of an economy. The first is Net Domestic Product, which is GDP adjusted for the depreciation of capital. In addition, Statistics Canada publishes a variant of GDP called Gross Domestic Income (GDI) that accounts for changes in the terms of trade, which happen during commodity price booms and busts. Finally, both Canada and the US calculate Gross Output, a measure of all the transactions needed to supply the goods and services that final users demand.[4]

This paper reviews each of the different ways of looking at GDP[5] and how they evolved in response to the needs of analysts. While the basic principles of national accounting apply to all statistical agencies, almost all of this paper's discussion of their application is for Canada alone. Finally, the paper summarizes the strengths and weaknesses of each and what can be learned by contrasting and combining them in analysis. In order the six are:

- GDP by industry;
- GDP by expenditure;
- GDP by income;
- The quantity equation;
- GDP by input/output; and
- GDP by factor input.

GDP by Industry, at Factor Cost

Industry production was the basis for the first GDP estimates in the 1930s. At the time, it was critical to obtain estimates of aggregate GDP to understand the full extent of the damage being wrought by the Great Depression. Ease of calculation is why GDP by industry is usually the preferred method when nations make their first attempts to measure total income. This is because industry production is relatively easy to measure both conceptually and statistically, especially in economies dominated by agriculture where counting the number of animals or bushels of wheat harvested gives a good first approximation of output.

Besides ease of calculation, it is also understandable that national accounting began with industry GDP, since the production view of GDP proved to be key to its definition. In building early estimates of GDP during the Depression, a wide range of income measures were available, including those reflecting transfers to and from government and capital gains and losses on existing assets. A convention quickly evolved to retain only those incomes earned from contributing to current

4 The use of the term "gross" can be confusing in national accounting; in the context of gross output, it refers to all the transactions needed to produce value-added output. In its use in gross domestic product or income, gross means that depreciation is not netted out of prices.

5 Every variant of domestic production and income has a national counterpart (GDP and GNP). Domestic output is the production within the borders of a country, irrespective of the nationality of the labour and capital. National output is the income earned by the labour and capital of a country anywhere in the world. The difference between the two is no longer large for Canada and is immaterial for this paper.

production, laying the foundation for economists to proceed with income-based estimates, the next step in the evolution of national accounting.

Usually, economists study changes in the industry composition of GDP only over long periods (Lawson et al. 2006). The shifts from agriculture to manufacturing and then from manufacturing to services were the key results Kuznets found in analyzing the trends of industry GDP. However, none of these shifts provided insights into the dynamics of the Depression.

In Canada, monthly GDP is produced on an industry basis because it is the easiest, quickest and most accurate way to measure changes, not because it is best for analysis.[6] Monthly shifts in the composition of industry production are mostly of little interest, apart from what they contribute to total GDP that month. For example, knowing that manufacturing production rose sharply in a particular month does not tell analysts very much, since it will not be known until quarterly GDP expenditure is compiled where it went – into inventories, business investment or exports. The same holds for other components; a shift in demand for business services is of interest if it represents a change in outsourcing by firms, but this can only be revealed by GDP input-output estimates.

One reason monthly GDP by industry can be calculated quickly is that it projects the value of output using physical volume measures as a proxy for production, such as the number of cars assembled, while keeping the structure of prices fixed. Using physical measures of volume, however, abstracts from some of the subtleties of price deflation, particularly for goods with a wide range of prices such as vehicles.

Indeed, the more precise deflation of expenditure approach to GDP helps make it the preferred quarterly measure.[7] As well, until the monthly estimates of industry GDP are benchmarked to the more comprehensive estimates from the Input-Output Accounts[8] with a lag of three years, they must assume a fixed ratio of value-added to gross output. This approach justifies using changes in gross measures such as monthly sales to project how value-added output is behaving. The use of a three-year lag is due to the need for detailed data in order to update the precise inputs each industry bought from all other industries. For all these reasons, the estimates for expenditure GDP are usually superior to value-added estimates (Jorgensen and Landefeld 2006).

A related difference between monthly GDP and its quarterly counterpart is that the last three years of monthly GDP are also based on a Laspeyres fixed-weighted index (which uses the structure of prices that existed three years earlier), while quarterly GDP uses a Fisher chain index (which uses the structure of prices that existed in the previous quarter). Again, the three-year lag is needed to process the detailed tax records and surveys required to estimate current-dollar GDP by industry. As a result, monthly constant dollar GDP during 2015 was measured as if the prices

6 As a practical matter, monthly estimates do not exist for key income and expenditure aggregates such as business investment, retail inventories, trade in services and corporate profits, many of which rely on surveys of business financial statements that are compiled only quarterly.

7 However, there are instances where industry GDP is a superior measurement. A good example occurred during the rapid appreciation of the Canadian dollar in 2007. This led to great difficulty in valuing cross-border trade flows, so Statistics Canada put more emphasis on the physical-quantity measures from monthly GDP by industry. For more on constant dollar versus physical measures of output, see Cross and Wyman (2010).

8 The input-output approach to GDP, which is discussed in more detail later in the paper, formally measures industry's value added by calculating its gross output and subtracting the inputs it purchases from all other industries.

of all production were frozen at their 2012 levels, while the quarterly GDP expenditure estimates were based on the price structure that existed in the previous quarter.

Usually, this discrepancy between monthly and quarterly GDP is not a major complication, except during periods when relative prices are changing rapidly. This is exactly what happened with the collapse of oil prices starting in 2014 – the monthly GDP measure for 2014 and 2015 valued oil production at the high price set in 2012, while quarterly GDP valued spending on oil at the price prevailing in the previous quarter. For all these reasons, monthly industry GDP industry is benchmarked to quarterly expenditure estimates (Wilson 2006).[9] Therefore, until the final industry estimates become available, the C.D. Howe Business Cycle Dating Committee gives more weight to expenditure GDP than industry GDP when weighing whether the economy is in recession.

Contrasting GDP by industry and by expenditure in 2014 and 2015 provides a good example of the practical importance of these differences. For all of 2013 and most of 2014, the two GDP measures were essentially identical (Figure 1a). However, when oil prices began to plunge late in 2014, this lowered GDP by industry relative to GDP by expenditure because the industry measure uses the Laspeyres index, which valued oil at its higher 2012 price. The differences are significant; from the third quarter of 2014 to the second quarter of 2015, GDP by industry increased by only 0.1 percent, while GDP by expenditure rose by 0.5 percent.

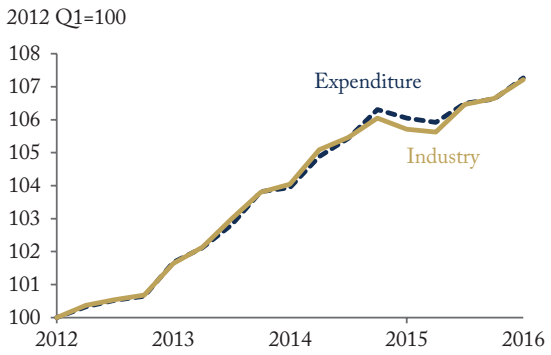
Higher GDP growth was evident for the expenditure measure compared with the industry approach in each of these quarters. This difference is especially important in analyzing the first half of 2015, when marginal declines in quarterly GDP raise the possibility the economy was in recession. When oil prices began to recover, the two measures of GDP quickly converged again.

However, there are times when the physical-volume approach to preliminary GDP estimates has an advantage over the expenditure approach, especially during times when the overall price level (and not just relative prices) is rising rapidly, as occurred from 1974 to 1975. Initially, both the GDP expenditure and GDP industry measures showed a recession during this period. However, large revisions to current dollar data, without corresponding revisions to prices, led to an upward revision of real GDP by expenditure. The result, as shown in the figure below, is a contradictory signal of a recession lasting four quarters in industry GDP but only a one-quarter, 0.1 percent dip in expenditure GDP, which is not enough to classify as a recession (Figure 1b). By averaging the two measures of GDP, one can still make a recession call, but this episode shows how GDP based on more physical volume measures can be more accurate when prices are rising rapidly.

Therefore, monthly GDP is most useful simply to provide a quick read of how the economy is growing or shrinking. However, most of the analytics of why it is doing so come from quarterly estimates of GDP expenditure. This is why most nations (including all G7 members except Canada) do not bother compiling monthly GDP. Shifts in industry GDP are most usefully analyzed over long periods of time.

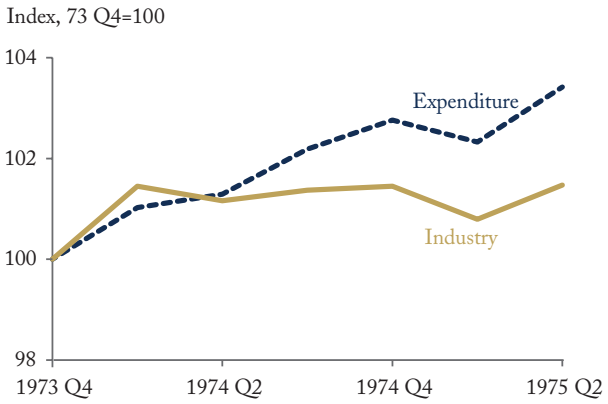
9 Another limitation to Statistics Canada's monthly GDP measure is that it is calculated at basic prices, while all the other GDP measures are calculated at market prices. The difference is taxes net of subsidies on products (taxes include the GST, excise taxes and import duties). However, this conceptual difference between basic prices and market prices usually does not impact the growth of GDP, except in months where governments make large changes to indirect taxes.

Figure 1a: GDP – Industry and Expenditure Based



Source: CANSIM Table 379-0031 and 380-0064.

Figure 1b: Real GDP



Source: CANSIM Table 379-0005 and 380-0002.

GDP by Expenditure

The original approach to estimating total GDP by industry quickly changed during the Second World War. In his pamphlet, *How To Pay For The War*, Keynes demonstrated that governments needed to know expenditures by the four main sectors of the economy (households, business, government and non-residents) in order to understand its overall productive capacity and how much tax revenues could be raised to help finance the war effort. Economists subsequently used GDP to assess how much aggregate demand might be depressed by the sudden end-of-war-related spending. By the 1950s, the development and popularity of expenditure-based estimates of GDP had reduced the industry approach to a subsidiary position in national accounting (Lewis 1959).

One major advantage of the expenditure approach is that it requires studying external trade in goods and services. For their parts, industry- and income-based GDP can be measured without reference to foreign trade. However, GDP expenditure, which tracks export and imports, explicitly recognizes the importance of international trade in the modern economy.

The expenditure approach also includes equilibrating saving and investment. While not directly needed to calculate GDP, providing the data on this key relationship is important to understanding business-cycle dynamics and long-run growth patterns. For example, the inflow of savings from abroad (especially Asia) into the US from 2003 to 2008 helped fuel the investment bubble in housing.

After the Second World War, the expenditure approach to GDP dominated analysis, leading economists to become "aggregate demand happy," in the words of John Lewis (1959). Elaborate theories were constructed to guide the modelling of spending in each sector of the economy. The behaviour of aggregates such as consumer spending, housing, business investment and inventories gave policymakers a guide to the economy's course in the short term and a hint to its long-term potential.

However, the sectoral-spending approach failed abysmally to predict recessions, which usually reflect forces that affect the whole economy and not just specific sectors. These forces include financial crises, commodity price shocks and tighter monetary policy to control inflation. The limitations of the expenditure-based approach in understanding even

the short-term dynamics of quarterly growth are one reason why research on large-scale econometric models has declined since its popularity in the 1970s.

Another major limitation to expenditure GDP is that it emphasizes demand over supply. Expenditure GDP provides only sparse information about the economy's structure and long-term potential growth, apart from how much an economy is investing. Economics provides little guidance as to the optimal levels of sectoral spending. There is little information in GDP expenditures about the evolution of human capital, which is growing in importance relative to physical capital as our economy becomes more knowledge-based. Spending on GDP has even less to say about technological change, productivity and innovation. In the immediate post-war period, it was not seen as a major drawback that the accounts were directed more to issues of Keynesian fiscal policy than to accounting for the sources of growth. However, economists today are much more interested in the determinants of long-term growth.

The expenditure approach to GDP has other drawbacks. The Hicks equation (C+I+G+X-M) leads to a fundamental misunderstanding among the public and even many economists about the forces driving economic growth because it props up the popular bromide that simply boosting consumer or government spending raises GDP. The reality is much different; research on fiscal policy has found, for example, that the fiscal multiplier varies widely depending on the cyclical state of the economy and the indebtedness of the government (Ramey 2011). In some situations, debt-financed government spending can damage short-term as well as long-term growth (Ilzetzki et al. 2010).

Worse for the public's understanding of economic growth, the plus sign (+) in front of exports and the minus (-) before imports in the Hicks equation fosters a mercantilist mentality that we should maximize exports and minimize imports. Instead, economists are nearly unanimous in attributing the gains from trade to productivity-enhancing specialization and not to a surplus of exports over imports. (One of the best examples refuting the idea that a trade surplus boosts income creation is the sharp increase in Canada's trade surplus during the worst of the Depression in the 1930s).

One creative use of expenditure-based GDP is that it has proved to be uniquely capable of being adaptable to an economy, such as Canada's, that regularly experiences shocks to its terms of trade (Baldwin and Macdonald 2012). Statistics Canada formalized this approach when it integrated real Gross Domestic Income (GDI) into its regular release of the quarterly GDP estimates.[10] GDI adjusts GDP for changes in the purchasing power of exports by deflating exports by the price of imports, not the price of exports. Since Canada's export prices fluctuate much more than import prices because of the preponderance of natural resource exports, this implies that exports will fluctuate much more in GDI than in GDP, rising faster during commodity booms and falling more during commodity busts. However, it is important to note that GDI is more indicative of the trend of purchasing power, since it is unrealistic to assume that all export earnings will be spent on imports.

GDP by Income

After the initial efforts to measure GDP using the

10 It is worth emphasizing that what Statistics Canada calls GDI (which is GDP adjusted for the terms of trade) is quite different than the measure used by the US Bureau of Economic Analysis, which formally designates GDI as its income-based estimate of GDP.

industry approach, the next GDP compilation was based on the costs incurred and the incomes earned from current production. These include labour income, corporate profits, proprietors' income, net interest, indirect taxes and depreciation charges.

Precise estimates of earned income rely heavily on income tax records. As such, incomes-based estimates of GDP work best in advanced countries with low levels of tax evasion. The superiority of income tax data over notoriously unreliable self-reported income in surveys also implies that income-based GDP data will not be highly accurate until benchmarked to annual income tax data.[11]

The income-based approach is the least-studied version of GDP, partly because it is practically impossible to deflate this measure into constant dollars. Another limitation of the income-based approach is that there is no simple separation between labour and capital income. Although the allocation of labour income and corporate profits is straightforward, it is difficult to allocate the other income components, which are a mixture of the two.

Therefore, while there are plenty of theories about the distribution of total income between labour and capital, there are no precise measures of this allocation. This practical limitation is unfortunate since some key concepts in macroeconomics depend on the share of income accruing to labour and capital. The income earned by labour and capital is related to the underlying stock and quality of labour and capital inputs, which are fundamental to understanding the supply side of the economy. Their rates of return can be estimated only by comparing the income earned from the stock of labour and capital.

The apex of interest in studying of the functional distribution of income between capital and labour came during the 1960s and 1970s when some theories of that era's growing inflation were based on Kalecki's post-war work on income distribution and the necessity of wage and price controls. This approach was surpassed by the monetarist school, which demonstrated convincingly that inflation had a monetary origin, and research into the functional distribution dried-up. Still, the long-run shift of income shares from labour to profits in recent decades throughout advanced market economies has sparked a revival of research into income-based GDP estimates, notably Piketty's Capital in the Twenty-First Century. This highlights how a particular approach to studying GDP can revive after being dormant for decades.

The Quantity Equation

The quantity equation is an identity, not a theory, that ties the stock of money and the velocity of its circulation to economic activity. For centuries, economists have observed a link between the quantity of money and price changes. In the 19th century, this was called the equation of exchange.

Fisher first proposed the quantity equation in 1911 in a different form than the one that later became widely used. Originally, the equation held that there was an identity of MV = PT, where T was all transactions, including not only the goods and services captured by GDP but also transactions in paper assets. P is the average price of these transactions. However, because of the difficulty of measuring T, and improvements in measuring GDP, Fisher and most economists soon modified the equation to the form of MV = PQ that is popular today.[12]

The quantity of money is a stock, while GDP is a flow. Velocity provides the conceptual link between

11 For more on the difference between incomes measured by tax data versus by surveys, see Cross and Sheikh (2015).

12 The Cambridge formulation of the quantity equation, or Cambridge cash-balance theory, is that M=k(PQ), implying V=1/k where k is non-transactional public holdings of money.

Box: Implications for the C.D. Howe Business Cycle Council

The above discussion of the three conventional GDP measures has implications for how the C.D. Howe Institute Business Cycle Council should use GDP in its deliberations on whether and when Canada's economy is in recession. First, primacy should be given to the expenditure-based measure of real GDP (which is the average of the current dollar income and expenditure measures, adjusted for prices to get real GDP), at least until the final estimates for industry GDP become available three years later. Then, both the expenditure and industry measures of real GDP should be given equal weight. This also implies that, potentially, in an instance like 2015 when growth was very close to zero, the Council may not be able to make a final determination of a recession and its dates until three years after the fact. However, in the case of recessions that are clear cut in all the measures of GDP – such as in the 1981-1982 and 2008-2009 periods – it is readily apparent from the preliminary data that a recession occurred, even if a few more months might be needed to determine its precise dates.

the stock of money and the flow of income. To use the analogy introduced by Lipsey (1963), imagine a circular pipe filled with 100 litres of water. The number of times the stock of water flows by a certain point of the pipe depends on its velocity as determined by a water pump.

The quantity equation requires several assumptions to provide meaningful estimates. First, dividing GDP by the money supply to estimate the velocity of money presupposes that GDP measures transactions conducted in the marketplace. Including unpaid transactions, such as the value of household work, would distort the calculation of velocity.

Second, for the quantity equation to be meaningful, most transactions have to be conducted legally and openly. Transactions paid with money that is not captured in GDP, such as criminal activity or the underground economy, will depress the calculated velocity of money, distorting its relationship to GDP.

In practice, GDP does not include many non-market transactions. As for illegal transactions, Statistics Canada (Morissette 2015) estimates that the size of the underground economy is relatively small at about 2.3 percent of GDP (it is greater in some European countries such as Italy and Greece, and even larger in emerging markets).

The quantity equation's largest statistical problem is that the velocity of money has to be calculated residually since it cannot be observed directly. As a residual, all the difficulties in defining GDP appropriately (such as the inclusion of services outside of the marketplace and the exclusion of criminal and underground activity) and then in measuring GDP will be concentrated and magnified. These statistical challenges sound daunting and risky. However, as I show below, in practice most velocity estimates are reassuringly stable.

Additionally, there are conceptual problems in the quantity equation. Most importantly, there has to be agreement on how to measure the money supply, because it cannot be observed directly, just as GDP itself cannot be observed directly, but must first be defined conceptually and then artfully measured indirectly.

Today, all conventional measures of the money-supply include cash, but disagreement quickly begins about what types of deposits to add (chequing, savings or time deposits) and whether

deposits should be limited to just the banking system or extended to other accounts such as money market funds.

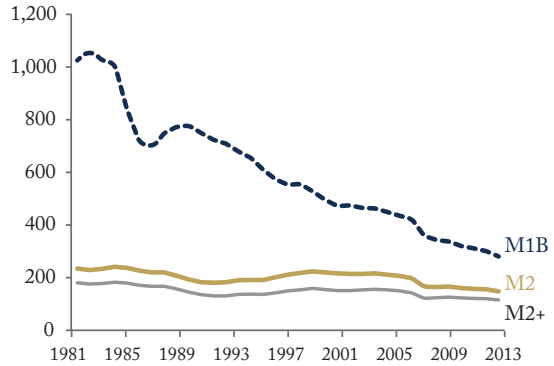
There is also no consensus on the best definition of the money supply. One literature review on defining the money supply concluded, "It is impossible to identify a unique aggregate whose relationship to GNP is uniformly superior over different sample periods relative to other aggregates."[13]

Fortunately, in practice short-term movements in the velocity of money are relatively impervious to different definitions of the broad money supply. Velocity for M1B declines steadily over time, since it only includes cash and bank chequing deposits (Figure 2). The broader measures, M2 and M2+, which include personal savings and term deposits, are relatively constant over time, showing that the shift out of cash and chequing accounts that depressed M1B went into deposits that bore a higher rate of interest, especially when interest rates were high in the 1980s and 1990s. The only times velocity moves sharply are during the declines one would expect during recessions, when spending shrinks. This implies that arguments about the definition of the money supply mostly concern the velocity level of money, not its behaviour.

Is the quantity equation still useful?

In its heyday, the quantity theory of money provided the ruling paradigm of macroeconomics, just as the Keynesian determination of aggregate demand dominated in the post-war decades. By assuming velocity was roughly constant over the long term (but definitely not over the whole business cycle), quantity theorists stretching back to Hume, Smith and Ricardo through to Marshall, Fisher and Friedman believed the economy could be controlled by changing the money supply.

Figure 2: Money Velocity



Source: CANSIM Table 380-0063 AND 176-0025.

Moreover, pre-Keynesian thinking was confident that most GDP fluctuations were the result of price changes, not real output shifts. Of course, in the Great Depression there were precipitous declines in both prices and output. This counter-factual led to the displacement of the quantity equation by Keynesian aggregate demand.

However, quantity theorists had always predicted that velocity could change abruptly in the short run, sometimes with catastrophic results since such shifts tend to reinforce, not offset, changes in the money supply (Sowell 2007). For example, increases in the money supply encourage even more spending and reduce holdings (raising velocity) because of fears of a decline in their purchasing power due to inflation, while a falling money supply would lead to people holding onto money longer (dampening velocity) as demand increased for precautionary balances in the expectation of lower prices. The assumption that velocity was stable over longer periods was always nuanced for short-term shifts in economic activity.

13 See Papademos and Modigliani (1990) p. 460.

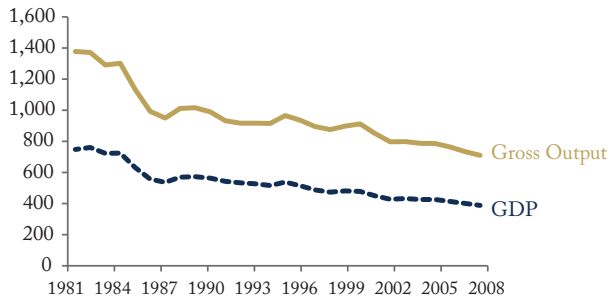
Friedman and Schwartz resuscitated money supply and velocity as keystone macroanalysis variables in their 1963 study of US monetary history. Friedman's monetarist theories put the quantity of money at the centre of monetary policy and macroeconomic analysis, culminating in central banks in the US, England and Canada targeting growth in the money supply and not interest rates in the late 1970s and early 1980s.

Subsequently, the unstable relationship between money supply and GDP[14] during a period of high inflation, deregulation of interest rates and financial innovation resulted in central banks abandoning monetarism. As a result, interest in the quantity equation has declined markedly in recent decades, despite velocity stabilizing after the 1980s.

However, the recent widespread use of quantitative easing by central banks has raised concerns that a surge in the money supply will follow, sparking higher inflation and showing that the basic idea behind the quantity equation remains in wide circulation. If inflation does rise in the near future, this would undoubtedly trigger a resurgence of interest in the quantity equation similar to the one seen in the 1970s.

Calculating velocity using Gross Output, which is closer to Fisher's original formulation relating money to all transactions, shows it moves in a very similar manner to velocity using GDP (Figure 3). Since the trend of velocity seems largely impervious to changes in the definition of money or to using either GDP or Gross Output calculations, this suggests velocity is relatively stable, outside of recessions or periods of high inflation.

Figure 3: Velocity of Money*



*Using M1+.
Source: CANSIM tables 381-0013, 380-0063, 176-0025.

GDP by Input-Output Analysis

Statistics Canada published the first official set of input-output tables for 1961, using a 42-by-42 matrix of inputs and outputs. Today, those estimates are produced annually in a matrix of 750 inputs by 300 outputs. Because of their detailed scrutiny of every productive process, the input-output tables have become the lynchpin of Canada's national accounts and ultimately the whole system of economic statistics.

Input-output tables provide a detailed accounting of how an economy combines labour and materials to generate incomes. Input-output is the only national accounting framework that sheds light on the crux of the modern exchange economy, which is the link between production and consumption. In this way, these national income measurements provide a reliable guide through a maze of complex interrelationships.

However, the detail available from input-output estimates can also be a liability for analysis. One drawback is that such detail requires tax records, business surveys and government public accounts, implying annual data is available only after a

14 Velocity rose during the 1981-1982 recession, in contrast to the declines posted in previous recessions, and then unexpectedly fell in the 1985-1986 period.

considerable time lag. Another pitfall of this disaggregated level of analysis is that it diverts attention from the long-term determinants of labour quality, capital inputs and technology, which are available only from studies of multifactor productivity.

The input-output approach to industry-based GDP is the preferred methodology to study structural changes in modern economies. This is because it focuses explicitly on the relationship between inputs and outputs, the bedrock of productivity analysis, and the vast amount of detail it makes available. However, it encourages a mechanistic view of the economy, where society can boost output by simply increasing its inputs. A better understanding of long-term growth sources comes from viewing it as evolutionary, in which innovations cumulate and combine with each other, rather than as a machine (Ridley 2015).[15]

Another disadvantage is that while the input-output approach reflects the impact of changes in technology and the production function, it cannot explain them. To do that, one needs a productivity theory.

GDP by Factor Input

Productivity

Higher productivity is the most important source of long-term economic growth. The great virtue of productivity analysis is that the focus shifts from the Keynesian preoccupation with aggregate demand to the inputs and production techniques needed to generate that income.

In the neoclassical model of economic growth, productivity growth is exogenous. While steadily increasing use of labour necessitates more capital accumulation, technical change is the residual, after accounting for these labour and capital inputs; as such, it is a "measure of our ignorance," as Griliches famously called it.[16]

The concept of Total Factor Productivity grew from dissatisfaction with this simple neoclassical view of productivity that dominated early research. Dissident researchers speculated that the large "residual" in economic growth calculations was not due to disembodied technical change, but instead resulted from mismeasurement of labour input. In particular, they adjusted labour inputs not just for increased quantity over time, but also for higher quality as human capital increased. It was not long before the same adjustments were being made for capital.

The result was Total Factor Productivity (also called Multifactor Productivity or MFP). As specified by Romer in 1990, GDP is related to the amount of knowledge discovered and a vector of labour and capital production inputs. GDP growth became a function of quality-adjusted labour and capital inputs along with MFP growth, which reflected the efficiency with which labour and capital (both adjusted for quality) were combined to generate incomes. MFP helpfully disaggregates labour and capital inputs into changes in quantity and quality, such as a more educated labour force.

The MFP shift was revolutionary for both the theory and the measurement of economic growth. Instead of growth being exogenous and driven by a little understood residual, the "new

15 Ridley's basic idea is that innovative ideas cumulate, building on each other; e.g., the telephone and the computer combined to become the Internet. In contrast, the machine approach is that each occurs in isolation.

16 Quoted in Jack Triplett and Zvi Griliches's essay in *Economic Measurement. Hard-to-Measure Goods and Services: Essays in Honour of Griliches*. Ed by Ernst Berndt and Charles Hulten. University of Chicago Press. 2007.

models of endogenous growth questioned the neoclassical emphasis on capital accumulation as the main engine of growth, focusing instead on the Schumpeterian idea that growth is primarily driven by innovations that are themselves the result of profit-motivated research activities and create conflict between the old and the new by making old technologies obsolete (Aghion and Durlauf 2005)."

Studying trends in how an economy organizes its capital and labour efficiently to produce GDP only makes sense when done for long periods of time. So MFP estimates, especially for the productivity of capital, are produced only on an annual basis. For its part, Statistics Canada produces quarterly labour productivity estimates that translate to GDP per-hour worked. However, these estimates are not a good proxy of MFP, an important driver of long-run economic growth.[17]

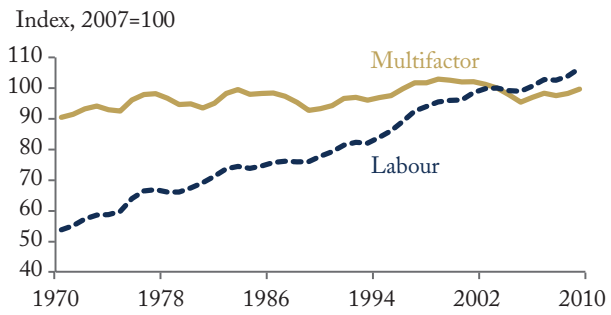
Labour productivity growth can be disaggregated into capital deepening, labour quality and MFP. For example, the increase in labour productivity accompanying Canada's oil boom after 2002 was accomplished with large doses of business investment, especially in Alberta's oil sands. Accounting for this rise in capital inputs, MFP actually fell over this period (Figure 4), reflecting the fact that the oil sands are a high-cost and, therefore, low-productivity way of extracting oil.

The productivity approach to GDP has its limitations and pitfalls. The productivity calculation is made only for the business sector, because of the intractable problems in measuring public sector productivity. Like all detailed estimates, it is available only after a considerable time lag. For MFP, there is controversy over how to make adjustments for changes in the quality of labour and capital.

However, the largest potential problem with studying productivity is the mirror image of one of its advantages. By focusing on long-term trends – most productivity analysis is conducted by comparing growth over decades or even longer periods – productivity minimizes the noise from short-term movements. However, arbitrary accounting conventions become more important over longer periods of time. As noted in the introduction, the concept of GDP changes over time (for example, the current inclusion of investment in software and research and development).

As important, issues of comparable quality become more important the longer the time span under study. For example, the quality of housing or education today is much different from the post-war years. Furthermore, what is included in GDP and its quality-adjusted price change varies significantly from decade to decade. Even the administrative data used to measure parts of GDP will change over time as governments change the information they collect.

Figure 4: Productivity



Source: CANSIM Table 383-0021.

17 The lack of recent MFP growth in Canada demonstrates how growth has been accomplished by increasing the inputs of labour and capital. This form of growth can be successful for long periods, but as the energy slump starting in 2014 revealed, growth needs eventually to be rooted in higher MFP, or incomes will stagnate.

As a result, since GDP estimates are, in the words of Simon Kuznets, "partly a by-product of administrative activity, partly a result of direct observation of complex phenomena without controls designed to reduce the variations observed, the best we can do is to express an opinion in quantitative form."[18] It is sobering for users of GDP estimates to think of the data as a quantified opinion, where opinions regularly change over time, not the hard fact so cherished by empiricists.

Gross Output

Both Statistics Canada and the US Bureau of Economic Analysis (BEA) produce estimates of gross output (GO), which includes all the intermediate inputs used in production. As such, GO more closely resembles the financial accounts maintained by businesses and people, even if the concept of value added is the correct way to measure GDP.

While GDP measures the distribution of aggregate demand, GO shows how supply is organized to meet that demand. GO showed how steeply business activity fell during the last recession. While nominal GDP in the US fell 2 percent during the 2008-2009 recession, GO contracted 7 percent as intermediate inputs dropped by 10 percent. (GO can be measured only in nominal terms).

Indeed, GO is a better measure than GDP of the market collapse that individuals and businesses faced during the recession. However, value-added GDP is better than GO in foretelling the loss of jobs resulting from the recession, since it is what drives labour demand. (The duplication of purchases in GO exaggerates the demand for labour because it double counts intermediate inputs.)

GO is also used to determine in which sectors economic activity takes place. It is often said that nearly 70 percent of US GDP originates in personal consumption and 20 percent in business investment. However, using GO reduces the share of consumption to about 40 percent while investment rises to more than 50 percent, reflecting the more specialized and complex production process in producing capital goods.

One major problem with GO is that its level alone is virtually meaningless, reflecting the lack of detail available in a country's statistical system. Indeed, if Statistics Canada reduced the number of industry or product classes it measures, GO would fall even if nothing actually changed in the economy. However, as long as the classification system remains constant, GO changes are meaningful measures of transactions in the economy.

GO has proven useful enough as an analytical tool that the BEA recently began to publish it on a quarterly basis. In Canada, GO is available only on an annual basis. As well, it is available only by industry, so the comparable calculation of the share of major expenditure sectors cannot be done for Canada.

In the US, the GO ratio to value-added GDP was 1.75 in 2012. This is close to 1.90 value in Canada (Figure 5), suggesting that Canadian firms use intermediate inputs slightly more than in the US, based on the reasonable assumption that the classification detail is the same in both countries.

Net Domestic Product

The production process uses up a certain amount of capital, either through wear and tear on machinery and structures or through obsolescence. Deducting this from GDP yields Net Domestic Product

18 Quoted in Grant, 2014 (69).

(NDP), which is closer to John Hicks's concept of true growth "as the maximum amount which can be spent during a period if there is to be an expectation of maintaining intact the capital value of prospective receipts (Hicks 1946)."

Both GDP and NDP are needed to understand fully how the economy functions. GDP is the appropriate concept for studying the production function and how input productivity changes over time, while NDP is the appropriate concept for studying economic welfare.

In practice, there are long-standing problems in estimating depreciation in the national accounts. Individual firms estimate depreciation allowances based on how much is needed to maintain the nominal value of capital. However, for the economy as a whole, the concept of keeping intact the total physical stock of capital flounders due to innovation. Indeed, innovation renders obsolete the physical capital of individual firms, which is what the national accounts uses for its estimates.

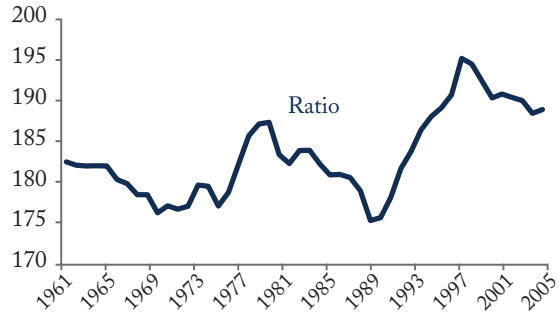
However, as noted by Ruggles and Ruggles (1956): "Technological progress causes no real loss to the economy as a whole . . . . The fact that a new invention exists that does the same job better does not mean that the amount of replacement of capital goods required to maintain the existing level of production in the economy is increased."

Technical progress reduces capital consumption for the total economy, even if it increases depreciation for individual firms. More broadly, the very nature of capital changes over time due to changing prices, tastes and technology, making the notion of replacing worn-out capital complex and practically impossible to estimate.

Using the Different Measures of GDP in Analysis

Contrasting these different ways of looking at how each measure treats an economic phenomenon is revealing. For example, the GDP concept is often criticized because it appears to simple mindedly reward bad social choices in the form of higher incomes. The classic example is the "broken window" fallacy of what happens when a youth throws a rock, breaking a house window. Analysis based on GDP expenditure may suggest that this leads the homeowner to purchase a repair (never mind the cost of public spending on police and courts if the perpetrator were caught), which lifts GDP in the short run but adds nothing to society's long-term well-being.

Figure 5: Ratio of Gross Output to Value-added GDP



Source: CANSIM tables 381-0012, 381-0013.

However, changing the optic to the impact on productivity would reveal the shortcoming of this approach. Breaking a window does nothing to expand either the stock of labour or capital, or the efficiency with which they are used. So there is no benefit to long-term potential growth. Put another way, it is not productive spending; in fact, diverting money to repairing the window subtracts funds that could potentially be invested in productive enterprises.

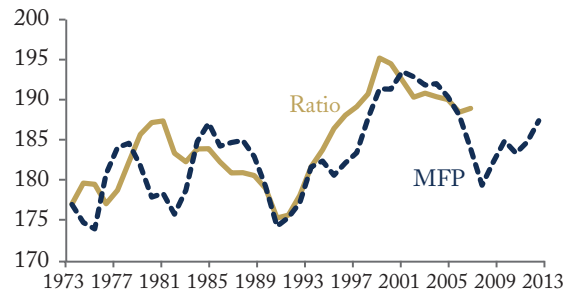
The same analysis applies to the Keynesian prescription of digging holes and filling them up again to combat the Great Depression. While this does provide a temporary fillip to government spending and aggregate demand, from a long-term perspective it is a waste of spending that could have gone to increase either the stock of labour or capital, or to raise their productive use.

The paradox that not all spending is beneficial or productive has deep philosophical roots in national accounting. In national accounting's infancy in 1937, Kuznets advocated a welfare-based rather than a production-based analysis. His approach removed spending that represented costs rather than benefits such as defence or financial speculation. Not surprisingly, in view of the subjective judgments involved in determining what is speculative or frivolous, this welfare-based analysis ceded to Keynes's GDP approach. The ascendancy of the Keynesian approach to measuring incomes was secured by the treatment of government spending on defence during the Second World War. If such spending were not included, GDP would have fallen rapidly.

Examining the different approaches to GDP also helps determine whether war stimulates economic growth. Many analysts mistakenly believe that stepped-up government spending on war material boosts the economy, citing the end of the Great Depression and the start of the Second World War as more than a coincidence. However, from a productivity perspective, it is hard to see how blowing up human and physical capital in a war enhances long-term potential growth.[19] Indeed, Higgs (2006) argues that US living standards declined rapidly during the war, reflecting that people were working harder, longer, more inconveniently and more dangerously in return for fewer consumer goods.

This same framework that contrasts expenditures on GDP with long-term productivity also provides some guidance on whether lower taxes stimulate growth. Tax cuts are a classic Keynesian stimulus to spur short-term growth. Lower taxes on labour or capital would encourage increased supply of either (or both) and so should also boost long-term growth.

Figure 6: Ratio of Gross Output to Value-added GDP and Multifactor Productivity



Source: CANSIM tables 381-0012, 381-0013, 383-0021.

However, a Total Factor Productivity perspective cautions that increasing labour and capital inputs does not mean that their combined use is more efficient or more innovative. To quote Romer, "Economic growth occurs whenever people take resources and rearrange them in ways that make them more valuable."[20]

New perspectives on growth can be gained by combining the different measures of the macroeconomy. For example, the ratio of gross GDP to value-added GDP was compared in Figure 5, a measure of the amount of outsourcing firms use to produce goods and services. Comparing trends in this ratio to MFP shows that firms after 1990 started reorganizing their purchases from other industries just before shifts occurred in MFP measurements (Figure 6). The reasons for this correlation are worth pursuing in further research.

19 Another way of understanding this is using the national balance sheet of wealth, where the destruction of physical capital is subtracted from the capital stock.

20 See Paul Romer, *Economic Growth*. Library of Economics and Liberty. 2008. Available at http://www.econlib.org/library/Enc/EconomicGrowth.html.

As well, the ratio of gross output to GDP always falls sharply during recessions, as cutbacks in spending ripple through the supply chain of producers. The point made here is that some interesting questions are raised by analyzing the relationship between national accounts aggregates instead of studying them in isolation.

Conclusion

Porter (1995) said that, "Accounting is a measurement system which is plagued by the existence of alternative measurement methods." This is not true for national accounting, where the diversity of approaches to measuring GDP is an asset. There are many different ways of calculating and studying total incomes in an advanced economy, each with particular strengths and weaknesses, whose usefulness varies over time as economic circumstances change.

For example, during the depths of a severe downturn the focus tends to be on reviving aggregate demand. When growth stagnates for long periods, the emphasis shifts to the long-run determinants of productivity. For statisticians, the different measures of GDP act as an internal check on their conceptual and empirical consistency. For economists, the different optics for viewing economic activity lead to a more profound understanding of the process of economic growth. Good analysis and policy prescription often depend on finding the right optic to understand a particular problem.

Faced with the prospect that slow growth could continue for years, economists are focusing more on the determinants of growth over the long run. As a result, supply-driven measures of understanding the economy are growing in importance at the expense of the traditional focus on aggregate demand that dominated economic discourse after the Second World War. Concomitant with this shift has been a downplaying of high-frequency monthly and quarterly GDP measures in favour of annual measures that incorporate supply variables such as inputs and technology. Statistical agencies should shift their resources accordingly.

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