**RATES OF CHANGE**

(This piece occasionally presupposes a passing knowledge of CirF. If you don’t have that, just ignore the references and carry on.)

I believe that macro instruction should take place in the most relevant vocabulary. For the most part, that is the vocabulary of rates of change. The inflation rate is more important than the price level; the real growth rate matters more than the level of real GDP; the rate of money growth matters more than the amount of the money supply. By “more important” and “matters more” I mean for the purposes of reading the popular press and participating in the discussion of macro topics. An interesting distinction is that the questions, “What were real GDP and the price level in the year 2018?” have no meaningful answers. These numbers change whenever the base year changes. The growth rates, however, remain unchanged.

I use a fairly consistent notational scheme: capital letters denote levels (P for the price level, Q for real GDP, X for nominal GDP, M for the money supply, etc.), lower case letters denote rates of change (p for inflation, q for the real growth rate, x for nominal growth, m for the rate of monetary growth, etc.).

Using rates of change depends on accepting the simplification that, for any X, Y and Z:

X = Y⋅Z, implies that, as an approximation, x = y + z. This approximation is better the smaller are x, y, and z. Most economic data involves variables whose annual rates of change are single-digit. We can treat the approximation as if it is true.

See [Appendix](#Notation_Appendix) for a complete listing. See [Appendix](#RatesOfChange_App) for more comments on AD/AS instruction, including a defense of the use of

**The Equations of Exchange**

I will use the Equation of Exchange to illustrate. The equation states that MV = PQ, which is actually the combination of two separate descriptions of total spending. Using X to denote nominal GDP, the two equations are X = PQ and X + MV. Each of these two equations is useful in its own right for presenting a variety of issues. The utility of the two equations is greatly increased when they are recast in their rate-of-change forms. In that form (allowing for the approximations), the two equations are (in my vocabulary)

1. The Product Market Equation: x = p + q and

2. The Credit Market Equation: x = m + v

3. The Equation of Exchange: p + q = m + v

WHERE:

x = nominal GDP growth rate

m = growth rate of the money supply

v = rate of change of the velocity of money

q = real GDP growth rate

p = inflation rate

**Justifying the equations**

I have tried several ways to justify the equations to classes. Straightforward description seems best.

-- The Credit Market Equation (x = m + v) is presented as, “For spending to rise, at least one of two things must happen: either there is more money, or the money that is there is being spent faster.”

-- The Product Market (x = p + q) is described as saying, “If spending rises there must be some combination of raising prices and more real output.” (‘Stuff’ is my preferred description of “real output.”)

-- “Trust me that the math of adding the percents is a good approximation of the truth.[[1]](#footnote-1) If you want the details see me after class.[[2]](#footnote-2)”

**THEORIES:** The equations are an important part of comparing Keynesian and Classical theories.

1. **Credit Market Equation (x = m + v) assumptions:**

In Classical theory v = 0; In Keynesian theory v can change.

The velocity of money is considered to be inversely related to the demand for money. A constant velocity of money means v = 0. In that case, we are left with x = m, a statement indicating the power of the quantity of money in determining spending and, hence, macro performance, especially in monetarist theory.

2. **Product Market Equation (x = p + q) assumptions:**

In Classical theory a rise of x will lead mostly (entirely?) to a change of p (inflation) with little or no effect on real growth.

In Keynesian theory a rise of x will lead mostly (entirely?) to a change of q (real growth) with little or no effect on p (inflation).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| m | v | x | p | q |
| 6 | 0 | 6 | 3 | 3 |

In numerical examples I typically start with these numbers.

They are on the high side for describing the American economy for the last few decades, but they are in the correct ball-park. Knowing these numbers is itself useful information.

**The Relationship to Supply and Demand and CirF**

The equations (x = p + q and x = m + v) become another way to present conclusions about the behavior of the Product and Credit Markets that complement the use of supply and demand and the Circular Flow, especially in the ability to generate simple numerical examples.

The Credit Market Equation relates to the credit market in that changes of m shift the supply curve in the Credit Market. Changes of v, at least those caused by changes of borrowing behavior, such as fiscal policy, show up as shifts of the credit demand curve. This establishes that shifts in the Credit Market, shown by changes of m or v, result in changes of x, as summarized by x = m + v.

The Product Market Equation has that name because p and q are the endogenous variables in the AD/AS view of the Product Market. If one takes x as being generated in the Credit Market, then it can be treated as (short-run) exogenous to the Product Market. The equation of AD is now p = x - q, an easily drawn, easily shifted curve. AD is equivalent to spending. A simple version of this economy is that spending (x) is determined by the Credit and Foreign Exchange Markets (described below) and that the job of the Product Market is to “decide” how much of the growth of spending goes to inflation and how much goes to real growth.

The Product Market Equation illustrates that an increase of spending (x) will likely lead to increases of both p and q – an alternative description of the supply and demand result. A supply shift is shown by changing either p or q without changing x.

Another use of the Product Market Equation is in defining “real growth.” Nominal growth (x) is presented as data collected largely from tax records. A brief description of the process of measuring the price of a representative basket of goods is sufficient to tell where the measure of inflation (p) comes from. So what is real growth? It is q = x – p, the part of the extra spending that did not just turn into higher prices; the part that actually bought “more stuff.” We can see, quite literally, that real GDP is nominal GDP “adjusted for (minus) inflation.”

For numerical examples we can use a table to display the equation of exchange as:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | m | v | x | p | q |
| 0 | 6 | 0 | 6 | 3 | 3 |

**Some Applications.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | m | v | x | p | q |
| 0 | 6 | 0 | 6 | 3 | 3 |
| 1 | 6 | 0 | 6 | 3 | 3 |

1. A Short Run (Keynesian) increase of Government Purchases. Since there is no monetary policy involved we leave m = 6. Fiscal policy can only have an effect if it raises velocity (v). The increased spending will cause some combination of real growth and inflation. The effects are salutary – lots of real growth, not much inflation

In the LR, spending returns to its 6% level and it appears that nothing has happened. What has happened is that we now have a larger government sector and a smaller private sector. Someone has been crowded out.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | m | v | x | p | q |
| 0 | 6 | 0 | 6 | 3 | 3 |
| SR | 6 | +2 | 8 | 3 | 5 |
| LR | 6 | 0 | 6 | 3 | 3 |

2. Friedman’s money growth rule. Assume we want zero inflation (p = 0)[[3]](#footnote-3) and that, as quasi-Classicals, we believe that in the Long Run v = 0 and q = q\* (here taken to be q\* = 3). Inserting those numbers into the equations we are led to m = x = 3. Monetary expansion should equal long-run real growth. If you substitute q = 0 for q = 3, you have the Quantity Theory of Money.

3. A liquidity trap looks like:

|  |  |  |
| --- | --- | --- |
| m | v | x |
| 6 | 0 | 6 |
| 9 | -3 | 6 |

4. The effects of monetary expansion. **Does money matter?**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | m | v | x | p | q | matters? |
| 0 | 6 | 0 | 6 | 3 | 3 | initial state |
| 1 | 9 | -3 | 6 | 3 | 3 | no. “Liquidity trap” |
| 2 | 9 | 0 | 9 | 4 | 5 | yes. Looks good |
| 3 | 9 | 0 | 9 | 5 | 4 | yes. Looks less good |
| 3 | 9 | 0 | 9 | 6 | 3 | no. “Money is a veil.” |

|  |  |  |
| --- | --- | --- |
| x | p | q |
| 6 | 3 | 3 |
| 6 | 1 | 5 |

5. Supply Side Growth due to increases or improvements of the factors of production or reductions of business costs look like this. Note that by keeping x = 6 we are asserting that AD did *not* shift.

Almost any problem can be illustrated with a numerical example.

**Procedure**

1. For a general demand change.

* Change x to show the demand/spending change
* Change p and q, both in the direction that tends to solve the problem. E.g. If x rises, increase both p and q
* Be sure x = p + q

2. For a general supply change.

* Change q in the direction of the supply change
* Do NOT change x (we are looking at a *ceteris paribus* change of supply)
* Change p to keep x = p + q.

**RATES OF CHANGE AND MARKET GRAPHS**

**The Product Market**

I use AD/AS graphs that use inflation (p) and real growth (q) as the variables on the axes. Note the following in Figure 7:

3

**Figure 7.** AD/AS with rates of change

q

p

3

AD

AS

3

a) Negative numbers become important: it is now possible, and important, to distinguish graphically between disinflation and deflation; between slow growth and recession. Compare this to standard AD/AS analysis, which proclaims that any decrease of AD creates deflation and recession.

b) I usually use p = 3 and q = 3 as my starting place for examples, in as much as those values represent an easy approximation of the US economy.

c) It is significant to describing the US economy that the AS curve passes through the second quadrant, rather than the fourth. In most of twentieth century US, a decrease of AD has created recession before deflation. The 1920s may be an exception to that generalization.

Using rates of change means that converting a nominal growth rate into a real growth merely involves subtracting the inflation rate.

For GDP: q = x – p. For interest rates: r = i – p. For wages: w\_real (wr) = w – p

**Curve Shifters.** The events that shift AD and AS are the same ones one would typically use. I find that for principles purposes I can say that AD is synonymous with total spending. Anything that raises total spending raises AD.

AS is shifted by the quantities and costs of the factors of production. Under this we can include wages, energy costs, technological change, business taxes and regulation.[[4]](#footnote-4)

Using rates of change provides the bonus of bringing the insights of the Phillips Curve -- short-run or long -- back into use. If one assumes that real growth is inversely related to the unemployment rate (which is a decent principles-level truth), then AD/AS is merely the mirror image of the Phillips curve.

Using rates of change has its pitfalls and raises interesting questions about the difference between “causes inflation” and “raises the price level.” The oil-price increases of the 1970s are shown as “causing inflation” in this treatment; in standard treatment they are represented as “raising the price level.” On the principles level I don’t think the difference is profound. The fact is, we all tell tales and half-truths in teaching macro. The tales and half-truths are different if you use this method. I prefer the stories I tell in this fashion, but that may well be a matter of taste. For instance, the long-run AS curve, drawn vertically, states that there is an equilibrium *growth rate*, rather than an equilibrium *level* of real GDP. I find this appealing.

My favorite mathematical model of the Product Market (not explicitly used in class) is:

AD: p = x – q (i.e. the Product Market Equation, x = p + q. The curve is shifted by changes of x)

AS: p = 1.5 + .5q. (shifting AS involves altering the number 1.5). The equation states:

1. Equilibrium is at q = 3%; p = 3%

2. a 1% demand –induced increase of real GDP growth ‘causes’ an extra .5% inflation.

3. We expect that an additional 1% growth of nominal spending, will induce a 1/3% rise of inflation and a 2/3% rise of real output

3. At the ‘edge’ of a recession (q = 0) inflation is 1.5%

4. Deflation will occur when AD falls enough that q = -3%

These numbers seem a ball-park reflection of reality.

**The Labor Market**

I also present the labor market using rates of change: the variables on the x-axis n, is the growth rate of employment; on the y-axis is either w, the growth rate of wages, or wr, the growth rate of real wages (wr = w – p). Personally I think the labor market works better if one thinks of the price as being real wage growth (wr), though I rarely bother to make the distinction in class. I am far less likely to use numerical examples in the labor market than in the product market so the issue can be easily sidestepped. (The computerized Market Mode Circular Flow Diagram has a “real” or “nominal” option in the labor market.)

1

The Labor Market

n

wr

2

DL

SL

Through which quadrant the supply curve passes is an interesting question. (I noncommittally drew it through the origin). That depends partly how one defines “wages.” I would hazard a guess that the nominal Supply of Labor passes through the second quadrant and the real supply curve through the fourth. This predicts the following: a decrease of the demand for labor will first cause real wages to fall, then cause employment to fall, then cause nominal wages to fall.

I mention this not because it necessarily belongs in a principles class, but to point out that thinking in rates of change has a way of throwing new light on old subjects even for those of us quite familiar with them.

**Labor Market Curve Shifters**

Demand shifters Supply Shifters  
real GDP size of the labor force

labor productivity taxes

**The Other Markets, The Other Variables. When NOT to use rates of change:**

The two other macro markets I use are the Credit Market (I prefer the flow market for credit to the market for the stock of money) and the Foreign Exchange Market. See Figures 9 and 10 for my presentations of those markets. I do *not* represent these two markets using rates of change. Interestingly, both of their “price” variables are already rates.

This means that the left side of the CirF diagram is done in rates of change, the rest in done in levels.

i0

**The** Credit Market

Z, X

i

Z0

X0

B

L

**The Credit Market.** L and B stand for Lending and Borrowing respectively. The price variable in the Credit Market is the interest rate (whether this is better real or nominal is unclear to me. In the computer versions real/nominal is an option).

There are two quantity variables. The first is Z – defined as the dollar value of credit; the second is X, nominal GDP. The rationale for putting both credit and spending on the axis is that the two “always” move in the same direction. I use the Z variable when the issue at hand is confined to the credit market (E.g. “What is the effect on interest rates of increasing money growth?”). When the X (spending) variable is used, the result is essentially an IS/LM graph -- with no four-quadrant derivation required! The effect is to link events in the Credit Market to results on the Product Market.

e0

The Foreign Exchange Market

$

e

$0

D$

S$

**The Foreign Exchange Market** uses the exchange rate (e) as its price variable and the number of dollars traded ($) as the quantity variable. The demand for dollars is seen as equal to Exports + Foreign Capital (D$ = E + K); the supply of dollars is equal to Imports (S$ = F).[[5]](#footnote-5)

The relationship of the four macro markets is well presented by the circular flow diagrams. Here is a way to picture the model this creates. Adopt the fiction (i.e. “assume”) that nominal spending is determined by the Credit Market and the Foreign Exchange Market (or in IS/LM space) so that nominal GDP and its growth rate are exogenous to the Product Market. Clearly this is a simplification, but it makes much exposition radically easier. The job of the Product Market is now seen as merely dividing a given rate of spending into its inflation and real growth components.

1. Especially in macro where rates of change are typically small numbers. [↑](#footnote-ref-1)
2. Those with the math background and the curiosity are often delighted to be walked through an application of logarithms and their derivatives. [↑](#footnote-ref-2)
3. One can describe the actual targets – usually 1% - 2% – of many monetary authorities. [↑](#footnote-ref-3)
4. Note that these very standard curve shifters. [↑](#footnote-ref-4)
5. [↑](#footnote-ref-5)