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Questions? Email dwheat@wheatresources.com

Stock and Flow Tutorial

Prepared for students
in ECO201

Learning Objectives

In this slide show, you will review:

- *how to use Aggregate Demand to estimate GDP*
- *the relationship between production, inventories, and sales*

You will also learn

- *why we will separate "inventory changes" from "investment"*

Suggestion: *Review "causal links" in the Links Tutorial.*

Estimating GDP

If the quantity of goods & services *produced* during a year equals the quantity *sold*, then

annual production = annual sales

Nationwide, the value of annual **production** is called ***gross domestic product*** **(GDP).** For those of you accustomed to thinking about "supply & demand" in economics, think of GDP as ***aggregate supply***. (Aggregate just means "nationwide total.") The nationwide total value of annual **sales** is called ***aggregate demand.***

Therefore, *when production and sales are equal nationwide*,

GDP = Aggregate Demand

or, in other words,

Aggregate Supply = Aggregate Demand

In that case, adding up the components of aggregate demand (consumption, investment, government purchases, and net exports) would provide a good estimate of GDP.

By underlining "if"…"when"… "in that case," we are emphasizing that special conditions must exist if these equations are true. When those conditions are not met, the equations are false.

Estimating GDP, cont'd.

Aggregate Demand = Consumption + Investment
+ Government purchases + Net eXports
= C + I + G + NX

When the annual value of production and annual value of sales are equal nationwide, GDP is equal to aggregate demand.* In that case, it is appropriate to use this equation:

GDP = Aggregate Demand = C + I + G + NX

*An analogy with your own wages and your own spending habits might be helpful here. Suppose you earned $25,000 last year, but you weren't sure about that and needed an estimate. Then suppose that your only financial records were your spending receipts (not likely, but bear with me). You could estimate your income for the year by adding up all of your expenses. In terms of arithmetic, your expenses would be equivalent to your income. That does not imply that income and expenses have the same meaning; clearly, "income" is not the same as "outgo." However, the arithmetic works out that way--adding up your expenses equals the same number of dollars that you were paid (if you spent all of your income and did not use any of your savings or borrow any money). In that case, your expenses provide a useful way to estimate your income. Likewise, GDP and aggregate demand do not have the same meaning, but if there is reason to believe they are mathematically the same number, then knowing one permits estimating the other.

Estimating GDP, cont'd.

Question: How can we know whether adding up C, I, G, and NX provides a good estimate of GDP? *In other words, how can we know whether sales and production are equal?*

Answer: By observing whether business inventories are stable.

Production adds to inventories. Sales subtract from inventories.

Production $\xrightarrow{s}$ Inventories $\xleftarrow{o}$ Sales

When production and sales are equal, then the quantity added to inventories will be the same as the quantity subtracted, and there will be no net change in the inventory level. Therefore, when we see that inventories are stable, we can conclude that production are sales are equal.

Nationwide, if we see that inventories are stable, then we can conclude that aggregate demand (C + I + G + NX) provides a good estimate of GDP.*

*Continuing the personal wages and expenses analogy from the previous slide, you could be confident that your expenses did, in fact, equal your total wages if you also knew that your "inventory" of money (bank accounts and cash) was the same at the beginning and end of the year. (And, incidentally, that your "inventory" of debt was at the same level, indicating that any credit card expenses during the year had been exactly offset by credit card payments during the year.)

Estimating GDP, cont'd.

Question: What if inventories at the end of the year were higher than at the beginning of the year; i.e, what if inventories increased?

Answer: Remember that production adds to inventories, and sales subtract from inventories.

Production $\xrightarrow{S}$ Inventories $\xleftarrow{O}$ Sales

If inventories are rising, then more is being added to inventories than subtracted, which means that more is being produced than sold.

Therefore, **when inventories rise, GDP is greater than aggregate demand:**

GDP > Aggregate Demand

GDP > (C + I + G + NX)

The difference between GDP and Aggregate Demand is equal to the change in inventories.

GDP = Aggregate Demand + ΔInventory

***** The symbol "Δ" mean "change in…"

Estimating GDP, cont'd.

Question: What if inventories at the end of the year were lower than at the beginning of the year; i.e, what if inventories decreased?

Answer: Remember that production adds to inventories, and sales subtract from inventories.

If inventories are falling, then more is being subtracted from inventories than added, which means that more is being sold than produced.

Therefore, **when inventories fall, GDP is less than aggregate demand:**

GDP < Aggregate Demand

GDP < (C + I + G + NX)

The difference between GDP and Aggregate Demand is equal to the change in inventories.

GDP = Aggregate Demand + ∆Inventory

When inventories are falling, the change would be a negative number.

Estimating GDP, cont'd.

Hypothetical Example #1, when inventories **rise**:

C = $6.0 trillion/year
I = $2.5 trillion/year
G = $2.0 trillion/year
NX = - $0.5 trillion/year

AD = 6.0 + 2.5 + 2.0 - 0.5 = $10.0 trillion/year

Inventories on Dec 31, 2003: $0.4 trillion
Inventories on Dec 31, 2004: $0.7 trillion

Inventory chg = 0.7 - 0.4 = $0.3 trillion/year

GDP = (Aggregate Demand) + (Change in Inventories)
= (C + I + G + NX) + (ΔInv)
= (6.0 + 2.5 + 2.0 - 0.5) + (0.3)
= 10.0 + 0.3
= $10.3 trillion/year*

*To conclude the personal wages & expenses analogy, suppose that after adding up all of your expense receipts, the sum was $24,000. But then suppose you noticed that your bank account balance was $1000 higher on Dec 31, 2004 than it had been on Dec 31, 2003. Adding the $1000 "change in bank account inventory" to your spending totals would enable you to derive the correct conclusion that your wages had been $25,000 during the year.

Estimating GDP, cont'd.

Hypothetical Example #2, when inventories **fall**:

C = $6.0 trillion/year
I = $2.5 trillion/year
G = $2.0 trillion/year
NX = - $0.5 trillion/year

AD = 6.0 + 2.5 + 2.0 - 0.5 = $10.0 trillion/year

Inventories on Dec 31, 2003: $0.4 trillion
Inventories on Dec 31, 2004: $0.2 trillion

Inventory chg = 0.2 - 0.4 = - $0.2 trillion/year

GDP = (Aggregate Demand) + (Change in Inventories)
= (C + I + G + NX) + (ΔInv)
= (6.0 + 2.5 + 2.0 - 0.5) + (- 0.2)
= 10.0 - 0.2
= $9.8 trillion/year

Estimating GDP, cont'd.

The federal government's National Income & Product Accounts (NIPA) definition of "Investment" *includes* "change in inventories." Using that definition in example #2,

C = \$6.0 trillion/year

I = (spending on plant & equipment) + (change in inventories)

= (2.5) + (- .02) = \$2.3 trillion/year

G = \$2.0 trillion/year

NX = - \$0.5 trillion/year

$$AD = 6.0 + 2.3 + 2.0 - 0.5 = \$9.8 \text{ trillion/year}$$

Here, the Aggregate Demand computation has already included the change in inventories and, therefore, the result is equal to GDP by definition.

GDP = Aggregate Demand, *including* Change in Inventories
= \$9.8 trillion/year

However, using this method gives the impression that GDP is always equal to aggregate demand, and that is not true. In this course, therefore, **we will separate "change in inventories" from "investment." Unless noted otherwise, when we use the the term "investment," we will mean only spending on plant & equipment.** We have good reasons to examine inventories separately.

Equilibrium

Why does it matter if GDP is greater or less than Aggregate Demand?

*It matters because **GDP** can be thought of as "**aggregate supply**." When aggregate supply and aggregate demand are not equal, the economy is not in equilibrium, and that is important to recognize.*

When the inventory changes are "buried" inside the definition of investment, that gives the misleading impression that aggregate supply and aggregate demand are always equal, and that the economy is always in equilibrium.

A departure from equilibrium may occur because of insignificant random fluctuations. However, it also occurs when the economy is in some kind of transition--an acceleration or slowdown that might last a year or more.

Being able to recognize when the economy is in transition and whether it is accelerating or slowing down--and *why*--is an important skill that you will learn in this course.

If you wish, you can take a break before studying the rest of this Tutorial.

More Learning Objectives

In the first part of this tutorial, you learned:

- *how to use Aggregate Demand to estimate GDP*
- *the relationship between production, inventories, and sales*
- *why we will separate "inventory changes" from "investment"*

Now you will learn

- *how the concepts of "stock & flows" can clarify the meaning of "equilibrium"*

Equilibrium with Causal Links

You are already familiar with the causal link method of showing the relationship between production, inventories, and sales.

Recall that production adds to inventories, while sales subtract from inventories.

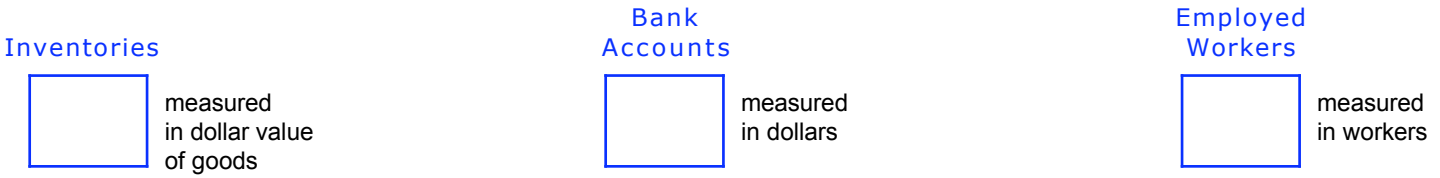
The concept of equilibrium is sometimes abstract and difficult to visualize. Perhaps this diagram makes it intuitively clear to you that inventories would be in equilibrium if production equals sales. Perhaps not.

To provide you with a precise definition of ***equilibrium***, we will now introduce concepts called ***stocks*** & ***flows***. Stock & flow concepts provide a very useful way to highlight key pressure points in the economy, as you will see later in the course.*

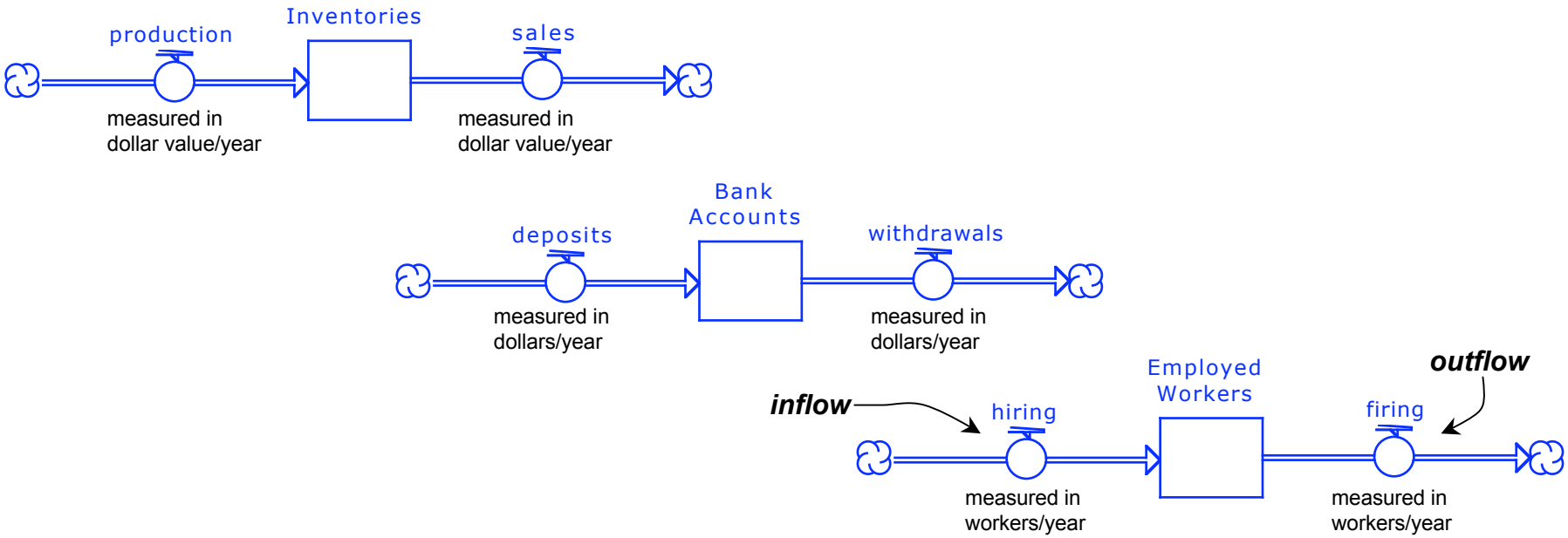
*The MacroLab version for a course in *intermediate* macroeconomics makes extensive use of stock & flow diagramming. In the *introductory* course, only a few essential relationships are described that way. An appendix (final slide in this slide show) compares causal link diagramming with stock & flow diagramming.

Stocks & Flows

Stocks. A stock is an accumulation of something. A stock icon resembles a box or container. Familiar examples of stocks include inventories, bank accounts, and employed workers.

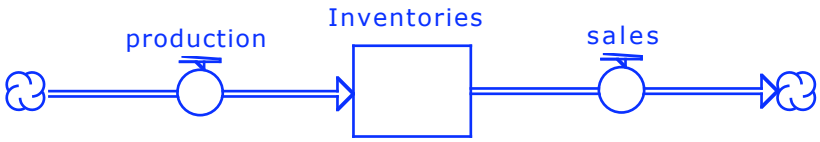


Flows. A flow adds to or subtracts from a stock. A flow icon resembles a pipeline. The pipeline has a valve that controls the speed at which such inflows (adding) or outflows (subtracting) occur. Here are examples of a stock with an inflow and outflow:

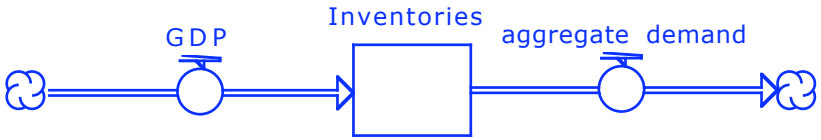


Equilibrium with Stocks & Flows, cont'd.

Equilibrium Condition for a Stock: *A stock is in equilibrium--i.e., the stock's level is neither rising nor falling--when the stock's inflows equal its outflows*. For example, inventories are in equilibrium when production equals sales.



Nationwide, inventories are in equilibrium when GDP equals aggregate demand.

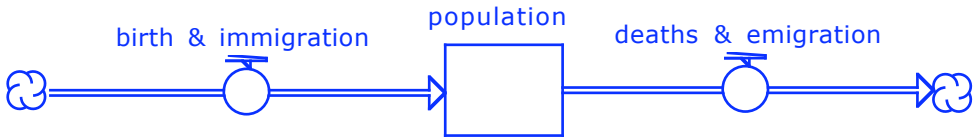


Equilibrium Condition for a System. A system such as an economy consists of many stocks. *A system is in equilibrium when all of its stocks are in equilibrium at the same time*. For example, an economic system includes inventories, bank accounts, and workers (and many other stocks). For an economy to be in equilibrium, all of those stocks must be in equilibrium at the same time.

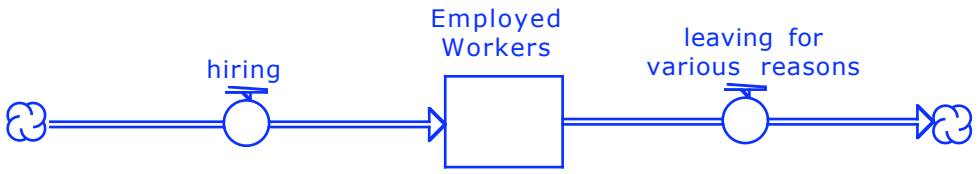
Equilibrium with Stocks & Flows, cont'd.

Very Important: ***Equilibrium does <u>not</u> mean "nothing is happening."***

A stock can be dynamic (changing over time) yet still be in equilibrium. Imagine a nation that has a stable population size. That does *not* mean that everyone lives forever and no babies are ever born. It merely means that, over a specific time period such as a year, the additions to the population (e.g., by birth or immigration) are equal to the subtractions from the population (e.g., by death or emigration). People are flowing into the population stock at the same rate they are flowing out.



Likewise, in an economy with a stable population, new workers might be hired at the same rate that workers are fired (or retire or leave for other reasons), and in that case the stock of employed workers would be in equilibrium even though "changes" were happening.



Equilibrium: One Last Word

Very Important: ***Equilibrium never exists in a complex real-world system such as an economy.***

So, why do we put so much emphasis on equilibrium?

First, many complex systems do exhibit "tendencies" toward equilibrium, even if they never get there. Such systems may "overshoot" or "undershoot" their stability goals. Having a way to describe what would constitute a system's *steady state* (another term for "equilibrium") helps to understand what is causing the system to behave in certain ways at certain times.

In addition, people sometimes want to control or influence the behavior of a complex system, such as an economy. Whether that is possible or advisable requires understanding the normal tendencies of that system, including whether it seeks equilibrium on its own, how long that takes under various circumstances, and the costs and benefits of "interfering" with that normal process.

Finally, when studying a computer model of a system--such as the MacroLab economic model--it is often important to be able to isolate the effects of a simulation experiment. That is accomplished in the model by establishing equilibrium conditions initially (all stocks having equal inflows and outflows), then "shocking" the system in some specific way, and observing the way the system responds. If the resulting behavior of the model resembles behavior observed in the real world, then we may tentatively conclude that the structure of the model (what pieces it includes and how they fit together and influence one another) is similar to the structure of the system it is designed to represent. *To the extent that's true, then understanding how the model works should improve understanding of how the real-world system works*.

Self-Quiz on Stock & Flow Tutorials

1. When inventories are rising, GDP must be ____ aggregate demand.

   (a) equal to (b) greater than (c) less than

2. Which causal link diagram is correct?

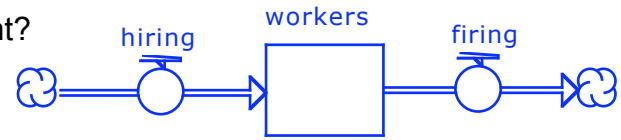
   (a) production --->(s) inventories (b) sales ---->(o) inventories

   (c) production ---> (s) inventories (o) <----sales (d) all of the above are correct

3. Which measurement unit is NOT correct for the stock & flow diagram at right?

   (a) stock: workers (b) inflow: workers per year

   (c) outflow: workers (d) all are correct



4. A stock is in equilibrium when its inflows are ____ its outflows.

   (a) equal to (b) greater than (c) less than

5. Imagine a system containing just three stocks: products, workers, and savings accounts. The system would be in equilibrium when…

   (a) the products stock was in equilibrium in year 1, the workers stock was in equilibrium in year 2, and the savings accounts stock was in equilibrium in year 3.

   (b) the products and workers stocks were in equilibrium in year 1, and the savings accounts stock was in equilibrium in year 2.

   (c) the savings account and products stocks were in equilibrium in year 2, and the workers stock was in equilibrium in year 3.

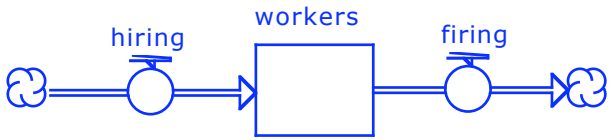
   (d) all three stocks were in equilibrium at the same time.

Self-Check on Quiz*

1. When inventories are rising, GDP must be ___ aggregate demand. **(b) greater than**

2. Which causal link diagram is correct? **(d) all of the above are correct**

3. Which measurement unit is NOT correct for this stock & flow diagram? **(c) outflow: workers**



4. A stock is in equilibrium when its inflows are ____ its outflows. **(a) equal to**

5. Imagine a system containing just three stocks: products, workers, and savings accounts. The system would be in equilibrium when…

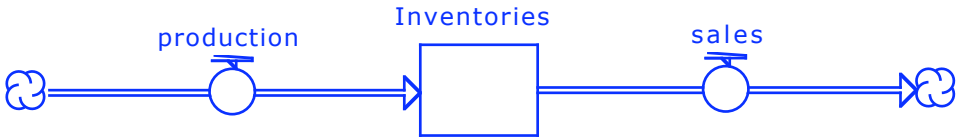
(d) all three stocks were in equilibrium at the same time.

*** Email me (dwheat@wheatresources.com) if you have any questions about this tutorial or quiz.**

Appendix: Direction of Links and Outflows

This red causal link diagram

has the same meaning as this blue stock-and-flow diagram.



Some students will be puzzled, however, because the "opposite" causal link sales arrow points *toward* inventories, while the pipeline arrow on the sales outflow points *away* from the inventories stock. There is no inconsistency, however.

- The causal link means that sales affect inventories. Rising sales means falling inventories if production remains the same. Falling sales means that inventories will rise if production remains the same.*

- The sales outflow means that goods within the inventory stock are being removed as sales occur; goods are flowing out (away) from the stock. Again, rising sales means falling inventories.

The two "meanings" are the same.*

* Be sure you notice that the issue of whether inventories actually rise or fall depends on *both* production and sales. If production exceeds sales, inventories rise. If production is lower than sales, inventories fall.