ECON 180

Introduction to Principles of Microeconomics and Financial Project Evaluation

Lecture 21: Adjusting for Inflation

October 26, 2021

Version 1

Required Reading and Viewing

- Stand-Up Economics: Chapter 17 (all)
- Stand-Up Microeconomics: http://standupeconomist.com/stand-up-economics-the-micro-textbook/ (Choose the version with calculus.)
- InflationGuide. (2012). Inflation Guide Chapter 3: Nominal versus real prices [Video File]. Retrieved from https://youtu.be/YXWr2cEIhI4
- Khan Academy. (2011). Real and nominal return [Video File]. Retrieved from https://www.youtube.com/watch?v=cNm196bVE5A

Recommended Reading (Adjusting for Inflation)

- Book I, Chapter V of Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations*:
- On the Real and Nominal Price of Commodities, or their Price in Labour, and their Price in Money:
- https://www.marxists.org/reference/archive/smith-adam/works/wealth-of-nations/book01/ch05.htm
- (It's available for free in lots of places. This Marxist site just happened to have a very clean, readable version.)

Optional Reading: Adjusting for Inflation

- Feldman, A. M. (1990). Discounting in Forensic Economics. *Journal of Forensic Economics, 3*(2), 65-71. Retrieved from https://www-jstor-org.ezproxy.library.uvic.ca/stable/42755343
  - **Explains in detail the importance of adjusting interest for inflations, and how you might decide on which interest rate to use when analyzing something that is yet to happen.**
- Smith, G. (1988). Nominal and Real Required Returns in Present Value Analysis. *The Engineering Economist*, *33*(4), 331-348. Retrieved from https://doi-org.ezproxy.library.uvic.ca/10.1080/00137918808966960
  - **Talks about the importance of adjusting for inflation, in practical terms.**

Sources for Apple Data & Biogas Example

- Adeoti, O., Ilori, M.O., Oyebisi, T.O. & Adeyoka, L.O. (2000). Engineering design and economic evaluation of a family-sized biogas project in Nigeria. *Technovation*, 20, pp. 103 – 108. Retrieved from https://doi-org.ezproxy.library.uvic.ca/10.1016/S0166-4972(99)00105-4
  - **Biogas Example.**
- Statistics Canada. (2017). Food and other selected items, average retail prices. Retrieved from http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/econ155a-eng.htm
  - **Price of Apples.**

Learning Objectives

- Understand the difference between real and nominal (current) values and discount rates.
- Be able to convert between nominal and real values and discount rates when 'Year 0' is taken as the base year.
- Know how to adjust for inflation when evaluating projects, by either using real discount rates and cash flows or nominal discount rates and cash flows.
- Be able to adjust for inflation when applying simple evaluation techniques - present/annual worth, benefit/cost, IRR/ERR.

Relevant Solved Problems

- From Engineering Economics, Chapter 9
- Converting between Real & Nominal values: Example 9.2, Example 9.3, Review Problem 9.1, 9.1, 9.2, 9.3, 9.4.a, 9.8, 9.18.a, 9.19.a, 9.20.a
- Present Worth: Example 9.7, Example 9.9, Example 9.10, 9.4.b, 9.4.d, 9.5.b, 9.10, 9.12, 9.13, 9.14, 9.18.b, 9.20.b, 9.29.a
- Present and Annual Worth (Trickier): Review Problem 9.3, Review Problem 9.4, 9.15, 9.19.b, 9.21, 9.22, 9.25, 9.27.e, 9.30, 9.31, 9.32, 9.34
- MARR/real interest rate: Example 9.4, Example 9.5, 9.4.c, 9.5.a, 9.11, 9.17.b, 9.27.a
- IRR/ERR: Example 9.6, Example 9.8, Review Problem 9.2, 9.6, 9.7, 9.17.a, 9.26, 9.27.b.c.d, 9.28, 9.29.b.c.d

More Relevant Solved Problems, Adj. for Inf.

- From Stand-Up Economics (solutions at end of the chapter)
- Year X dollars: 17.7
- Real Interest Rate: 17.1, 17.2, 17.3, 17.6, 17.8, 17.9
- Present Value: 17.4, 17.10

Notation Dictionary

(Not provided on quiz/final formula sheet)

- C = Nominal dollar value (from textbook's 'Current')
- f = Inflation Rate
- i = Nominal Interest Rate
- N = Time Index (usually, years from present)
- P = Present Value
- r = Real Interest Rate
- R = Real dollar value
- t = general time index

$f(x)$

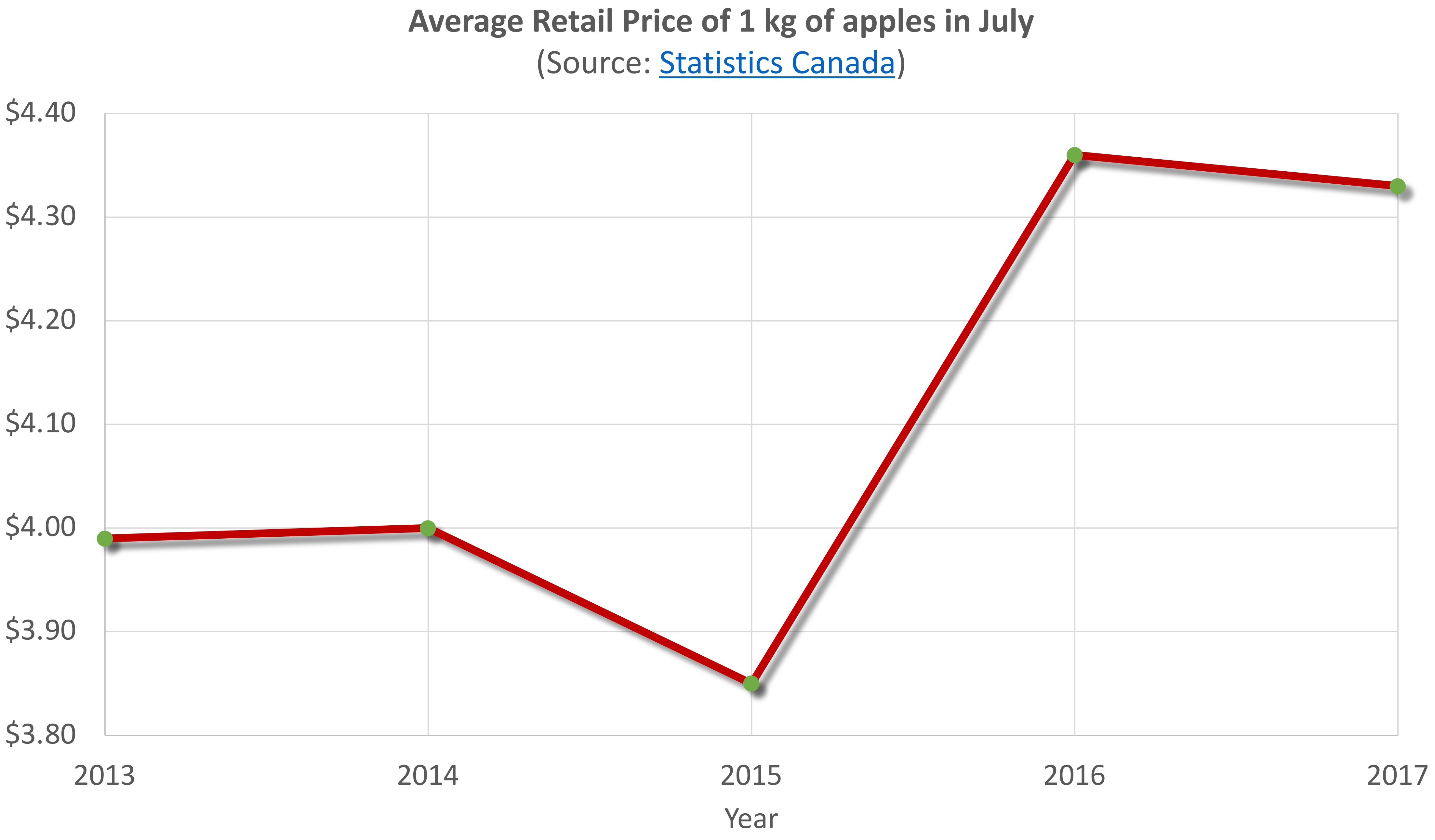
New Equations

- Notation: The orange symbol on a slide indicates a formula sheet formula is introduced there.
- Current Dollars (Textbook) = Nominal Dollars (Economics)

ESSENTIALS (19 slides)

Suppose you live only on apples...

- In July 2014, you lent your friend $4.00.
- That was enough to buy 1 kg of apples.
- In July 2017, she paid you back the $4.00, plus an extra 25 cents.
- Problem: By then, 1 kg of apples cost $4.33.
- You were paid ‘more money’ than you lent out.
- In money terms, there was a positive interest rate on your loan.
- That’s a gain *in name only*, though…
- ...since you lost in terms of what you REALLY care about: apples.



Average Retail Price of 1 kg of apples in July
(Source: Statistics Canada)
$4.40
$4.30
$4.20
$4.10
$4.00
$3.90
$3.80
2013
2014
2015
2016
2017
Year

What's the REAL value of that $4.25?

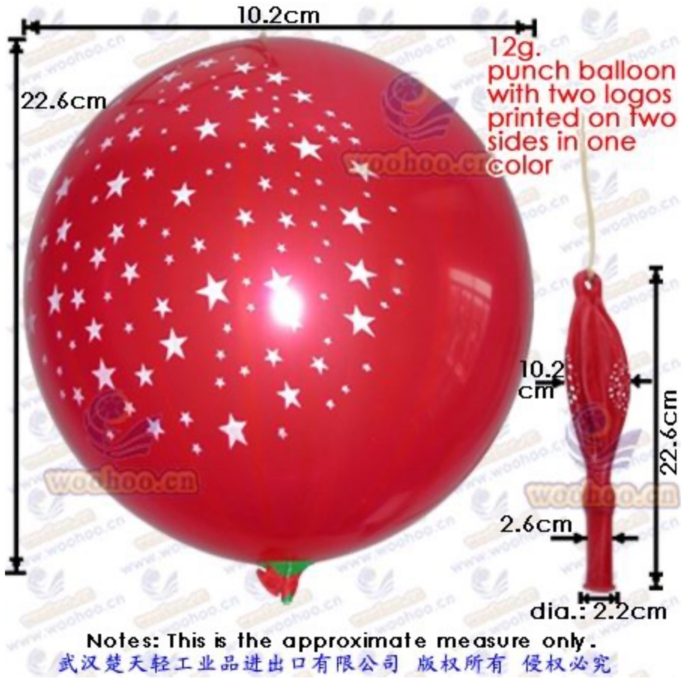
- What you REALLY care about is apples.
- In 2014, you gave up 1 kg of apples by lending the $4.00.
- In 2017, 1 kg of apples costs $4.33 and you received $4.25.
- In terms of apples, you received 425/433 = 0.98 kg of apples.
- You LOST 0.02 kg of apples by making that loan.
- In terms of 2017 purchasing power (that is, using 2017 as the ***base year***), you gave up $4.33 to get $4.25.
- In terms of 2014 purchasing power (that is, using 2014 as the ***base year***), you gave up $4.00 to get 0.98 x $4.00 = $3.92.
- Even though you received more currency than you lent out, this gain is in name only. In real terms, you lost purchasing power due to inflation.
- Base year: the year whose prices you take as the standard of comparison. In many engineering applications, this will be chosen to be the 'present' – the project's 'Year 0' – for the sake of convenience.

What is inflation?

- A rise in prices (a *fall* in prices is called *de*flation).
- There's not necessarily anything *real* going on with inflation…
- Consider an inflated balloon vs a deflated balloon: the substance is largely the same, and the difference is mostly hot air.
- (One is more pleasing than the other, though.)
- →Non-inflation-adjusted values are *nominal*
- (Latin *nomine* = name → in name only)

Q: Are these the same?

A: (Economist) In real terms.



Finding the REAL value of \$1 in N years

- Suppose inflation is constant each year: the price of everything (including apples) goes up by a factor f each year.
- Something that costs \$1 today, costs \$1 x (1 + f) 1 year from now.
- Something that costs \$(1 + f) 1 year from now costs…
- ...\$(1 + f) x (1 + f) = $\$(1 + f)^2$ 2 years from now.
- In general, something that costs \$1 today costs $\$(1 + f)^N$, N years from now.
- →If you get \$1 N years from now, it has the same purchasing power as $\$1/(1 + f)^N$ today.
- Using the present (today) as the base year...
  ...the real value of \$1 N years from now is $\$1/(1 + f)^N$ today.
- Going the other way...
- The nominal value of \$1 today is $\$(1 + f)^N$, N years from now.
- (When N = 0, the \$1 value is both nominal and real. Inflation hasn't had time to work!)

Real and Nominal Values

- The dollar values we see on price tags are prices *nominally*, or in name only.
- What something *really* costs is what must be given up in order to obtain it.
- $1 in 1915 could buy a lot more than $1 in 2015, so paying $1 for a good in 1915 meant giving up much more than it does in 2015.
- More practically:
- **REAL** = Adjusted for inflation (changes in the general price level)
- **NOMINAL** = Not adjusted for inflation (e.g. prices you see posted)

If we have constant annual inflation…

- Consider a world with constant 25% annual inflation.
- This means something that costs $1 this year, costs $1.25 next year.
- Suppose an apple today costs $1. If we take today as the **base year**, that means the real value of the apple is $1.
- This doesn't change. That '$1 in the base year' will always stand for '1 apple'. The **real** value is the value in base year prices, which you are using as your standard of comparison.
- The *nominal* value of the apple after 1 year is $1.25. That $1.25 buys you what $1 did in the base year, 1 apple, so the real value of $1.25 in year 1 is $1.

Year-to-year inflation (and deflation)

- In 2014, apples cost \$4.00 per kg.
- In 2015, apples cost \$3.85 per kg.
- \$3.85/\$4.00 = .9625 = 96.25%, so the price fell by 3.75%.
- There was year-on-year inflation of -3.75% (*de*flation of 3.75%).
- In 2016, apples cost \$4.36 per kg.
- \$4.36/\$3.85 = 1.1325 = 113.25%, so the price went up by 13.25%.
- There was year-on-year inflation of 13.25%.
- Since our loan lasted three years, though, it'll be useful to look at the *average yearly inflation* for each of those three years.

Year	Price of 1 kg of apples in July	Year-on-Year Inflation
2013	$3.99	
2014	$4.00	0.25%
2015	$3.85	-3.75%
2016	$4.36	13.25%
2017	$4.33	-0.69%

Total and average annual inflation

- We know what the year-on-year inflation was…
- ...but what was the average annual inflation between 2014 and 2017?
- 1 kg of apples cost \$4.00 in 2014 and \$4.33, 3 years later.
- If inflation had been constant at f per year, something that cost \$4 in 2014 would cost \$4 x $(1 + f)^3$, 3 years later.
- Setting the expressions equal and solving, average annual inflation was
- $4 \times (1 + f)^3 = 4.33 \rightarrow f = (4.33/4)^{1/3} - 1 = 2.67\%$
- TOTAL inflation over the 3-year period can be found by assuming 1 time period:
- $4 \times (1 + f) = 4.33 \rightarrow f = 4.33/4 - 1 = 8.25\%$

Let’s practice real/nominal value calculation!

- This is a good chance to check how this works when f isn’t constant.
- Let’s use 2014 as our ‘base year’ (year when prices are ‘real’).
- Nominal value of \$4.00 (real 2014 dollars) in 2017:

$$\$4.00 \times (1 - 3.75\%) \times (1 + 13.25\%) \times (1 - 0.69\%) = \$4.33$$

- Real value of \$4.25 in 2017:

$$\frac{\$4.25}{(1 - 3.75\%) \times (1 + 13.25\%) \times (1 - 0.69\%)} = \$3.92$$

Real and nominal interest rates

- In *nominal* terms, you lent out \$4.00 and got \$4.25 3 years later.
- The equivalent annual interest rate is the i that satisfies
- $4 \times (1 + i)^3 = 4.25 \rightarrow i = (4.25/4)^{1/3} - 1 = 2.04\%$
- That's the NOMINAL interest rate – the rate in name only.
- In real terms, you KNOW you lent out 1 kg of apples, and got back less than 1 kg of apples. Let's use our values from the previous slide.
- In 2014 dollars, we gave up \$4.00 and got \$3.92.
- Let the *real* annual interest rate be r.
- $4 \times (1 + r)^3 = 3.92 \rightarrow i = (3.92/4)^{1/3} - 1 = -0.67\%$

Real Interest Rates

- Apples cost \$1, and you live entirely on apples.
- Your bank gives yearly interest *i* on savings, and the price of apples rises by a factor *f* per year (yearly inflation is *f*).

- Suppose you put \$1 in the bank today – enough to buy 1 apple.
- 1 year from now, you will have \$(1 + i) in the bank, and apples will cost \$(1 + f) each.
- You can buy (1 + i)/(1 + f) apples with the saved money.

The real return, r

- You sacrificed 1 apple.
- One year later, you are able to afford $\frac{1+i}{1+f}$ apples.
- Let r = real return (or real interest rate, or real discount rate)
- r = (How much you got) – (How much you gave up)

$$r = \frac{1+i}{1+f} - 1$$

- (This is a growth-adjusted interest rate, i^o, for a growth rate of f.)

Implications for the MARR

- Sometimes we think of MARR in real terms: we think ‘I need at least a 20% return’ when we mean ‘I want to be able to buy 20% more stuff than I can afford now.’
- Other times, we just want to match a nominal rate (say, the rate on government bonds): ‘I need at least the 3% return that I can get on government bonds’.
- The nominal (current dollar) MARR, $MARR_C$, can be treated as just another interest rate and is subject to the same equation, which we can rearrange...
- Let $MARR_R$ be the real (constant dollar) return you require on an investment.

$$\mathrm{MARR_C} = (1 + \mathrm{MARR_R})(1 + \mathrm{f}) - 1$$

- So, if you want at least a 20% real return on your investment, and inflation is 25%, you’ll need a nominal dollar return of 50%.

What about putting everything together?

- We now know how to adjust *interest rates* for inflation, including the MARR, the interest rate that measures the opportunity cost of our time .
- We also know how to adjust *dollar values* (cash flows) in year N for inflation. This takes into account that a dollar has different purchasing power in different years.
- How do we put them both together?
- The good news is that you just have to keep like with like:
- Cash flows and interest rates must BOTH be <u>nominal</u>, or both be <u>real</u>. Either works.

How to evaluate projects given inflation

- **Option 1: Use real cash flows and real interest rates.**
- **Option 2: Use nominal cash flows and nominal interest rates.**

- Step 1: Convert everything into either nominal <u>or</u> real terms. This means cash flows, AND interest rates.
- Step 2: Run your usual analysis.

- **THIS IS A UNITS ISSUE!**
- If a MECH problem had a mix of Imperial & SI units, how would you solve it?
- Put everything in Imperial *OR* everything in SI, and then solve as usual.
- **IT'S THE SAME THING HERE. Think of Real & Nominal as different units.**
- **Real cash flows & real MARR → real values. Nominal cash flows & MARR → Nominal values.**
- If there's no 'mix of units', there's no extra adjustment to be made.

Adding apples

- I have 20 kg of green apples and 20 lb of red apples. What is the combined weight of the red and green apples?
- Option 1: Put everything in terms of pounds:
- 1 kg = 2.20 lb (approx.), so 20 kg = 44.09 lb
- →44.09 lb of green apples + 20 lb of red apples = 64.09 lb of apples
- Option 2: Put everything in terms of kg:
- 1 lb = 0.45 kg (approx.), so 20 lb = 9.07 kg
- →20 kg of green apples + 9.07 kg of red apples = 29.07 kg of apples
- Using the conversion factors, we see 64.09 lb = 29.07 kg, so both answers are correct.

Now for PV & inflation

- Your real MARR is 10% per year, and inflation is 5% per year.
- The base year for inflation purposes is Year 1.
- The present is Year 0.
- You are paid 100 nominal dollars every year, from Year 1 to Year 2.
- What is the present value of these payments?
- Option 1: Everything in nominal terms
- Option 2: Everything in real terms

Working through it

- Option 1: Nominal MARR = (1+10%) x (1+5%) – 1 = 15.5%
- Nominal cash flows: $100 from Year 1 to Year 2
- PV = $100 x (P/A,15.5%, 2) = $161.54
- Option 2: Real MARR = 10%
- Real cash flows: $100 in Year 1 (the base year), $100/(1+5%) in Year 2
- PV = 100 x (P/F,10%,1) + (100/1.05) x (P/F,10%,2) = $169.62
- Since the base year is Year 1, not Year 0, the *nominal* value of 169.62 real dollars in Year 1 is 169.62/(1+5%) = $161.54
- (Can't see this? If inflation is 5% a year, and today something costs $105, that implies that last year it cost $100.)
- →Both answers are correct.

AFTER HOURS

- Why would you ever have a mix of units? (8 slides)
- Numerical example (2 slides)
- If inflation isn‘t constant (2 slides)
- Biogas in Nigeria (6 slides)

Why would you *ever* have a mix of units?

- We don’t see real values in the wild, so why do we need to learn this stuff?
- Partly because you’ll often be working with project *estimates*.
- Consider Sam’s problem, from the Projects.
- Sam probably has an excellent idea of how their salary will change with time. That’s something that’s written into contracts ahead of time.
- How much the price of food will change? That’s uncertain.
- Often, the best guess is, ‘I think it’ll go up at the same rate as other consumer goods’ – that is, that it’ll go up with the CPI.
- And if CPI inflation is about 2% per year, well…

A simplified version

- Let’s suppose Sam’s grocery bill is $100 a week, today.
- And Sam thinks that this will go up by f a week, where f is a per-week growth rate corresponding to the usual yearly inflation in Canada.
- Sam, in other words, thinks that the price of food will stay constant *in real terms*.
- They think that food will go up only as part of a more *general rise in prices*, as opposed to a *relative rise in prices* that would change the tradeoff between food and other CPI basket goods.
- If there is no *relative rise* in the price of food, then really, all we’re doing is changing labels: food is f% more this week, but so is everything else.

General vs Relative price changes

- Suppose today, Cookies cost $1 each and Pop costs $2 a bottle.
- The tradeoff between cookies and Pop is 2 cookies / Bottle of Pop.
- Now suppose that ALL prices double – a *general* rise in prices.
- Cookies cost $2 and Pop costs $4 a bottle.
- The tradeoff between cookies and Pop is 2 cookies / Bottle of Pop.
- Nothing has changed in real terms.
- But if the price of cookies triples while the price of Pop doubles…
- Cookies cost $6 and Pop costs $4 a bottle.
- The tradeoff between cookies and Pop is 2/3 cookies / Bottle of Pop.
- The *opportunity cost*, in terms of forgone Pop, of buying a cookie has changed because of the change of the change in *relative* prices.
- General price changes don't affect the choices you make, because the tradeoffs stay the same. Changes in *relative* prices DO affect your choices.

Back to Sam’s food

- Food costs $100 this week. Sam knows this because they’ve already paid for this week’s food.
- Using this week as the *base week* – the week to whose prices we compare all other prices – AND the present - let’s calculate the next 2 weeks of Sam’s food bills.
- We’ll do this two ways: using nominal cash flows and MARR, and using real cash flows and MARR.
- Nominal with Nominal → Nominal, Real with Real → Real.
- Because nominal values = real values in the base ‘year’ (inflation hasn’t had time to do anything), we should get the same result.

Nominal cash flows and MARR

- Suppose Sam's (nominal) MARR is i per week.
- Food prices go up by f per week. Food cost \$100 this week (Week 0).
- We want the present (Week 0) value of the food costs in Week 1, and in Week 2.
- In Week 1, food will cost $\$100 \times (1+f)$
- In Week 2, food will costs $\$100 \times (1+f) \times (1+f) = \$100 \times (1+f)^2$
- PV of Week 1 food: $\$100 \times (1+f) \times (P/F,i,1) = \$100 \times (1+f)/(1+i)$
- PV of Week 2 food: $\$100 \times (1+f)^2 \times (P/F,i,2) = \$100 \times (1+f)^2/(1+i)^2$
- Total PV = $\$100 \times (1+f)/(1+i) + \$100 \times (1+f)^2/(1+i)^2$

Real cash flows and MARR

- We've assumed Sam's food costs are *constant* in *real terms*. That they only go up with inflation, at the same rate as other consumer goods.
- →The *real* cost of food in Week 1 and Week 2 is \$100.
- We need the *real* MARR to use with these real cash flows.
- Real MARR = (1+i)/(1+f) – 1.
- PV of Week 1 food cost: $\frac{\$100}{\left(1+\left(\frac{1+i}{1+f}-1\right)\right)} = \frac{\$100}{\left(\frac{1+i}{1+f}\right)} = \$100\,\frac{1+f}{1+i}$
- PF of Week 2 food costs: $\frac{\$100}{\left(1+\left(\frac{1+i}{1+f}-1\right)\right)^2} = \frac{\$100}{\left(\frac{1+i}{1+f}\right)^2} = \$100\,\frac{(1+f)^2}{(1+i)^2}$
- Total PV = \$100 x (1+f)/(1+i) + \$100 x $(1+f)^2/(1+i)^2$
- It's the same as before!

Nominal = Real in the base year

- By *definition*, nominal values (not adjusted for inflation) are the same as real values (adjusted for inflation) in the base year.
- Why? Because the base year is your standard of comparison.
- Your base year is where you say, ‘these are what the prices are when inflation (or deflation) hasn’t had a chance to work yet’.
- You can CHOOSE what your base year is…
- So in engineering economics, it’s common to set the base year equal to whatever you’ve chosen as your ‘present’.
- That way, ‘distance from the year we’re using as the standard for everything else’ is the same in both cases – and it gives you *two* options (all nominal or all real) for solving for the present value. (Other values won’t match.)
- It doesn’t HAVE to be that way, though. The base year can be different than the present. (Currently, Statistics Canada uses 2002 as the base year for its CPI.)

Now do you see why you might mix them?

- For all those ‘oh, I think they’ll just go up with inflation’estimates…
- You can make your life a *lot* easier by taking that into account explicitly, and using a real MARR when working with them.
- Instead of a bunch of geometric gradients, you have a bunch of annuities, etc., and instead of having to apply the price increases individually to each cash flow, you can just convert the MARR once.
- Also, if there’s a reason for your estimate of inflation to change (more on that next lecture), you can just change one parameter & everything will adjust.
- (You should also see now that ‘I think the price will stay constant in *nominal* terms is a VERY strong assumption, which implies *relative* price changes that would lead to changes in decision-making! ‘I think it’ll stay constant in real terms’ is a more benign assumption.)

Another simple example

- An investment pays you \$100, 1 year from now.
- Suppose inflation is 25%, $MARR_R$ is 10%. Find the present value.

I. Real Cash flow and MARR

- Step 1: find the real value today of \$100, 1 year from now:

$$R = \frac{100}{(1 + 0.25)}$$

- Step 2: Discount by $MARR_R$:

$$P = \frac{100}{(1 + 0.25)(1 + 0.1)} = 72.\overline{72}$$

Now let’s do it the other way…

- II. Nominal cash flow and MARR

$$MARR_C = (1 + 0.1)(1 + 0.25) - 1 = 0.375$$

- The $100 is already in nominal terms, so discount by $MARR_C$:

$$PW = \frac{100}{(1 + 0.375)} = 72.\overline{72}$$

Your turn: What if it’s more than 1 year, and inflation <u>isn’t</u> constant?

If inflation isn’t constant …

- Pick the periods over which inflation IS constant, and work with those individually. Let’s look at a simple example.
- It is Year 0. You want to find the present value of an investment that pays, in real terms, \$230 in Year 1 and \$100 in Year 2.
- Suppose your nominal MARR is 10%. Inflation is 0% from Year 0 to Year 1, and 10% from Year 1 to Year 2.
- This means that your real MARR is 10% from Year 0 to Year 1, and 0% from Year 1 to Year 2.
- We look at these two ‘regimes’ separately, starting with the later regime (real MARR = 0%) first.

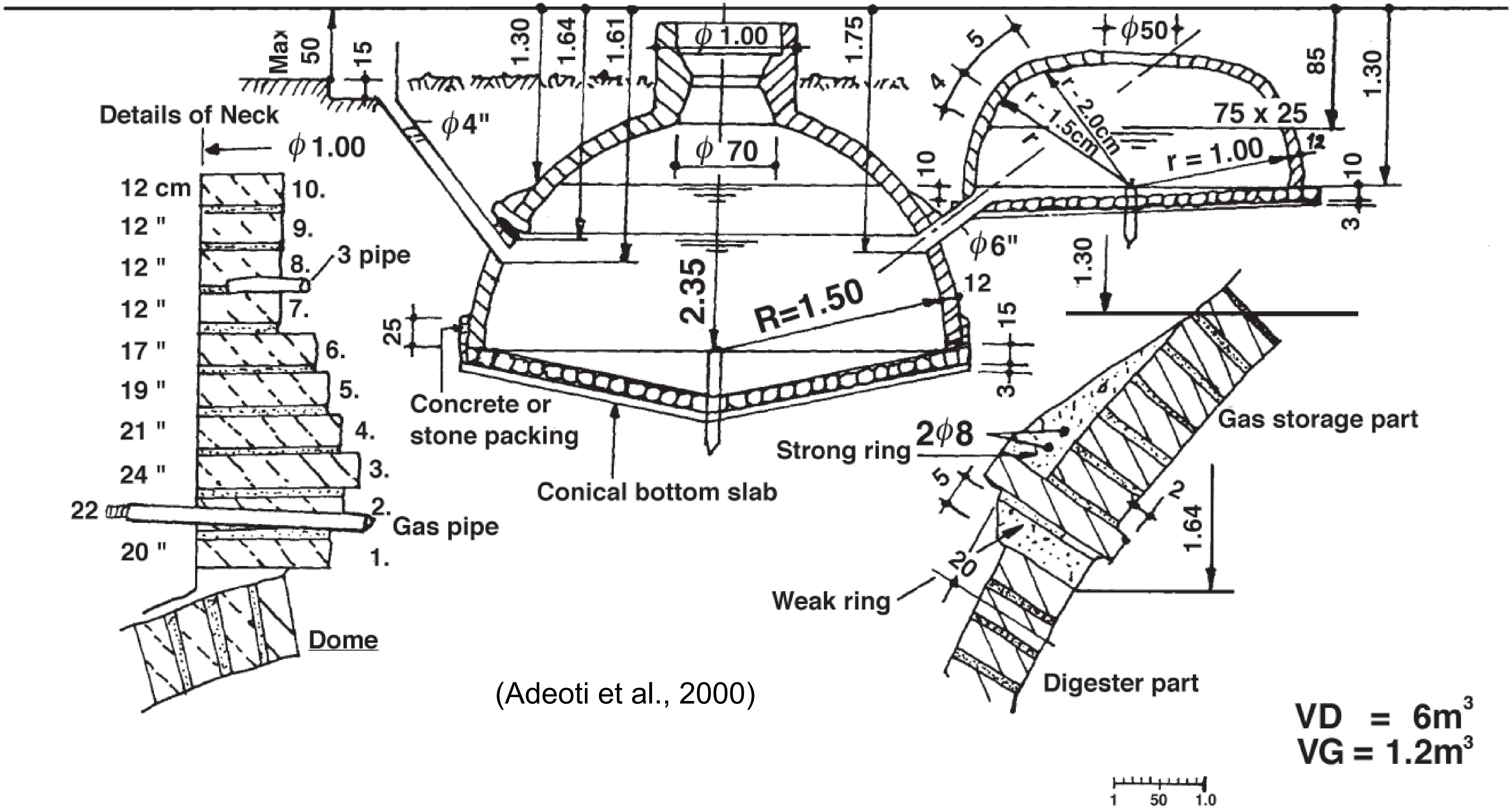
Going over it

- Year 1 to Year 2: Real MARR = 0%, therefore the Year 1 value of real \$100 in Year 2 is real \$100 in Year 1. (0% interest means we don’t have to worry about the time value of money).
- We can add that \$100 to the \$230 payment in Year 1, for a total Year 1 real value of \$330.
- From Year 0 to Year 1, the real MARR is 10% (since there is no inflation), and we proceed as usual.
- P = \$330 / (1 + 10%) = \$300
- →The present value of the payment is \$300.

Example: Biogas in Nigeria

- Nigeria has high inflation, and any project must take this into account.
- We'll look at a family-sized biogas project using cattle dung as a substrate, and intended to provide heat for cooking.
- The paper we'll take the numbers from ran BCR, NPV and IRR analyses, all adjusted for inflation.

A Nigerian official visiting a biogas plant under construction in Vietnam.



(Adeoti et al., 2000)

Basic Information

(All values in **real** terms)	Naira	Total
First Cost		**41,088**
Construction	26,775	
Facilities and Installation	9,111	
Labour (construction)	3,870	
Land	1,332	
Annual expenditure		**5,909**
Substrate (cattle dung)	720	
Hydrogen Sulfide Filter	300	
Labour cost (household)	1,500	
Operation & Maintenance	3,389	
Output and Benefit		**13,347**
Biogas	9,072	
Digested bio-manure	4,275	

(Nominal) Market interest rate: i = 21%
Annual inflation: f = 15%

Real interest rate (using our formula):
(1 + 21%)/(1 + 15%) – 1 = 5.2%

Project life cycle: N = 20 years

N	20
i	0.21
f	0.15
r	0.0521739

Cost Benefit Analysis

- Keep both cash flows and interest rate in real terms.
- PW Benefits, B_R = $B_R(P/A, r, N)$
- PW Initial Cost, C = C
- PW Annual costs, $M_R = M_R(P/A, r, N)$

$$BCR = \frac{B_R(P/A, r, N)}{C + M_R(P/A, r, N)} = 1.44$$

Note: Despite writing the correct formula, the original paper lists an incorrect BCR of 2.26. This does not affect the recommendation, since both BCR values are greater than 1.

NPV Analysis

- For the present worth analysis, we keep both cash flows and interest rates real.

$$\mathrm{PW} = -\mathrm{C} + (\mathrm{B_R} - \mathrm{M_R})(\mathrm{P/A}\,, \mathrm{r}, \mathrm{N}) = 49{,}920.88$$

- Since this is greater than 0, the project is worthwhile.

IRR and Inflation

- The $\mathrm{IRR_R}$ is found in the usual fashion from the real cash flows (the ones listed in the table). Solving, it is about 17%.
- The nominal $\mathrm{IRR_C}$ can be calculated from the real $\mathrm{IRR_R}$ using our formula (1.17 x 1.15 – 1) or found directly from the inflated cash flows, and is about 35%.
- (To find the nominal, inflated value of a real cash flow in year t, multiply it by (F/P,f,t).)