

# **Time Value of Money: Inflation**

Michael R. Roberts

William H. Lawrence Professor of Finance

The Wharton School, University of Pennsylvania

# Last Time

## Time Value of Money

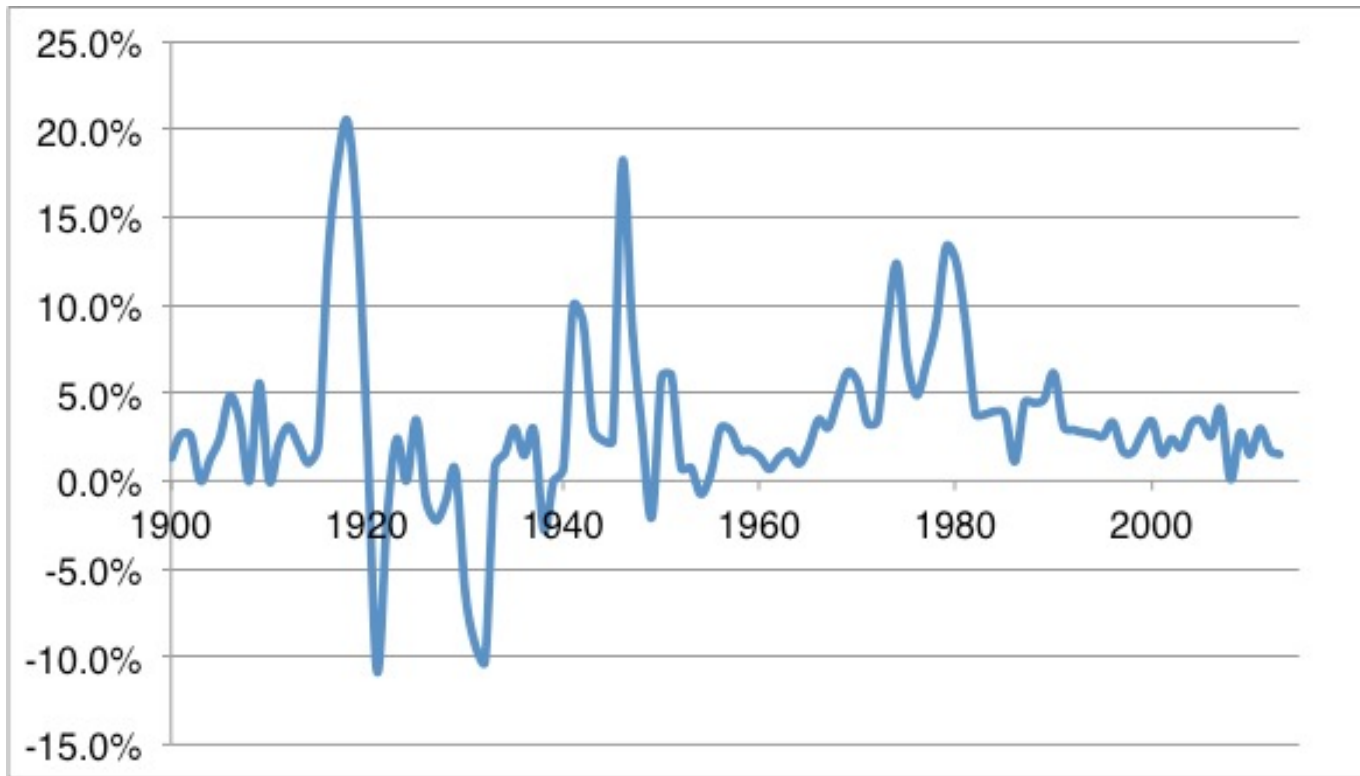
- Taxes

# This Time Time Value of Money

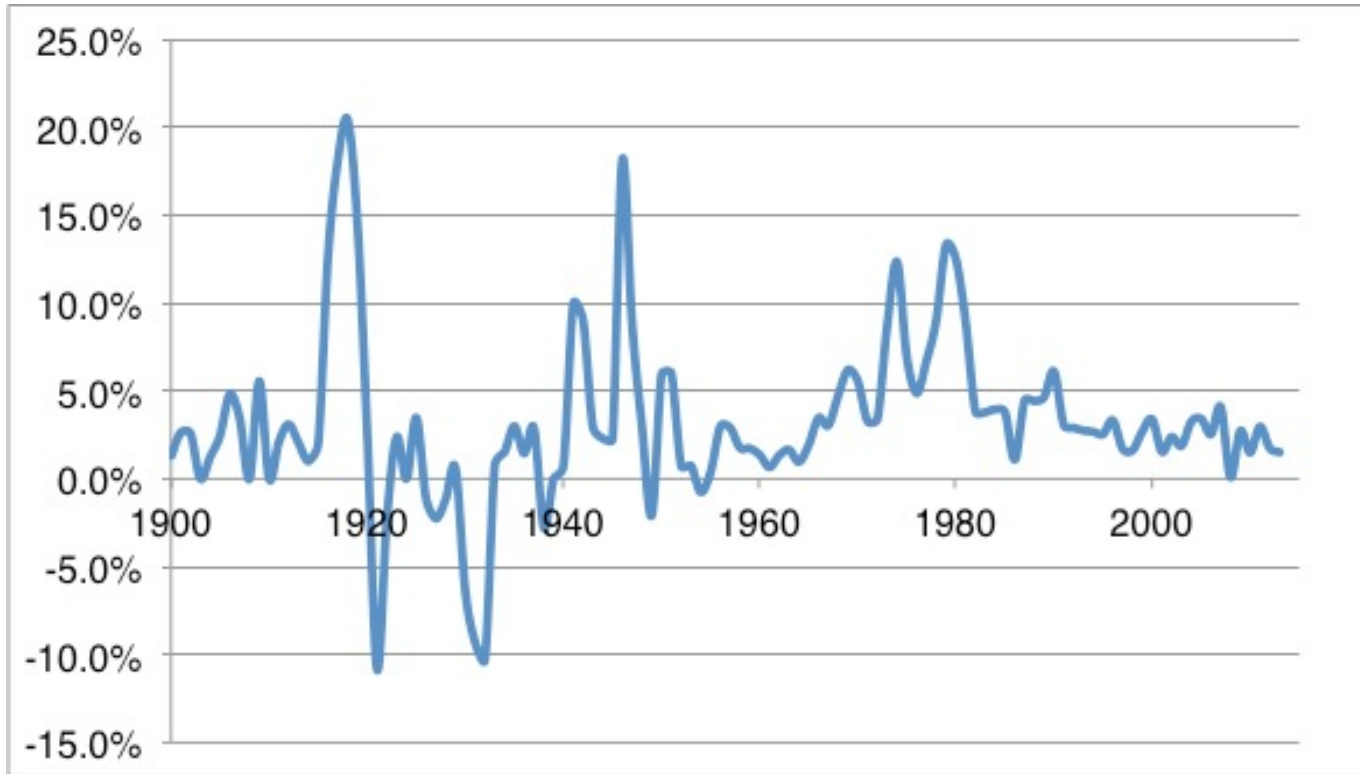
- Inflation

# Inflation

# Inflation




# Inflation




## How does inflation impact our returns?

# Example – Savings (Account)

Year	Interest	Pre-Withdrawal		Post-Withdrawal	
		Balance	Withdrawal	Balance	
0				\$354.60	
1	\$17.73	\$372.32	\$100.00	\$272.32	
2	\$13.62	\$285.94	\$100.00	\$185.94	
3	\$9.30	\$195.24	\$100.00	\$95.24	
4	\$4.76	\$100.00	\$100.00	\$0.00	

# Example – Savings (Account)

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$354.60
1	\$17.73	\$372.32	\$100.00	\$272.32
2	\$13.62	\$285.94	\$100.00	\$185.94
3	\$9.30	\$195.24	\$100.00	\$95.24
4	\$4.76	\$100.00	\$100.00	\$0.00

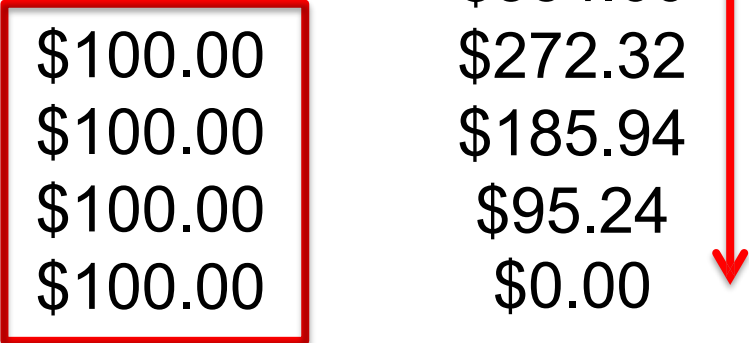


**Lesson:** Inflation won't affect the money we earn



# Example – Savings (Account)

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$354.60
1	\$17.73	\$372.32	\$100.00	\$272.32
2	\$13.62	\$285.94	\$100.00	\$185.94
3	\$9.30	\$195.24	\$100.00	\$95.24
4	\$4.76	\$100.00	\$100.00	\$0.00



**Lesson:** Inflation will affect what we can buy with the money

# Real Discount Rate

$$1 + RR = (1 + R) / (1 + \pi)$$

$RR$  is the real discount rate

$\pi$  is expected inflation

# Real Discount Rate

$$1 + RR = (1 + R) / (1 + \pi)$$

$RR$  is the real discount rate

$\pi$  is expected inflation

- Commonly used approximation:

$$RR = R - \pi$$

# Real Discount Rate

$$1 + RR = (1 + R) / (1 + \pi)$$

$RR$  is the real discount rate

$\pi$  is expected inflation

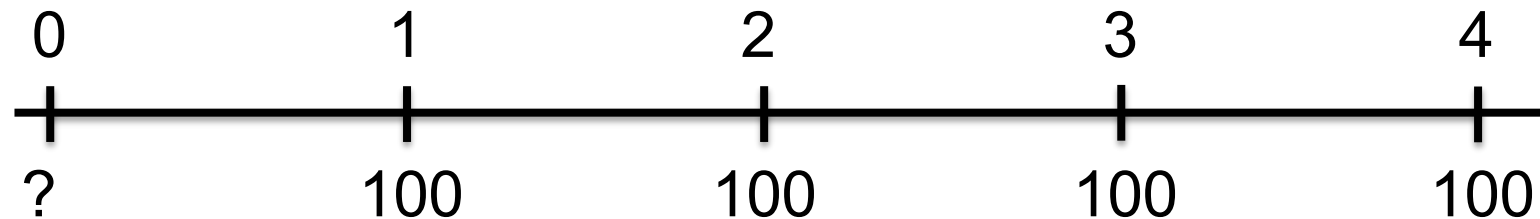
- Commonly used approximation:

$$RR = R - \pi$$

- For our example:

$$RR = (1 + 0.05) / (1 + 0.025) - 1 = 2.44\%$$

# Savings with Inflation



$$\frac{100}{(1 + 0.0244)}$$

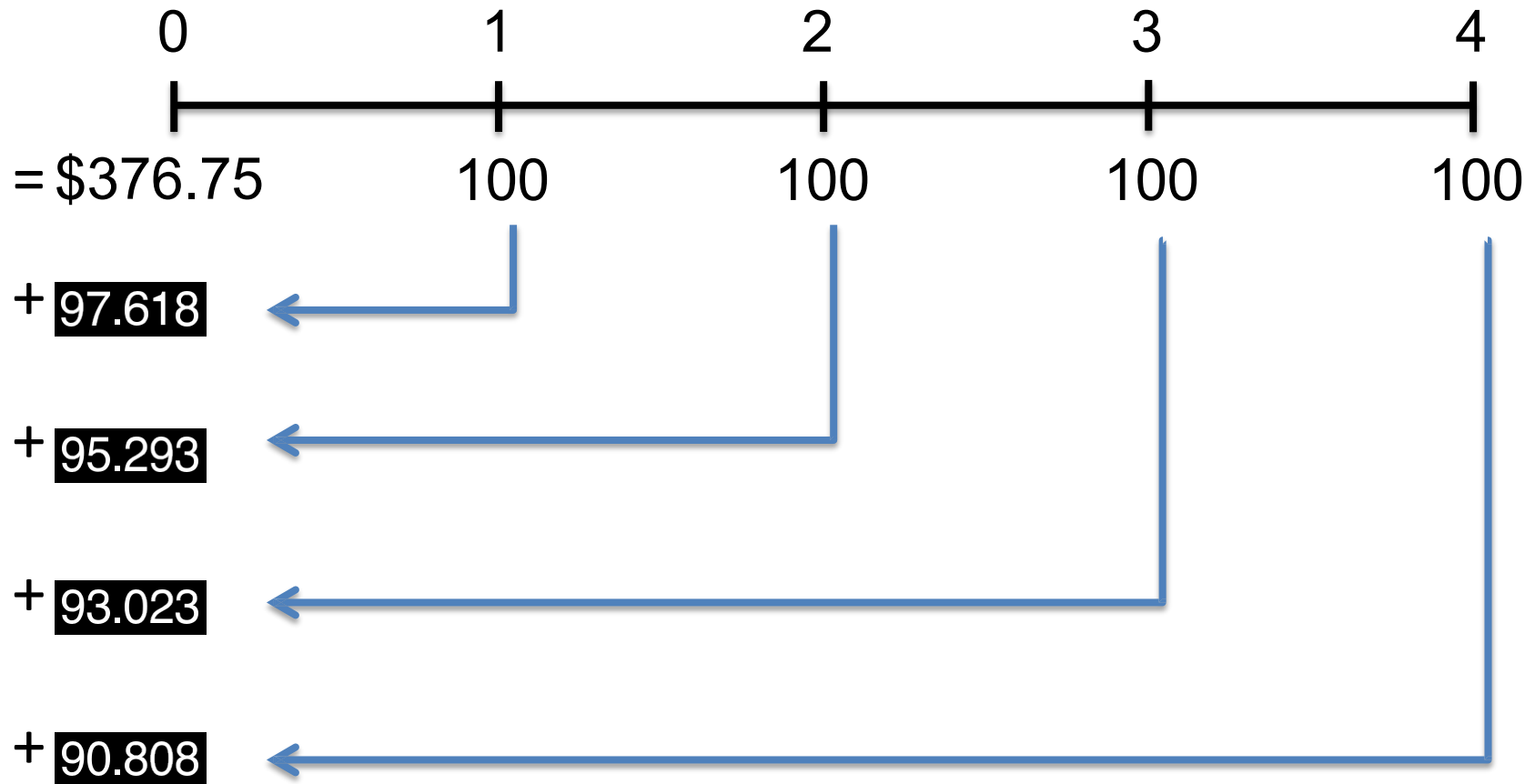
$$\frac{100}{(1 + 0.0244)^2}$$

$$\frac{100}{(1 + 0.0244)^3}$$

$$\frac{100}{(1 + 0.0244)^4}$$



# Savings with Inflation



# Savings with Inflation

- Difference:
  - taxes affect \$
  - Inflation affects consumption, not \$
    - Earn nominal return but can't buy as much

# Savings with Inflation

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$376.75
1	\$18.84	\$395.59	\$100.00	\$295.59
2	\$14.78	\$310.37	\$100.00	\$210.37
3	\$10.52	\$220.89	\$100.00	\$120.89
4	\$6.04	\$126.93	\$100.00	\$26.93

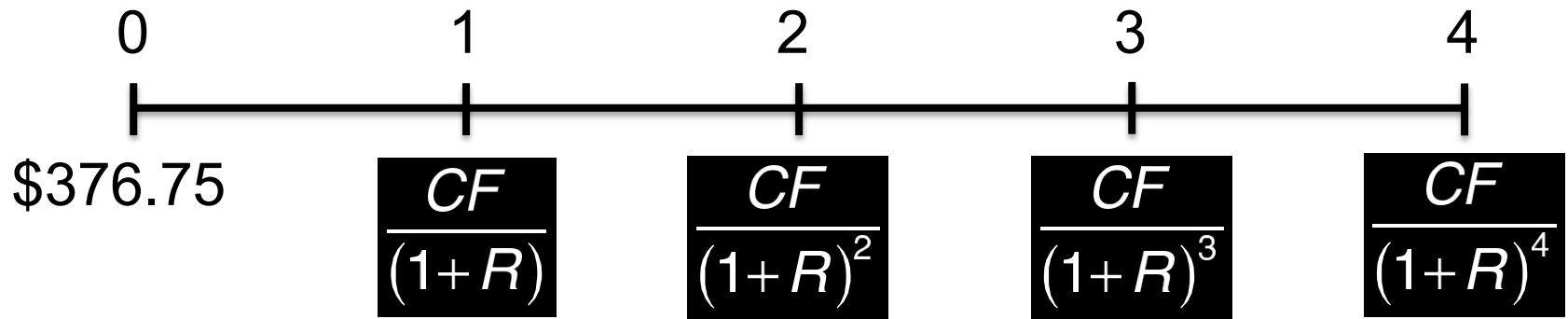


# Savings with Inflation

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$376.75
1	\$18.84	\$395.59	\$100.00	\$295.59
2	\$14.78	\$310.37	\$100.00	\$210.37
3	\$10.52	\$220.89	\$100.00	\$120.89
4	\$6.04	\$126.93	\$100.00	\$26.93

**Implication:** We have extra money(?).  
We need to change withdrawal amount.  
(Increase to buy costlier goods.)

# Savings with Inflation



What is  $CF$ , the amount of money we can withdraw each year?

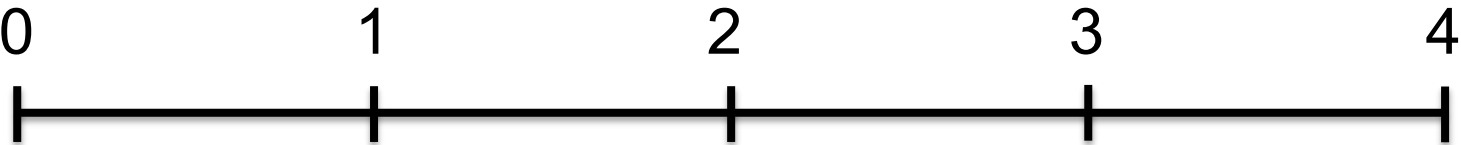
# Savings with Inflation

0 1 2 3 4

$$\$376.75 = \frac{CF}{(1+0.05)} + \frac{CF}{(1+0.05)^2} + \frac{CF}{(1+0.05)^3} + \frac{CF}{(1+0.05)^4}$$

Use nominal rate since that reflects \$ we earn

# Savings with Inflation



A horizontal timeline with five tick marks labeled 0, 1, 2, 3, and 4. Below the timeline, the equation  $\$376.75 = \frac{CF}{(1+0.05)} + \frac{CF}{(1+0.05)^2} + \frac{CF}{(1+0.05)^3} + \frac{CF}{(1+0.05)^4}$  is displayed. The terms  $\frac{CF}{(1+0.05)^k}$  for  $k=1, 2, 3, 4$  are each enclosed in a black box.

$$\$376.75 = \frac{CF}{(1+0.05)} + \frac{CF}{(1+0.05)^2} + \frac{CF}{(1+0.05)^3} + \frac{CF}{(1+0.05)^4}$$

$$CF = \$376.75 \left( \frac{1}{(1+0.05)} + \frac{1}{(1+0.05)^2} + \frac{1}{(1+0.05)^3} + \frac{1}{(1+0.05)^4} \right)^{-1}$$
$$= \$106.25$$

# Savings with Inflation

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$376.75
1	\$18.84	\$395.59	\$106.25	\$289.34
2	\$14.47	\$303.81	\$106.25	\$197.56
3	\$9.88	\$207.44	\$106.25	\$101.19
4	\$5.06	\$106.25	\$106.25	\$0.00

# Savings with Inflation

Year	Pre-Withdrawal		Post-Withdrawal	
	Interest	Balance	Withdrawal	Balance
0				\$376.75
1	\$18.84	\$395.59	\$106.25	\$289.34
2	\$14.47	\$303.81	\$106.25	\$197.56
3	\$9.88	\$207.44	\$106.25	\$101.19
4	\$5.06	\$106.25	\$106.25	\$0.00

Ideally withdrawals grow each year to accommodate inflation

# Savings with Inflation

Year	Withdrawal
0	
1	$100 \times (1 + 0.025)^1 = \$102.50$
2	$100 \times (1 + 0.025)^2 = \$105.06$
3	$100 \times (1 + 0.025)^3 = \$107.69$
4	$100 \times (1 + 0.025)^4 = \$110.38$

This sequence of withdrawals maintains purchasing power of \$100 in today's terms

# Savings with Inflation

Year	Withdrawal
0	
1	$100 \times (1 + 0.025)^1 = \$102.50$
2	$100 \times (1 + 0.025)^2 = \$105.06$
3	$100 \times (1 + 0.025)^3 = \$107.69$
4	$100 \times (1 + 0.025)^4 = \$110.38$

These are “nominal” values corresponding to the real \$100 purchasing power in year 0.



# Savings with Inflation

Year	Withdrawal
0	
1	\$102.50
2	\$105.06
3	\$107.69
4	\$110.38

PV at 5% discount rate = \$376.75

We discount nominal cash flows by the nominal rate to get the price.

# Savings with Inflation

Year	Withdrawal
0	
1	\$102.50
2	\$105.06
3	\$107.69
4	\$110.38

PV at 5% discount rate = \$376.75

**Note:** PV of nominal CFs at nominal discount rate = PV of real cash flows at real rate

# Savings with Inflation

Year	Withdrawal
0	
1	\$102.50
2	\$105.06
3	\$107.69
4	\$110.38

PV at 5% discount rate = \$376.75

**Intuition:** The inflation term in the numerator and denominator cancel

# Savings with Inflation

Year	Interest	Pre-Withdrawal Balance	Withdrawal	Post-Withdrawal Balance
0				\$376.75
1	\$18.84	\$395.59	\$102.50	\$293.09
2	\$14.65	\$307.74	\$105.06	\$202.68
3	\$10.13	\$212.81	\$107.69	\$105.13
4	\$5.26	\$110.38	\$110.38	\$0.00

# Summary

# Lessons

- Inflation does not affect \$ return
- Inflation does purchasing power of \$
- Real return,  $RR$

$$RR = \frac{1+R}{1+\pi} - 1 \simeq R - \pi$$

where  $R$  is the nominal return and  $\pi$  is the rate of inflation

# Lessons

- Discount real cash flows by the real rate of return, nominal cash flows by the nominal rate of return.

# Coming up next

- Interest Rates
  - How do we value non-annual and irregular cash flows streams?
  - How do different compounding periods affect our valuations?