

# Lecture 2

## Forward contracts



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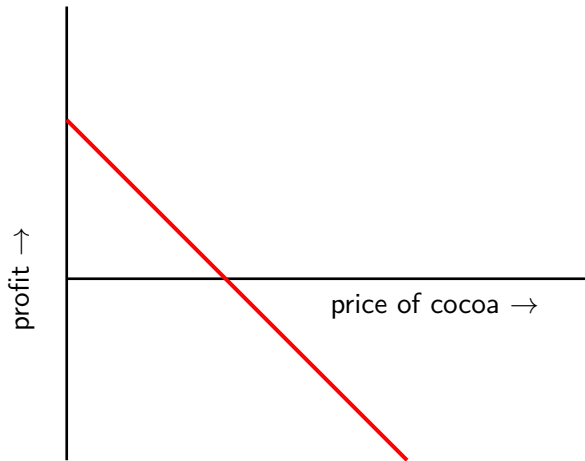
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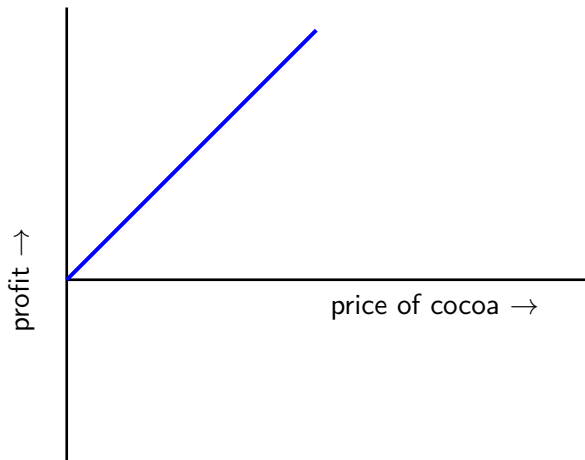
## Chocolate and cocoa

- ▶ The price of a Hershey chocolate bar is **stable**.
- ▶ But have you seen the price of **cocoa**?
- ▶ How does Hershey avoid passing on volatility to consumers?

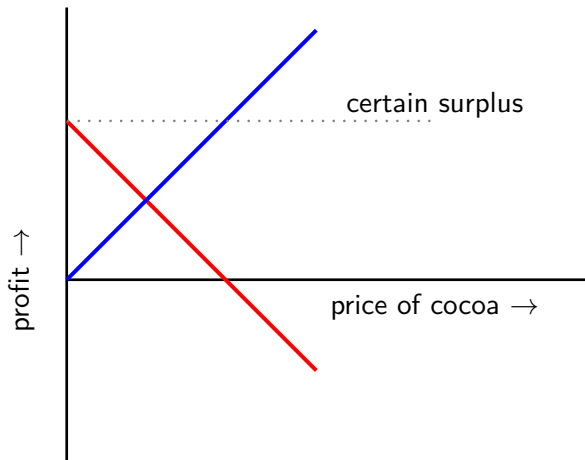
## Hershey's unhedged exposure



## Cocoa producer's unhedged exposure



## Opportunity arises to share risks



## Basic idea behind forward contract

- ▶ Hershey and the producer can lock-in a price for cocoa.
- ▶ This will fully insure both of them against cocoa price risk.
- ▶ Moreover, Hershey can keep chocolate bar prices stable.

# Roadmap: forward contracts

## 1. Definitions and payoffs

## 2. Basic risk management

## 3. Interest rates

## 4. Summary

# Forward contracts

- ▶ A **forward contract** is an agreement to buy or sell an asset at a future date at a price specified today (called the **forward price**).

## Agriculture

INDEX	UNITS	PRICE	CHANGE	%CHANGE	CONTRACT	TIME (EST)
C1:COM Corn (CBOT)	USd/bu.	389.25	+13.75	+3.66%	Mar 2020	1/17/2020
W1:COM Wheat (CBOT)	USd/bu.	570.50	+5.25	+0.93%	Mar 2020	1/17/2020
CC1:COM Cocoa (ICE)	USD/MT	2,797.00	+85.00	+3.13%	Mar 2020	1/17/2020



## Forward contract details

- ▶ Every forward contract has a buyer and a seller:
  - Buyer (long) is obligated to pay the forward price.
  - Seller (short) is obligated to sell at the forward price.
- ▶ Typically, no money is exchanged when the contract is initiated.
- ▶ Contracts are usually cash-settled on the expiration date.

## Contract payoffs

- ▶ The **payoff** to a derivative is its cash flow or value at expiration.
- ▶ The payoff to a long forward contract is:

$$X_T = S_T - F_{t,T}$$

where:

$T$  = expiration date in years (**timeline**).

$t$  = origination date (usually  $t = 0$  or “today”).

$S_T$  = price of the underlying asset at date  $T$ .

$F_{t,T}$  = forward price agreed upon at date  $t$  for date  $T$ .

## Practice problem

Today's spot price of cocoa is  $S_0 = \$2,500$  per ton. The one-year forward price for cocoa is  $F_{0,1} = \$2,750$ . A buyer and seller agree to enter a forward contract for one ton of cocoa.

1. Assume the future spot price is  $S_1 = \$2,600$ . Calculate the payoff to the long and short parties.
2. Plot a payoff diagram for the long forward. What is the minimum and maximum payoff?
3. Plot a payoff diagram for the short forward. What is the minimum and maximum payoff?

## Practice problem scratch paper

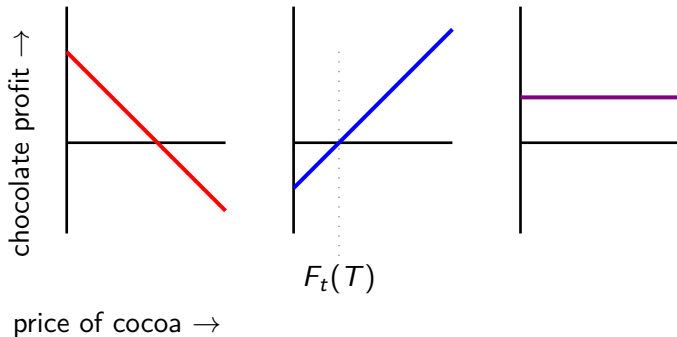
## Practice problem scratch paper

# Roadmap: the basics of forward contracts

1. Definitions and payoffs
- 2. Basic risk management**
3. Interest rates
4. Summary

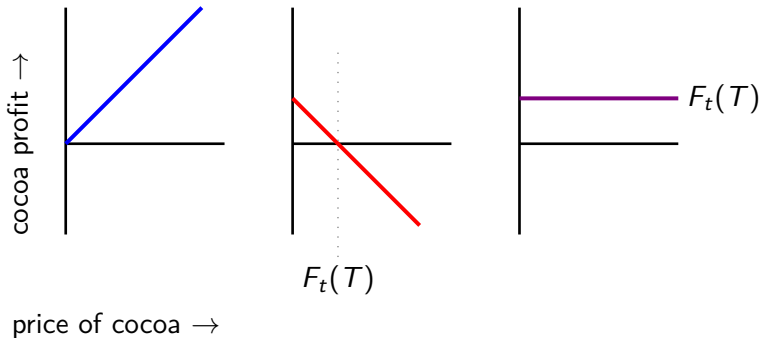
# Hershey's hedged exposure

original exposure + long forward = hedged position



# Cocoa producer's hedged exposure

original exposure + short forward = hedged position





## Practice problem

A farmer is planning to grow one ton of cocoa. She will sell her crop one year from today. The cost of producing cocoa is  $S_0 = \$2,300$  per ton, payable in one year.

1. Is the farmer long or short cocoa? Plot the farmer's unhedged profit as a function of  $S_1$ .
2. The one-year forward price is  $F_{0,1} = \$2,600$ . Plot the payoff diagram of the long forward contract.
3. How should the farmer hedge using forwards? What is her hedged profit if  $S_1 = \$2,000$ ?  $S_1 = \$2,600$ ?

## Practice problem scratch paper

## Practice problem scratch paper

# Roadmap: the basics of forward contracts

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## Technical note on interest rates

- ▶ Throughout the semester, we will assume there is a single continuously compounded (c.c.) risk-free interest rate of  $r$ .
- ▶ Discounting risk-free cash flows using c.c:

$$PV_t(\$1) = e^{-r(T-t)}$$

- ▶ Converting  $n$ -times per annum compounded rate  $r^*$  to c.c. rate:

$$r = n \cdot \log \left( 1 + \frac{r^*}{n} \right)$$

## Practice problem

The c.c. risk-free interest rate is  $r = 0.05$ . What is the price of a risk-free zero-coupon bond that pays \$100 in five years?

## Practice problem scratch paper

## Practice problem

The price of a risk-free zero-coupon bond that pays \$500 in ten years is \$400. What is the c.c. risk-free interest rate?



## Practice problem scratch paper

## Practice problem

The semi-annually compounded risk-free rate is 0.10. What is the equivalent continuously compounded risk-free rate?

## Practice problem scratch paper

# Roadmap: the basics of forward contracts

1. Definitions and payoffs
2. Basic risk management
3. Interest rates
- 4. Summary**

# Summary

- ▶ A forward contract is an agreement to buy or sell an asset at a future date at the forward price.
- ▶ Date  $T$  payoff of long forward originated at date 0:

$$X_T = S_T - F_{0,T}.$$

- ▶ Forwards can be used to hedge input and output price risk.
- ▶ Date 0 price of risk-free \$1 payoff at date  $T$  is  $e^{-rT}$ .

# References

- ▶ Textbook chapters 2.1, 4.1, 4.2, and appendix B.2.
- ▶ Hershey chocolate article is in the [Wall Street Journal](#).
- ▶ Commodity prices from Bloomberg terminal and [Bloomberg](#).
- ▶ Slides are created using code on my [Github](#).

# Cocoa spot price



Return

# Timeline

Return

origination

expiration

$t$  —————  $T$

- $S_t$  spot.
- $F_{t,T}$  set.
- \$0 exchanged.

- $S_T$  spot.
- $X_T = S_T - F_{t,T}$  to long.
- $-X_T = F_{t,T} - S_T$  to short.