Intermediate Microeconomics (22014)

I. Consumer Theory Applications

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Outline Part 1. Consumer Theory Applications

1. Topic 0. Consumer Theory Review
   1.1 Budget Constraints
   1.2 Preferences
   1.3 Utility Function
   1.4 Choice
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2. Topic 1. Buying and Selling

3. Topic 2. Intertemporal Choice

4. Topic 3. Choice under Uncertainty
TOPIC 0. CONSUMER THEORY REVIEW

Budget Constraints

Definitions

The consumer’s **budget set** is the set of all affordable bundles,

\[ B(p_1, \ldots, p_n; m) = \{(x_1, \ldots, x_n) : x_1 \geq 0, \ldots, x_n \geq 0 \text{ and } p_1 x_1 + \ldots + p_n x_n \leq m\} . \]

The **budget constraint** is the upper boundary of the budget set.

![Diagram showing budget set and budget constraint](https://via.placeholder.com/150)

- **Budget constraint:** \( p_1 x_1 + p_2 x_2 = m \)
- **Budget set:** the collection of all affordable bundles.

\[ x_2 = \frac{m}{p_2} - \frac{p_1}{p_2} x_1 \]
Preferences

Definitions

The set of all bundles equally preferred to a bundle $x'$ is the *indifference curve* containing $x'$. The slope of the indifference curve at $x'$ is the *marginal rate of substitution* (MRS) at $x'$, which is the rate at which the consumer is only just willing to exchange commodity 2 for commodity 1:

$$MRS(x') = \lim_{\Delta x_1 \to 0} \left( \frac{\Delta x_2}{\Delta x_1} \right) = \frac{dx_2}{dx_1}$$
Utility Function

Definition

A **Utility function** \( U(x) \) represents a preference relation if and only if

\[
\begin{align*}
    x' &\succ x'' \iff U(x') > U(x'') \\
    x' &\prec x'' \iff U(x') < U(x'') \\
    x' &\sim x'' \iff U(x') = U(x'')
\end{align*}
\]

The general equation for an indifference curve is

\[ U(x_1, x_2) = k, \] where \( k \) is a constant. Totally differentiating this identity we obtain that the MRS is equal to the ratio of marginal utilities:

\[
\frac{\partial U}{\partial x_1} dx_1 + \frac{\partial U}{\partial x_2} dx_2 = 0 \iff \frac{dx_2}{dx_1} = -\frac{\partial U}{\partial x_1} \frac{dx_1}{\partial x_2}
\]
Choice

Definition

A decisionmaker chooses the most preferred affordable bundle, which is called the consumer’s *ordinary demand* or gross demand.

- The slope of the indifference curve at ordinary demand \((x_1^*, x_2^*)\) equals the slope of the budget constraint:

\[
MRS(x_1^*, x_2^*) = -\frac{p_1}{p_2} \iff \frac{\partial U}{\partial x_1} \frac{\partial U}{\partial x_2} = \frac{p_1}{p_2}
\]
Slutsky Equation

Changes to demand from a *price change* are always the sum of a *pure substitution effect* and an *income effect*.

- **Pure substitution effect**: change in demand due only to the change in relative prices. “What is the change in demand when the consumer’s income is adjusted so that, at the new prices, she can only just buy the original bundle?”

- **Income effect**: if, at the new prices, less income is needed to buy the original bundle then “real income” is increased; if more income is needed, then “real income” is decreased.
Slutsky Equation graphically

Pure Substitution Effect Only

Adding now the income effect
Slutsky Equation formally

- Let \((p_1, p_2)\) be the initial price vector, \(m\) the income level and \((x_1^*, x_2^*)\) the initial gross demand.
- Define the Slutsky demand function \(x_i^s\) as the demand of good \(i\) after the price change when income is adjusted to give the consumer just enough to consume the initial bundle \((x_1^*, x_2^*)\):

\[
x_i^s (p_1', p_2', x_1^*, x_2^*) \equiv x_i \left( p_1', p_2'; \frac{p_1' x_1^* + p_2' x_2^*}{m} \right)
\]

- Take the derivative with respect to \(p_1\) on both sides,

\[
\frac{\partial x_i^s}{\partial p_1} = \frac{\partial x_i}{\partial p_1} + \frac{\partial x_i}{\partial m} x_1^* \quad \Leftrightarrow \quad \frac{\partial x_i}{\partial p_1} = \frac{\partial x_i^s}{\partial p_1} - \frac{\partial x_i}{\partial m} x_1^*
\]

substitution effect income effect
Slutsky Equation formally

- The sign of the substitution effect \( \frac{\partial x_1^s}{\partial p_1} \) is negative: the change in demand due to the substitution effect is the opposite to the change in price (\( p_1 \uparrow \Rightarrow x_1^s \downarrow \) and \( p_1 \downarrow \Rightarrow x_1^s \uparrow \)).

- If the good is normal, the sign of the income effect is also negative: an increase in a price is like a decrease in income, which leads to a decrease in demand; a price fall is like an income increase, which leads to an increase in demand.

\[
\frac{\partial x_1}{\partial p_1} = \frac{\partial x_1^s}{\partial p_1} - \frac{\partial x_1}{\partial m} x_1^* = (-) + (+) = (-)
\]
Outline Part I. Consumer Theory Applications

1. Topic 0. Consumer Theory Review

2. Topic 1. Buying and Selling
   2.1 Endowments
   2.2 Net Demand
   2.3 Slutsky Equation
   2.4 Labor Supply

3. Topic 2. Intertemporal Choice

4. Topic 3. Choice under Uncertainty
TOPIC 1. BUYING AND SELLING

- So far, consumers’ income taken as exogenous and independent of prices. In reality, consumers’ income coming from exchange by sellers and buyers.
- How are incomes generated? How does the value of income depend upon commodity prices?
- How can we put all this together to explain better how price changes affect demands?
In this chapter, consumers get income from endowments. This makes the budget set definition change slightly.

**Definition**

The list of resource units with which a consumer starts is her **endowment**, denoted by $\omega = (\omega_1, \omega_2)$.

**Definitions**

Given $p_1$ and $p_2$, the **budget constraint** for a consumer with an endowment $\omega = (\omega_1, \omega_2)$ is

$$p_1 x_1 + p_2 x_2 = p_1 \omega_1 + p_2 \omega_2.$$  

and the **budget set** is formally defined as

$$\{(x_1, x_2) \mid x_1 \geq 0, x_2 \geq 0 \text{ and } p_1 x_1 + p_2 x_2 \leq p_1 \omega_1 + p_2 \omega_2\}.$$
Endowments and Budget Sets

- Graphically, the endowment point is always on the budget constraint.
- Hence, price changes pivot the constraint around the endowment point.

\[ p_1 x_1 + p_2 x_2 = p_1 \omega_1 + p_2 \omega_2 \]

Before price change:

\[ p_1 x_1 + p_2 x_2 = p_1 \omega_1 + p_2 \omega_2 \]

After the price change:

\[ p'_1 x_1 + p'_2 x_2 = p'_1 \omega_1 + p'_2 \omega_2 \]
Net demand

Definition

The difference between final consumption and initial endowment of a given good \( i \), \( x_i^* - \omega_i \), is called \textit{net demand of good} \( i \).

- The sum of the values of net demands is zero:

\[
p_1 x_1 + p_2 x_2 = p_1 \omega_1 + p_2 \omega_2
\]

\[
\iff p_1 (x_1 - \omega_1) + p_2 (x_2 - \omega_2) = 0.
\]
Price offer curve

Definition

*Price-offer curve* contains all the utility-maximizing gross demands for which the endowment is exchanged.
Slutsky equation revisited

In an endowment economy, the overall change in demand caused by a price change is the sum of a pure substitution effect, an (ordinary) income effect, and an endowment income effect.

- **Pure Substitution Effect**: effect of relative prices change.
- **Income Effect**: effect of original bundle cost change.
- **Endowment Income Effect**: change in demand due only to the change in endowment value.
Slutsky Equation revisited

- Let $x_1(p_1, p_2; m(p_1, p_2))$ be the demand function of good 1 and $m(p_1, p_2) = p_1 \omega_1 + p_2 \omega_2$ the money income.
- Then, the total derivative of $x_1$ with respect to $p_1$ is

$$
\frac{dx_1}{dp_1} = \frac{\partial x_1}{\partial p_1} + \frac{\partial x_1}{\partial m} \omega_1.
$$

- Using that $\frac{\partial x_1}{\partial p_1} = \frac{\partial x^s_1}{\partial p_1} - \frac{\partial x_1}{\partial m} x^*_1$, we obtain

$$
\frac{dx_1}{dp_1} = \frac{\partial x^s_1}{\partial p_1} - \frac{\partial x_1}{\partial m} x^*_1 + \frac{\partial x_1}{\partial m} \omega_1.
$$

- Rearranging,

$$
\frac{dx_1}{dp_1} = \frac{\partial x_1}{\partial p_1} + (\omega_1 - x_1) \frac{\partial x_1}{\partial m}.
$$
Slutsky equation revisited

Overall change in demand of normal good (demand increases with income) caused by own price change:

- When income is exogenous, both the substitution and (ordinary) income effects increase demand after an own-price fall; hence, a normal good’s ordinary demand curve slopes down (thus, Law of Downward-Sloping Demand always applies to normal goods when income is exogenous).

- When income is given by initial endowments, endowment-income effect decreases demand if consumer supplies that good (negative net demand); thus, if the endowment income effect offsets the substitution and the (ordinary) income effects, the demand function could be upward-sloping!
An application: labor supply

Environment description:

- A worker is endowed with $m$ euros of nonlabor income and $\overline{R}$ hours of time.
- Consumption good’s price is $p_c$, and the wage rate is $w$.
- Worker decides amount of consumption good, denoted by $C$, and amount of leisure, denoted by $R$.

Budget constraint:

$$p_c C = m + w (\overline{R} - R)$$

$$\Leftrightarrow p_c C + wR = m + w\overline{R}$$

Expenditures value = Endowment value
Labor supply choice

Budget constraint equation:

\[ C = -\frac{w}{p_c} R^* + \frac{m + w R}{p_c} \]

Endowment point
Labor supply curve

Effect of a wage rate increase on amount labor supplied:

- Substitution effect: leisure relatively more expensive → decrease leisure demanded / increase labor supplied.
- (Ordinary) income effect: cost original bundle increases → decrease leisure demanded / increase labor supplied.
- Endowment-income effect: positive endowment income effect because worker supplies labor → decrease leisure demanded / increase labor supplied.

⇒ Labor supply curve may bend backwards.
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   3.3 Intertemporal Choice
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   3.5 Valuing Securities

4. Topic 3. Choice under Uncertainty
So far, only static problems considered, as if consumers only alive one period or only static decisions.

However, in the real world people often make intertemporal consumption decisions:

- Current consumption financed by borrowing now against income to be received in the future.
- Extra income received now spread over the following month (saving now for consumption later).

In this section, we study intertemporal choice problem using a two-period version of our consumer’s choice model.
Intertemporal Choice Problem

- Notation:
  - Let interest rate be denoted by $r$.
  - Let $c_1$ and $c_2$ be consumptions in periods 1 and 2.
  - Let $m_1$ and $m_2$ be incomes received in periods 1 and 2.
  - Let consumption prices be denoted by $p_1$ and $p_2$.

- Intertemporal choice problem:
  - Given incomes $m_1$ and $m_2$, and given consumption prices $p_1$ and $p_2$, what is the most preferred intertemporal consumption bundle $(c_1, c_2)$?
  - Need to know: the intertemporal budget constraint, and intertemporal consumption preferences.
Present and Future Values

Definitions
Given an interest rate $r$, the **future value** of $M€$ is the value next period of that amount saved now:

$$FV = M(1 + r).$$

The **present value** of $M€$ is the amount saved in the present to obtain $M€$ at the start of the next period:

$$PV = \frac{M}{1 + r}.$$

▶ Example:

▶ Example: if $r = 0.1$ the future value of 100€ is $100(1 + 0.1) = 110€$.

▶ if $r = 0.1$, the present value of 1€ is the amount we have to pay now to obtain 1€ next period: $\frac{1}{1 + 0.1} = 0.91$. 

**Intertemporal Budget Constraint**

**Case I: No inflation, \( p_1 = p_2 \)**

- Consumption bundle when neither saving nor borrowing:
  \[
  (c_1, c_2) = (m_1, m_2)
  \]

- If all period 1 income saved for period 2:
  \[
  (c_1, c_2) = (0, m_2 + (1 + r) m_1)
  \]

- If all period 2 income borrowed in period 1:
  \[
  (c_1, c_2) = \left( m_1 + \frac{m_2}{1 + r}, 0 \right)
  \]
Intertemporal Budget Constraint

- Given a period 1 consumption of $c_1$, period 2 consumption is

  \[ c_2 = m_2 + (1 + r) m_1 - (1 + r) c_1 \]

  intercept  slope

  \[
  m_2 + (1+r)m_1 \\
  m_2 \\
  0
  \]

  \[
  c_2 \\
  c_1 \\
  0
  \] 

- Intertemporal budget constraint:
  - Future-valued form: \((1 + r) c_1 + c_2 = m_2 + (1 + r) m_1\)
  - Present-valued form: \(c_1 + \frac{c_2}{1+r} = m_1 + \frac{m_2}{1+r}\)
Intertemporal Choice

- Optimal intertemporal consumption bundle given by tangency point of intertemporal indifference curves and intertemporal budget constraint:

The consumer saves.

The consumer borrows.
Comparative Statics: Slutsky equation re-revisited

- The Slutsky equation for the change in $c_1$ due to a change in $p_1$ is the same as the one seen in topic 1:

$$\frac{dc_1}{dp_1} = \frac{\partial c_s^1}{\partial p_1} + (m_1 - c_1) \frac{\partial c_1}{\partial m}.$$ 

- Since a change in $r$ is equivalent to a change in $p_1$, the Slutsky equation is exactly the same.

  - If $r \uparrow$, the substitution effect (the first term in the equation above) is negative; if $r \downarrow$ the substitution effect is positive.

  - The sign of the total income effect (the second term in the equation above) depends on whether the consumer is a saver or a borrower:

    - If borrower ($c_1 > m_1$), total income effect is negative.
    - If saver, ($c_1 < m_1$), total income effect is positive.

- Note: effects of $r \downarrow$ are the opposite as effects of $r \uparrow$. 
Comparative Statics: Interest rate decrease

- Graphically, since slope budget constraint curve is $-(1+r)$,

$$r \downarrow \Rightarrow \text{flattening budget constraint.}$$

- Effects of $r \downarrow$ on optimal intertemporal consumption bundle:
  - Substitution effect: increase in cost future consumption relative to present consumption.
  - Total income effect:
    - If saver, total income effect is negative.
    - If borrower, total income effect is positive.
Comparative Statics: Interest rate decrease

Total effect:

If saver, $c_1^?, c_2\downarrow$

If borrower, $c_1\uparrow, c_2?$

The consumer saves.

The consumer borrows.
Inflation

Definitions

The *inflation rate* is the rate at which the level of prices for goods increases. It is equal to

\[ \pi = \frac{p_2 - p_1}{p_1} \iff 1 + \pi = \frac{p_2}{p_1} \]

The *real-interest rate*, \( \rho \), is an interest rate adjusted to remove the effects of inflation. It is equal to

\[ 1 + \rho = \frac{1 + r}{1 + \pi} \iff \rho = \frac{r - \pi}{1 + \pi} \]

and, if the inflation rate is small, it can be approximated by the difference between the interest rate and the inflation rate:

\[ \rho \approx r - \pi. \]
Intertemporal Budget Constraint

Case II: Inflation, \( p_2 = (1 + \pi) p_1 \)

- Intertemporal budget constraint with inflation:
  \[
  p_1 c_1 + \frac{p_2 c_2}{(1 + r)} = p_1 m_1 + \frac{p_2 m_2}{(1 + r)}
  \]
  \[\Leftrightarrow c_1 + \frac{c_2}{1 + \rho} = m_1 + \frac{m_2}{1 + \rho}\]

- Intertemporal budget constraint curve:
  \[
  c_2 = \left(1 + \rho\right) m_1 + m_2 - \left(1 + \rho\right)c_1
  \]
  intercept \quad slope

\[\pi \uparrow\text{ same effects as } r \downarrow\]
Valuing Financial Securities

Definition

A financial security is a financial instrument that promises to deliver an income stream.

Example:

Consider a security that pays $m_1$ at the end of period 1, $m_2$ at the end of period 2, and $m_3$ at the end of period 3.

What is the most that should be paid now for this security? The present value of this security!

$$PV = \frac{m_1}{1+r} + \frac{m_2}{(1+r)^2} + \frac{m_3}{(1+r)^3}.$$
Valuing Bonds

Definition
A bond is a type of security that pays a fixed amount $x$ for $T$ years (its maturity date) and then pays its face value $F$.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
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<td>$\frac{x}{(1+r)^2}$</td>
<td>...</td>
<td>$\frac{x}{(1+r)^{T-1}}$</td>
<td>$\frac{F}{(1+r)^T}$</td>
</tr>
</tbody>
</table>

- The value of the bond is its present value:

$$PV = \frac{x}{(1+r)} + \frac{x}{(1+r)^2} + \ldots + \frac{x}{(1+r)^{T-1}} + \frac{F}{(1+r)^T}$$
Outline Part I. Consumer Theory Applications

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   4.2 Preferences under uncertainty
   4.3 Insurance
   4.4 Risk spreading
TOPIC 3. CHOICE UNDER UNCERTAINTY

▶ So far, dynamic problems considered had no uncertainty.

▶ However, in the real world people often make decisions with uncertainty about future prices, future wealth, or other agents’ decisions.

▶ In this section, we study the choice problem under uncertainty using a two-state version of our consumer’s choice model.

▶ Optimal responses: insurance purchase, risk diversification.

▶ Example:
  ▶ 2 possible states of nature: car accident (loss of $L\€$), no car accident.
  ▶ Probabilities for each state: $\pi_a$, $\pi_{na}$.
  ▶ Insurance: get $K\€$ if accident by paying $\gamma K\€$ as insurance premium.
State-contingent budget constraints

Definitions
A contract is *state contingent* if it is implemented only when a particular state of Nature occurs. A *state-contingent consumption plan* specifies the consumption to be implemented when each state of Nature occurs.

▶ Example:

▶ Consumption if no accident: \( c_{na} = M - \gamma K \)
▶ Consumption if accident: \( c_a = M - L - \gamma K + K \).

Hence, \( K = \frac{c_a - M + L}{1 - \gamma} \) and

\[
c_{na} = M - \gamma \left( \frac{c_a - M + L}{1 - \gamma} \right) = \frac{M - \gamma L}{1 - \gamma} - \frac{\gamma}{1 - \gamma} c_a
\]
State-contingent budget constraints

Car Insurance example

State-contingent budget constraint in car insurance example:

\[ c_{na} = \frac{m - \gamma L}{1 - \gamma} - \frac{\gamma}{1 - \gamma} c_a \]

Where is the most preferred state-contingent consumption plan?
Preferences under Uncertainty

- To know what is the agents’ choice, we need to know their preferences about the different state-contingent consumption plans.
- Utility across state-contingent consumption plans is a function of the consumption levels and probabilities at each state, \( U(c_1, c_2, \pi_1, \pi_2) \).

**Definition**

A utility function \( U(c_1, c_2, \pi_1, \pi_2) \) satisfies the *expected utility* or *von Neumann–Morgenstern* property if it can be written as the weighted sum of the utility at each state, where the weights are the probabilities of each state:

\[
U(c_1, c_2, \pi_1, \pi_2) = \pi_1 v(c_1) + \pi_2 v(c_2)
\]

It satisfies the independence property, which means that the utility in a given state is independent of the utility in other states.
Risk aversion

Definition
We say an agent is **risk averse** if the expected utility of wealth is lower than the utility of expected wealth, **risk lover** if it is higher, and **risk neutral** if it is equal.

▶ Example:

▶ Lottery: 90€ with probability 1/2, 0€ with prob 1/2.
▶ Utility levels: \( U(\$90) = 12, \ U(\$0) = 2 \).
▶ Expected utility: \( EU = \frac{1}{2} \times 12 + \frac{1}{2} \times 2 = 7 \).
▶ Expected money value: \( EM = \frac{1}{2} \times 90 + \frac{1}{2} \times 0 = 45 \).
Indifference Curves

- State-contingent consumption plans that give equal expected utility are equally preferred and on the same indifference curve.

- Slope of indifference curves:

\[ EU = \pi_1 U(c_1) + \pi_2 U(c_2) \implies dEU = \pi_1 \frac{\partial U(c_1)}{\partial c_1} dc_1 + \pi_1 \frac{\partial U(c_2)}{\partial c_2} dc_2 \]

\[ \pi_1 \frac{\partial U(c_1)}{\partial c_1} dc_1 + \pi_2 \frac{\partial U(c_2)}{\partial c_2} dc_2 = 0 \implies \frac{dc_2}{dc_1} = -\frac{\pi_1 \frac{\partial U(c_1)}{\partial c_1}}{\pi_2 \frac{\partial U(c_2)}{\partial c_2}} \]
Choice under uncertainty

- The optimal choice under uncertainty is the most preferred affordable state-contingent consumption plan.
- In the car insurance example, the optimal consumption plan is where the slope of indifference curves is tangent to the budget constraint:

\[
\frac{\pi_a \partial U(c_a)/\partial c_a}{\pi_{na} \partial U(c_{na})/\partial c_{na}} = \frac{\gamma}{1 - \gamma}
\]
Insurance

Fair Insurance

Definition
We say an insurance is *fair or competitive* if the expected economic profit of the insurer is zero, or, equivalently, if the price of a 1€ insurance is the probability of the insured state.

- Car insurance example:
  \[
  \gamma K - \pi_a K - (1 - \pi_a)0 = 0 \Rightarrow \gamma = \pi_a
  \]

- If the insurance is fair, the optimal choice of risk-averse consumers is **full insurance**:
  \[
  \frac{\pi_a}{\pi_{na}} \frac{\partial U(c_a)}{\partial c_a} / \frac{\partial U(c_{na})}{\partial c_{na}} = \frac{\pi_a}{1 - \pi_a} \Rightarrow \frac{\partial U(c_a)}{\partial c_a} = \frac{\partial U(c_{na})}{\partial c_{na}}
  \]
  Hence, for risk averse consumers, \( c_a = c_{na} \).
Insurance

Unfair Insurance

Definition

We say an insurance is *unfair* if the insurer makes positive expected economic profits.

- If the insurance is unfair, the optimal choice of risk-averse consumers is less than full insurance:

\[
\gamma K - \pi_a K - (1 - \pi_a)0 > 0 \Rightarrow \frac{\gamma}{1 - \gamma} > \frac{\pi_a}{\pi_{na}}
\]

Hence, \(\frac{\pi_a}{\pi_{na}} \frac{\partial U(c_a)/\partial c_a}{\partial U(c_{na})/\partial c_{na}} = \frac{\gamma}{1 - \gamma}\) implies that

\[
\frac{\partial U(c_a)}{\partial c_a} > \frac{\partial U(c_{na})}{\partial c_{na}}
\]

so, for risk averse consumers, \(c_a < c_{na}\).
Diversification

- Asset diversification typically lowers (or keeps) expected earnings in exchange for lowered risk. This is going to be the case as long as the asset prices are not perfectly correlated across states.

- Example: two firms, two states (prob. 1/2), agent with 100€ to spend in firms’ share.
  - Firm A: shares’ cost 10€, profits per share in state 1 100€, in state 2 20€.
  - Firm B: shares’ cost 10€, profits per share in state 1 20€, in state 2 100€.

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<th>10 shares of B</th>
<th>5 of A, 5 of B</th>
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<tbody>
<tr>
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<td>200€</td>
<td>600€</td>
</tr>
<tr>
<td>Profits in 2</td>
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<td>1000€</td>
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<tr>
<td>Expected profits</td>
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