

Inventory Planning

Balancing Inventory

Why do we need inventory?

Mitigate risks

- Supplier delays
- Forecast error
- Production hazards

Reduce costs

- Transaction costs through scale effect
- Purchasing costs thanks to grouped orders and volume discounts
- Financial speculation

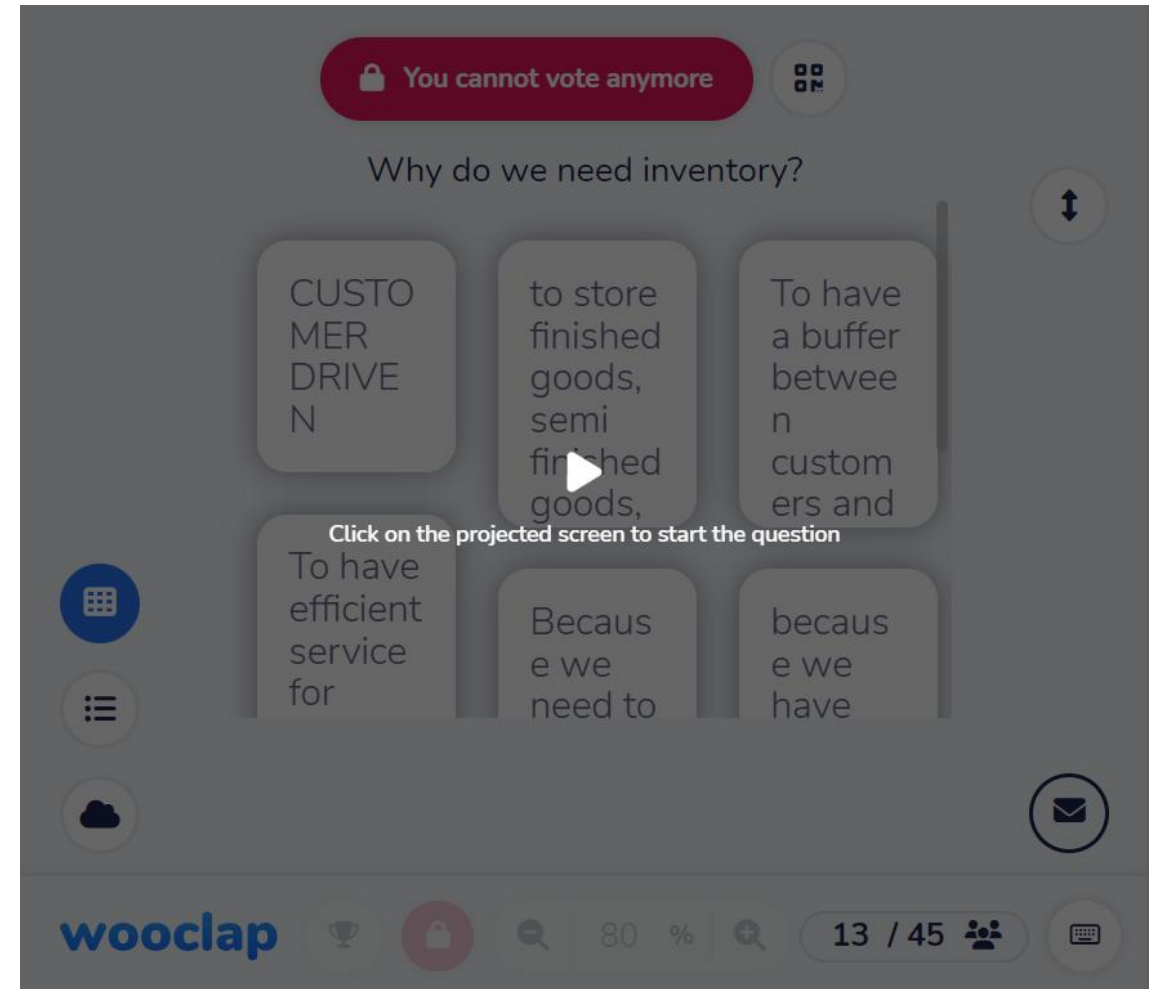
Logistical constraints

- Compensate for any bottleneck (production, logistics)

Marketing

- Merchandizing: you want to be seen.
- Satisfy clients on time (MTS/MTO)

Shortage gaming



Why do we limit inventory?

Mitigate risks

- Obsolescence & Dead stocks

Reduce costs

- Holding costs
- Perishable goods

Logistical constraints

- Storage space

Marketing

- Feeling of scarcity

But

Hides bottlenecks: no incentive to streamline operations.

Balancing Inventory

We Want More

Mitigate risks

- Supplier delays
- Forecast error
- Production hazards

Reduce costs

- Transaction costs through scale effect
- Purchasing costs thanks to grouped orders and volume discounts
- Financial speculation

Logistical constraints

- Compensate for any bottleneck (production, logistics)

Marketing

- Merchandizing: you want to be seen.
- Satisfy clients on time (MTS/MTO)

Shortage gaming

We Want Less

Mitigate risks

- Obsolescence & Dead stocks

Reduce costs

- Holding costs
- Perishable goods

Logistical constraints

- Storage space

Marketing

- Feeling of scarcity

Operations

- Hides bottlenecks: no incentive to streamline operations.

Balancing Inventory

Too little inventory

Shortages

Transaction costs

Production flexibility

Too much inventory

Dead stocks

Holding costs

Storage space

Service level



Service Levels: Definitions

Cycle Service Level (α in $Ss = z\sigma\sqrt{L + R}$)

The probability of not stocking out during an order replenishment cycle.

Period Service Level (α_p)

Fraction of periods (a day, a week, a month) without shortages (= inventory on-hand > 0).
(Often called on-shelf availability)

Great if you track sales

(Item) Fill Rate (β)

Fraction of items directly supplied from on-hand inventory.

Great if you track all orders

Order Fill Rate (On Time in Full, OTIF)

Fraction of clients' orders entirely supplied from on-hand inventory. (One order often contains multiple different products.)

Fill Rate > Period Service Level > Cycle Service Level

Service Level: DIY

Over these 8 periods, what is the ...

- Cycle service level (we received two orders)
- Fill rate
- Period service level

Day	Inventory		Demand	Lost sales
	Start	End		
1	80	60	20	0
2	60	25	35	0
3	25	0	25	0
4	0	0	10	10
5	80	65	15	0
6	65	40	25	0
7	40	25	15	0
8	25	5	20	0
Total			165	10

Go to **wooclap.com** and use the code **INVENTORY**

Service Level - What's your favorite KPI?

- ① Cycle Service Level (α)
- ② Period Service Level (α_p , on-shelf availability)
- ③ (Item) Fill Rate (β)
- ④ Order Fill Rate (On Time in Full, OTIF)
- ⑤ Something else

Click on the projected screen to start the question

Service level

Beer Game

👤 Team performance

Total Cost
€ 587

Retailer On-time Sales
91.2% 135/148

Average Stock
48 units

Backorders Duration ⓘ
13 /20 Weeks

Fresh Connection

Product	Customer	<i>i</i> Service level (pieces)	<i>i</i> Service level (order lines)	<i>i</i> OSA
💡 <i>Fressie Orange 1 liter</i>	💡 Food & Groceries	93.8%	91.9%	87.1%
	💡 LAND Market	92.7%	92.4%	87.5%
💡 <i>Fressie Orange PET</i>	💡 Food & Groceries	97.5%	96.9%	96.6%
	💡 LAND Market	97.8%	97.6%	97.5%
	💡 Dominick's	98.4%	97.9%	98.1%

+ a lot of other internal metrics

Inventory Policies

How Inventory Policies Control Inventory

Inventory policy: **How much** to order, **When** to order, (**Where** to store)



Inventory Definitions

On-Hand

Inventory physically available for a client to buy.

Backorders

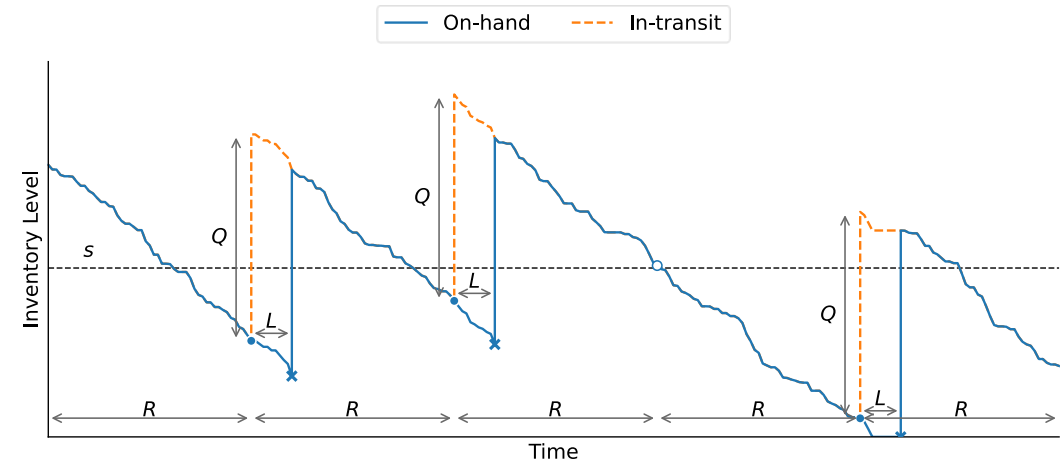
Backlog of open orders that are not yet fulfilled. This happens when you do not have enough on-hand inventory to fulfill orders directly, and the orders are not lost.

In-transit Inventory

Goods ordered from a supplier but not yet available in our warehouse for our clients to buy. These goods are considered to be *in-transit* between two warehouses.

Net-Inventory Level

Inventory level including: available on-hand inventory and in-transit inventory, minus backorders, orders not yet shipped, etc.



$$\text{Net} = \text{On-Hand} + \text{In-Transit} - \text{Backorders}$$

Inventory Policies

Static vs. Dynamic

Static

When 2 left, I will buy 5.

Pro: Simple

Con: Not future-proof

Dynamic

When less than 2 weeks of forecast, I buy 5 weeks of forecast.

Pro: future proof! More adequations with real needs

Con: needs integration with forecast.

Continuous vs. Periodic

Continuous

At any point in time, if I need to do an order, I do it.

Pro: Reactive!

Con: You can't do it in practice.

Periodic

Once a day/week/month, I make an order.

Pro: Grouped orders

Con: Less reactive

Order Quantity: Fixed vs. Variable

Fixed Quantity

I always order full pallets.

Pro: Lower order/logistical costs

Con: You might order too much or not enough

Variable Quantity

I order what I need.

Pro: You have exactly what you need

Con: High order costs

Policy #1: (R,S) Periodic Review & Up-to Level

Policy

Review Period

- **When?** Every R periods
- **How Much?** Up to a level S

💡 $S = \text{Forecast over Risk-Horizon} + \text{Safety Stocks}$

Pros

Lead time + Review Period

- Simple to group different SKUs in a single order toward one supplier.
- Fixed order timings can allow smooth operations (collaboration with supplier).

Cons

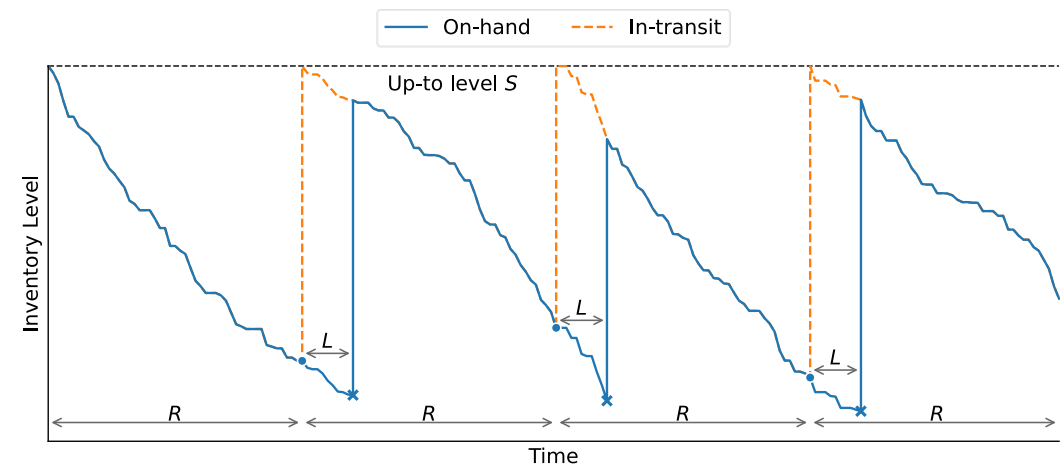
- Less reactive: riskier to wait for a specific period to make an order.
- Order quantities are not aligned with batch size.
- Fixed order timings can create bottlenecks.

Static

Every Friday, I buy milk so that I have 3 liters.

Dynamic

Every week, we buy enough raw materials to have 4 weeks of forecast in stock.



Policy #2: (s,Q)

Continuous Review & Fixed Quantity

Policy

- **When?** When net inventory is below or equal to **s**.
 $s = \text{Forecast over Lead Time} + \text{Safety Stocks}$
- **How Much?** **Q**

Pros

- You make an order when you need it: limited risk of shortage (better when demand/supply variability is high)
- Fixed, optimized order quantity (useful for operations, batch size, full truckload)

Cons

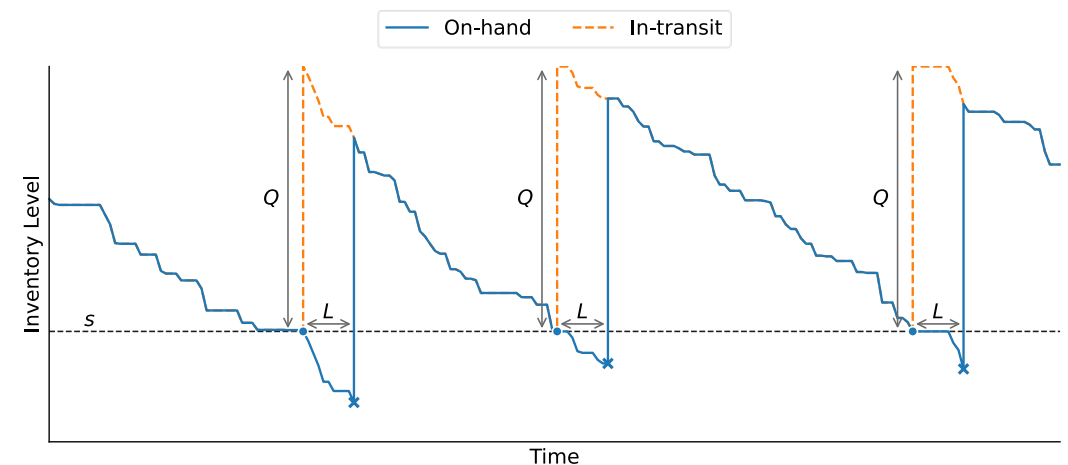
- Need to be able to make orders at any point in time to your internal/external supplier
- Cannot group orders of different products toward the same supplier

Static

When I have less than 10% of ink in my printer, I buy a new cartridge.

Dynamic

When we have 2 weeks of forecast worth of goods, we order one pallet from our supplier.



Policy #3: (R,s,Q) Periodic Review & Up-to Level

Policy

- **When?** Every R periods, if less than s
 $s \approx \text{Forecast over Lead Time} + R/2 + \text{Safety Stocks}$
- **How Much?** Q

Pros

- Fixed, optimized order quantity (useful for operations, batch size, full truckload).
- Simple to group different SKUs in a single order toward one supplier.
- Fixed order timings can allow smooth operations (collaboration with supplier).

Cons

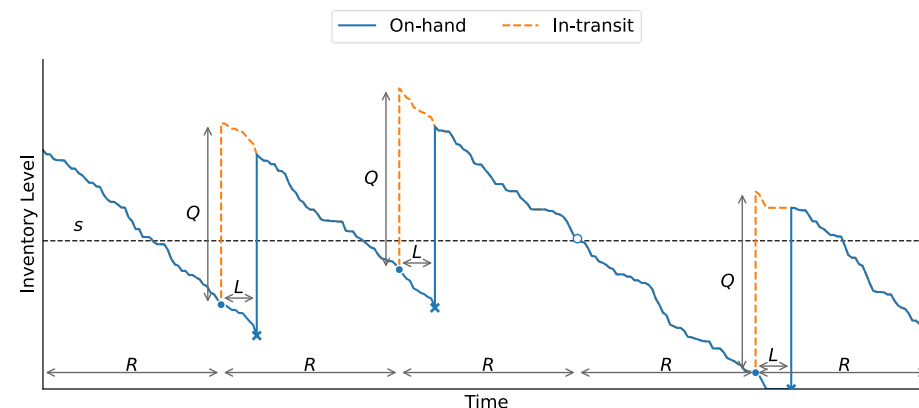
- Riskier policy with two ordering conditions (can even be less reactive than a (R,S) policy). You can set short review periods, but at the expense of grouped orders.
- More difficult to optimize.

Static

Every Friday, if I have less than 3 bottles of milk, I buy a pack of 6.

Dynamic

Every Friday, if I have less than three weeks' worth of expected milk consumption, I buy a pack of 6.



Inventory policy

Inventory policies tell you **when** and **how much** to order

In practice, there is
no *real* continuous systems

- ✓ Fixed order quantities → Packaging & logistic optimization
- ✓ Fixed review periods → Grouped orders (but riskier)
- ✓ Dynamic → Future-proof
- ✗ Multiple conditions → Riskier, complex policies

s and *S* can be *static* or *dynamic*
(period-coverage).

Replenishment	Reorder Point <i>s</i>	Order Quantity <i>Q</i>	Policy	
Continuous	Yes	Fixed <i>Q</i>	(<i>s</i> , <i>Q</i>)	If less than <i>s</i> , order <i>Q</i>
Continuous	Yes	Up-to level <i>S</i>	(<i>s</i> , <i>S</i>)	If less than <i>s</i> , order up to <i>S</i>
Periodic <i>R</i>	Yes	Fixed <i>Q</i>	(<i>R</i> , <i>s</i> , <i>Q</i>)	Every <i>R</i> , if less than <i>s</i> , order <i>Q</i>
Periodic <i>R</i>	Yes	Up-to level <i>S</i>	(<i>R</i> , <i>s</i> , <i>S</i>)	Every <i>R</i> , if less than <i>s</i> , order up to <i>S</i>
Periodic <i>R</i>	No	Fixed <i>Q</i>	(<i>R</i> , <i>S</i>)	Every <i>R</i> , order up to <i>S</i>

Go to **wooclap.com** and use the code **INVENTORYOLD**



Our inventory policy says to place a new order (of 20 units) when stock levels fall below a certain threshold (15 units).



This morning, we had 17 units in stock. A client came by and bought 5 units.

How many units should we order to maintain our inventory levels according to our policy?

Click on the projected screen to start the question





Go to **wooclap.com** and use the code **INVENTORYOLD**



Select the primary reasons for having (high levels of) inventory for supply chains



- ① Prevent inaccurate forecasts.
- ② Mitigate risks of supply chain disruptions.
- ③ Reduce costs by optimizing order and shipping costs.
- ④ Identify issues in the production process.
- ⑤ Buffer against forecast inaccuracies



Click on the projected screen to start the question



Go to **wooclap.com** and use the code **INVENTORYOLD**



Which business drivers incentivize supply chains to keep low inventory levels?



- ① To achieve economies of scale in purchasing
- ② To minimize the costs associated with holding and storing inventory
- ③ To reduce expenses related to frequent ordering and receiving
- ④ To efficiently utilize available storage space and avoid overflow
- ⑤ To ensure effective merchandising strategies that match inventory displays to consumer demand patterns.
- ⑥ To mitigate the risk of inventory obsolescence and dead stock



Click on the projected screen to start the question



Go to **wooclap.com** and use the code **INVENTORYOLD**



Match these descriptions to inventory policies



The store automatically orders 100 units whenever the stock falls below 20 units.

1

A

(R,s,S)

The shop reviews inventory every Monday and orders enough to have 50 units on hand.

2

B

(R,s,S)

Inventory is checked every third Friday; if stock is under 30 units, it is replenished to 75 units.

3

C

(s,Q)

The warehouse conducts a bi-weekly inventory check and orders 100 units if stock is below the ...

4

D

(R,s,Q)

A local art supply store orders a new batch of paints whenever their best-selling colors are nearly out o...

5

E

(s,Q)

A grocery store checks its stock every Sunday night and orders enough to fully restock the shelves for ...

6

F

(R,S)

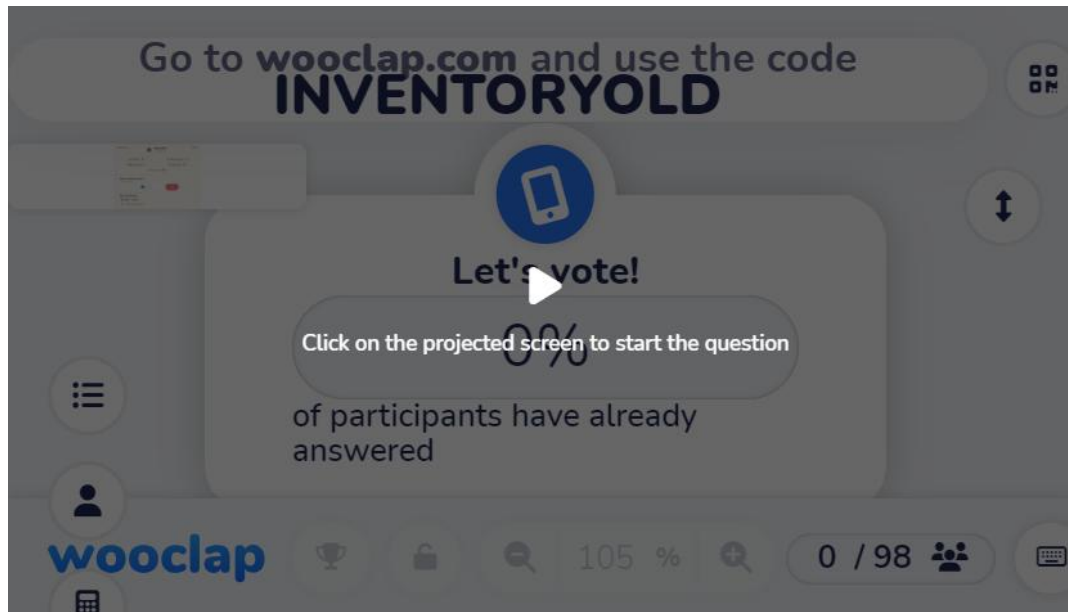
Click on the projected screen to start the question



Policies in Practice

I am following a periodic up-to-level policy ($R=1$, $S=30$).

How much should I order?
(You need to account for incoming orders and backlog)



Order-up-to level (S): 30

Net inventory level: 0 (on-hand) -2 (backorders) +18 (in-transit)
= 16

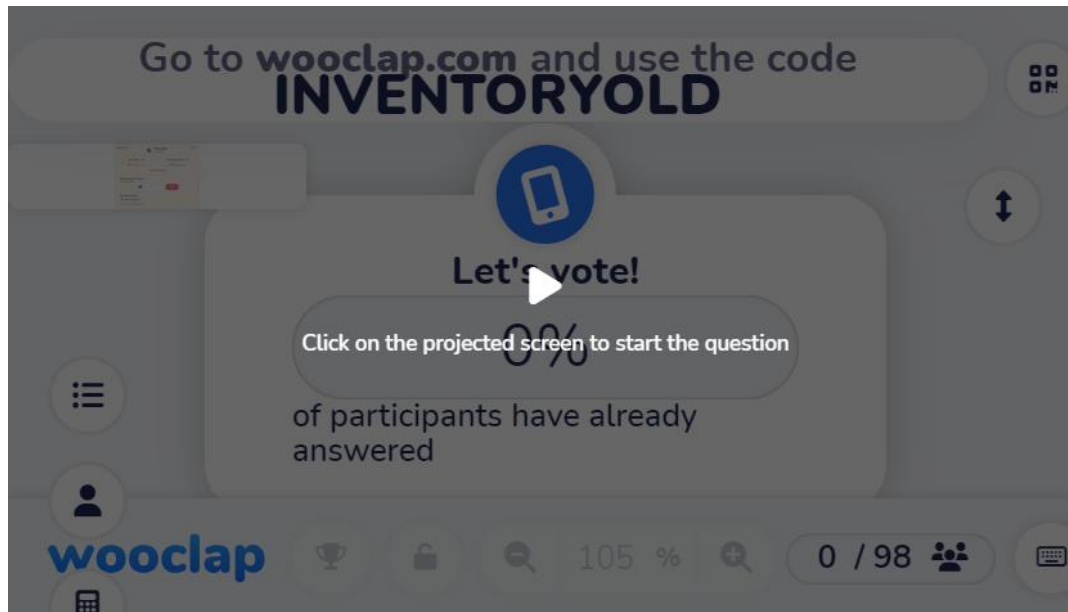
Order = 14 (= Net Inventory - Order-up-to- level = 30 - 16)

A screenshot of a supplier interface. At the top, it says "Cost: \$ 86" and "Wholesaler Nicolas". Below that, it shows "Stock: 0 → 0" and "Backorder: 6 → 2". There is also "Demand: -8" and "Receipt: +12". A "Shipment: 12" is shown with a red 'X' and a question mark. Below this is a "New Purchase Order" section with a "Lead time: 3 weeks" and a text input field with "0" and an "Order" button. At the bottom, there is a "Planned Orders" section showing "+8 in 1 week" and "+10 in 2 weeks".

Policies in Practice

I am following a policy with a fixed quantity ($Q=20$), a periodic review ($R=1$), and a reorder point ($s=20$).

How much should I order?
(You can order multiple batches at once)



- Reorder point (s): 20
- Net inventory level: $0 \text{ (on-hand)} - 4 \text{ (backorders)} + 20 \text{ (in-transit)} = 16$
- Order = 20

A screenshot of a web interface for a "Wholesaler" named "Nicolas". The top bar shows "Cost: € 62". The main section displays inventory status: "Stock: 4 → 0", "Demand: -8", "Backorder: 0 → 4", "Receipt: +0", and "Shipment: 4". Below this, there's a "New Purchase Order" section with a "Lead time: 3 weeks" and a form to enter a quantity (currently "0") with an "Order" button. At the bottom, a "Planned Orders" section shows "+0 in 1 week" and "+20 in 2 weeks".