The Role of Partial Information and Commitment in Dynamic Transportation Procurement

Pol Boada-Collado
Sunil Chopra
Karen Smilowitz
I. Context and Introduction

Commitment Contract

Depot

Spot Market

DC

Demand

Home Delivery
I. Context and Introduction

Commitment Contract

Depot

Spot Market

DC

Demand

Home Delivery

1 week visibility
I. Context and Introduction

Commitment Contract

- Capacity
  - $ \downarrow$
  - \( \tau = 4 \text{ weeks} \)

Depot

Spot Market

24 h LTL

DC

Demand

Home Delivery

1 week visibility
I. Context and Introduction

Capacity
$\downarrow$
$\tau = 4 \text{ weeks}$

Commitment Contract

Depot

Spot Market

$\uparrow$
$\tau = 0$

DC

Demand

Home Delivery

1 week visibility
I. Partial Information

Capacity
$↓
τ = 4 weeks

Commitment Contract

Depot

Spot Market

$↑
τ = 0

DC

1 week visibility

Demand

Home Delivery

Northwestern
I. Commitment

Capacity

$↓

τ = 4 weeks

Commitment Contract

Depot

DC

Spot Market

$↑

τ = 0

1 week visibility

Demand

Home Delivery

Northwestern
I. Dynamic

Commitment Contract

Capacity
$ \downarrow$
$\tau = 4$ weeks

Spot Market

$\uparrow$
$\tau = 0$

Revisit Actions

1 week visibility

Demand
Home Delivery

Northwestern
The decision process faced by the company is a common scenario:

- Brick and mortar and e-commerce offering delivery service operate in partial visibility of their demand as transportation needs are known within their delivery time window.
I. Context and Introduction

The decision process faced by the company is a common scenario:

- Brick and mortar and e-commerce offering delivery service operate in partial visibility of their demand as transportation needs are known within their delivery time window.

- According to National Retail Federation, 60% of the online transaction included FREE shipping.
I. Context and Introduction

The decision process faced by the company is a common scenario:

- Brick and mortar and e-commerce offering delivery service operate in partial visibility of their demand as transportation needs are known within their delivery time window.

- According to National Retail Federation, 60% of the online transaction included FREE shipping.

- More and more often, companies assume the cost of transportation, increasing the cost of moving their products. For instance, Amazon’s loss on shipping reached $7.2B in 2017 (GreekWire).
I. Context and Introduction

The decision process faced by the company is a common scenario:

• Brick and mortar and e-commerce offering delivery service operate in partial visibility of their demand as transportation needs are known within their delivery time window.

• According to National Retail Federation, 60% of the online transaction included FREE shipping.

• More and more often, companies assume the cost of transportation, increasing the cost of moving their products. For instance, Amazon’s loss on shipping reached $7.2B in 2017 (GreekWire).

How can partial information and commitment be used to reduce costs for home delivery?
I. Context and Introduction

Assume demand is stationary and capacity of the contract can be chosen...
I. Context and Introduction

Assume demand is stationary and capacity of the contract can be chosen...

If there is NO demand visibility:

- The solution is a straightforward Newsvendor critical fractile.
- At each decision epoch, the same action is taken.
I. Context and Introduction

Assume demand is stationary and capacity of the contract can be chosen...

If there is NO demand visibility:

- The solution is a straightforward Newsvendor critical fractile.
- At each decision epoch, the same action is taken.

If there is demand visibility: Assume we see that next week demand is almost zero:

- Do not sign the commitment contract.
  Use the spot market and wait one week.
I. Context and Introduction

Assume demand is stationary and capacity of the contract can be

The visibility of demand changes the structure of the optimal policy.

If there

- The solution is a straightforward Newsvendor critical fractile.
- At each decision epoch, the same action is taken.

If there is demand visibility: Assume we see that next week demand is almost zero:
- Do not sign the commitment contract.
  Use the spot market and wait one week.
Assume demand is stationary and capacity of the contract can be relaxed.

The visibility of demand changes the structure of the optimal policy.

Partial visibility allows to use more efficiently the contract option.

If there is demand visibility: Assume we see that next week demand is almost zero:

- Do not sign the commitment contract.
  Use the spot market and wait one week.
I. Context and Introduction

Assume demand is stationary and capacity of the contract can be

The visibility of demand changes the structure of the optimal policy.

Partial visibility allows to use more efficiently the contract option.

Partial visibility creates value by dynamically changing contracting and capacity decisions.
# I. Context and Introduction: Literature Review

<table>
<thead>
<tr>
<th>Level of demand information available</th>
<th>Citations</th>
</tr>
</thead>
</table>
| Null                                 | Bassok and Anupindi (1997)  
                                      | Martínez-de Albéniz and Simchi-Levi (2005)  
                                      | Inderfurth et al. (2013) |
| Full                                 | Atamtürk and Küçükyavuz (2005)  
                                      | Martínez-Costa et al. (2014)  
                                      | Sargut and Romeijn (2007) |
# I. Context and Introduction: Literature Review

<table>
<thead>
<tr>
<th>Level of demand information available</th>
<th>Citations</th>
</tr>
</thead>
</table>
| Null                                 | Bassok and Anupindi (1997)  
Distribution of the future demand is known.  
Martínez-de Albéniz and Simchi-Levi (2005)  
Inderfurth et al. (2013) |
| Partial                              | Boada-Collado et al. (2018)*  
Deterministic information in the information horizon.  
Only distribution demand known after information horizon. |
| Full                                 | Atamtürk and Küçükyavuz (2005)  
Martínez-Costa et al. (2014)  
Sargut and Romeijn (2007) |

II. General Model Formulation

We formulate the decision process as a discounted MDP with infinite time horizon and stationary demand and one period demand visibility.

$\gamma$ : Information Horizon ($\gamma=1$).
$\tau$ : Commitment Horizon.
$m$ : Type of contract.
II. General Model Formulation

We formulate the decision process as a discounted MDP with infinite time horizon and stationary demand and one period demand visibility.

\( \gamma \) : Information Horizon (\( \gamma = 1 \)).
\( \tau \) : Commitment Horizon.
\( m \) : Type of contract.
III. Fixed Capacity

We study first the case where there exist only a single capacity \((c)\) with one period of visibility.
III. Fixed Capacity

We study first the case where there exist only a single capacity $(c)$ with one period of visibility.

Null-Info policy:

\[
\begin{array}{ccccccc}
\text{Sign a Contract} & & & & \text{Do not Sign} \\
0.0 & 0.2 & 0.4 & & 0.6 & 0.8 & 1.0 \\
\end{array}
\]

$p$: price contract

$p'$: price spot market
III. Fixed Capacity

We study first the case where there exist only a single capacity \( c \) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity

We study first the case where there exist only a single capacity ($c$) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity

We study first the case where there exist only a single capacity \((c)\) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity

We study first the case where there exist only a single capacity \( c \) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity

We study first the case where there exist only a single capacity (c) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity

We study first the case where there exist only a single capacity ($c$) with one period of visibility.

Null-Info policy:

Partial-Info policy:
III. Fixed Capacity: Value of Information

capacity=1

![Graph showing the value of information with expected cost and expected demand.](image)
III. Fixed Capacity: Value of Information

The value of information is lower at the extremes of the expected value. (70% of the capacity in this it is higher for intermediate values experiment)
IV. Variable Capacity

We now consider that capacity is chosen by the decision maker:

- Observe next period Demand
- Do we sign a contract?
  - Yes
  - No
  - Next period
IV. Variable Capacity

We now consider that capacity is chosen by the decision maker:

Observe next period Demand

Do we sign a contract?

Yes

What Capacity?

Commitment $\tau$ periods

No

Next period

It is assumed that capacity can be chosen from a continuum ($\mathbb{R}$)*

*(see article for the discussion on the discrete case)
IV. Variable Capacity

We now consider that capacity is chosen by the decision maker:

It is assumed that capacity can be chosen from a continuum ($\mathbb{R}$)*

If we have no information:

- Always sign the contract.
- Always the same capacity:

$$C_{null}:$$ Null information capacity. It is the 1-period Newsvendor solution.

*(see article for the discussion on the discrete case)
IV. If we have partial information

Do we always sign the contract?
IV. If we have partial information

Do we always sign the contract?

Proposition:

(“If the observed demand is small enough, do not sign the contract”)
IV. If we have partial information

Do we always sign the contract?

Proposition:

(“If the observed demand is small enough, do not sign the contract”)

What is ‘large’ demand or ‘small’ demand when capacity can be chosen?
IV. If we have partial information

Do we always sign the contract?

Proposition:

("If the observed demand is small enough, do not sign the contract")

What is ‘large’ demand or ‘small’ demand when capacity can be chosen?

If we sign, at what capacity?
IV. If we have partial information

Do we always sign the contract?

**Proposition:**

(“If the observed demand is small enough, do not sign the contract”)

What is ‘large’ demand or ‘small’ demand when capacity can be chosen?

If we sign, at what capacity?

**Proposition:**

(“If we choose to sign the contract, the committed capacity depends on the observed demand”)
IV. Variable Capacity

With partial information: How do we choose capacity?
IV. Variable Capacity

With partial information: How do we choose capacity?

Assume that we sign the contract...
IV. Variable Capacity

With partial information: How do we choose capacity?

Assume that we sign the contract...

(Signed capacity explicitly depends on the demand observed. It adapts to the demand observed (up to a limit).)
IV. Variable Capacity

With partial information: How do we choose capacity?

Assume that we sign the contract...

Signed capacity explicitly depends on the demand observed.
It adapts to the demand observed (up to a limit).
IV. Variable Capacity

With partial information: How do we choose capacity?

Assume that we sign the contract...

Signed capacity explicitly depends on the demand observed. It adapts to the demand observed (up to a limit).
IV. Variable Capacity

With partial information: How do we choose capacity?

Assume that we sign the contract...

Signed capacity explicitly depends on the demand observed. It adapts to the demand observed (up to a limit).
IV. Variable Capacity

How does the value of information change with commitment time?
IV. Variable Capacity

How does the value of information change with commitment time?
IV. Variable Capacity

How does the value of information change with commitment time? and expected demand?
IV. Variable Capacity

How does the value of information change with commitment time? and expected demand?

Partial information is valuable in all the range of expected demand
V. Conclusion and further research
V. Conclusion and further research

- In practice, many companies operate under the partial information scenario.
V. Conclusion and further research

- In practice, many companies operate under the partial information scenario.
- When used appropriately, partial information creates value.
V. Conclusion and further research

- In practice, many companies operate under the partial information scenario.
- When used appropriately, partial information creates value.
- Partial visibility changes when whether you commit or not.
- In practice, many companies operate under the partial information scenario.

- When used appropriately, partial information creates value.

- Partial visibility changes when whether you commit or not.

- Partial visibility also changes the level of capacity at which you commit.
V. Conclusion and further research
V. Conclusion and further research

- How do this analysis and conclusions generalize to a network of DC?
V. Conclusion and further research

- How do this analysis and conclusions generalize to a network of DC?
- What can we say when demand is non-stationary?
V. Conclusion and further research

- How do this analysis and conclusions generalize to a network of DC?
- What can we say when demand is non-stationary?
- How do the policies change when we can sign more than one contract?
Thank you

Pol Boada-Collado

@P_boadacollado

SSNR: The Role of Partial Information and Commitment in Dynamic Transportation Procurement