

Institutt for industriell økonomi og teknologiledelse

## Eksamensoppgave i TIØ4285 Produksjons- og nettverksøkonomi

Faglig kontakt under eksamen: Peter Schütz

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**Eksamensdato:** 15. mai 2018

**Eksamensstid (fra-til):** 09:00 – 13:00

**Hjelpekode/Tillatte hjelpeemidler:** A – Alle trykte og håndskrevne hjelpeemidler tillatt.  
Alle kalkulatorer tillatt.

**Annен informasjon:**

**Målform/språk:** Bokmål

**Antall sider (uten forside):** 3

**Antall sider vedlegg:** 0

### Informasjon om trykking av eksamensoppgave

Originalen er:

1-sidig  2-sidig

sort/hvit  farger

skal ha flervalgskjema

Kontrollert av:

07.05.18 Peter Sc   
Dato Sign

## Exercise 1 (20 %)

Traditionally, Bank Trønder has only given out loans to customers with a low credit risk that have a high probability of paying back the loan. Richard, the bank's new CEO, considers now to also give out loans to customers with high credit risk.

If he only gives out loans to customers with low credit risk, the bank will make a profit of 160 million. In case he also gives out loans to customers with high credit risk, the bank will earn 800 million, as long as the economy is good. If the economy is bad on the other hand, the bank will lose 320 million, as many customers will no longer be able to pay back their loans.

There is a 75% probability that the economy will be bad. Richard's work contract guarantees him a bonus of 1% of the profits as long as these are positive. Both Richard and the bank's owners are risk-neutral.

- a) Which decision is Richard going to take? Will he give out loans to customers with high credit risk?
- b) Would Richard have taken a different decision, if he had been risk-averse with the following utility function:  $u = \sqrt{b}$ , where  $u$  is Richard's utility and  $b$  is Richard's bonus?
- c) Which decision would the bank's owners prefer Richard to make?

The bank's owners consider giving a new contract to Richard. According to the new contract, Richard will get a fixed salary of 1.15 million plus 0.25% of the bank's profit.

- d) Will the new contract cause Richard to take a different decision? Will Richard be happy with the new contract?
- e) Which problem do the bank's owners face?

## Exercise 2 (25 %)

Over the past years, Norwegian Wood has managed to establish themselves as one of Norway's most important producers of pinewood and is serving large and small customers from the furniture industry both in Norway and abroad. Fine Stoler AS needs a supplier for its newly established product line Furu Premium. We assume in this exercise, that one unit of pinewood from Norwegian Wood results in one unit of processed goods that Fine Stoler can sell.

Customer demand for Furu Premium that Fine Stoler AS faces in the market is given as:

$$p = 100 - \frac{1}{2}q,$$

where  $p$  is the price Furu Premium is sold for in the market and  $q$  is the number of products sold in the market.

Fine Stoler's cost function is given as  $C_L = 75 + 40q$ , while the cost function of Norwegian Wood is  $C_N = 60 + 10q$ . If Norwegian Wood does not enter into a contract with Fine Stoler AS, they can sell the pinewood to one of their other customers giving them an alternative profit of 540.

The initiative for suggesting contracts has been given to Fine Stoler AS. The company considers two different types of contracts: a one-part linear contract and a two-part linear contract.

- a) How does the optimization problem look like that Fine Stoler AS has to solve in order to maximize its profits?
- b) Assume that both companies have the same information. Which two contracts will Fine Stoler offer to Norwegian Wood and how will these contracts distribute the profit between the two companies?
- c) How would the optimal contracts look like if Norwegian Wood had taken the initiative to suggest contracts?

Assume now that Norwegian Wood's true cost function is unknown to Fine Stoler AS. Fine Stoler AS has therefore employed some consultants, who are experts on the production of pinewood, and they estimate that Norwegian Wood's variable costs are constant and most likely uniformly distributed between  $\underline{c}$  and  $\bar{c}$  ( $\underline{c} \leq 10 \leq \bar{c}$ ).

- d) Discuss the consequences this information asymmetry has for the contracts Fine Stoler AS is offering to Norwegian Wood.

### Exercise 3 (20 %)

Løsøre AS needs a new main supplier and is currently negotiating with several potential candidates to determine who will be awarded the contract. The company considers to use a first-price, sealed-bid auction in order to take the final decision, but needs a little bit of help to evaluate the consequences of this process. The candidates Løsøre AS has negotiated with so far are risk-neutral, symmetric and have reservation prices that are uniformly distributed between 60 and 75.

- a) Løsøre AS has so far talked to 5 possible suppliers. What is the expected price Løsøre has to pay if it awards the contract to the bidder with the lowest bid?
- b) It is still possible for other suppliers to join the auction, but Løsøre AS may have to spend some money to attract them. How much should Løsøre be willing to spend to attract one additional bidder?
- c) The cost of attracting new bidders (in addition to the 5 Løsøre already has) is given as  $c_b = 1 + 1,25n$ , where  $n$  is the number of new bidders. With how many bidders should Løsøre AS carry out the auction?
- d) Could Løsøre AS have reduced its cost further by choosing a different auction type? Explain.

### Exercise 4 (20 %)

A company produces goods in country  $A$  and sells the amount  $q_A$  in country  $A$  and the amount  $q_B$  in the neighboring country  $B$ . To transport goods to country  $B$ , the supplier has to rent pipeline capacity from a transportation service provider (TSP). The goods supplier is a monopolist in both countries. The TSP is a price-taking agent and offers transportation services in the amount of  $f^T$ .

Consider a single period problem wherein the producer maximizes profits consisting of sales revenues, quadratic production costs and transportation charges (rental cost + congestion fee). The TSP maximizes congestion fee revenues. Ignore losses in transportation.

We can write the producer's problem as:

$$\max \begin{pmatrix} (a_A - b_A q_A)q_A + (a_B - b_B q_B)q_B \\ -c^P(q_A + q_B) + d^P(q_A + q_B)^2 \\ -(c^T + \tau^T)q_B \end{pmatrix}$$

subject to  $q_A + q_B \leq cap^P \quad (\lambda^P \geq 0)$

We can write the TSP problem as:

$$\max \tau^T f^T$$

subject to  $f^T \leq cap^T \quad (\lambda^T \geq 0)$

The following condition enforces market clearing in the market for transportation services:

$$f^T = q_B \quad (\tau^T \in \mathbb{R})$$

The complementarity problem for the market equilibrium is then given as:

$$0 \leq q_A \perp c^P + 2d^P(q_A + q_B) - a_A + 2b_A q_A + \lambda^P \geq 0 \quad (1)$$

$$0 \leq q_B \perp c^P + 2d^P(q_A + q_B) + (c^T + \tau^T) - a_B + 2b_B q_B + \lambda^P \geq 0 \quad (2)$$

$$0 \leq \lambda^P \perp cap^P - q_A - q_B \geq 0 \quad (3)$$

$$0 \leq f^T \perp \lambda^T - \tau^T \geq 0 \quad (4)$$

$$0 \leq \lambda^T \perp cap^T - f^T \geq 0 \quad (5)$$

$$\tau^T \in \mathbb{R}, \quad f^T - q_B = 0 \quad (6)$$

- a) Reformulate condition (2) such that it can be read as the optimality criterion "marginal cost equals marginal revenue" (MC=MR) for the amount sold to country  $B$ ,  $q_B$ .
- b) The main difference between condition (1) and condition (2) is the term  $(c^T + \tau^T)$ . What is the meaning of  $c^T$  and  $\tau^T$ ? What can you say about the value of  $q_B$ , if  $\tau^T > 0$  (strictly positive)?
- c) Is it possible that both  $\lambda^P > 0$  and  $\lambda^T > 0$  at the same time? Explain why not or sketch a possible situation wherein that would happen.

## Exercise 5 (15 %)

In this exercise, you are given four different discussion questions. In each case, you are requested to explain and/or discuss the statement using what you have learnt in this course. The statements may be right or wrong, and some of them may be vague or imprecise. State the necessary assumptions in each case and, when necessary, discuss the relevant aspects of imprecise formulations.

- a) The Bullwhip-effect can be reduced by changing the distribution system.
- b) In a Vickrey auction (second-price, sealed-bid), risk-averse bidders will increase their bids to increase the probability of winning the auction.
- c) Centralized distribution systems will always have lower safety stocks than decentralized distribution systems.
- d) One of the challenges of Moral Hazard in the insurance industry is that it causes insurances to have the wrong prices.

Department of Industrial Economics and Technology Management

## Examination paper for TIØ4285 Production- and Network Economics

**Academic contact during examination: Einar Belsom**

**Phone: 415 09 767**

**Examination date: Tuesday, May 30, 2017**

**Examination time (from-to): 0900-1300**

**Permitted examination support material: A: All printed and hand-written support material is allowed. All calculators are allowed.**

**Other information: Answer in English, Norwegian, Swedish or Danish.**

**Language: English**

**Number of pages (front page excluded): 5**

**Number of pages enclosed: 0**

<b>Informasjon om trykking av eksamensoppgave</b>
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Originalen er:

1-sidig  2-sidig

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Date

Signature

## **1. Construction kit from IKEA or exclusive design from Boffi (25 %)**

Kitchen furnishings consist of cupboards, drawer cabinets, counter tops, sinks, taps, appliances and some other stuff. The different brands offer, broadly speaking, the same functionality, but price levels are dramatically different. A medium size furnishing from IKEA may cost 30 000 NOK without appliances, tap and sink. The customer then must organize the construction of cabinets from parts and also fix them to walls etc. A similar amount of cabinetry from one of the luxury suppliers, such as Italian firm Boffi, can easily cost 300 000. Then the cabinets aren't construction kits. The design is more exclusive, but there are no significant differences in functionality.

Kitchen furnishings are distributed through several sales channels. We have shops that primarily focus on kitchen. Often, they also sell bathroom furnishings and wardrobes which are closely related products. Vi have furniture, building supplies as well as appliance and electronics warehouses that sell kitchen furnishings in addition to a vast number of other products. Consumers and professional property developers thus can buy kitchen furnishings at IKEA, Maxbo or Elkjøp if they like.<sup>1</sup>

The specialized kitchen stores in Norway had a turnover of about 5.3 billion NOK (excluding value added tax) in 2016 according to Virke.<sup>2</sup> In addition there is sales from for example IKEA, that has about one third of the market, Elkjøp that sells Epoq kitchens, Maxbo that sells Marbodal and Harmoni and so on. The total Norwegian market can be estimated at about 8 billion NOK turnover per year.

IKEA has had great success with construction kit kitchens and clearly is the largest kitchen supplier in Norway. Others have tried roughly the same recipe. Examples include Kvik, Gjør Det Selv HTH and Norema Best Pris.<sup>3</sup> Moreover there are many suppliers in what we can denote a medium segment that deliver cabinets assembled from factory and offer kitchens in different styles and materials. Some well-known brands in Norway are HTH, Norema, Strai, Sigdal, JKE, Mabalpa and Huseby. As a simplification, we can say that the medium segment costs twice of the construction kit segment.

The more exclusive brands focus on more elegant surfaces, more expensive materials, even more sturdy material in cabinet bodies and puts more emphasis on tailored solutions. Multiform, uno form, Next 125 are examples of brands that are marketed in Norway. They are in a significantly higher price range than for example HTH. Above this premium segment we can define a luxury segment. Boffi, Swedish brand Kvänum, German Poggenpohl, bulthaup and SieMatic are good examples. Then a kitchen with appliances often comes at a half million NOK or more.

Cupboards and drawers require hinges and drawer slides that must endure frequent use over many years. Kitchen producers typically buy such parts from subsuppliers. Austrian, family owned Blum, with 6 800 employees, 15 billion NOK yearly turnover and some 1 000 patents, maybe is the best-known firm in a supplier niche that seems much more concentrated than the kitchen industry.

The material use for countertops is quite varied. Stainless steel, laminate, solid wood and natural stone, like granite, are traditional options. Over the last decades other materials have become usual. Engineered stone consists of crushed stone, typically containing much quartz, bound together with an adhesive into slabs that appear very similar to natural stone. Corian is an

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<sup>1</sup> IKEA is a large furniture warehouse chain. Maxbo is a well-known, Norwegian building supplies chain. Elkjøp is one of the largest appliance and electronics warehouse chains in Norway.

<sup>2</sup> Virke, the Enterprise Federation of Norway, organizes and represents over 20 000 businesses with more than 225 000 employees in Norway.

<sup>3</sup> "Gjør Det Selv" means "do it yourself". "Best pris" means "best price". Kvik, HTH and Norema are brand names.

example of another material. It is made from plastic and aluminum hydroxide. In recent years, also so-called porcelain slab countertops have been introduced. This material is similar to the porcelain used in e.g. dinner plates.

At least some brands produce some of the countertops they offer. But also these important parts of kitchen furnishing are to a large degree produced by a subsupplier industry. It is, however, not as dominated by a few large firms as is the case for hinges, drawer slides etc. Similarly, are taps and sinks mainly produced by a subsupplier niche where some firms surely are larger and more known than other firms, but where competition is intense.

As for some other industries, like sun glasses, cosmetics and branded clothes, there are some firms that own several of the brands in the kitchen industry. One example, particularly relevant for us in Scandinavia, is the Swedish company Nobia. The table below lists the kitchen brands Nobia owns and what markets they are in. Nobia has 13 production sites in a total of 6 European countries.

Brand	Markets
HTH	Denmark, Norway, Sweden, Finland
uno form	Denmark, Norway, Sweden
Marbodal	Sweden, Norway
Norema	Norway
Sigdal	Norway
Invita	Denmark
Petra	Finland
A la Carte	Finland, Russia
FM	Austria, Germany, Switzerland
ewe	Austria, Germany, Switzerland, Great Britain, Slovenia
INTUO	Austria, Germany, Switzerland, Great Britain, Slovenia
Commodore & CIE	Great Britain
Gower	Great Britain
Interior Solutions	Great Britain
Magnet	Great Britain
Rixonway Kitchens	Great Britain

Several kitchen brands are undoubtedly strong brands. It is maybe still surprising for many that some of them are considered among their country's leading luxury brands in competition with for instance expensive cars, watches and clothes. In the ranking published by Inlux, a consulting firm specializing on luxury markets, and EY, the accounting giant, bulthaup is in fifth place among German luxury brands in 2016. The exclusive, sporty car brand Porsche, must settle for tenth place.

bulthaup markets three kitchen designs: b1, b2 and b3. b2 is a very untraditional design that appeals to a narrow target audience. It consists of a workbench with sink and cooktop, and tall, wide cabinets. b2 thus does not have traditional cabinets with doors or drawers with countertop on top. b3 is a luxury kitchen with a normal combination of different sized cabinets, countertops and so on. It is considered the company's big seller. b1 is an entry-level model with many of the same elements as b3, but much more limited selection of options, and the quality level is not as high. The intention is that b1, which is significantly cheaper than b3, will appeal to a younger target audience. This series is produced by a company bulthaup does not own.

At bulthaup the same employee bevels all edges on the fronts of drawers and cupboards of the b3-kitchen for a particular customer, thus avoiding that minor differences in technique of different

persons result in differences in finishing for different parts of the kitchen. These parts are only made after the customer has ordered the kitchen. It is maybe no surprise then that the time from order to delivery regularly is three months. The company exports 80 % of the production. They claim that 85 % of the kitchens they produce contain parts tailored for that particular kitchen.

Consumers and property developers hunting for a kitchen can choose among many suppliers in different market segments. There are several sales channels. Kitchen producers use subsuppliers for many important parts. They may have several brands that each come in different models. And they to some extent outsource production of cabinets also. The degree of concentration varies for different parts of the value chain. Why is there such a large variation in the production network for a group of products that have been produced for so long?

*Based on the story above and course learning material, answer the questions below! Evaluation will be based on ability to use the relevant terminology, focus on the most central aspects as well as precise and concise communication.*

- 1.1 Several very important elements in kitchens are produced by subsuppliers. Discuss the circumstances that contribute to this!
- 1.2 Nobia owns 16 kitchen brands where several of them compete against each other in the same market. What mechanisms can explain this strategy?
- 1.3 bulthaup has chosen to develop and market a kitchen model, b1, that is not as exclusive as the other models and has entered into a long-term agreement with an independent firm that produces this model. Discuss potential benefits and risks related to such a strategy!
- 1.4 Explain why the industry niche that supplies countertops is less concentrated than the one that supplies hinges, drawer slides and similar parts!

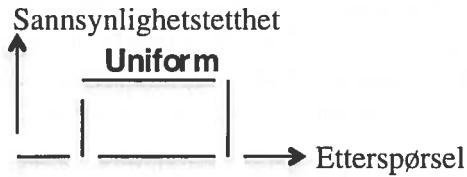
## **2. Value of integration under asymmetric information (50 %)**

Cool Clothes Inc. (CCI) sells clothes through stores the company does not own. The strategy is to adapt to the newest trends among very fashion conscious adolescents. It yields high margins for clothes that are actually sold, while garments that are not sold during a relatively short period, must either be discarded or sold to at considerable discount. In this assignment, you are to analyze the relationship between CCI and a store and, towards the end, assess the potential value vertical integration.

In order to not make it too complicated, we will consider a typical garment with a price of 1 500 to the customer. The store has variable costs that amount to 100 per garment sold. If the garment is not sold quickly the average value is 750. CCI demands a wholesale price at 1 000 for the garment, and has a unit production cost of 500. This cost includes all variable costs CCI has related to the product, including costs of transportation to the store. (Both CCI and the store has fixed costs as well, however we shall not relate to them in this assignment.)

CCC sells theirs clothes through about 50 stores, and each store markets collections that corresponds to about 100 typical garments.

Even though CCI works intensely to capture the latest trends among adolescents and typically is quite successful in creating popular designs, there is significant uncertainty related to the demand for individual garments. Here we shall assume that demand for the typical garment is uniformly distributed from 800 to 1600 units in the period it can be sold at full price. The figure below illustrates what is implied by a uniform distribution.



Until question 2.4 you are to assume CCI has full information regarding the costs of the store, the distribution of demand and how the store relates to the demand. Until question 2.5 you are to assume both CCI and the store acts as if they are risk neutral. In question 2.1 the premise is that the contract between CCI and the store implies that the store chooses how many garments to order at a given wholesale price of 1 000 per unit and must sell the garments at a price of 1 500 to customers. In 2.2 you evaluate alternative contracts that can increase the profit for CCI given that the price to customers still is 1 500. In 2.3 you will evaluate contracts in a setting where the store can determine the price to customers and the expected demand depends on this price. In 2.4 you are to take into consideration that CCI doesn't necessarily know the cost structure of the store exactly, assess implications for contracts and estimate the value of vertical integration in terms of the economic issues raised in the assignment. In 2.5 you assess the implications of removing the assumption of risk neutrality. Question 2.6 is independent from other subtasks.

- 2.1 For each of the three following assignments you are to define appropriate symbols and express general answers in terms of them. These answers are expected to reflect the uniform distribution as defined in the case text. Then you are to provide numerical values for the particular cases as well.
  - a. How many units of the typical garment should the store order?
  - b. What is the expected profit for the store related to the garment?
  - c. What is the expected loss for the store due to uncertainty related to the garment?
- 2.2 For the following two assignments, you do not need to provide answers in terms of symbols, but document your logic. For each of the contract forms specified in the two subtasks below, you are to find an optimal contract as seen from the perspective of CCI and estimate change in profit relative to the contract 2.1 was based on.
  - a. Evaluate a two-part, linear contract, i.e. a contract that specifies a fixed money transfer between CCI and the store in addition to a unit price per garment ordered by the store!
  - b. Evaluate a buy-back contract, i.e. a contract that specifies a unit price per unit of the garment the store orders as in 2.1, but where CCI must pay the store some amount for each garment that is not sold so that the value increases by this amount from the mentioned value of 750!
- 2.3 Expected demand for the garment can be expressed as  $E[Q] = 1575 - 0,25 \cdot P$  where  $E[Q]$  is the expected quantity and  $P$  is the price. Assume now that for each possible expected quantity  $E[Q]$ , demand is uniformly distributed in the interval  $\left[\frac{2E[Q]}{3}, \frac{4E[Q]}{3}\right]$ . Also assume that the store decides on the price and determines how many units of the garment to order.
  - a. Consider a one-part, linear contract, i.e. a contract where CCI only specifies a unit wholesale price the store must pay per garment it orders. What wholesale price should CCI charge? What will the price to customers become and what profits will CCI and the store earn?
  - b. In this subtask calculations are not required, but good arguments for your assessments are expected. Compared to the situation where the price is given so that the store cannot set the price, will CCI have stronger or weaker economic incentives to introduce a two-part

linear or a buy-back contract?

- 2.4 Assume now that CCI does not know the marginal costs of the store exactly, but relates to a uniform distribution from 50 to 150 for it. In the two following subtasks, the expectation is primarily qualitative arguments based on insights regarding the magnitude of effects, but supplementing, exact calculations are also welcome.
- Explain what implications it will have for the contracts discussed in earlier tasks that CCI does not know the marginal costs of the store exactly!
  - Will asymmetric information lead to the value creation in the value chain not being optimal? Explain why or why not! Assuming vertical integration is the only option for solving potential problems asymmetric information causes for value creation, estimate the value of vertical integration related to the typical garment!
- 2.5 Discuss implications for analysis above of removing the assumption of risk neutrality and instead assume CCI and stores are risk averse related to their total profit! Evaluate to what extent a normal degree of risk aversion is apt to change optimal orders, profits, profitability related to various contracts and the value of vertical integration! Calculations are not necessary, but explain!
- 2.6 The so-called bullwhip effect is discussed in the course syllabus. Explain briefly what this effect is and what mechanisms causes is! How will this kind of effect possibly arise in the relationship between CCI and stores! What can CCI and stores potentially do to limit the effect?

### **3. Auction forms (15 %)**

In this assignment, you are to discuss insights from auction theory based on the "independent private value model".

- Explain the meaning of the "revenue equivalence theorem" and what mechanisms that lead to this result!
- What effect will risk aversion among bidders or for seller have in relation to which of the common first- and second price auction forms will be preferred?
- In a so-called "all-pay auction" all bidders pay their bid, but only the highest bidder gets the object. Is the "revenue equivalence theorem" relevant for this auction form? What can we say about the effect of risk aversion for this auction form?

### **4. Principal agent theory and transfer pricing (10 %)**

Discuss similarities and differences between principal agent theory and perspectives on transfer pricing discussed in course syllabus!



Department of Industrial Economics and Technology Management

## **Examination paper for TIØ4285 Production- and Network Economics**

**Academic contact during examination: Einar Belsom**

**Phone: 415 09 767**

**Examination date: Friday, June 3, 2016**

**Examination time (from-to): 0900-1300**

**Permitted examination support material: A: All printed and hand-written support material is allowed. All calculators are allowed.**

**Other information: Answer in English, Norwegian, Swedish or Danish.**

**Language: English**

**Number of pages (front page excluded): 4**

**Number of pages enclosed: 0**

**Checked by:**

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Date

Signature

## **1. Gigafactory (25 %)**

In May 2016, Panasonic Corporation, founded by Konosuke Matsushita in 1918, had a market capitalization of equity of about \$20 billion. It had some 250 000 employees in about 475 subsidiaries. It is active in many areas related to electronics, including household appliances, consumer electronics, and batteries. In 2015 the company had net sales of \$69 billion and a net income of \$1.8 billion.

Electric car producer Tesla Motors Inc. had total revenues of \$4,0 billion in 2015. It has about 13 000 employees. The net income was negative as it has been since the company was founded in 2003. This year the loss was about \$0.9 billion. The market capitalization of equity in May 2016 was \$29 billion.

Considering the market prices of Tesla stock, it is clear that investors bet on Tesla becoming very profitable in the future. And one key to that profitability might just be a joint venture with Panasonic to build and run the so-called Gigafactory that will produce battery packs.

Tesla's first car was a two-seated roadster with a selling price at around \$100 000. The battery pack contained 6 831 lithium-ion cells of the same type used in e.g. laptops. Hence, the company could source the cells from a global market. And since it only produced this car in limited numbers – only about 2 600 in total from 2008 to 2012 – it did not need a major part of the world production of the cells. The second model, the model S which is a large luxury car that has been produced since 2012, so far has reached cumulative global sales of some 120 000 units. The newest model in production, Model X that can be considered the SUV version of the Model S, had reached cumulative deliveries of about 2 700 units early April 2016. Deliveries of this model started in the fourth quarter of 2015. Model S has a base price in USA of \$76 500 while Model X starts at \$83 000.

Late March 2016 Tesla formally introduced the Model 3. This is supposed to be a high volume model. It is a compact car that Tesla claims will have a base price of \$35 000. By May more than 373 000 cars of this model, which will not be delivered until late 2017 at best, had been reserved. Tesla CEO Elon Musk projects that the company will be producing some 500 000 cars per year by 2020. (This is a total number for Model S, Model X, Model 3 and a new roadster model that is expected in 2019.)

The most expensive part of long range, high performance electric cars is the battery. Current cost for Tesla is nearly \$200/kWh and the cars have battery packs from 70 kWh to 90 kWh. While the smaller Model 3 is expected to have a battery pack of about 60 kWh, the battery pack's proportion of costs will be higher. It seems unlikely that Tesla can sell the Model 3 with a profit if the battery pack alone costs \$12 000.

The Gigafactory is currently being built in Nevada. It is supposed to be producing 35 GWh of lithium-ion cells in 2020. "It will produce more lithium ion batteries than all other factories in the world combined," Elon Musk has revealed. Total investments in the factory are estimated to be in the range of \$5 billion. Out of this Panasonic has committed about \$1,6 billion.

Panasonic is a leader in lithium-ion cell production with a market share around 20 % in 2015. It has twice that market share within deliveries to plug-in cars (electric cars and chargeable hybrids). Tesla is Panasonic's major customer in the car industry, though Tesla also buys cells from other producers. In the Gigafactory, Panasonic will be responsible for producing cells, while Tesla will be responsible for assembling them into battery packs with integrated heat management systems. The plant is expected to be producing about 50 GWh of battery packs per year in 2020. Tesla claims the factory will deliver battery packs at 30 % lower cost than current production.

Tesla's first model was made in cooperation with British sports car maker Lotus. The

roadster was based on the Lotus Elise though only 6 % of parts were identical. Lotus helped with basic chassis development and also delivered partly assembled cars. The electric drive train in recent models is very similar to the one Tesla developed for the roadster. In the meantime Tesla has become a more integrated car company. It produces body parts in-house, assembles cars from scratch while still producing battery packs and the electric motor. And now its sourcing strategy for cells seems to turn towards a higher degree of integration within a factory that has the largest footprint of any building in the world.

*Based on the story above and course learning material, answer the questions below!  
Evaluation will be based on ability to use the relevant terminology, focus on the most central aspects as well as precise and concise communication.*

- 1.1 Tesla sources standard lithium-ion cells from the global market. Explain what mechanisms are likely to have made this a sensible strategy so far!
- 1.2 Tesla and Panasonic now build a common factory where Panasonic will be responsible for cell production and Tesla responsible for the production of battery packs. What mechanisms can explain why Tesla no longer plans to source most cells in the open market?
- 1.3 The Gigafactory is a form of a joint venture, though Panasonic formally will be a tenant occupying about half of the building. What are likely reasons for the choice of this form of cooperation!
- 1.4 The case text specifies that cell production in the Gigafactory will be about 35 GWh while battery pack production is estimated to 50 GWh in 2020. Packs cannot have more energy than the cells they contain. Explain the significance of this information!

## **2. Value of forecast improvement and flexibility (45 %)**

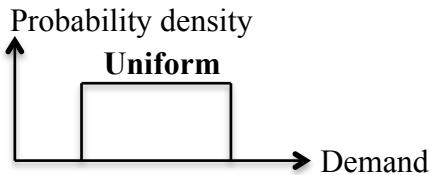
Ace Ice Cream (AIC) sells ice cream, and liquid refreshments to tourists and others in remote places. Selling crews travel in the morning by vans to tourist sights, sell during the day, then return in the evening. Currently the vans do not have mechanical freezers or refrigerators so they keep ice and drinks cold in insulated boxes that also contain ice blocks. By the end of the day, when returning to the depot, left over ice cream will have melted and has to be discarded. Drinks are usually still cold enough for enjoyable consumption, and can in any case be refrigerated to required temperature by the next day. So they are almost never discarded.

The average selling price for ice cream is €1.5 per unit. AIC pays an average of €0.75 for each unit of ice cream. For drinks, the corresponding numbers are €1 and €0.3. (The cost numbers include handling, storage etc. at the depot.) You are to assume ice cream that must be discarded has zero value, but the cost of discarding amounts to €0.01 per unit. The extra cost of offloading, refrigerating and reloading drinks that are left over, amounts to €0.02 per unit.

Currently they fill vans in the morning based on the average sales during the last 14 days. To determine the amount of drinks to bring they multiply the average sales by 1.2. For ice cream they multiply by 1.1.

Recently a master student has been working as a seller while reviewing the forecasting approach. Noting the exact times stockouts occur, the student estimates actual demand even in case some product is sold out during the day. After a substantial number of days, the student compares demand numbers with the forecasts for the corresponding days, and estimates forecast errors for both ice cream and drinks to be uniformly distributed, so that demand can be assumed uniformly distributed around the 14-day average. However it seems

ice cream demand is more volatile – the student thinks it is related to just how hot it is during the day. For drinks the estimated low and high limits in the distribution are 25 % below and 25 % above the average. Corresponding numbers for ice cream are 40 % below and 40 % above. The figure below illustrates a uniform distribution.



Having studied the relationship between actual temperatures and demand and also the accuracy of weather forecasts, the student believes a refined forecasting model would yield much lower forecasting errors. This model would still use the 14-day average as a reference. But the forecast would be calculated by adjusting this number according to the weather forecast. For drinks the demand could then be expressed as uniformly distributed from 15 % below to 15 % above the forecast. For ice cream the corresponding numbers are from 20 % below to 20 % above the forecast. The cost of carrying out of this procedure is so low that it does not influence profitability assessments.

Until part 2.5 you are to assume vans have capacity to carry more than the quantity of ice cream and drinks AIC will want to fill them with in the morning. Throughout you are to disregard costs not explicitly mentioned in the text.

- 2.1 Consider the two approaches to forecasting mentioned in the case text. Characterize them using syllabus terminology! Discuss, briefly, strengths and weaknesses of these methods compared to likely alternatives considering the case at hand!
- 2.2 Assume that for a particular day and particular site, the average sales over the last 14 days has been 500 units of drinks and 250 units of ice cream. For simplicity assume there is only one kind of ice cream and one kind of drink. Consider the current forecasting approach with the student's estimates for forecast error. For each of the three following assignments you are to define appropriate symbols and express general answers in terms of them. These answers are expected to reflect the uniform distribution as defined in the case text. Then you are to provide numerical values for the particular cases as well.
  - a. What quantity of ice cream and drinks should be brought along in the van that morning?
  - b. What is the expected profit for that van that day?
  - c. What is the expected loss due to uncertainty that day?
- 2.3 For the following assignments you do not need to provide answers in terms of symbols, but document your logic. Consider expected profits of different approaches to determining quantities to bring in the van.
  - a. Do your calculations in 2.2 represent an improvement over the current approach to determining how much to bring? If so, by how much?
  - b. Assuming the student is right about forecast errors, what impact would using weather forecasts to adjust quantities have?
- 2.4 AIC is considering whether to modernize the vans. Freezers and refrigerators could be installed so they no longer would need to discard ice cream or reload drinks. What impact would this equipment have on expected profit on this typical day when assuming

medium hot weather so that expected demand is as above?

- 2.5 Consider now the possibility that on a given day the combination of forecast and methodology to determine quantities to bring could imply larger quantities than the capacity of the van. Assume both the current and the potential new equipment would allow flexibility in terms of the proportion of drinks relative to ice cream. Explain in what way capacity restraints would influence optimal quantities with the different equipment types!
- 2.6 The student arrived at uniform distributions. Many would think this unlikely to be an accurate description of actual forecast error distributions. What kind of distributions would be more likely? If they have the same standard deviation as the uniform distributions, in what way would results above change? Calculations are not necessary, but explain!

### **3. Double marginalization and asymmetric information (15 %)**

Firm Up sells its product through firm Down. Assume firm Up specifies contract terms and Down responds to them by ordering quantities as to maximize firm profit. There are no negotiations. Firm Down faces a demand given by  $Q = a - bP$ , where  $Q$  is the quantity,  $P$  is the price, and  $a$  and  $b$  are strictly positive parameters. Marginal costs for firm Down are  $MC_{Down} + w$  where  $MC_{Down}$  is the internal marginal cost while  $w$  is the unit wholesale price for the product bought from Up. Up has marginal costs  $MC_{Up}$ .

In the first assignment below, you shall only consider one-part linear contracts. I.e. contracts specifying only the wholesale price  $w$ . In the second you shall also consider two-part linear contracts. I.e. contracts specifying a fixed payment  $F$  in addition to the unit wholesale price.

- 3.1 Assume that both firms have perfect information regarding demand and that firm Up knows the marginal costs of Down. Derive an expression for the optimal wholesale price,  $w$ , in case firm Up offers a one-part linear contract!
- 3.2 Assume now that firm Up cannot know the marginal costs of Down but relates to some distribution of it. Down knows its marginal costs. Up might behave strictly risk neutral or show some degree of risk aversion regarding the contracting outcomes. Explain what effect the asymmetric information will have on optimal one-part and two-part linear contracts while relating to risk preferences!

### **4. Mixture (15 %)**

The following assignments are independent. Answers to each should not exceed 500 words. They may include formulas and/or illustrations whenever useful. Precise answers utilizing relevant terms and models correctly are expected.

- 4.1 The term risk pooling is sometimes used in relation to the need for security stock. Explain!
- 4.2 The revenue equivalence theorem suggests that several auction forms would give the same expected revenue for the seller. Discuss what real life phenomena might mean sellers would prefer some auction forms to others!
- 4.3 A principal agent model might be viewed as a two-stage process. In the first stage the principal sets contract terms. In the second the agent either rejects the contract or accepts it, performs his duties and gets paid. It might be the case that the principal does not know the preferences of the prospective agent and that the link between effort and results

linked to pay is stochastic. Based on this information, compare the principal agent model to principles of two-stage stochastic optimization problems?



Department of Industrial Economics and Technology Management

## **Examination paper for TIØ4285 Production- and Network Economics**

**Academic contact during examination: Einar Belsom**

**Phone: 415 09 767**

**Examination date: Thursday, May 21, 2015**

**Examination time (from-to): 0900-1300**

**Permitted examination support material: A: All printed and hand-written support material is allowed. All calculators are allowed.**

**Other information: Answer in English, Norwegian, Swedish or Danish.**

**Language: English**

**Number of pages (front page excluded): 3**

**Number of pages enclosed: 0**

**Checked by:**

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Date

Signature

## **1. Oakley – Innovator in the sunglass industry (30 %)**

James Jennard founded Oakley in 1975 with an investment of 3 000 dollars. He produced grips of a special rubber compound for motocross bikes in his garage and traveled to races using his car as a shop. Later the product range was extended with shin and elbow guards as well as some other products intended for motocross and BMX cycling. But it was the sunglasses that made Oakley a world-renowned brand.

The first goggles for motocross came in 1980. In 1983 models for alpine skiing were introduced. And in 1984 a model intended for road cycling. The first sunglasses designed for use outside sport activity came in 1985.

Oakley sold shares for 230 million dollars at the initial public offering in 1995. Twelve years later Luxottica paid 2,1 billion dollars for the shares and Oakley now is a subsidiary in a giant corporation in the eyewear business. But it also markets clothing, bags and some other products.

Oakley has had a stunning success with a strategy of differentiation where eye-catching design has been combined with technological innovations that have resulted in over 600 patents. The company has developed lens materials with high impact resistance combined with good optical performance making them suitable for sport activity. Frame materials are light, flexible and strong. The rubber compound that started the whole business, and that is supposed to become even less slippery when wet, makes sure glasses stay put even with straight temples – i.e. that do not grip around the ears.

An important element in the marketing strategy is the message of superior technology that is communicated using names that aim to signal exclusivity. The lens material is called *Plutonite*, the frame material *O-matter*, and the rubber *Unobtainium*. Sports idols that use the glasses are of course effective marketing agents. Oakley is also known for developing products in cooperation with athletes. And other companies have followed making sunglasses with similar design.

Oakley has developed sunglasses with design and technology aimed at sports and then succeeded in marketing products for large groups of consumers outside sports. It has created enormous value for shareholders and stimulated change in the sunglass industry.

Luxottica is the world's largest company in the eyewear business. It controls some 80 % of major eyewear brands. In 2014 turnover was over 7,6 billion Euro. The value of equity currently is about 31,6 billion dollars. It has more than 77 000 employees. The table below shows the most important brands.

Alain Mikli	Armani	Miu Miu
Arnette	Brooks Brothers	Polo Ralph Lauren
Eye Safety Systems (ESS)	Bulgari	Paul Smith Spectacles
K&L	Burberry	Prada
Oakley	Chanel	Ralph Lauren
Oliver Peoples	Coach	Ralph Lauren Purple Label
Persol	Dolce & Gabbana	Stella McCartney
Ray-Ban	DKNY	Tiffany & Co.
Sferoflex	Donna Karan eyewear	Tory Burch
Vogue Eyewear	Michael Kors	Versace

The company owns the brands in the first column and produces glasses on license from the other. Luxottica also owns several retail chains that sell eyewear.

Customers buying glasses from opticians normally will pay for examination, fitting, frame and lenses. Often the lenses represent the largest cost entry. Firms like Essilor, Carl Zeis AG and Baush & Lomb dominate the lens supplier industry.

Contact lenses are alternatives or complements to glasses for many. That industry is also relatively concentrated, but not to the same degree as the lens industry. Another substitute is laser eye surgery. But that is a totally different industry consisting of many small suppliers.

*Based on the story above and course learning material, answer the questions below! Evaluation will be based on ability to use the relevant terminology, focus on the most central aspects as well as precise and concise communication.*

- 1.1 Luxottica sells branded products both through retail chains it owns and through other stores. Discuss pros and cons related to integration of the retailing part of the value chain and assess whether it is a natural strategy in this industry!
- 1.2 Oakley produces frames and lenses for sunglasses in their own factories. Suppliers produce clothing and other products. Explain what properties these two product groups have that it is reasonable to believe have led Oakley to choose different degrees of integration!
- 1.3 Like many other firms that sell differentiated goods, Oakley uses famous athletes for marketing purposes. Explain what economic mechanism, discussed in course syllabus, creates a need to convince consumers about product attributes using this approach!

## **2. Rush Delivery Option (50 %)**

The Exclusive Bread Firm (EBF) distributes and sells its products to independent retailers. The product quality deteriorates quickly so that units that are left over at the end of the day have very limited sales value. Until now it has been delivering its products early in the morning. A fresh recruit from an elite industrial economics program at Norwegian university NTNU has however suggested it should offer stores a rush delivery option early in the afternoon. Here you are to analyze the economics of this proposal within a simplified setting.

Throughout you are to disregard fixed costs and assume marginal costs to be independent of quantity. EBF currently has marginal production costs of 10. The cost of delivering to a given retailer is primarily related to truck driving time and is considered independent of amount delivered each time. Assume cost per retailer that gets a delivery is 250. Currently EBF does not charge separately for delivery, but charges a wholesale price of 20 per unit of product. The price to consumers is 40. Retailers have marginal selling costs of 5 in addition to the wholesale price they have to pay. Products left over at the end of the day have a value of 3 per unit for the retailers. (Retailers sell to farmers that collect and use them in meat production.)

Assume EBF has many retailers and that demands faced by retailers are independently distributed. When analyzing the rush delivery option you are to assume it will allow EBF to produce over a longer period each day reducing marginal costs to 9. Retailers will be observing demand intensity in the first part of the day and then decide whether to order more. Assume they will behave as if they observe demand from a uniform distribution from 50 to 100, and then accurately forecast total demand of the day as twice this outcome. (Hence, for simplicity, assume that once they have observed demand intensity in the first part of the day, the total demand for the day is deterministically determined as two times this number.) The demand distribution for the whole day then becomes uniform from 100 to 200. Until 2.3 you are to assume EBF has full information regarding the retailers' costs and beliefs about demand distributions.

- 2.1 Assume first that the retailers believe daily demand is uniformly distributed from 100 to 200 and there is no rush delivery option.
- What quantity will each retailer order each day?
  - What is the expected profit for each retailer and for EBF per retailer?
  - What is the expected loss due to uncertainty per retailer?
- 2.2 Consider now some possible ways to improve profits for EBF.
- Mention some options EBF has in terms of changing its current pricing scheme towards retailers that does not involve rush delivery options! Provide at least one suggestion for an improved contract and calculate expected profit increase per retailer!
  - Explain the economic mechanisms that might lead to a positive value for rush delivery options in this setting! What is the significance of the assumption of many retailers and independent demand distributions?
  - With a pricing scheme consisting only of a wholesale price of 20, evaluate the effect on EBFs per retailer profits of introducing the rush delivery option! Also calculate the value for each retailer!
  - In answering the following question you may choose to support your arguments with calculated numbers, but it is not required. If EBF were to offer rush delivery options, what kind of contract terms would be natural for EBF to offer in this setting?
- 2.3 Consider now the more realistic assumption that EBF does not know with accuracy the marginal selling costs of retailers, nor their beliefs about the demand distribution.
- Discuss briefly how asymmetric information would influence the profit potential for EBF in the case of no rush delivery option!
  - How does asymmetric information influence the value of the rush delivery option?

### **3. Mixture (20 %)**

The following assignments are independent. Answers to each should not exceed 500 words. They may include formulas and/or illustrations whenever useful. Precise answers utilizing relevant terms and models correctly are expected.

- One insight from economic analysis suggests firms will make a trade-off between motivation for hard work and efficiency in risk sharing. Explain!
- From time to time we observe students evaluating the performance of a forecasting model using the same data that was used to calibrate the model. Explain why this might lead to inaccurate evaluations of the relative performance of forecasting models! What kind of models would tend to look good in this approach to model evaluation?
- A stochastic optimization problem is to be solved based on a scenario generation procedure. Before concluding on optimal solution, stability tests are performed. Explain the reasoning behind such reliability testing!



Department of Industrial Economics and Technology Management

## **Examination paper for TIØ4285 Production- and Network Economics**

**Academic contact during examination: Einar Belsom**

**Phone: 415 09 767**

**Examination date: Monday, June 2, 2014**

**Examination time: 0900-1300**

**Permitted examination support material: A: All printed and hand-written support material is allowed. All calculators are allowed.**

**Other information: Answer in English, Norwegian, Swedish or Danish.**

**Language: English**

**Number of pages: 5**

**Number of pages enclosed: 0**

**Checked by:**

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Date

Signature

## 1. Moods Of Norway – From Stryn to the World (30 %)

Two designers from Stryn, Simen Staalnacke and Peder Børresen started Moods Of Norway in 2003. Together with Stefan Dahlkvist they have built the brand based on the motto “Happy Clothes for Happy People”. Turnover the first year was about NOK 400 000. In 2012 it was over NOK 300 millions. The table below shows how the firm has grown over the last years.

NOK	2012	2011	2010	2009	2008
Sales income	332 843 000	291 070 000	208 162 000	79 227 000	41 158 000
Operating income	51 357 000	95 207 000	75 832 000	17 991 000	7 302 000
Pre tax profit	50 018 000	96 099 000	75 937 000	17 713 000	7 096 000
Profit after tax	32 258 000	68 948 000	52 747 000	11 986 000	4 329 000

Moods Of Norway now sells a broad selection of products. The main focus is clothes for both men and women. But there is also a wide selection of accessories like watches, sunglasses, shoes, bags, ski goggles, cosmetics and even a waffle iron. The products are sold through stores the company owns, so called “Flagship stores”, that only have Moods Of Norway products, through the web store and in shops that also sell other brands. The table below shows the number of outlets in different countries.

Country	Flagship Stores	Shops
Norway	18	250
USA	3	50
Sweden	-	14
Germany	-	9
Canada	-	6
Greece	-	1
Mexico	-	1
Russia	-	1

Production is located in factories around the world that produce for different brands. Most are in China, but several other countries are represented on the company’s list of suppliers as demonstrated by the table below.

Country	Number of factories
China	45
Italy	12
Turkey	3
France	2
India	2
Portugal	2
Lithuania	1
Norway	1
Poland	1
Romania	1
Sweden	1
Taiwan	1
Sum	72

Moods Of Norway, like many other firms in the apparel retailing industry, produces most of its products outside Europe. A drawback of the sourcing strategy is that it takes a rather long time from developing a product until it is in stores. The industry average is about half a year. And they tend to order large quantities a long time before the selling season hoping to sell everything before fashion trends change.

The highly successful retailer Zara that had sales over € 10,8 billion in 2013 and is owned by the Spanish firm Inditex, has chosen a different strategy. More than 75 % of its products are

produced in Europe and more than half in factories they own in Spain and Portugal. The geographic proximity and close control of factories enable Zara to develop new products and have them in stores within four weeks. Production plans can be quickly adapted as demand is observed. Zara exploits its production flexibility by producing some 11 000 different items a year, compared to 2 000 to 4 000 for key competitors, while still ending up selling a much smaller fraction of products at end of season markdown prices.

Moods Of Norway sells relatively high value designer merchandise that spans a large number of stock keeping units (SKUs). Each color and size of a particular garment is for many purposes a separate product that ideally should be available in stores for potential customers. But even with an advanced data system linked directly to barcode scanners at check out points they do not have accurate information on the number of each SKU available on display or in the storage at stores. Some reasons for inaccuracies are:

- Suppliers have made mistakes regarding the number of each SKU sent. (These numbers are entered into the enterprise resource planning system as starting stock levels.)
- There is shrinkage due to theft or misplaced products.
- Barcode errors – wrong barcodes attached to the product or errors reading the barcode.

Since it is rather tedious to count the contents of store floors and storage it is not done more than a few times a year. When they do, they scan barcodes on all items. But mistakes are made so that results are inaccurate. Thus even just after a count, numbers of current stock will be wrong for many SKUs. And often an item is in stock, but not easily available for customers. Such events, coined NOSBOS (not-on-shelf-but-on-stock) will sometimes lead to lost sales.

In order to increase efficiency and customer satisfaction Moods Of Norway is currently exploring an alternative to barcodes as product identifier. Since New Year two flagship stores have been testing Radio Frequency Identification (RFID) tags. These tags can be read without line of sight. A tunnel scanner can read all tags in a box. And hand held scanners can read all tags in the store or in storage shelves in a short time. This means they will be able to have almost 100 % accurate numbers for each SKU that is in the store or in storage e.g. on a weekly basis. In a full-scale implementation the suppliers will attach RFID tags to each item, and Moods of Norway then hopes this initiative will make the firm even more profitable.

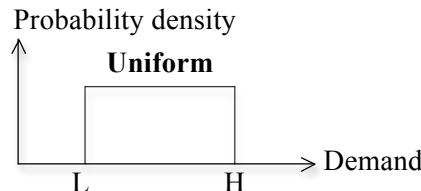
The concept of Moods Of Norway is not unique. Several design-oriented brands share their business model. Examples include Hermes, Hugo Boss, Gant, Tommy Hilfiger, and Yves Saint Laurent. Moods Of Norway thus have succeeded in entering an industry with many competitors that have a similar approach. The logo, a pink Ferguson TE20 tractor, called “Gråtass” in Norwegian, is, however, unique. And the three entrepreneurs behind “Happy Clothes for Happy People” can laugh all the way to the bank.

*Based on the story above and course learning material, answer the questions below!  
Evaluation will be based on ability to use the relevant terminology, focus on the most central aspects as well as precise and concise communication.*

- 1.1 Moods Of Norway produces in many factories around the world that they do not own themselves. Explain why this might be a sensible choice!
- 1.2 What benefits can Moods Of Norway and the supply chain gain from a full implementation of RFID tagging?
- 1.3 Zara has higher costs per item than competitors producing in overseas, low cost countries, but is still remarkably successful. Explain how supply chain performance effects might compensate for much, or all, of the cost disadvantage in production!

## 2. Down and Up (50 %)

The downstream firm, Down, is developing a new product that will require a part produced by an upstream firm called Up. Denote the wholesale price for the part  $W$ . Demand for the product Down plans to produce is uncertain and is assumed uniformly distributed between a lower bound  $L$  and an upper bound  $H$  as illustrated in the figure. The product must be produced before actual demand is observed. The price of the product,  $P$ , is assumed given independently of demand. In case they produce more of the product than demand, the value of each leftover unit is  $S$ . Marginal costs for the two firms are  $MC_{Up}$  and  $MC_{Down}$ . (For simplicity, disregard fixed costs and assume marginal costs are independent of quantity.) The table below summarizes parameters along with numerical values to be used.



Selling price	$P$	1 100
Value of unsold product	$S$	100
Marginal cost Up	$MC_{Up}$	200
Marginal cost Down	$MC_{Down}$	300
Lower bound on demand	$L$	5 000
Upper bound on demand	$H$	25 000

- 2.1. Assume now that the firms aim to maximize expected value chain profit. Provide answers to the following questions in terms of both symbols and numbers.
  - a. What quantity,  $Q$ , of the product should the firms produce?
  - b. What is the expected value chain profit?
  - c. The expected value chain profit can be decomposed into three parts. One reflects profits as if there were no uncertainty. The other two reflect expected loss due to either too high quantity or too low quantity. Compute all three!
- 2.2. Assume now that Up sets a wholesale price,  $W$ , with complete information regarding costs and the demand distribution. Down will then decide on production volume and, thus, the number of parts to order from Up.
  - a. What wholesale price will Up set? What is the consequence for value chain profit?
  - b. How does this situation compare to the concept of double marginalization?
  - c. Propose and discuss alternative contracts that can improve value chain performance!
- 2.3. More realistically the firms do not have exact information about each other's costs and Down probably has better information regarding demand than Up has.
  - a. Discuss implications of asymmetric information for contracts and value chain performance!
  - b. Assume now that Up will have to make an investment in production capacity in order to be able to produce the part but can decide on how much capacity to invest in. Explain how Down can design a two-part linear contract in such a way that it credibly conveys a belief in a high level of demand, which in turn will induce a high capacity investment by Up!

### **3. Auctions (20 %)**

The revenue equivalence theorem is central in auction theory. Here you are expected to reflect on it.

- 3.1. Explain – you are not expected to supply mathematical derivations – what the revenue theorem implies! What are the key assumptions?
- 3.2. Assume all assumptions leading to the revenue equivalence theorem hold except that bidders instead are risk averse. What are the implications of risk aversion among bidders?
- 3.3. Assume all assumptions leading to the revenue equivalence theorem hold except that bidders instead are risk averse and, also, uncertain about the value of the object in the sense that they have an opinion but will update that opinion based on information regarding other bidders' valuation of the object. What are the implications of risk aversion and this form of valuation uncertainty among bidders?