RAPPORT 1107

Harald M. Hjelle og Ola Bø

IMPLEMENTERING AV IT-SYSTEMER I VERDIKJEDEN FOR FROSSEN FISK

Sluttrapport for FIESTA-prosjektet

MØREFORSKING MOLDE

Høgskolen i Molde

Harald M. Hjelle og Ola Bø

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Forfatter(e)	Harald M. Hjelle og Ola Bø
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Sammendrag

Verdikjeden for frossen fisk har stått i fokus for FIESTA-prosjektet. I denne sluttrapporten fokuseres det på en beskrivelse av forskningsaktivitetene i prosjektet og de funn som er gjort i prosjektet knyttet til effekter av implementering av IT-systemer i verdikjeden, samt relaterte aktiviteter. Prosjektet har vært tredelt: Første del har bestått i utviklingen av et problembasert læringsopplegg knyttet til IT-investeringer og effektivitet i verdikjeden (FIESTA-skolen). Andre del har vært utviklingen av nye integrerte IT-verktøy for forbedring av effektiviteten i verdikjeden for frossen fisk. Siste del har bestått i følgeforskning knyttet til implementeringsprosesser i de deltakende bedriftene. Det har også vært gjennomført et doktorgradsarbeid knyttet til prosjektet. I studien av implementeringsprosessene har man blant annet sett at det finnes muligheter for å få til sporingsteknologiske framskritt uten at man har verdikjeder med dominerende eller spesielt sterke aktører. De strategier og virkemidler man har anvendt er analysert i prosjektet.

FORORD

Denne rapporten utgjør sluttrapporteringen for FIESTA-prosjektet (Forskning på Implementeringsprosesser og Effektiviseringspotensialet i ny SporbarhetsTeknologi Anvendt på forsyningskjeden for fisk).

FIESTA-prosjektet er et brukerstyrt innovasjonsprosjekt (BIP) under Norges Forskningsråds SMARTRANS-program. Prosjekteier er Logistikk og Transportindustriens Landsforening (LTL) med firmaene Eimskip-CTG AS (E-CTG) og Tyrholm & Farstad AS (TF) som deltakere. FoU-partner er Møreforsking Molde AS (MFM). Prosjektperioden var opprinnelig fra 2008 til 2010, men er utvidet til medio 2011.

Gjennom FIESTA-prosjektet er forsyningskjeden for frossen fisk analysert med aktiv deltakelse fra alle ansatte i de berørte bedriftene, noe som har gitt utgangspunkt for en god beskrivelse av verdikjeden og de sentrale kvalitetsparametrene i denne. Forskning på virkninger av IT-investeringer i verdikjeden har vært en sentral del av prosjektet, spesielt knyttet til ny sporbarhetsteknologi.

Denne rapporten omhandler sentrale aktiviteter, funn og observasjoner fra prosjektet. Formatet på rapporten er slik at den inneholder en oversiktsdel skrevet på norsk, og fire artikler på spesielle undertemaer skrevet på engelsk. Disse, og deler av det øvrige innholdet, er hentet fra Ola Bøs doktoravhandling.

Et utkast til rapporten er behandlet både i prosjektgruppa og i styringskomitéen for prosjektet, og kommentarer og innspill er forsøkt ivaretatt i denne endelige rapporten.

Molde . 15 september 2011

Harald M. Hjelle
Prosjektleder for FIESTA-prosjektet
Møreforsking Molde AS

INNHOLD

1 GENERELT OM FIESTA-PROSJEKTET

FIESTA-prosjektet er et brukerstyrt innovasjonsprosjekt (BIP) under Norges Forskningsråds SMARTRANS-program. Prosjekteier er Logistikk og Transportindustriens Landsforening (LTL) med firmaene Eimskip-CTG AS (E-CTG) og Tyrholm & Farstad AS (TF) som deltakere. FoU-partner er Møreforsking Molde AS (MFM). Prosjektperioden var opprinnelig fra 2008 til 2010, men er utvidet til medio 2011.

Formålet med prosjektet har vært å utvikle effektive terminal- og transportløsninger med avanserte og robuste IT-løsninger basert på bruk av internasjonale standarder som TraceFish og XML.

Prosjektet har hatt tre hovedmål som er knyttet sammen:

- Å utvikle kunnskaper og læringsprogram som skaper forståelse for sammenheng mellom avanserte IT-systemer, god logistikkplanlegging og sikker, effektiv og miljøvennlig transport.
- Å utvikle nye, integrerte IT-løsninger basert på eksisterende systemer fra Edi-Systems AS (tidligere Edi-Fish AS), med nødvendig tilleggsfunksjonalitet, som skal bidra til bedre logistikkplanlegging, mer sikker, effektiv og miljøvennlig transport og bedre grunnlag for sporing av gods.
- Å implementere, teste og tilpasse nytt IT-system i et logistikknettverk hos prosjektpartnerne og gjennomføre følgeforskning i implementeringsprosessen for å se på virkningene av det nye IT-systemet.

De største forskningsutfordringene i prosjektet har vært

- Å finne ut hva som skjer under implementering av nye IT-systemer i komplekse verdikjeder.
- Å utvikle organisasjonenes forståelse for sin rolle i en effektiv verdikjede, inklusive utarbeide et læringsprogram.

I denne rapporten oppsummerer vi aktiviteter og funn i prosjektet. Først presenterer vi erfaringene med den såkalte FIESTA-skolen, dernest beskriver vi utviklingsarbeidet knyttet til IT-systemene, så fokuserer vi på potensialet til RFID-baserte løsninger i verdikjeden, før vi presenterer hovedelementene i det tilknyttede doktorgradsprosjektet gjennom fire artikler på temaene

- Implementering av sporingssystemer i verdikjeder med uavhengige tredjepartsaktører
- Beslutningsstøtte for teknologivalg i matvarekjeder
- En skisse til et begrepsapparat for informasjonskartlegging i forsyningsskjeder
- En analyse av potensialet til sporingssystemer knyttet til bærekraftige verdikjeder for villfanget sjømat

I tillegg til den dokumentasjonen som finnes i denne sluttrapporten, finner man utfyllende informasjon om de enkelte temaene i

- Kompendiet som er utviklet for FIESTA-skolen (Hjelle and Bø 2010)
- Rapporten om gjennomføring og evaluering av FIESTA-skolen (Hjelle 2010)
- Rapporten med vurdering av potensialet til RFID-teknologi i FIESTA-verdikjeden (Hjelle and Bø 2011)
- Ola Bø’s doktoravhandling som vil bli utgitt i Høgskolen i Moldes serie av doktoravhandlinger, sannsynligvis sent høsten 2011 eller i første kvartal 2012.

2 FIESTA-SKOLEN – FOKUS PÅ ANALYSE AV EGEN VERDIKJEDE

En bærende ide i FIESTA-prosjektet har vært at kunnskap og refleksjon knyttet til egne arbeidsoppgaver virker motiverende og kvalitetssikrende på egen verdikjede. I den forbindelse er det utviklet et kursopplegg som kalles FIESTA-skolen. Sentrale elementer i dette opplegget er

1. Utvikling av et kompendium som inneholder temaer knyttet til logistikk med spesiell relevans til verdikjeden for eksport av norsk frossen fisk.
2. Utvikling og utprøving av et kurs med samlinger for bedriftenes tilsatte
3. Arbeid med case fra egen verdikjede

Dette opplegget ble utviklet i løpet av 2009, og utprøvd i perioden desember 2009 til mai 2010, med samlinger i Ålesund og på Sortland.

Dette avsnittet presenterer på en kortfattet måte innholdet i FIESTA-skolen, fakta om gjennomføringen, tilbakemeldinger fra deltakerne på opplegget, erfaringer gjort av kurslederne samt vurderinger knyttet til en videreutvikling av dette kursopplegget rettet inn mot andre relevante bedrifter. En mer utfyllende versjon av dette kapitlet finnes i Hjelle (2010).

2.1 Pedagogisk opplegg og rammer rundt FIESTA-skolen

Deltakerne i FIESTA-skolen var ikke skoleelever eller studenter i vanlig forstand. Deltakerne var med fordi de har erfaringer som er viktige for at opplegget skulle bli en suksess. Det var et viktig poeng at man hadde klart for seg at kunnskapen sitter på begge sider av "kateteret", og det har vært et mål å dra nytte av det. Deltakerne skulle heller ikke opp til eksamen i teoretisk logistikk, men ha et læringsutbytte som er tett knyttet opp til egen arbeidsplass og egen bedrifts rolle i verdikjeden.

Det har vært et sentralt prinsipp at i den grad vi skulle bringe inn ting fra logsitikk-teorien, så skulle det ha en klar relevans til den aktuelle verdikjeden og til aktuelle problemstillinger for de som jobber i den. Innenfor dette prosjektet har det dreid seg om verdikjeden for frossen fisk.

De mest sentrale læringsmålene for FIESTA-skolen har vært at:

1. Deltakerne skal gjennom undervisningsopplegget få et mer reflektert forhold til de arbeidsprosessene de deltar i
2. Den enkelte skal få økt forståelse for sentrale problemstillinger knyttet til egen verdikjede
3. Deltakerne skal bli mer motivert for egne arbeidsoppgaver gjennom økt forståelse for helheten arbeidsoppgavene inngår i
4. Sammen skal en utvikle en best mulig beskrivelse og analyse av egen verdikjede gjennom undervisningsopplegget

2.2 Samlinger er gjennomført i Ålesund og på Sortland

Samlingene ble gjennomført etter to litt ulike opplegg i Ålesund og på Sortland. I Ålesund ble det gjennomført to lange samlinger på lørdager (utenom ordinær arbeidstid), på Sortland ble det gjennomført 4 kortere samlinger på ettermiddag/kveld etter ordinær arbeidstid. Det ble også lagt betydelig vekt på at en vesentlig del av læringen skulle skje gjennom arbeid *mellom* samlingene gjennom case som deltakerne definerte. Her skulle hver gruppe beskrive og analysere to kvalitetsproblem i egen verdikjede. Minst ett av kvalitetsproblemene skulle være fra den delen av verdikjeden som gruppens deltakere representerer. Det andre problemet kunne være fra deler av verdikjeden som man ikke jobber direkte med, men som man ser har konsekvenser for hvordan kjeden som helhet fungerer. For hvert av de to problemene skulle man beskrive

- Hva problemet består i – og hvorfor det er et problem
- Analysere hvorfor problemet oppstår (årsaker)
- Forslag til hva som kan gjøres for å unngå problemet
- Vil forslaget til løsning bidra til å gi økt verdi for kunden, eller lavere kostnad og lik verdi for kunden – eller begge deler?

Det skulle tas utgangspunkt i en konkret eller typisk hendelse som representerer et kvalitetsproblem. I alt deltok 13 ansatte hos prosjektpartnerne i Ålesund og 26 på samlingene på Sortland. I tillegg deltok prosjektsekretær og observatører fra prosjekteier LTL, samt kurslederne fra Møreforsking Molde.

Til samlingene ble det utviklet et nytt kompendium. Innholdet og innretningen på dette ble fastlagt gjennom en lang dialog med prosjektdeltakerne. Deltakerne så det som viktig at innretning ble slik at man hadde nytte av det, når man skulle legge inn så mye ressurser i et slikt kursopplegg. Det endelige kompendiet ble på over 90 sider, og fikk følgende innholdsfortegnelse:

1. Innledning og bakgrunn
2. Pedagogisk utgangspunkt
3. Hva er en verdikjede og hvorfor fokuserer vi på den?
4. Kartlegging av verdikjeden
5. Analysere og forbedre verdikjeden
6. Effektiv logistikk – hva er det?
7. Om særlige kvalitetskrav til matvarekjeder
8. Transportjuss – trenger jeg å vite noe om det?
9. Informasjonsflyt og varestrømmer – to ting som må fungere godt sammen
10. Er strekkoder på vei ut – og RFID på vei inn?
11. Case som skal løses mellom samlingene
12. Referanser og kilder til mer kunnskap om logistikk
13. Vedlegg

Det ble lagt vekt på å ta inn eksempler hentet fra egen verdikjede, for å gjøre stoffet mest mulig relevant og matnyttig for kursdeltakerne. Kompendiet ble trykt opp (i farger) og delt ut til kursdeltakerne. Kompendiet finnes i sin helhet i vedleggsdelen av denne rapporten.

2.3 Deltakernes tilbakemeldinger og vurdering av disse

Vi har mottatt i alt 63 skjemaer med tilbakemeldinger. Om lag halvparten av disse gir uttrykk for forventningene til kurset, og halvparten er evaluering av kurset i ettertid. De aller fleste deltakerne leverte altså to skjemaer hver.

Det virker som om deltakerne i Ålesund generelt sett er godt fornøyd med kurset. 9% svarer at de generelt er "passe" fornøyd, mens de resterende 91% er godt fornøyd med kurset generelt sett. 27% er passe fornøyd med kvaliteten på undervisningen og andre kursaktiviteter, mens de resterende 73% er godt eller svært godt fornøyd med dette.

91% er godt fornøyd med læringsutbyttet de har fått. 36% er passe fornøyd med den praktiske gjennomføringen av kurset, mens de resterende er godt eller svært godt fornøyd med dette.

Generelt virker det som om deltakerne på Sortland er godt fornøyd med kurset. 40% svarer at de generelt er "passe" fornøyd, mens de resterende 60% er godt eller veldig godt fornøyd med kurset generelt sett. Nøyaktig samme fordeling gjør seg gjeldende på spørsmål om hvordan man er fornøyd med kvaliteten på undervisningen og andre kursaktiviteter.

Når det gjelder læringsutbytte er det litt færre som er fornøyd (53%), men ingen som svare "lite" eller "veldig lite" fornøyd med hva de har fått ut av kurset. De resterende 47% er altså "passe" fornøyd med dette.

Hele 87% er godt eller svært godt fornøyd med den praktiske gjennomføringen av kurset.

Både basert på egne erfaringer, og sett i lys av reaksjonene som kommer fram i evalueringsskjemaene, er det vårt hovedinntrykk at denne første gjennomføringen av FIESTA-skolen har vært forholdsvis vellykket. Faktisk er det ingen av deltakerne som har krysset av på den negative delen av evalueringsskalaene i det hele tatt.

Det vil imidlertid alltid være et behov for å justere ett opplegg som dette når en har gjort seg visse erfaringer i praksis. Sett i forhold til målsettingene vi hadde med FIESTA-skolen, er det vårt inntrykk at vi har klart å øke refleksjonsnivået og kunnskapen om sentrale forhold knyttet til egen verdikjede gjennom dette opplegget. Vi opplever at begge gruppene har vært engasjerte deltakere – i alle fall når det gjelder ting som ligger tett innpå egen hverdag. Det har kanskje vært vanskeligere å få til det store engasjementet når det gjelder mer teoretiske elementer, men det var heller ikke uventet.

De aller fleste synes å være rimelig godt fornøyd med kurset, og det er helt klart case-delen som har engasjert mest – i alle fall på Sortland. Case-delen fungerte ikke spesielt godt i Ålesund fordi det egentlig ikke ble levert inn noen case-rapporter fra gruppene der. I stedet ble det presentert ett case litt på sparket, og så ble siste samling delvis gjort om til en diskusjon av case som man etablerte i et gruppearbeid der og da. Sett i lys av at det helt klart er case-biten som har fungert best på Sortland gjør vi oss følgende refleksjoner:

- Det faktum at ledelsen i E-CTG på Sortland har fulgt opp gruppeoppgaveprosessen så godt, bidro helt klart til at andre samling ble meget god.
- Det er gjennom arbeidet og presentasjonen av casene at det alt vesentlige av læringen foregår. Da får man knagger å henge kunnskapen på – og man lærer mer om andre aktørers sentrale problemstillinger.
- Det er naturligvis krevende å få til arbeid med slike case mellom samlingene i bedrifter som har en travel hverdag. Om man ikke ser seg i stand til å følge opp dette, gir det også et visst utbytte å kaste frem, og diskutere aktuelle case i en slags ”workshop-form” under samlingen
(slik det ble gjort i Ålesund).

Tilbakemeldingene ellers tyder på at det er vanskelig å engasjere forsamlingen på mer teoretiske elementer, selv om man her gjorde et forsøk på å hente eksemplene fra egen hverdag. Det betyr vel ikke nødvendigvis at slike elementer bør fjernes, da det er vårt helt klare inntrykk at en god del av dette stoffet ble hentet inn av deltakerne i løsningen av caset. Eksempelvis henviste svært mange av gruppene til begreper som ”skape verdi for kunden” og ”informasjonsflyt i verdikjeden”.

2.4 Videre utvikling og bruk av konseptet for FIESTA-skolen

Selve grunnideen bak FIESTA-skolen er at logistikk-kunnskap læres best når stoffet knyttes tett opp mot egen hverdag, og problemstillinger som oppleves som relevante for deltakernes ansvarsområde. Det gjør at det opplegget som er laget her, både knyttet til samlinger og til innholdet i kompendiet er relativt tett relatert til verdikjeden for frossen fisk. Det vil likevel ikke være umulig å tenke seg at opplegget kan ha noe for seg også for andre verdikjeder og bransjer. Aktørene her kan karakteriseres som tredjeparts logistikkaktører, og andre bedrifter som har en slik rolle vil kunne nyttegjøre seg opplegget i stor grad. Det spesielle her er først og fremst knyttet til det faktum at dette dreier seg om en verdikjede med matvareprodukter. En del av innholdet er derfor spesifikt knyttet til problemstillinger som har med dette å gjøre (eksempelvis krav til dokumentasjon, krav til hygiene etc.)

3 OM UTVIKLING AV NYE IT-SYSTEMER FOR VERDIKJEDEN FOR FROSSEN FISK[1]

EDI-Systems AS har vært innleid i FIESTA prosjektet med ansvar for å utvikle programvaren i prosjektet. EDI-Systems leverer EDI-Lagerhotell, som Tyrholm&Farstad (T&F) har brukt i en årrekke for lagerstyringen sin, samt EDI-Ship som Eimskip-CTG (ECTG) benytter på 3 av fryseskipene sine.

Sporbarheten til varer (og frossen fisk) som går inn og ut av lager er ivaretatt for terminalen gjennom EDI-Lagerhotell. Her registreres pallene og merkes med gyldig SSCC-kode, og man har elektronisk sporbarhet på hvor varen kom fra, og hvor den er sendt videre.

Varer som ikke tas inn på terminalens lager, men som omlastes direkte (transitt eller containerstuffing) har ikke hatt sporbarheten og kontrollen som i EDI-Lagerhotell. I FIESTA prosjektet ble derfor målet for utviklingen av nye IT-systemer å få samme sporbarhet for varer som håndteres som transitt eller containerstuffing. Programmet som ble utviklet for dette, er EDI-Transit. Funksjonalitet og utseende følger malen fra EDI-Lagerhotells truckmodul som var velkjent for T&F. EDI-Transit er utviklet på samme plattform som EDI-Lagerhotell, EDI-Ship og ECTGs bookingsystem.

3.1 Funksjonalitet i EDI-Transit

Følgende funksjonalitet er lagt inn i EDI-Transit-programmet:

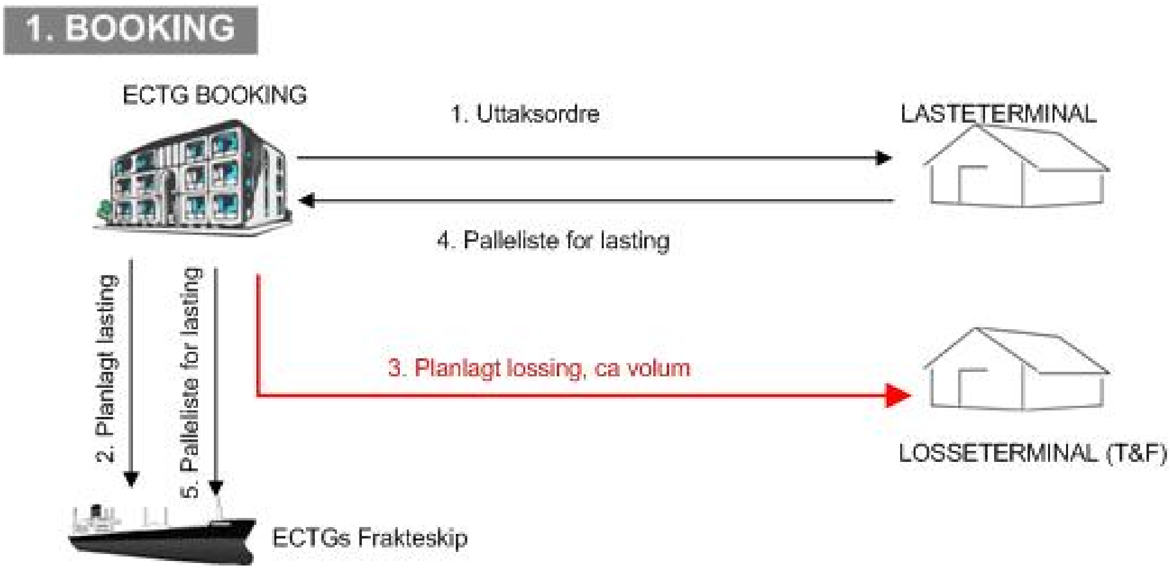
- Elektronisk datautveksling mellom terminalen og ECTG-Booking
- Egen registrering av mottak, paller og utskrift av palleetiketter
- Scanning av strekkoder for kontroll av paller mot pallelister
- Registrering av containere og hvilke paller som plasseres i dem.
- Rapporter som tallyseddel og stufferapport
- Fakturering av transittbehandling og stuffing

[1] Det som rapporteres i dette avsnittet er arbeid utført av EDI-Systems AS. Denne delen av FIESTA-prosjektet inngår ikke i Møreforsking Molde AS sitt ansvarsområde, men vi har likevel valgt å inkludere rapporteringen angående dette arbeidet i vår sluttrapport for fullstendighetens del. Avsnittet er i hovedsak forfattet av Espen Amundsen, EDI-Systems AS.

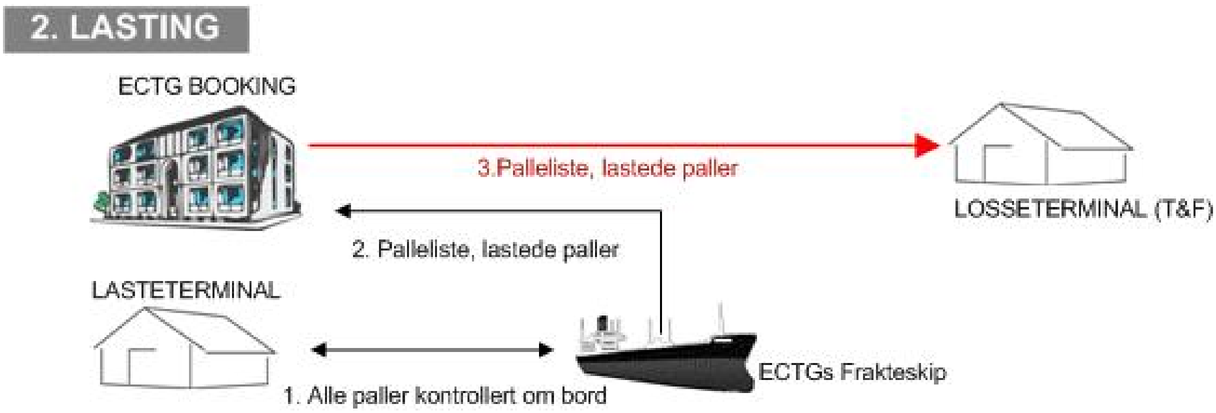
3.2 Integrasjon mot Eimskip-CTGs booking, Eimskip-CTGs båter og EDI-Lagerhotell

En stor del av programvareutviklingen har vært integrasjon mellom EDI-Transit, EDI-Lagerhotell og ECTGs Booking system. Informasjon om last, paller og uttak overføres elektronisk gjennom hele systemet og oppdateres automatisk i databasen hos aktørene med minst mulig manuell operasjon. Kommunikasjonskomponenten BookCom som ECTG utviklet i Tracefish prosjektet er vidreutviklet for dette og tar seg av kommunikasjonen mellom aktørene.

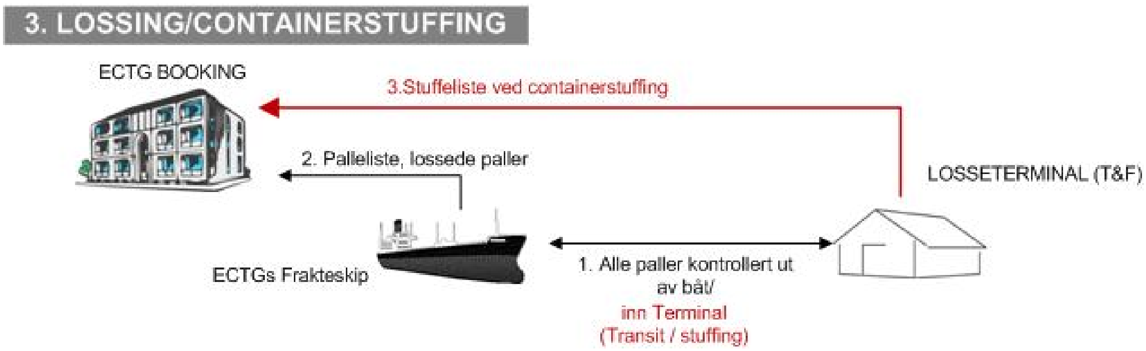
Den elektroniske informasjonsflyten i prosessene "booking", "lasting" og "lossing/containerstuffing" er illustrert i nedenstående figurer.



Figur 1 Illustrasjon av elektronisk informasjonsflyt i prosessen "booking"



Figur 2 Illustrasjon av elektronisk informasjonsflyt i prosessen "lasting"



Figur 3 Illustrasjon av elektronisk informasjonsflyt i prosessen "lossing/containerstuffing"

3.3 Erfaringer

EDI-Transit ble installert hos Tyrholm & Farstad 1. oktober 2010 og har vært i bruk der siden. T&F har hatt ansvaret for pilottesten, og underveis har det vært tett kontakt mellom T&F og EDI-Systems. Underveis i testperioden har det dukket opp nye ønsker til funksjonalitet, og 10 større og mindre programvareoppdateringer er foretatt.

Det ble tidlig klart at den største utfordringen i bruken av det nye systemet var liten andel av korrekt merkede paller. Mange produsenter mangler strekkoder på etikettene sine. Noen av terminalene hadde ikke gyldig strekkode på sine etiketter. ECTG Booking videresender ikke eventuelle pallelister fra disse. I tillegg kommer det pallelister kun fra terminaler som benytter EDI-Lagerhotell. I starten utgjorde andelen scannbare partier ca 10 %. Etter tiltakene vi gjorde, har andelen økt til over 40%.

De to største terminalene i Tromsø, Tromsøterminalen og Troms Fryseterminal (F/A) er lasteterminal for mye av det som sendes med ECTG til Ålesund. Ingen av disse to hadde strekkode på etikettene sine. Vi fikk begge innmeldt i GS1 og fikk lagt strekkode med gyldig SSCC på etikettene deres. Det samme ble gjort hos Båtsfjord Fryseterminal.

Vi har også fått øket andelen av pallelister som blir videresendt i systemene fra ECTG-Booking. I utgangspunktet videresendte ECTG-Booking bare pallelister fra partier som ble transportert med skipene som benytter EDI-Ship. I starten var det kun et skip med dette systemet. Etter hvert er EDI-Ship installert og igangsatt på to skip til. I tillegg benytter ECTG 4 innleide skip, og disse blir det nå også videresendt pallelister fra til losseterminalen (T&F).

Korrekt pallemerking fra produsent er avgjørende for å beholde informasjonsflyten gjennom systemene. Når ECTGs frakteskip som benytter EDI-Ship laster paller som ikke er merket med gyldig/scannbar SSCC-kode, så blir disse merket om bord med en transportetikett for sporbarhet. Transportetiketten inneholder kun ny SSCC-kode og erstatter eventuell tidligere SSCC-kode. Dermed mistes eventuell annen informasjon (som vareinformasjon etc.) tilknyttet pallen i systemene.

Med EDI-Transit har T&F fått det de trenger for å håndtere transittvarer og varer til containerstuffing med samme sporbarhet og kontroll som varer som tas inn på lager i EDI-Lagerhotell. Det viktigste arbeidet videre er å fortsette arbeidet med å få flere produsenter og aktører til å merke pallene sine med gyldige SSCC-strekkoder.

Ved prosjektslutt (september 2011) rapporteres det at man i løpet av prosjektperioden har fått til en økning i antall lesbare strekkode-etiketter på paller som håndteres av E-CTG fra ca 15% til ca 45%. En vesentlig del av denne økningen skyldes at man har fått med terminalene i Tromsø på slik merking. Det vil framover bli jobbet aktivt med andre terminaler for å øke graden av lesbar strekkodemerking videre.

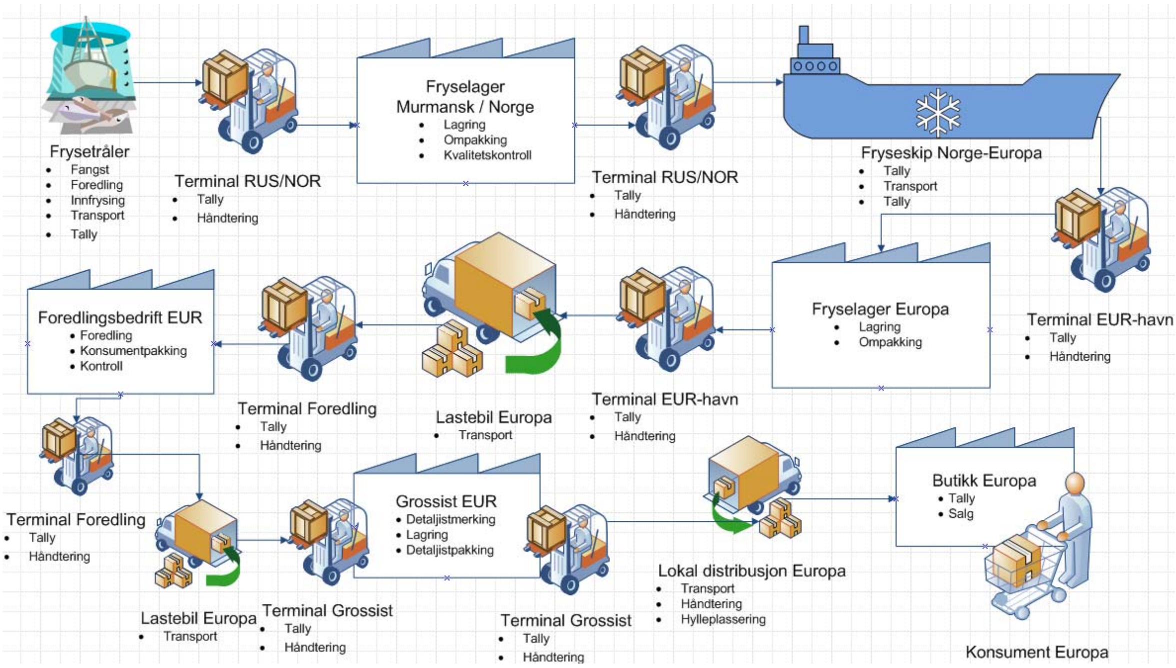
4 VURDERING AV POTENSIALET TIL EN EVENTUELL INNFØRING AV RFID-TEKNOLOGI I FIESTA-KJEDEN

Fokuset på sporbarhet i matvarekjeder har økt kraftig de siste årene. I hovedsak har dette sitt utgangspunkt i ønsket om økt matvaresikkerhet, og myndighetspålagte krav som i stor grad er kommet som en konsekvens av konkrete hendelser i inn- og utland knyttet til dette området. Det har vært en lang rekke tilfeller der matvarer har vært helsefarlige på grunn av forurensning med kjemiske stoffer eller sykdomsfremkallende mikroorganismer (Knowles, Moody *et al.* 2007). Dette har gjort at medier og allmennhet har blitt opptatt av at man raskt skal kunne spore kilden til de problematiske forholdene oppstrøms i verdikjedene når et slikt forhold har oppstått. I tillegg til myndighetspålagte krav, kan en også se en tendens til at man i enkelte markeder i større grad er villig til å betale for sporbarhet (Angulo and Gil 2004; Latvala and Kola 2004; Hobbs, Bailey *et al.* 2005). Denne betalingsviljen kan være knyttet til matvaresikkerhet, men også til andre forhold som bærekraftig ressursforvaltning og økologisk drift som har betydning for kunden. Med bedret sporbarhet vil en også kunne få gevinster på logistikksiden som vil bidra til å effektivisere verdikjedene.

Matloven stiller krav til sporing, men det stilles ingen konkrete betingelser til hvordan disse kravene skal ivaretas. Forskrift av 23. desember 2004 om sporbarhet av næringsmidler stiller krav om sporing i alle ledd i verdikjeden. Hvert ledd i kjeden skal kunne spore et ledd bakover og et ledd framover. Det vil si at bedriftene skal ha oversikt over hvem de mottar råvarene fra, og hvem de har sendt de ferdig produserte produktene til. Det betyr at de må ha system og prosedyrer for sporing slik at myndighetene kan få informasjon om dette når de måte ønske det (eSporingsprosjektet 2009).

Både EU og andre regionale og nasjonale myndigheter har gradvis implementert strengere krav til sporbarhet gjennom de siste årene. Bedre matvaresikkerhet vil kunne spare liv og helse i vesentlig grad. I USA regner en med at 76 millioner sykdomstilfeller og 5 000 dødsfall årlig kan knyttes til sykdom som kan knyttes til mat (Sundmaeker, Guillemin *et al.* 2010)

Fokuset for dette avsnittet er på potensialet for å anvende RFID i sporbarhetsløsninger knyttet til fiskeprodukter. En mer utfyllende versjon av dette kapitlet finnes i Hjelle (2011). I den rapporten finnes en mer utførlig beskrivelse av RFID-teknologien og dens faktiske og potensielle anvendelse i sporbarhetsløsninger. Dernest er det fokusert spesifikt på anvendelsen av RFID-basert teknologi i verdikjeder for matvarer. I dette avsnittet vil vi nøye oss med å gjengi de vurderinger vi har gjort i dette prosjektet knyttet til hva denne teknologien kan tenkes å bety for de ulike prosessene i verdikjeden for eksport av frossen fisk. Utgangspunktet for denne vurderingen er informasjon framskaffet gjennom FIESTA-prosjektet, i hovedsak knyttet til den delen av verdikjeden som er kontrollert av tredjeparts logistikkaktører knyttet til landing, terminalhåndtering, lagring og transport av fisken.



Figur 4 **FIESTA-verdikjedens hovedelementer (Hjelle and Bø 2010)**

4.1 RFID-teknologiens potensiale i verdikjeden for frossen fisk

Om vi skal forsøke å se litt inn i framtiden, kan vi tenke oss at teknologien kunne tas i bruk i verdikjeden for frossen fisk i stedet for strekkoder på følgende områder:

- Områder der hvor strekkoding er vanskelig på grunn av klimamessige påkjenninger eller vanskelige materialer:
- Fiskekasser
- Paller
- Paller eller kasser med krøllete krympeplast
- Individuell merking av stor og høyverdig fisk (laks, torsk, kveite) for markeder hvor sporbarhet er ekstra viktig – enten på grunn av myndighetskrav, eller økt markedsverdi av sporbar fisk.
- Kombinasjon av strekkodemerking og RFID-merking, for eksempel ved at en palle kan ha en RFID-brikke som får lagt inn informasjon fra strekkoder som er på kasser med fisk som er stablet på pallen. Pallen "vet" da hvilke kasser som hører til pallen.

- Bare godkjente paller (med rett innhold, eller rett klassifikasjon) vil slippe inn på lager (porten går ikke opp dersom pallens RFID-brikke sender feil signal)
- Fiskekassenes, eller fiskens, RFID-merke vil jevnlig bli oppdatert med informasjon fra temperaturfølere, og en komplett logg med temperaturdata kan leses av når kunden mottar kassen/fisken (lignende loggen som kan avleses fra reefer-containere). Temperaturfølere kan også bygges inn i RFID-tag'en slik at den ikke blir avhengig av informasjon fra eksterne følere.
- Mindre tallyfeil – ved at man kan "lese av" lagerbeholdningen til enhver tid – og ikke bare ved inn- og uttak (forutsetter aktive brikker).
- Automatisk tally ved passering av et gitt punkt – uten behov for direkte visuell kontakt.
- Personell kan bli utstyrt med RFID-brikker for å sikre at bare autoriserte ansatte får adgang til lager og andre sensitive områder.
- Lastebiler og trucker kan også få adgangskontroll via RFID-brikker.

Dette er altså rent hypotetiske anvendelser – og det er slett ikke sikkert at dette ville fungere teknologisk, at det vil redusere kostnader eller at det vil tilføre produktene merverdi. I neste kapittel går vi nærmere inn på en konkret vurdering av potensialet til RFID-teknologien for FIESTA-verdikjeden.

4.2 En kort beskrivelse av FIESTA-verdikjeden

I dette kapitlet vil vi analysere potensialet til dagens RFID-teknologi i forhold til den konkrete settingen aktørene i FIESTA-prosjektet er i. Aktørene er tredjeparts logistikkaktører i en verdikjede for eksport av frossen fisk, landet i Nord-Norge eller i Murmansk, og eksportert til det europeiske kontinentet eller til Storbritannia. Den konkrete verdikjeden vil i praksis framstå i flere ulike varianter, avhengig av typen råstoff, hvem som kjøper og prosesserer råstoffet og hvilke markeder fisken skal ende opp på.

Den verdikjeden som er representert i Figur 4, gir et noenlunde riktig bilde av en typisk variant av denne verdikjeden. I figuren er også noen av forretningsprosessene knyttet til det enkelte ledd i kjeden tatt med. Hovedaktørene i kjeden er fiskebåten/rederiet, eier og operatør av mottaket/fryselageret/terminalen hvor fisken landes, transportører (skip og bil), foredlingsbedriftene, ferdigvarelagre, grossister og detaljistleddet. Siden dette dreier seg om frossen fisk, må denne verdikjeden fungere som en ubrutt temperaturkontrollert kjede som også tilfredsstiller viktige krav til matvarekjeder generelt.

4.3 Vurdering av RFID som alternativ teknologi i FIESTA-prosjektet

Vurdering av RFID som alternativ teknologi for automatisk identifikasjon av gods (AutoID) må bygge på valg av implementeringsløsning for teknologien og på hva slags gevinster, kostnader og risiko som knytter seg til den valgte implementeringsløsningen. Vi vil derfor først diskutere hva som kan være aktuelle implementeringsløsninger for teknologien og deretter prøve å vurdere gevinster, kostnader og risiko for hver håndteringsprosess i forsyningskjeden.

Diskusjonen i dette avsnittet bygger på litteratur om RFID, men også på undersøkelser utført hos to store RFID brukere i Skandinavia: Pack and Sea (P&S), en pool for fiskekasser som dekker hele den danske ferskfisk-virksomheten fra produsent, via auksjon, til foredlingsbedrift, og hos Norsk Lastbærer Pool (NLP), en pool for kasser og paller som brukes i vareflyten mellom dagligvareleverandørene, de fire store dagligvarekjedene og deres detaljister.

4.3.1 Implementeringsløsninger

RFID-implementeringer kan variere langs flere dimensjoner. Vi vil i det følgende fokusere på følgende elementer:

1) Granularitet
2) Grad av sanntidssporing
3) Dekningsgrad i forsyningskjeden
4) Informasjonsomfang
5) Arkitekturvalg i det underliggende Inter-Organisatoriske Systemet (IOS)
6) Bruk av sensorteknologi
7) Grad av endring i de tilhørende forretningsprosessene
8) Tagge- og leserløsninger
9) Grad av automatisering

Vi diskuterer hver av disse dimensjonene for seg, og vurderer hva som kan være aktuelle løsninger i FIESTA-prosjektet relatert til de ulike elementene.

Granularitet (vare-granularitet)

I en finkornet RFID-løsning er hver enkelt vare tagget med et unikt identifikasjonsnummer. I en grovkornet løsning er bare større lastbærere som paller eller konteinere identifiserbare. En finkornet løsning gir høyere kostnader og datamengder, men også bedre kontroll på detaljnivå. I FIESTA-prosjektet, der aktørene stort sett håndterer godset på pallnivå, kan det være en løsning å tagge hver pall. En annen løsning kan være å tagge hver enkelt fiskepakke (sekk, kartong) for å kunne løse det vanlige problemet med feilsortering av fiskepakker på pallene, men på grunn av signalgjennomtrengningsproblemet i vannholdig gods er det ikke sannsynlig at RFID vil fungere særlig bra i en slik anvendelse. Problemene kan løses hvis pakkene utstyres med RFID brikker i begge ender og man bruker flere leserantenner. En slik løsning vil føre til dyrere emballasje og krever at brikken knyttes til informasjon om pakkens innhold om bord, og at denne informasjonen overføres til landingsterminal.

Vi vurderer det derfor slik at *merking på pallnivå sannsynligvis vil være mest aktuelt valg av granularitet i den nærmeste framtid*, men behandler likevel spørsmålet om automatisk pallbygging på grunnlag av RFID-merking på sekkenivå er gjennomførbart når vi diskuterer landing av fisk nedenfor.

Grad av sanntidssporing (tids-granularitet)

Sanntidssporing betyr at man til en hver tid har oppdatert kjennskap til hvor hver enhet befinner seg. Dette kan oppnås ved at alle bygninger utstyres med nok antenner til å triangulere posisjonen til alle varer og at alle transportmidler og containere utstyres med GPS-mottaker for å holde styr på egen posisjon og mobile kommunikasjonsløsninger for å sende fra seg posisjonen. Den motsatte ytterlighet er å bare registrere når og i hvilken retning enheter passerer en bestemt posisjon, for eksempel porten på et lager. Mellom disse to ytterpunktene har vi løsninger der vi for eksempel også registrerer hvor på lageret en vare blir plassert bare når den blir flyttet. Sanntidssporing av ressurser i lagermiljø har vært pilottestet med brukbare resultater (Chow, Lun *et al.* 2006), men sanntidssporing kan gi store datamengder, og kan være utfordrende både fra en teknologisk og en økonomisk synsvinkel. *Sannsynligvis vil en løsning der varer registreres inn og ut av lager eller transportmiddel, og der lagerlokasjon registreres når varen lagres, kunne utgjøre et tilfredsstillende kompromiss mellom muligheter og kostnader*.

Dekningsgrad i forsyningskjeden

Ettersom pallene vanligvis bygges ved landingsterminalen, og brytes senest når råvaren blir tatt i bruk i fiskeforedlingsindustrien, er de mulige ytterpunktene for sporingsløsningen gitt. *For å høste mest mulig fra RFID-løsningen bør pallene tagges med RFID hos landingsterminal*. Jo flere aktører som kan dra nytte av løsningen langs forsyningskjeden, jo bedre blir totaløkonomien for forsyningskjeden. Det bør undersøkes om fiskeforedlingsindustrien kan være interessert i å knytte seg på sporingsløsningen og eventuelt om de kunne være villige til å betale noe for informasjonen. Lederen for Pack and Sea arbeider for en slik løsning og ser for seg å gi fiskere som stiller informasjon til rådighet et pristillegg. En liknende løsning kan vurderes for å dekke kostnadene som er forbundet med RFID-merking i FIESTA-verdikjeden.

Informasjonsomfang

Informasjon samles opp og spres gjennom sporingssystemet for å støtte planlegging og korrekt håndtering av godset hos nedstrøms-aktørene. *Vi antar at informasjonsutvekslingen som ble realisert i FIESTA-prosjektet inneholder tilstrekkelig informasjon og at det derfor ikke er nødvendig å gjøre endringer i informasjonsomfanget*. Det kan likevel flere grunner til å vurdere økt informasjonsomfang, for eksempel muligheten til å høste gevinster i siste ledd dersom man kan gi mer eksakt informasjon om hvor fisken kom fra og hvordan den ble høstet. Manglende standardisering av formatet for slik informasjon kan være en hindring, og likeledes at slik informasjon krever endringer i informasjonen som leveres av et stort antall fiskebåter.

Arkitekturvalg i det underliggende Inter-Organisatoriske Systemet (IOS)

Arkitekturen i den eksisterende løsningen er et distribuert nettverk av bedriftsinterne systemer. Nettverket er knyttet sammen med en enkel og proprietær, meldingsstandard for elektronisk datautveksling (EDI) ved hjelp av en kommunikasjonsmodul i standardsystemet for lagerhold som brukes i nettverket (EDI-Lagerhotell). Alternativt kan man vurdere en felles databaseløsning som kunne gi bedre tilgang til den samlede informasjonen i nettverket – og en felles kilde til sporingsdata for foredlingsleddet. Dessverre kan det være forretningsmessig risikabelt å samle all denne informasjonen i en fellesløsning, så det trolig greit å beholde den nåværende arkitekturen. Det bør også være mulig å videreutvikle kommunikasjonsmodulen, slik at den eventuelt kan levere data på et format som er brukbart for foredlingsindustrien. ECTG sitt sporingssystem kunne teknisk sett også fungere som en slik felles datakilde ettersom den inneholder data om den (store?) andelen av produktene som transporteres av ECTG, men det er et spørsmål om en slik løsning er akseptabel for de andre aktørene.

Bruk av sensorteknologi

En av mulighetene i RFID er at man kan velge tagger som kan logge temperaturer. Slike tagger er betraktelig dyrere enn minimumstaggen, fordi de må ha vesentlig større minne og sitt eget batteri. Ettersom mange av produktene i prinsippet kan ligge opp til tre år på lager trenger man lang levetid på batteriet. Temperaturloggende tagger kan brukes til å dokumentere at frysekjeden har vært intakt, og eventuelt angi når temperaturen har vært for høy. Har man også oversikt over hvor varen har vært til en hver tid, kan man plassere ansvar, noe som gjør at ”claims” havner hos riktig aktør. Reduksjon av ”claims” er en effekt av RFID-basert sporing som også har vist seg dokumenterbar i andre sammenhenger (se for eksempel Langer(2007)). Økt ansvarliggjøring vil føre til mer oppmerksomhet om og sannsynlig reduksjon av problemet på lengre sikt. På den annen side fins det alternative løsninger: Dedikerte temperaturloggere har vært brukt i flere tiår for slike formål, og både frysekonteinere og kjøleanlegg om bord og i land har innebygd temperaturloggings-funksjonalitet.

På grunn av de høye kostnadene, kan være en ide å vente med å implementere RFID som teknologi for temperaturlogging til den er blitt rimeligere, men man bør kanskje ta høyde for muligheten i forbindelse med andre løsningsvalg.

Det er antakelig ingen grunn til å høste temperaturdata fra brikken mens den er underveis i forsyningskjeden. Men i forbindelse med ”claims” fra foredlingsindustrien, kan den avleses og brukes til å lokalisere hvor i kjeden temperaturen ikke ble holdt lav nok. Et annet spørsmål er om man er villig til å gi foredlingsindustrien et slikt ”våpen” mot egen kjede. Prinsipielt kan det tenkes at slik kontinuerlig temperaturlogging ville gi økt verdi for sluttkunden, og at det eksisterer en betalingsvilje for en garanti om ubrutt temperaturkjede, men det vil være svært krevende å få fram slik informasjon på en måte som er troverdig for kundeleddet.

Grad av endring i forretningsprosessene.

NLP og P&S implementerte nye forretningsprosesser for administrasjon av returnerbare lastbærere. Grunnlaget var den nærmest perfekte datakvaliteten som RFID gir mht til kontroll over lastbærerne. De kontraktsfestet at deres regnskapsførsel skulle gjelde og brukes til å fakturere partene og at nye prinsipper skulle gjelde, spesielt med innføring av tidsleie for å motivere til retur. Disse to poolene er i en spesiell situasjon. NLP, fordi den eies i felleskap av sine kunder, leverandørene og kjedene i dagligvarebransjen, PS fordi den eies av produsentene via fiskehavnene og fordi håndteringen av leierskifte utføres av fiskeauksjonene, offentlige institusjoner som nyter høy tillit.

Med RFID vil man kanskje kunne redusere arbeidsinnsatsen og redusere feil og ”claims” ytterligere. Dette vil gi økt opplevd kvalitet for kunden, og det kan i sin tur også medvirke til at de impliserte medarbeiderne i bedriftene får en positiv og motiverende effekt ved at man er i stand til å yte bedre service samtidig med at man kan utføre arbeidsoppgavene på en mer effektiv måte. Likevel er det etter vår vurdering vanskelig å se hvordan RFID-baserte løsninger i seg selv skal kunne gi vesentlige endringer i forretningsprosessene i FIESTA-kjeden i forhold til den strekkodeløsningen som nå er blitt implementert.

Vi vil komme tilbake til mulighetene for slike endringer når vi går inn på de ulike forretningsprosessene senere.

Tagge- og leserløsninger

I en løsning der det ikke er returordning for lastbærere, utgjør taggene den største andelen av kostnaden for RFID (IBM and A. T. Kearny 2004). Det kan være vanskelig å lese RFID tagger på eller gjennom metaller og vannholdig materiale. Menneskekroppen kan for eksempel forstyrre avlesningen. Metaller kan også gi vanskeligheter. Frossenfisk har høyt vanninnhold, og miljøet om bord på fryseskip og i fryselager er i høy grad metallisk. Det betyr at man blir nødt til å gjennomføre tester for å undersøke om RFID-tag’er og –lesere vil fungere i praksis, før man velger tagger og hvor de skal plasseres. Det betyr sannsynligvis også at det ikke vil være tilstrekkelig med én RFID-tag per pall.

P&S, som leverer plastkasser for ferskfisk, og NLP, som leverer plastkasser og paller for dagligvarer generelt har brukt fire RFID tagger per pall og to RFID tagger per kasse for å sikre lesbarhet, og for å ha noe å gå på dersom en tagg svikter.

I FIESTA-kjeden, som håndterer frossenvarer for den globale fiskeforedlingsindustrien, der returordninger for paller synes umulig å oppnå, blir det brukt engangspaller. Man har derfor valget mellom å bruke engangspaller med innebygd RFID og etiketter der RFID brikken er innbakt.

Dersom man bruker paller i tre vil treets fuktighetsinnhold kreve spesielle tagger, men spesialtaggene er for dyre til å brukes på engangspaller (Brindley 2008). Confidex sin nettbutikk angir $44 for 20 stk dvs. $2,2 per tag, eller NOK 12,20 per tag. Dersom man trenger to tag'er per pall for å sikre lesbarhet blir det ca NOK 25 per pall, eller en kostnadsøkning på pallen på over 30 %. Iflg. NLP fins det engangspaller i plast med innbakte RFID-brikker.

Etiketter med innbakt RFID tag koster $110 for 500 eller NOK 1,20 per etikett, RFID tag-produsenten Alien (Alien Technology 2010) angir at den fungerer på metall og fuktig materiale, men spørsmålet er i hvor høy grad. Dersom denne enklere løsningen fungerer, ville man eliminere behovet for endringer i arbeidsprosessene ved palletering. Eneste nødvendige endring er å oppgradere gjeldende printere og programvare til å å skrive SSCC koden til RFID-brikken som er innbakt i etiketten. Et annet spørsmål som kun kan besvares gjennom testing er om det er nok med to slike etiketter per pall for å oppnå lesbarhet.

I det følgende vil vi anta at man velger å erstatte gjeldende palletiketter med etiketter med innebygd RFID-tag og at taggen og strekkoden på etiketten innkodes med samme SSCC-kode. Fordelene med en slik løsning er at man kan fortsette å bruke gjeldende utstyr og system i parallell med innføring av RFID. Dermed kan man foreta en glidende overgang, noe som er det eneste mulige i et stort forsyningsnettverk med mange selvstendige aktører. En annen fordel er at strekkoden være en bedre teknologi når det er nødvendig å registrere data om en bestem pall, for eksempel ved registrering av skader. Dessuten gir en slik løsning små og rimelige endringer i de eksisterende informasjonssystemene. Det gjenstår imidlertid at teknisk funksjonalitet bare kan stadfestes gjennom praktisk utprøving i den aktuelle forsyningskjeden.

Det fins i hovedsak fire typer lesere som kan være aktuelle på forskjellige punkter i forsyningskjeden

- **Håndholdte lesere (ca. NOK 25 000/stk)**
  Informasjon skal hentes ut eller bindes til enkeltpaller av en operatør til fots. P&S bruker håndterminaler for å registrere leierskifte på fiskekasser på auksjonen.

- **Truckmonterte lesere (ca. NOK 50-75 000/stk)**
  Tilsvarende lesere til bruk for truckoperatør.
- **Portaler**
  Brukes for å automatisk håndtering av varestrøm som passerer en port. NLP bruker leseportaler for å registrere inngående og utgående lastbærerstrømmer på sentralterminalen.
- **Antenne knyttet til maskineri**
  P&S bruker en antenne ved transportbåndet i vaskeautomatene for fiskekasser. Dersom man ønsker å lese tagger på pakker på en pall, anbefales det å la pallen rotere, noe som for eksempel skjer på wrappemaskiner, der antenne koplet til rullen vil gi en systematisk scanning av pallen fra alle retninger(Alien Technology 2007).

Grad av automatisering

RFID støtter rask og automatisk lesing av et stort antall tagger (200 per sekund) og dessuten kan lesingen bli tilnærmet komplett og feilfri hvis man oppnår en god nok løsning for tagger og lesere. Dette betyr at RFID støtter automatisering. Muligheten for automatisering vil bli vurdert for noen av prosessene i neste kapittel.

4.3.2 Prosessene i forsyningskjeden

Gevinster fra bruk av RFID i sporingssystemet kan først og fremst oppstå gjennom bedre og mer kostnadseffektiv kontroll over godset, noe som kan bidra til ytterligere reduksjon i feil og "claims" og til bedre data for planlegging, men med mindre forbruk av arbeidskraft.
Kostnadene ved RFID er først og fremst taggene (IBM and A. T. Kearny 2004), men det vil også kreves investeringer i form av utstyr og integrasjonsløsninger mellom utstyret og de eksisterende softwareløsningene.

Landing

Beskrivelse av landingsoperasjonen bygger på observasjon på TF sitt anlegg i Ålesund og ved ECTG sitt anlegg i Sortland.

Ved landing blir fangsten tatt i land fra fiskebåt og sortert etter art og størrelsesklasse til homogene paller. Arbeidet gjøres av innleide lossegjenger – eller (sjeldnere) av mannskapet om bord. Fisken er enten emballert i esker, eller i sekker, eller er stuet uemballert i rommet - Det siste gjelder spesielt stor fisk som ikke får plass i sekker. Slik fisk skal i prinsippet stables på pall om bord og emballeres i pallboks før den tas i land. Sekkene er merket med et tall som angir varekategori i båtens system. Tallet brukes for å støtte sortering. Det kan være ganske mye emballasjeskade på sekkene, en stor andel revnede sekker, og sekker som man ikke har klart å lukke skikkelig har vært observert. Dette skyldes delvis at lukkeløsningene fungerer dårlig under de fuktige og kalde omgivelsene om bord og delvis antakelig bevegelser i lasten i hardt vær og at man må gå på lasten under stuing og lossing av fryserommene. Videre kommer fangsten fra båter fra forskjellige nasjoner, noe som innebærer at sekkene har forskjellige dimensjoner. Dessuten er en del av sekkene vanskelige å stable på en stabil måte. Ved trålerlossing på Sortland ble det observert over 20 forskjellige fraksjoner (sorteringsgrupper). Etter palletering blir pallen veid, omviklet med plast, og merket – vanligvis på to sider med strekkodet etikett. Etiketten opplyser om antall sekker, vekt, art, størrelsesklasse, varetype, fangstområde, produsent og om fryseterminalen der pallen er blitt bygd. Strekkoden inneholder SSCC kode, og for noen terminaler også vekt, antall sekker og holdbarhetsdato.

Ettersom sortering og pallebygging er arbeidskrevende, og ettersom det rapporteres at feilsortering er et betydelig problem (HMI, SuRoFi), kunne det ha vært ønskelig å automatisere arbeidet ved hjelp av et sorterings/palleteringsanlegg. Et slikt anlegg kunne vært styrt ved hjelp av RFID-brikker på hver fiskepakke. Men i mange tilfeller vil et slikt anlegg fungere dårlig på grunn av forholdene som ble diskutert i forrige avsnitt: løs fisk, reven emballasje, varierende dimensjoner, vanskelig å oppnå stabile paller. Et stort antall fraksjoner vil komplisere sorteringsanlegget. At fiskeflåten er i bevegelse fra felt til felt, og stadig skifter landingsterminaler, gjør det også vanskelig å sikre at en slik investering vil få tilstrekkelig med RFID merkede landinger til å kunne være regningssvarende.

Men dersom man får noe last med RFID-merkede fiskepakker, kunne det være en mulighet å bruke en RFID leser for å sikre at alle tagger i en pall viser samme varenummer og dermed kvalitetskontrollere sorteringen. Alien Technology (2007) foreslår at slik skanning kan løses effektivt ved å montere en antenne i tilknytning til plastrullen som brukes ved ”wrapping”.

Derimot, kan det være mulig å merke pallene med RFID i det de blir etikettert, dersom man velger en etikett med innebygd RFID-brikke og programmerer brikken med samme SSCC som strekkoden på etiketten. Men det er vanskelig å se at dette kan gi særlig gevinst for landingsterminalen, ettersom ny-påsatte strekkodeetiketter vil være tilnærmet 100% lesbare.

Innsetting på/Uttak fra lager

TF rapporterer at den løsningen de nå har med strekkoder på paller og strekkoder på lagerlokasjoner har redusert problemet med tapte paller vesentlig. Enkelte av personalet mener at registrering av palle på lagerlokasjon nå skjer uten tap av tid, mens andre mener at det tar noen sekunder ekstra per innsett i forhold til å ikke registrere lagerlokasjon, men det er enighet om at løsningen er vesentlig raskere og gir langt færre feil enn den tidligere løsningen der pallelokasjonen ble registrert inn manuelt på håndterminal.

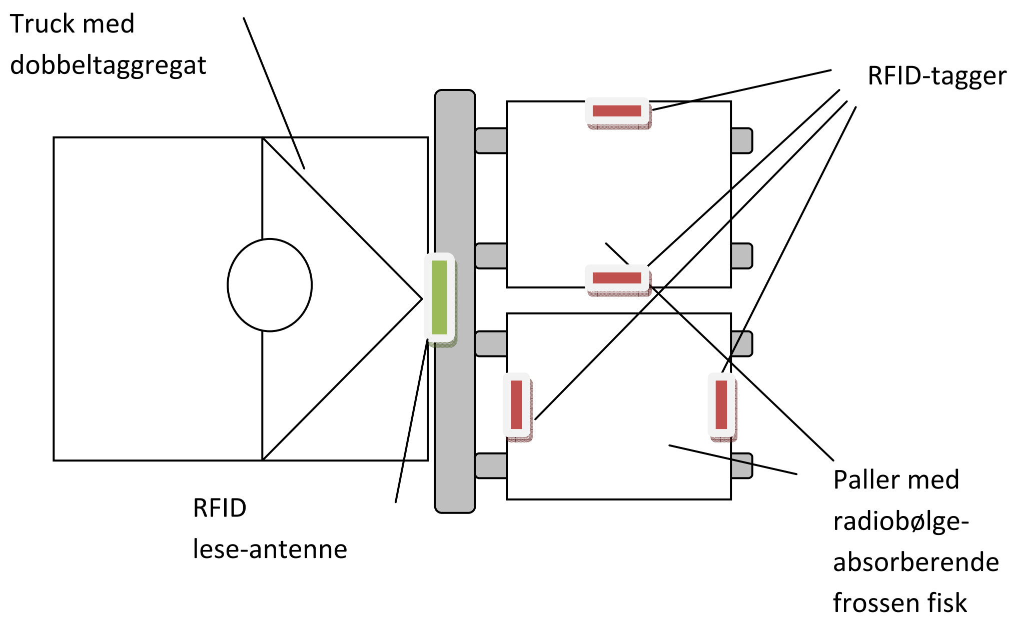
Man kan tenke seg løsninger der RFID-antenner montert på trucken registrerer pall-ID og lokasjon automatisk, dersom hver lagerlokasjon er utstyrt med en RFID brikke som identifiserer den, se for eksempel Becheldor (2009). Spørsmålet er om det som måtte gjenstå av palltap kan reduseres ytterligere, og om noen sekunder spart tidsforbruk per pall ved innsett forsvarer investeringen i en tagg på metalloverflate per reolposisjon.

Saken blir en annen dersom man skulle velge mer automatiserte lagringsløsninger. Vi kjenner ikke til i hvor stor grad slike løsninger kunne være aktuelle for noen av aktørene i forsyningsnettverket, men det har ikke vært nevnt som noe alternativ og vi velger derfor å ikke gå nærmere inn på denne muligheten.

Mottak til terminal

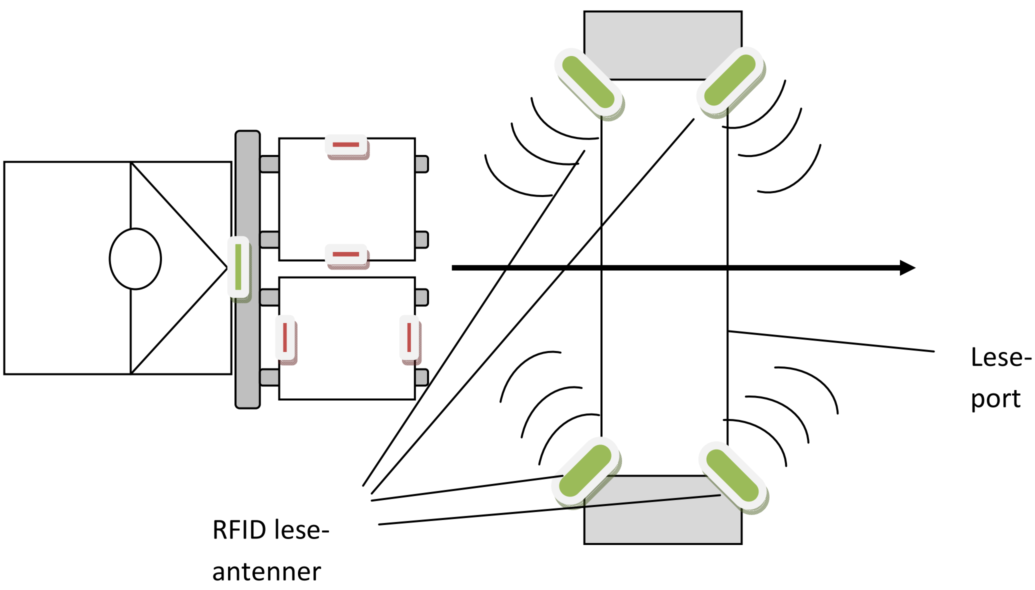
Mottak til terminal skjer når ferdigbygde paller fra en annen terminal ankommer terminalen. Dette avsnittet bygger på observasjon og intervjuer ved TF. Prosedyren ved mottak avhenger av hva som skal skje med godset videre. Hvis godset går direkte videre på annet transportmiddel, har det vært praksis å bare telle godset uten å registrere det nøyaktig inn i lagerhotellet. Den nye funksjonaliteten for oversending av pall-lister fra terminal til terminal kan gjøre det mer praktisk å registrere slik gods inn i systemet ved hjelp av pall-lista. For varer som skulle inn på lager har praksis vært å registrere varen manuelt inn i lagerhotellsystemet og å skrive ut en ny etikett med egen strekkode. Manuell registrering er arbeidskrevende og fører nødvendigvis til en del feil i data. Vi har ikke tall for hvor mye arbeidstid som forbrukes i manuell registrering av gods.

Foreløpig er erfaringen med innkommende gods som er strekkodemerket nedslående. I mange tilfeller er etikettene uleselige fordi de er plassert bak plasten, eller er blitt skrukket fordi plasten har trukket seg sammen. Slump-paller med noen få sekker utgjør også et problem, fordi det kanskje ikke fins to vertikale flater å sette etikettene på. Uleselige etiketter fører til en del manuelt ekstraarbeid. Videre er det et problem at mange paller kommer med etikettene på tverrsiden, slik at pallene må snues før de kan leses. Når lesing skal foregå fra truck med dobbelt gaffelsett, kan det bli arbeidskrevende å sikre korrekt orientering av pallene. Mannskapet på terminalen angir at all håndteringen forbundet med lesing av strekkoder fører til vesentlige forsinkelser i arbeidsprosessen. Dersom det ikke er mottatt pall-liste, vil lesningen heller ikke resultere i fullstendige data inn i lagerhotellet. Resultatet er sannsynligvis at gammel praksis som beskrevet i forrige avsnitt blir opprettholdt, med mindre bedre praksis for påsetting av strekkodemerker, sending av pall-lister og orientering av paller, blir gjennomført av oppstrømsterminaler og transportører. Det er mulig at slike praksisendringer til en viss grad kommer av seg selv når oppstrømsaktørene tar i bruk strekkoder for egne formål.



Figur 5 **Mulig problem med truckbasert RFID-lesning**

Det er sannsynlig at bruk av RFID vil kunne løse store deler av problemene som er nevnt ovenfor fordi RFID er mer leselig enn strekkoder. I hvilken grad pallorienteringen fortsatt vil være et problem, kan bare avgjøres gjennom eksperimentering, men det er mulig det typiske problemet vist i Figur 5 kan løses ved å dra pallene litt fra hverandre.



Figur 6 **Leseport som alternativ løsning til truck-basert RFID lesing**

Et annet alternativ vil være å installere leseporter (Figur 6) som varer kjøres gjennom på vei inn på lager fra sjøsiden eller fra landsiden. En slik automatisk løsning vil antakelig ha noe større mulighet for å kunne lese alle tagger, fordi antennene bestryker godset fra flere retninger under gjennomkjøring. Men løsningen blir vesentlig dyrere.

Stuffing av konteinere på terminal

Prosessen konteinerstuffing starter med planlegging basert på en liste over paller som skal lastes. Pallene fordeles på konteinere basert på mest mulig lik vare i samme konteiner, jevn lasting og sikring av last. Hensikten med planleggingen er å sikre at godset kommer fram i god stand og at det blir enklest mulig å håndtere godset og prosedyrene for å klarere det. Planen angir hva slags paller som skal i hvilke konteinere. Deretter blir pallene hentet fram fra lager og/eller de blir transportert inn med bil og/eller skip. Pallene blir løpende plassert inn i konteinere på grunnlag av planen og informasjon om hver pall. Hvilke paller som er blitt plassert i hvilke konteinere registreres etter hvert som pallene plasseres. I dag gjøres registreringen på lister over paller, med en liste per konteiner med alle paller som skal plasseres, men hvor paller som plasseres i denne konteineren krysses av. Deretter gjøres en arbeidskrevende summering for hver konteiner. I noen tilfeller gjøres det en manuell splitting og oppstabling av en del av pallene for å utnytte plassen i konteineren bedre. Strekkodeløsningen som er under uttesting innebærer at man velger konteiner å kjøre til og så skyter strekkoden på pallene etter hvert som de kjøres til konteineren. Man har da de samme leseproblemene som beskrevet under mottak til terminal. Dersom truckløsningen for RFID som er vist i Figur 5 fungerer tilfredsstillende, kan den brukes for å løse problemene. Leseportløsninger (Figur 6) er sannsynligvis ikke et alternativ her, fordi man enten må ha en kostbar port for hver konteiner under lasting, eller kjøre innom en fast leseport ved inngang lager, noe som både innebærer ekstra transport, men også vil kreve kompliserte softwareløsninger når flere trucker er aktive samtidig.

Lasting/Lossing på fryseskip

Gods som lastes og losses, kontrolleres av tallyman som kjører heisen og sjekker innkommende gods for skader. Den nåværende strekkodebaserte løsningen ser ut til å fungere greit i denne anvendelsen med unntak av at sterkt solskinn kan forstyrre scanningen. (Imaging scannner virker bedre enn lineær skanner, men den løser muligens ikke problemet helt).

Mange av problemene vi diskuterte under mottak til terminal kan enkelt løses av tallyman i samarbeid med truckførere, fordi tallyman lett kan flytte seg i forhold til godset og strekke ut eller løfte fram etiketter. Dessuten kan han også håndtere de få problemene som gjenstår ved å bruke terminal ved lasteporten. Tallymannen har også glede av selektiviteten til strekkodelesere, ettersom han kan skanne ønsket etikett fra opp til fem meters avstand og bruke strekkodeleseren til å redusere manuell input om eventuelle skader og avvikende antall kartonger. Det er godt mulig at strekkoder er den beste løsningen i denne prosessen dersom den skisserte manuelle tilnærmingen opprettholdes.

Med RFID vil en manuell løsning faktisk kunne bli mer tungvint ettersom den lave selektiviteten i håndholdte RFID-lesere (Weigand, Crook *et al.* 2011) kan kreve lesing på kortere avstand for å sikre at riktig pall er lest. Alternativt til manuell løsning kan man vurdere å installere en automatisk leseport i lasteporten, men det kan være vanskelig å finne en løsning som ikke vil kreve mange antenner eller være svært utsatt for skader under lasting. Motivasjonen for en slik løsning kan være reduksjon i antall feil eller mer fullstendig registrering av lastet gods, men RFID på pallnivå kan ikke se avvik i antall kartonger eller skader på gods, og en portalløsning kan gjøre det vanskeligere å knytte avvikene til en bestemt pall. Det kan anføres at strekkodeetiketter fra en del av terminalene ikke lar seg lese, eller ikke korresponderer til innsendt pall-liste, men det skyldes antakelig hovedsakelig rutineproblemer hos avsendende terminal som sannsynligvis ikke vil løses ved å satse på RFID-merking.

Ettersom tallymannen må være der uansett for å sjekke lasten for skader og ettersom tallymann i liten grad ser ut til å være flaskehalsen i laste og losseoperasjoner, er det kanskje heller ingen effektiviseringsgevinst ved å innføre en automatisert RFID-løsning i denne operasjonen.

4.4 Justert implementeringsløsning for RFID

Etter prosessdiskusjonen i forrige kapittel, er det naturlig å vurdere implementerings-løsningen i lys av disse momentene.

Det ser ut til at verken oppstrømsterminaler eller shippingselskap vil kunne høste vesentlige fordeler ved å oppgradere sporingsløsninga til RFID. Derimot, vil nedstrømsterminalen kunne løse lesbarhetsproblemer for gods som kommer fra andre, problemer, som virker sterkt forsinkende på arbeidsprosessene og som foreløpig har ført til at gamle arbeidskrevende rutiner med ommerking og manuell omregistrering av gods har blitt opprettholdt.

Problemene er knyttet til mottak av gods utenfra og har også konsekvenser for godsidentifikasjon ved innsett og uttak og ved konteinerstuffing. Problemene ved mottak kan løses ved å installere portalløsninger ved lagerbygningens porter, men slike løsninger er kostbare og passer dårlig sammen med behovet for å registrere skader på enkeltpaller. På den annen side kan alle aktuelle prosesser: Mottak, innsett, uttak og stuffing løses ved å installere RFID-lesere på alle trucker som er i bruk på terminalen. Leserne kan trolig knyttes til eksisterende truckterminaler og truckløsninger, noe som gir reduserte investerings-kostnader ved en eventuell oppgradering til RFID.

Forutsetningen er imidlertid at tekniske tester viser at løsningen vil fungere i praksis. Becheldor (2009) viser til en truckløsning som synes ideell for enkeltpalle-håndtering. Men erfaring fra flere tilfeller på TF der avansert utstyr på truckene har hatt dårlig holdbarhet, gir grunn til sunn skepsis.

4.5 Konklusjoner angående mulige RFID-løsninger

Etter en vurdering av mulige implementeringsløsninger for RFID landet vi på å vurdere et alternativ basert på etiketter med innbakt RFID brikke, og med den samme SSCC-koden i strekkode trykt på RFID etikettene. Man må sannsynligvis fortsatt ha to etiketter per pall.

Det ser ut til at strekkodeløsningen som allerede er innført i prosjektet har bidratt til å løse en betydelig del av problemene med kontroll over godset. RFID vil kunne bidra til ytterligere forbedringer, men ettersom RFID-løsninger vil kreve investeringer og også fører til økende løpende kostnader for tagger i landingsleddet, må man vurdere om gevinsten ved å satse på RFID rettferdiggjør de økte kostnadene. Landingsleddet har trolig liten ekstra gevinst å hente på å ta i bruk RFID, det vil derfor sannsynligvis være nødvendig å sette inn tiltak i form av økonomisk støtte for å få dem til å ta den ekstra kostnaden.

Ettersom nedstrømsterminalene opplever dårligere strekkodekvalitet, og siden strekkoding krever tidkrevende ekstra håndtering ved mottak og konteinerstuffing, noe som har ført til at gamle, kostbare og feilbarlige manuelle rutiner ser ut til å ha blitt opprettholdt, er det ved disse terminalene at man med størst sannsynlighet vil oppleve forbedringer knyttet til en innføring av RFID.

For å komme videre i vurderingen må man dermed gå til nærmere undersøkelser ved nedstrømsterminalen for å klarlegge mulige gevinster i mottaks og stuffeoperasjonene. Det er også nødvendig å få et klarere bilde av kostnadene av en RFID løsning her. Videre satsing på en RFID løsning forutsetter at man kan dokumentere at en slik investering vil kunne være lønnsom for nedstrømsterminalene og at tekniske tester viser at de foreslåtte merke- og leseløsningene kan fungere med varene og det fysiske miljøet på terminalene. Endelig må en vurdere om det er praktisk gjennomførbart med introduksjon av en slik løsning i en verdikjede hvor gevinstene i hovedsak vil opptre nedstrøms, men hvor kostnadene i betydelig grad ligger oppstrøms i verdikjeden.

4.6 Oppsummering og konklusjoner om potesialet til RFID-teknologien

RFID-teknologien har ikke fått et like raskt gjennombrudd som den ble spådd på 1980- og 1990-tallet. Årsakene til dette kan finnes både i teknologiske utfordringer, kostnadsmessige forhold og mer strategiske forhold. Selv om store aktører som den amerikanske Wal-Mart kjeden og USAs forsvarsdepartement har lagt store ressurser i en bred implementering av

RFID-teknologien det siste tiåret, venter man ennå på et større gjennombrudd. Likevel er teknologien for lengst tatt i bruk på mindre og mer spesialiserte områder som Autopass-brikkene som brukes ved bompengeanlegg, elektronisk lesbare pass og merking av dyr med RFID-brikker.

Historien viser at det ofte ikke er nok å ha en teknologisk overlegen teknologi for at den skal vinne innpass i markedene. Fra logistikkens historie kan en eksempelvis vise til at overgangen til bruk av containere ved multimodale transportløsninger har tatt mange tiår, på tross av at en kan vise til store effektivitetsgevinster knyttet til teknologien. Slik sett er det langt fra unikt at det også ser ut til å ta tiår før RFID-teknologien virkelig får sitt gjennombrudd.

Vi har i dette avsnittet vurdert potensialet til denne teknologien for verdikjeden for eksport av frossen fisk (FIESTA-kjeden) spesielt. På sett og vis ligger denne verdikjeden noe bak for eksempel dagligvarebransjen fordi man i begrenset grad har utnyttet potensialet som ligger i bruk av strekkoder som Auto-ID teknologi. I den sammenheng kan det synes som om de fleste nyttegevinstene man kunne håpe å oppnå ved innføring av RFID-teknologi i denne kjeden er effekter som man langt på vei også kan oppnå ved å etablere bedre sporingsordninger generelt, også basert på strekkodeteknologi. Behovet for standardisering av strekkoder for bruk på fiskekasser er da også pekt ut av sentrale bransjeaktører som et viktig første trinn (Haavardtun, Brevig *et al.* 2010).

Dersom RFID-teknologien skulle innføres, anser vi det som mest aktuelt å satse på en kombinert løsning med etiketter som både har strekkode og RFID innbakt. De potensielle nytteverdiene er størst nedstrøms i verdikjeden og det er mulig at en må iverksette incentivsystemer for å få oppstrøms-aktører med på en gjennomgående innføring av teknologien.

For å komme nærmere et informasjonsgrunnlag som man kan legge til grunn for en eventuell beslutning om å innføre RFID-teknologien er det fortsatt et betydelig behov for teknisk uttesting av utstyr i disse krevende omgivelsene med mye stål (i båtene), vannholdige produkter og krevende klimaforhold. Dernest vil en måtte gå inn på en nærmere vurdering av kostnader og nytteeffekter basert på et konkret teknologiscenario. Vi antar at de største potensielle gevinstene vil ligge i mottaks- og stuffeoperasjonene nedstrøms i verdikjeden. Det kan også være grunn til å gå i dialog med vareeierne for å kartlegge om det eksisterer noen markedsmessig merverdi i større grad av kjedsporbarhet i forhold til sluttbrukernes preferanser.

5 NÆRMERE OM METODE, DESIGN OG INFORMASJONSGRUNNLAG FOR FORSKNINGSARTIKLENE[2]

5.1 Forskningsspørsmål og tilnærmingen til disse

I FIESTA-prosjektet har det også vært utført et doktorgradsarbeid av stipendiat Ola bø. Arbeidet er p.t. er i sluttfasen og nærmer seg innlevering. I denne sluttrapporten er artiklene fra doktoravhandlingen tatt med i sin helhet i de følgende kapitler. Avhandlingen består i tillegg av en overbygning som blant annet beskriver metode, forskningsdesign og informasjonsgrunnlaget for forskningsartiklene. I dette avsnittet vil vi gi en kort versjon av disse, som en introduksjon og bakgrunn for artiklene som følger.

Artiklene baserer seg i hovedsak på en kvalitativ forskningsdesign med fokus på følgende overordnede forskningsspørsmål:

Q1 Hvordan kan en aktør uten dominerende posisjon i verdikjeden bruke ulike strategier for å oppnå implementering av sporingssystemer i sin verdikjede, og hvorfor kan disse strategiene sies å være effektive?

Q2 Hvordan kan en aktør som søker å innføre sporingssystemer gjøre teknologivalg som øker sannsynligheten for at systemet innføres av andre aktører i verdikjeden?

Q3 Hvordan kan en måle og kartlegge den informasjonskvaliteten som er tilgjengelig for en verdikjedes aktører?

Q4 I hvilken grad kan informasjonstilfanget fra sporingssystemer i oppstrøms verdikjede for villfanget sjømat støtte strategier for bærekraftig utvikling av verdikjeden?

Hvert av disse forskningsspørsmålene er forsøkt besvart med basis i ulike forskningsmessige tilnærminger, og ulikt datagrunnlag. Dette er forsøkt beskrevet i kort form i Tabell 1.

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[2] En atskillig grundigere gjennomgang av forskningsdesign og metode er gitt i Ola Bøs doktoravhandling.

Tabell 1 Den forskningsmessige tilnærmingen til de ulike problemstillingene

Forsknings-spørsmål	Forskningsmessig tilnærming og rasjonale for disse
Q1	FIESTA-prosjektets hoved-case kan sies å være et kritisk case i denne sammenheng, fordi det kan sies å stå i kontrast til vanlige oppfatninger om at en aktør må ha stor makt i verdikjeden og store ressurser for å lykkes i å implementere et sporingssystem i en verdikjede. Caset synes også å stå i kontrast til mange forskningsprosjekters funn knyttet til vanskeligheten med å inkludere SMB-aktører i slike systemer. Ett enkelt kvalitativt case kan være en hensiktsmessig design om man har tilgang til et kritisk case som dette. Dette kan være egnet til å gi svar på spørsmål om ”hvordan” og ”hvorfor”. Her er det gjennomført en følge-studie av implementeringsprosessen i dette caset for å kartlegge de ulike strategier som ble fulgt og i hvilken grad de var effektive. Studien er altså basert på ett case i form av én verdikjede, men med studier på flere steder i verdikjeden.
Q2	Her er formålet å utvikle et beslutningsverktøy for teknologivalg relevante for sporingssystemer. Vi ser på hvordan og hvorfor ulike teknologi-valg i etableringen av et sporingssystem kan påvirke den senere adopsjonen av systemet gjennom verdikjeden. I dette tilfellet ble flere case dratt inn for å representere bredden i mulige teknologivalg.
Q3	Her er formålet å utvikle et kartleggingsverktøy for informasjonsbehandling og informasjonskvalitet i forsyningskjeder. Kartet vil kunne brukes for å vurdere hvordan et påtenkt sporingssystem kan endre informasjonstilgangen og dermed gi grunnlag for videreutvikling av forretningsprosessene. Også her er flere case benyttet for å evaluere verktøyet i flere lignende, men likevel forskjellige verdikjeder.
Q4	For å studere hvordan sporingssystemer kan bidra til bærekraftige verdikjeder har man studert i hvor stor grad noen av de eksisterende sporingssystemene i sjømatindustrien kan utnyttes til å fremme en slik utvikling. En kvalitativ studie av 3 ulike case er benyttet for å belyse hvordan sporingssystemer kan bidra til å støtte strategier for å framstille ”bærekraftige” produkter.

5.2 Nærmere om informasjonsgrunnlaget for analysene

Som nevnt i forrige avsnitt baserer analysene seg i hovedsak på kvalitativ informasjon, i stor grad innhentet gjennom intervjuer med aktører i de respektive verdikjedene. Intervjumetodikken kan kalles semistrukturert i den forstand at det ble utviklet intervjuguider i forkant av intervjuene. Denne guiden var med på å sikre at man berørte sentrale elementer som man ønsket belyst, men formen på intervjuene var slik at det også var åpning for respondentene til å bringe fram informasjon og problemstillinger som gikk ut over det intervjuguiden inneholdt. Intervjuene ble, med noen få unntak, tatt opp og senere transkribert.

I tillegg ble direkte observasjon benyttet i mange tilfeller. Her ble det tatt notater og i stor grad ble også fotografier benyttet som dokumentasjonsform. Observasjonsaktivitetene fikk også i noen av tilfellene karakter av intervjuer fordi observasjonsobjektene ofte på eget initiativ valgte å kommentere aktivitetene underveis[3].

Tabell 2 Case, forskningsaktiviteter relatert til forskningsspørsmål

Case/Sted/Aktør	Forskningsaktivitet	Relatert forskningsspørsmål
Partnere i FIESTA-prosjektet • Operatør av fryseskip og fryselager • Multimodal terminaloperatør • IT-utviklingsfirma • Fiskesalgslag	• 23 intervjuer på mellom 45 minutter og 4 timer • 109 timer observasjon • Studier av mer enn 200 dokumenter • 4 samlinger med aktørene med problembasert logistikk-læring • Store mengder sporingsdata	Q1, Q2, Q3, Q4
Fiskeauksjon i UK • Fiskeauksjonen • Kjøper av fisk	• 2 intervjuer a 1 og 3 timer • 3 timer observasjon • Studier av ca 10 dokumenter	Q3
Hummerprodusent i UK	• 1 intervju a 30 minutter • Studier av ca. 20 dokumenter	Q3, Q4
Dansk fiskekassepool	• 1 intervju a 2 timer • 3 timer observasjon • Studier av ca 10 dokumenter	Q2, Q4
Norsk Lastbærerpool • Hovedkontor • Programvareleverandør	• 1 gruppeintervju a 2 timer • 1 telefonintervju a 45 minutter • Studier av ca. 10 dokumenter	Q2
Det norske e-sporingsprosjektet	• Studier av ca 10 dokumenter	(Q2, Q4)
20 utsalgssteder for sjømat i UK og Norge	• Studier av dokumentasjonen knyttet til 55 ulike sjømat-produkter	Q4

[3] Disse ”intervjuene” er ikke telt med som intervjuer i tabellen.

En tredje kategori av informasjon ligger i studier av mange ulike dokumenter relatert til problemstillingene. Dette er dokumenter av svært ulik karakter – fra studier av fraktbrev til studier av opprinnelsesdokumentasjon på forbrukerpakninger av sjømat. En oversikt over case og forskningsaktiviteter relatert til de respektive forskningsspørsmålene er gitt i Tabell 2.

6 AGAINST THE ODDS – IMPLEMENTING GOODS TRACKING IN A NETWORK OF INDEPENDENT THIRD PARTY LOGISTICS SUPPLIERS

ABSTRACT

Purpose of this paper

A product tracking system is being implemented in a network of third party logistics (TPL) providers, where adverse conditions makes succeeding difficult according to influential theories, and according to experience from similar projects. The goal of the paper is to analyze the strategies that were employed by managers resulting in success against the odds.

Design/methodology/approach

The research has been performed as a case study using interviews as the main source, but the findings are validated with data obtained from participant observation, and from document studies.

Findings

The paper identifies policies implemented and actions taken to align a critical mass of actors with the product tracking system, and analyzes how these different means contributed to the final success of the project.

Research limitations/implications

The research covers a single case, so results could be more or less applicable to other cases. However, a thorough case description makes the reader able to judge whether results could be applied in other settings familiar to the reader. The relationship to existing knowledge is also discussed.

Practical implications

SCM literature often suggests increasing supply chain transparency by integration of information systems across actors. In practice such integration has proven difficult to accomplish, and especially when actors are independent. The paper provides advice that could improve the chances of successful integration in similar cases.

What is the value of paper

In addition to the practical value, the paper could serve as a basis for further theory development.

Keywords: *Track and trace, Inter-organizational system, Power relations, Supply Chain Integration*

6.1 Introduction

A salient idea in Logistics and SCM is to improve supply chain efficiency and effectiveness by making information about the stream of goods electronically available from upstream and downstream actors. This is also called supply chain transparency. An early (80's and 90's) incarnation of that idea was to use Electronic Data Interchange (EDI) to establish links between supply chain actors, resulting in a loosely integrated Inter Organizational information System (IOS). However, the adoption of IOSs proved difficult, and especially amongst small and medium enterprises (SMEs). As a result supply chains largely continue to be run using manual procedures for information interchange to this day (Nurmilaakso, 2008).

By the start of the new millennium, new hopes were raised by the promising Radio Frequency Identification (RFID) technology, making automatic goods identification (AutoID) a feasible proposition. RFID can be combined with an IOS to disseminate the track and trace information to supply chain players. The combination between AutoID and an IOS can be dubbed an Inter-Organizational Product Tracking System (IOPTS), and could indeed provide the elusive supply chain transparency.

Despite reports from early successes obtained through mandates by powerful actors like Wall Mart and the U.S DoD, we are still waiting for the widely heralded RFID-revolution. Perhaps it is time to start research on how to increase IOPTS adoption in supply chains. This paper contributes to such research by reporting from a case study where a small third party logistics enterprise has successfully implemented an IOPTS in its supply chain against heavy odds. As other actors might wish to copy elements from the approach, the research question is: "*what strategies were employed, and how and why did they result in success?"*

The next sections describe the TPL network, the IOPTS, and the odds against the project, followed by a review of theory, and a description of the case study methods used in the research. The subsequent sections cover the strategies used in the integration project to align TPL actors with the system and a discussion of the theoretical implications. The final conclusion sums up the results and their relationship to existing knowledge.

6.2 The TPL network and the product tracking system

The TPL-network lands fish frozen at sea in the North East Atlantic from deep sea fishing vessels, and transports it towards the global market. Fish is typically landed at neutral cold stores along the Norwegian coast. These are neutral in the sense that they do not take title (ownership) to the goods. The goods are forwarded towards the processing industry in Europe and the Far East with reefer transportation. Regarded as a whole, the companies involved constitute a network of independent TPL providers. A number of these companies are small operations with a handful of employees, but they can still handle large amounts of merchandise by using effective equipment and by hiring additional manpower from stevedore-organizations. Figure 1 shows an example of how the network operates, with separate chains of goods handling and title.

Goods typically change owner one or more times on the way, so the TPL network is serving a network of customers – consecutive goods owners: fishing vessels, traders and firms in the processing industry. The customer and the TPL networks also have to cope with a large number of external actors like stevedore unions, auctions, and authorities in several nations.

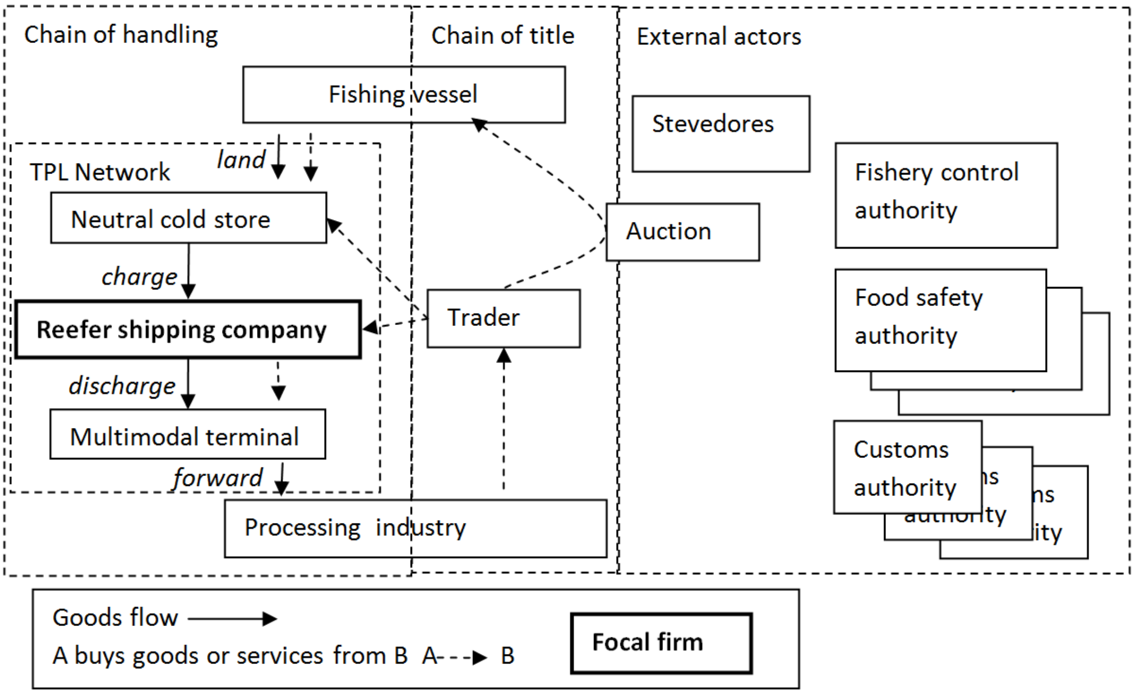

Figure 1 The TPL Network in context. Handling operations are shown in italics. Buyer-seller relationships are shown with dashed arrows.

6.2.1 The product tracking system

To understand the remainder of the paper, we need to look closer at the IOPTS functionality, and how it can improve logistics efficiency and effectiveness. An IOPTS registers and distributes information about the item being tracked, and about events related to that item. The handling operations shown in italics in this section and in Figure 1 are such events.

On board the fishing vessels, usually, fish is packaged when caught and then placed unsorted into the bulk hold. When *landed*, the packages are sorted onto homogeneous pallets and data about the content of each pallet is captured in the IOPTS. These data are used when the fish is put up for sale at the auction After having bought an auction lot, the trader places an order for the shipment of the pallets at the shipping company and also orders the release of the pallets at the neutral cold store. Then an electronic list of the pallets is sent from the neutral cold store to the reefer shipping company. This is performed using EDI (Electronic Data Interchange).

The electronic pallet list contains detailed up front information which can be used in the planning of the following *charge* and *discharge* operations. Such planning could improve vessel capacity utilization by predicting how much hold capacity will be used by each shipment. The vessel is the most capital intensive asset in the network, so high capacity utilization is crucial for economic performance. The information also supports tally during cargo handling operations – with a goal of controlling that all the correct pallets are *charged* and *discharged*. Correct tally mitigates a recurring problem in the trade where: “frequent errors with subsequent claims undermine the profitability of many reefer transportation operations” *Manager of Logistics Trade Organization.*

For the focal company, curbing claims expenses is the primary goal of the IOPTS. Providing exact and detailed information about the pallets handled in each operation is also perceived as an effective protection against some downstream actors who are suspected for making fraudulent claims about missing pallets. Another aim of the system is to support improved precision in the registration of cargo damage, i.e., to be able to make the upstream terminals accountable for cargo damage occurring before the *charge* operation.

6.2.2 The TPL network – an adverse environment for system implementation

There are a number of factors that could jeopardize IOPTS implementation in the TPL network:

1. **Asymmetric distribution of costs and benefits**: A crucial component of the IOPTS is tagging the goods for identification. This should be performed at the upstream neutral cold store where pallets are built, but will often need a change of routine. In addition, there may be costs for software, label printers, etc. Most of the benefits accrue to downstream actors, in the form of error elimination, saved manual data-entry and getting improved data for planning. Increased accountability for damaged goods could also lead to more claims hitting the upstream actors.
2. As we can see from Figure 1, the focal company has **no direct or indirect buyer power** over the upstream cold stores.
3. The customers for the upstream actors are fishing vessels and traders. Those customers are **extremely cost conscious** and do not care about how their cost-cutting affects the downstream actors. See photo 2.1 for an illustration. This means that the terminals are engaged in cut throat price competition for landing orders, and that customers are not likely to exert pressure for IOPTS implementation.
4. Upstream terminals typically use skeleton crews working as supervisors controlling manpower hired for each handling operation. This means that the terminals have

limited human resources. Limited human resources are seen as important barriers for EDI-adoption in Small and Medium Enterprises (SMEs) (Iacovou et al 1995).

5. There is a culture for **trade secrecy** in the network. This is a characteristic of the seafood industry (Jacquet and Pauly, 2008), confirmed by a number of interviews, for example: "We operate on a strictly need to know basis" *Shipbroker, reefer shipping company*

6. The various actors cooperating to fulfil the customers' requirements are, to some extent, **competitors**. For example, both the focal shipping company and a multi modal terminal run neutral cold stores.

Figure 2 Landing at a neutral terminal results in a pile of wrecked pallets (centre). The photo shows local cost saving on pallet quality of less than one ‰ of the pallet goods value. The bad pallets lead to expensive problems for downstream actors. (Photo: Ola Bø)

6.2.3 Success in an adverse environment

The implementation of the IOPTS depends upon two components: first – the pallets have to be tagged with two readable identity tags, and second – electronic lists of pallets to be charged should be received from the landing terminal before the reefer vessel arrives to pick them up. The first component makes it possible to register all pallets into the vessel and hence to document the correct tally for each consignment, while the second supports controlling that the pallets charged or discharged are the correct ones.

The tracking project now seems to be a success: A gross estimate indicates that 70% of the pallets loaded from landing terminals carry the necessary identification tags. The focal firm is moving on from pilot testing, to implementing the IOPTS on all their liner vessels.

Obtaining usable identity tagging by a large proportion of the players in what seems to be a loosely knit network of independent uncontrollable TPL providers with asymmetric distribution of risks, costs and benefits and a culture for cost minimization and secrecy is an accomplishment that other actors in similar situations would wish to copy.

6.3 Theoretical perspectives

The goal of this paper is to report on strategies used by an SME resulting in supply chain integration through the successful implementation of an IOPTS. As an IOPTS is an IOS, we could benefit from strategy advice offered in the large research stream on IOS adoption.

Starting from rationalizing early successes, subsequent stagnation in EDI adoption led IOS-adoption research to enter a probing phase where factor analysis tested factors that could influence adoption. Factors were taken from case research or from theories e.g. diffusion of innovation, socio political, or critical mass theory. However, these efforts did not result in consensus on one common IOS adoption theory. In the third stage, recognizing the complexity of the relationship between IOS adoption and the organizational context, research employed theories and methods supporting richer descriptive analysis (Somasundaram and Rose, 2003).

With no consensus on an IOS adoption theory, we could select studies specifically concerning SMEs. A much cited study of SME EDI-adoption is provided by Iacovou *et al.* (1995) building on 34 former studies, further extended and substantiated by e.g. Chwelos *et al.* (2001), Mehrtens *et al.* (2001), Morrell and Ezingeard (2001), and Nagy(2007)

For SMEs risk exposure could be especially critical, so Kumar and van Dissel's (1996) seminal treatment of risk mitigation in IOSs also seems relevant, especially since it has a solid theoretical basis in transaction cost economics (TCE).

Another possible perspective could be SCM, but SCM performed by low power actors is in some way a paradox, and it seems to have raised scant interest and treatment in the SCM literature, with Harland et al. (2001) as a notable exception. SMEs are seldom in a position to impose standards, so some papers discussing IOS standardization have also been included.

6.3.1 Strategies for IOS integration derived from literature

Table 1 summarises strategic advice on IOS implementation derived from the literature. Only Harland *et al.* (2001) and Nagy (2007) specifically treat focal firms with low power.

Table 1 Strategic advice from the literature

Strategic advice	Source
Aim for process and information processing improvements. Cope with the situation.	Harland *et al.*, 2001
Persuade the trading partner to use the system or change power balance. Increase benefits or more effective - lower the barriers of adoption	Nagy, 2007
Plan adoption of small partners from the beginning, assess their individual EDI preparedness and choose and implement an appropriate subsidy and influence strategy for each partner.	Iacovou *et al.*, 1995
Comprehensive long term leadership, Importance of change management, Handle specific asset risks, Exploit the installed base	Bowersox *et al.,* 2000
For “long-linked supply chain systems”, transaction risks can be mitigated by using the proper IT solutions, legal/contractual mechanisms and diplomacy.	Kumar and van Dissel, 1996
Exploit cheaper Internet technologies to reduce IOS cost	Stefansson, 2002
Integrate databases along the supply chain. Use a common data model for the whole supply chain.	Lee and Billington, 1992 Gulledge, 2006
Universal standardization is impossible. Idiosyncratic ITC solutions might be superior Differentiate integration solutions. Build bridges for SMEs. Support the varying business models of chain participants	Bowker and Star, ’00 Olsen and Sætre, ’07 Harland *et al.,* 2007

6.3.2 Low power SCM

Supply Chain Management research and thinking has evolved, from the study of how influential companies in stable situations can wield power to manage their suppliers (Cox, 1999, Harland *et al.,* 2001), to also looking at strategies available to less influential actors in unstable situations (Harland *et al*., 2001).

Power relations seem to be a major factor in the adoption of technologies like IOS and EDI (Iacovou *et al.,* 1995, Nagy, 2007), However, persuasive approaches could be more effective than coercive use of power for improving relationships and organizational coordination in an IOS context (Hart and Saunders, 1997).

6.3.3 Risk mitigation

Another perspective is that the IOSs can be used to impose dominance, resulting in conflict, and thus in the possible demise of the IOS. To make a viable IOS, the risks have to be mitigated. Risks and the mitigation strategies can be discussed using Transaction Cost Economics (TCE). The main transaction cost component for IOSs takes the form of exposure to a transaction risk that can be subdivided into asset specificity risk, information asymmetry and loss of resource control (Kumar and van Dissel, 1996).

Asset specificity means that an asset is acquired for serving a specific business relationship. The specific investment is lost if the relationship is lost, a fact which skews the power balance of the relationship. High investments in an IOS, thus increases the risk of being dominated.

Loss of resource control means that the counterpart gets control over critical resources. When discussing IOS, we talk about information resources. In the TPL-network considered, the traders are important customers that are exposed to the risk of disintermediation if too much information is divulged to actors in the processing industry or to competing traders.

6.3.4 Imposing standardization or permitting idiosyncrasy?

The controversy between imposing standardization and permitting idiosyncrasy has been sparsely covered in the SCM discipline. Standardization towards a common universal standard is an enticing idea promising easy, IOS integration – both Gulledge (2006) and Nagy (2007) discuss how the lack of standards makes integration difficult. The standardization idea comes in many flavors: For the single firm, Enterprise Resource Planning (ERP) is the embodiment of standardization, where all data is stored in a common system according to a common data model and supporting “best practice business processes”. In the SCM literature, the integration of databases across the supply chain is suggested as a panacea by Lee and Billington (1992). Gulledge (2006) goes further by proposing a single common standardized data model for the whole supply network as proper integration and other forms of integration using interfacing between systems as inferior.

Bowker and Star (2000) discussing standardization of classifications, which are necessary for creating data models, come to the opposite conclusion: “[The] permanent tension between attempts at universal standardization of lists and the local circumstances of those using them [..] should not and cannot be resolved by imposed standardization.” In addition, even if data is standardized, the data from other firms could be misinterpreted due to missing the contextual information (Jacobs, 2006). Gulledge(2006) also confirms the problems of the supply chain wide standardization when he goes on from lofty ideals to discuss real world examples, where standardization efforts drag on for years and where data consistency is a continuous struggle. Thus, real world IOSs could often be more like the patchwork discussed in Nagy’s (2007) case research, than a system built to common standard. Harland et al.

(2007) favours a differentiated contingency approach by the IOS initiator. For the individual firm, the standardization imposed when of adopting ERP can make the company lose the competitive edge that could be acquired using flexible idiosyncratic IT-solutions (Olsen and Sætre, 2007).

6.4 Researching strategies for ios alignment

The IOPTS project is studied in its natural context, so there is no opportunity for control. Therefore the options for research design are limited. As we are interested in how and why the focal firm succeeded in the IOPTS project, case research is a suitable method (Yin, 2003).

Table 2 Data Collection Methods

Method and extent	Who or what	Methodological details
Interviews, ca 20 during ¾ to 4 hours	Shipping, terminal and ITC personnel	Semi-structured, recorded and transcribed.
Participant observation, ca 100 hours	Logistics operations, Back offices. Project and personnel meetings	Documented using photography and note-taking
Document studies, more than 200 documents	Freight docuemts, minutes from meetings	Using document database
IOPTS operational data	Data from logistics operations	Analysis of Serial Shipment Container Codes (SSCC)
Data from problem based practitioner training: 4 sessions	Terminal and shipping company personnel,	Uses results from personnel analyzing problems in their own operation.

Because the project outcome seems to contradict widely held assumptions about the need for long-term, trust building relationships and/or power for a focal firm to successfully initiate IOS implementation, we can regard the project as a critical case. Then a single case design is appropriate (Yin, 2003). In case research, triangulation – the use of multiple data collection methods, provides the critical test for theories (Stuart *et al.*, 2002). Table 2 shows the methods applied. Data collection and analysis have proceeded simultaneously as proposed by Eisenhardt (1989) through write-ups, here in the form of illustrated field reports.

6.5 Findings: strategies employed in the project

To overcome the numerous challenges discussed in section 2.2, a number of different strategies and actions were necessary. Some of those were general long term strategies in place before the project was conceived, while others were implemented to handle specific problems in the project.

6.5.1 IT-strategy

The focal firm does not follow the trend of relying on commercial standard software and of outsourcing the IT department. Its strategy can be summarized in the following points:

- Core operational activity is supported by a custom built booking system. This strategy is followed in spite of considerable pressure from the parent company to implement SAP (an ERP system). The resulting SAP implementation was limited to functions like accounting, but with the necessary integration to the booking system.
- Internal and external integrations are being implemented to speed up document handling and to remove expensive and error-prone manual re-keying operations.
- A small, but effective IT-department supports and develops systems and integration.

These strategies imply that the firm has personnel combining deep business and system knowledge, personnel that can also develop the necessary interfaces for integration between the systems of the shipping company and the terminals.

6.5.2 Strategic involvement in neutral terminals – vertical integration

The focal company has historically been involved both in shipping and in a few neutral terminals, and it is still running one such terminal. This implies that the company has intimate knowledge on how upstream terminals are run and on their information processing routines. It also founded a software firm which served as an IT-department at the same time as it developed a Warehouse Management System (WMS) for neutral terminals. The WMS software firm was sold off in 1999 and succeeded in the market, making the WMS product the preferred solution for the neutral cold stores in the network.

6.5.3 Exploiting de facto standardization

The large market share of the WMS amongst upstream terminals could be exploited, by paying the software supplier for implementing functionality for sending of pallet lists to the focal company as a part of the WMS. This EDI functionality was made readily available on the screen used for selecting pallets for transportation along with functionality for printing the necessary pallet lists for use when physically taking pallets out of storage. The scope of this effective strategy is somewhat limited because some upstream terminals use other WMSs, but a low cost solution to provide EDI functionality to such actors is planned.

6.5.4 Change management strategy

Safeguarding internal motivation was a major concern for company management. In addition to meetings with the personnel involved and taking their response seriously, the management had to keep up momentum, while not keeping personnel working with a dysfunctional system:

When testing the initial version of the IOPTS, the mariners were far from satisfied with the functionality or the usability of the new system. Fixing problems and testing was time consuming, as the vessel used for pilot testing was in continuous service. To safeguard mariner motivation and support for the project, the company implemented two strategies: One was to enable quicker testing by setting up a complete in house testing environment. The second was to stop pilot testing on board until all changes requested by the mariners had been implemented and thoroughly tested in house. When finally installed, the mariners were delighted by a system well adapted to their requirements and felt ownership for the system.

6.5.5 Counterpart cost minimization strategy and direct subsidy

The cost of joining the IOS for the terminals was minimized by the focal company paying much of the cost for developing the functionality for sending EDI-pallet lists from the WMS using e-mail, and hence made it available to the terminals at a negligible cost. Also the expenses involved in changing terminal routines were minimized by making the EDI-functionality easily available on the same screen as used in the standard procedure for taking out goods from storage.

This removed the crucial cost barrier for most terminals. Towards the end of the project, a policy of direct subsidies in order to eliminate even the negligible cost of joining was implemented. This made two large volume stragglers jump on the bandwagon.

6.5.6 Information ownership strategy

As discussed in section 2.2 there is a norm for secrecy in the TPL network. However, the downstream actors need some information to complete their part of the goods handling. Some of this information has traditionally been provided in the documents sent with the cargo by upstream actors. The new functionality gives upstream actors the opportunity to send the same information electronically by clicking a button. Hence the terminal's information is still kept in the terminal's WMS, but some information necessary for downstream actors can be forwarded electronically under the control of terminal personnel.

6.5.7 Persuasion strategies

Implementing the tracking system involves changes at the upstream terminals by requiring a valid SSCC encoded in a bar code on the pallet label and new pallet labelling routines to ensure the proper printing quality and placement of the labels. But how can the focal company influence the terminals to make those changes? Even, there is an ongoing relationship created by the necessary cooperation in order to coordinate the handling of shipments, the focal company has no buyer power over most upstream terminals. Our claim is thus that the focal company does not have the power to force upstream terminals to comply.

A subset of the terminals participates in closer collaboration with the focal company. The managers of these terminals are meeting with the shipping company once every year. These terminal meetings were used as a forum of influence. During pilot testing, a number of e-mails were also sent from the focal company to the terminals to make them start sending electronic lists and improving labelling practices. Also the WMS software provider arranges a yearly user conference for the terminals. The software provider invited a speaker from GS1, the company standardizing SSCC labelling to inform terminal personnel on the benefits of registering with GS1 to obtain the necessary Global Location Number (GLN) for making the SSCC-codes valid. The persuasion seemed to have little effect, as labelling quality remained low, and few electronic pallet lists were received by the focal company. There was a need for better incentives for the upstream terminals to try out the new functionality in the system.

As Christmas was approaching, a new initiative was taken in the form of an advent calendar lottery: Every day a gift voucher for electronic products was awarded by drawing amongst the terminals that had used the EDI-functionality that day to send in the pallet list for a shipment. The result was above expectation, and led to a substantial adoption of the new functionality, and electronic lists continued to flow for a period. However, the pallet labeling quality still remained far below what was necessary. The sentiment amongst project participants at the time can be summarized in the following statement: "It will not get better before they start using the bar codes for their own purposes" *First mate reefer vessel, March 2009.*
Fortunately, in the same period, some terminals upgraded their WMSs for keeping track of pallets internally through the use of bar coded pallets and bar coded storage locations. This tendency gradually improved pallet labelling practices in the TPL network.

Effective persuasion could come from the master mariners and first mates of the vessel where pilot testing was carried out. These mariners use the system when charging or discharging at terminals, and can communicate with terminal personnel, both on labelling quality, and on the presence of electronic lists. As they are meeting terminal personnel face to face at each call, they can influence terminal practices on behalf of the focal company: "We talk with them and it seems to improve practices" *First mate, reefer vessel, November 2010.*

With the implementation of the system on all the liner vessels, the terminals will probably be subject to more face to face pressure to adopt the IOPTS, because non-adoption could imply slower charge and discharge operation and more work for their operational counterparts – the mariners.

6.5.8 Flexibility strategies

Even with negligible costs for most terminals and several attempts at persuasion, using different forums, a lottery and face to face mariner diplomacy, adoption was still patchy.

This situation could be expected both from the power relationships and from the scope limitations discussed in section 5.3 and can be expected to endure.

But still, the project can be declared a success, because of the flexibility strategies developed to reap benefits from the level of compliance actually achieved for each shipment by doing extra re-labelling work, or by sacrificing some of the potential functionality of the IOPTS. In all cases, these strategies retain the essential functionality for ensuring correct tally, and hence fulfil the primary goal of the project – to contain claims expenses due to erroneous tally.

Table 3 Flexibility strategies

Shipment's level of IOPTS compliance	Flexibility strategy	Resulting functionality
4. Bar codes and pallet list ok	Not applicable	Full functionality
3. Invalid bar codes, pallet list ok	Use bar code as is	Full functionality*
2. Readable bar codes, but missing or wrong pallet list	Use bar code, drop pallet list	Tally only
1. No readable SSCC bar code	Re-label with bar code	Tally only

The levels of shipment compliance to IOPTS requirements, the corresponding flexibility strategy and the resulting level of functionality are shown in Table 3.

At the time of writing in January 2011, most of the shipments have compliance level 2 or 3, as a rough estimate indicates that ca 70% of the pallets have readable bar codes, but most terminals have not complied with the requirement for GS1 registration, instead using a dummy number for the GLN. Still the bar codes can be used for pallet identification, as there is a small probability for having to cope with different pallets having the same identity in the system. This potential problem with the full functionality is indicated with an asterisk in the table, but will have to be handled even in the ideal situation of full compliance because occasionally terminals accidentally put the same SSCC on different pallets and also because some pallets will be transported several times by the TPL-network.

The heterogeneous base data mentioned in section 2.2 are not solved by standardization. Rather the product names used by the fishing vessels are passed on verbatim in the EDI messages. This flexible approach leads to some problems in goods categorization for downstream software, but for the human users, understanding the different product names and correcting classification is a small problem.

6.5.9 Win-win strategies

The strategy that finally made terminals interested in sending pallet lists was the implementation of system functionality that could make terminals save time and cost: "Now they started to phone me when the functionality for sending pallet lists didn't work. That had never occurred before" ICT-staff referring to the terminals.

To curb the claims expenses, the shipping company introduced a new document limiting their responsibility for cargo tally correctness. Initially, this "Mate's receipt" document was printed on board the reefer vessels after charging, forcing terminal personnel to wait while the document was produced. Waiting is both inconvenient and expensive as it often occurs out of office hours. The focal shipping company then introduced functionality for letting the terminals pre-print the Mate's receipt based on the transmitted electronic pallet list. This was probably the crucial move for making the sending of electronic pallet lists a standard operating procedure at some terminals.

6.6 Theoretical implications

As we can see from Table 1 and the corresponding discussion in the previous section, most strategic advice encountered in the selected literature was put to use in the project in some form.

6.6.1 Low power SCM

A central idea in SCM is a powerful focal company being able to impose standards on other actors. The literature on the low power position is sparse. Harland et al. (2001), discusses SCM when the focal firm is in a low power position and points to "process and information processing improvements" and "coping with the situation" as the general strategies to follow, but also points out that lacking the necessary incentives can limit process improvements in such settings. The project under scrutiny is indeed an information processing improvement project, but this study could perhaps clarify what coping could involve?

Some of the strategies presented in the previous section could be good candidates for categories of coping strategies, going from the passive flexibility strategies, to increasingly active strategies trying to increase adoption by persuasion, or by developing effective incentives in the form of win-win strategies.

1. **Flexibility strategies.** These are strategies for obtaining as much benefits as possible from the level of implementation currently achieved, a.k.a. the current installed base. In addition to the pragmatic dropping of requirements for standards compliance and the manual re-labelling, gateway technologies could be used to connect terminals using other WMSs.

2. **Persuasion strategies.** These are strategies for informing the counterparts about the potential benefits of implementing the innovation, and on how to implement it: Generally this seemed to have limited effect even if the focal firm and the software provider did several attempts. Interviews seem to indicate that the advent calendar and the repeated face to face comments on labelling quality from the mariners were amongst the more effective.
3. **Win-win strategies.** These are strategies where the focal firm seeks to locate potential actions that could improve the operational efficiency of the counterpart while simultaneously leading to increased adoption of the innovation. The high impact functionality for pre-printing mate's receipts based on EDI pallet lists sent from the terminals seems a case in point.

6.6.2 IOS risk mitigation strategies

As discussed by Kumar and van Dissel (1996), risk mitigation is essential for IOS viability. TCE discusses contracts to reduce such risks, while industrial network theory advocate long time trust building relationships and careful consideration of the paradoxes of such networks when strategizing.

The focal company was able to reduce the specific asset risks for the terminals by making their implementation costs negligible (section 5.5). The other counterpart risk elimination strategy was to adopt an IOS architecture where information ownership and control remains in the hands of the terminals (5.6). This observation could have implications for the architectural decisions in IOPTSs and in other IOSs which could be implemented either as central information repositories or as internal systems under the control of each player, but interconnected through EDI. The information risks inherent in a central repository can be mitigated using information security mechanisms in the data base management system (Kumar and van Dissel, 1996). However, a repository requires trust both in the technical safeguards and in the institution running it, while the semi-automatic EDI-linked system implemented in this project gives each player possession over proprietary data and control over when to exchange it. It might well be that the approach used in this project could be more acceptable to the counterpart than a central repository.

6.6.3 Standardization vs. Idiosyncrasy

The long term strategy of keeping an idiosyncratic in-house booking system and the knowledge to support it and to develop further integration with other systems combined with deep inside knowledge on the internal operations of the counterpart terminals (section 5.1 and 5.2), were crucial to several of the other strategies. Both the solution for incorporating the EDI functionality in the standard workflow of terminals and inventing win-win strategies depended on deep knowledge on terminal operations and information processing.

As pointed out by Harland et al. (2001), information processing improvements might be the main strategy open to companies in a low power position trying to manage the supply chain. Such improvements could be far easier to accomplish if the company follows the flexibility enhancing strategy discussed by Olsen and Sætre (2007) of sticking to proprietary software for its core activities. Furthermore, ERP systems, like SAP, are currently missing support for item level track and trace (Rönkkö et al., 2007). Therefore, if the focal company had followed the alternative strategy of using standard ERP software, such integration would have proven difficult. Thus the company benefited from following a non-standard practice internally.

The standardization in the terminal network is far from complete, as so far, many upstream actors do not follow the standards for using GLN in the SSCC bar-codes. This clearly shows that the low power focal firm has not been able to impose standards compliance, but remains dependent on the de facto standardization provided by the installed base. However, the cost minimizing strategy involved implementing changes in the standard WMS and hence the focal company was able to change the de facto standard from the inside. The limited level of standardization was handled successfully by the flexibility strategies, and win-win and persuasion strategies could imply better standards compliance in the future.

6.7 Conclusion: A panoply of strategies

A panoply of strategies were used. Many of those seem to be directly dependent upon each other or on resources created by pursuing other strategies, as shown in Figure 3. When comparing with Table 1, it seems that most strategies discussed in theory were pursued.

As far as we can see from the existing literature, the ideas of exploiting de facto standardization and using flexibility as strategies in the low power position have not been discussed before. The results also extend the discussion in Kumar and van Dissel (1997) by showing how specific asset risks can be eliminated by exploiting a de facto standard. The research also discusses the role of intimate knowledge of the operation and information processing practices of the counterpart when pursuing win-win strategies, and thus substantiates how such strategies could be effective for actors in a low power position.

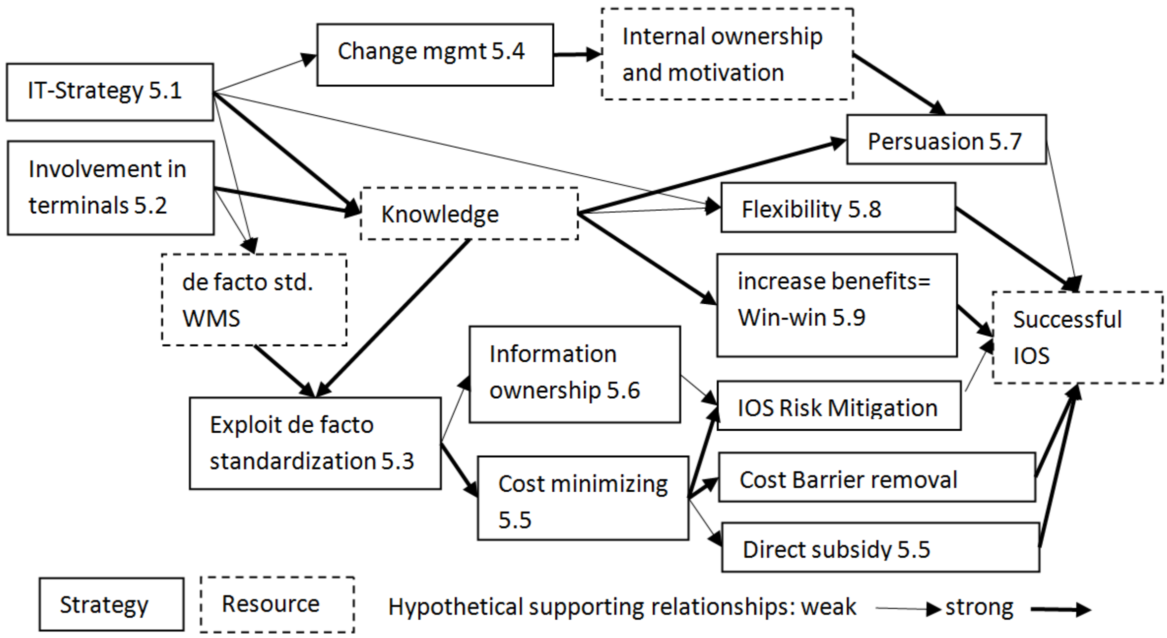

Figure 3 The panoply of strategies used and the relationships between them

Few firms are in a position where they can standardize an IOS and make all its counterparts adopt it by coercion, influence or persuasion. Patchy IOS implementation is thus probably more a rule than an exception. Flexibility strategies, able to handle heterogeneity and low standards compliance could thus be important general strategies for reaping benefits from IOSs in real world supply chains. Such strategies could be easier to implement if the company enhances IT flexibility by using custom built software solutions for its core activities.

Finally, it seems that implementing IOSs against the odds, even if feasible, is a demanding process, where success depends on a panoply of interdependent strategies which must be skilfully applied under long term leadership.

6.8 Acknowledgements

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7 PRODUCT TRACKING SYSTEMS IN THE SUPPLY CHAIN FOR FOOD – A SUPPORT MODEL FOR TECHNOLOGY DECISIONS

Abstract

This paper proposes a model to support the crucial technological decisions to be taken by companies wishing to implement an inter-organizational product tracking system (IOPTS) in their supply network. IOPTSs can be beneficial for e.g. food safety and supply chain transparency. Many SCM researchers propose RFID as the technology that could increase transparency, but in reality RFID is only an electable component in an IOPTS.

The proposed model supports decisions on technologies for automatic item identification (AutoID) and on the architecture of the supporting information system when the goal is cross actor supply chain visibility. There is already a relevant theoretical knowledge base from research on IOS adoption and on RFID. This knowledge base is combined with empirical results from case research in four IOPTSs in the supply network for food in Scandinavia as a basis for the model.

7.1 Introduction

Inter-organizational product tracking systems (IOPTS) can be used to improve supply chain transparency and for a number of other purposes in supply chains generally (Holmström et al. 2010). In the supply network for food, such electronic systems could be beneficial when used to improve food safety, to curb food quality problems and to support different strategies for sustainable SCM (Kumar et al. 2009; Bechini et al. 2005).

An IOPTS generally combines a technology for automatic identification (Auto ID) of tracked items with an inter-organizational information system (IOS) to collect and disseminate information about the tracked items to the players handling and transforming the items through the supply network.

There is much SCM literature about the potential of Radio Frequency Identification (RFID) for increasing supply chain transparency, but RFID is only an electable component in an IOPTS. Unfortunately RFID has grabbed all the attention (Holmström et al. 2010), while the question of how to implement the necessary IOS backbone in the supply chain has been scantily treated (Ngai 2009). The expected RFID revolution has failed to materialize so far (Economist 2007; Lee 2007), and few Supply Chain RFID implementations have been covered in the literature (Sarac et al. 2010).

The SCM community should now refocus interest on *how* to succeed with implementing IOPTSs in real world supply chains. From IOS adoption research we know that adoption has multiple aspects probably involving institutional, technological, socio-economic and cultural factors (Damsgaard & Lyytinen 1999).

This paper could contribute to filling the technological aspect of the gaps identified above. It uses empirical results from case research in four food supply chain IOPTSs in Scandinavia to discuss the applicability of results from the literatures on IOS adoption and on RFID in SCM. The result is an Inter Organizational Product Tracking Technology and Architecture Choice (IOPTTAC)-model that could inform both technological decisions and initiatives to increase IOPTS adoption amongst supply chain players.

The paper has five sections. Section 2 briefly presents existing research on IOS adoption and on AutoID. Section 3 covers the case research. Section 4 treats the model and discusses the theory versus the empirical findings of the technological properties used as inputs. Section 5 concludes and discusses the applicability of the model.

7.2 Implementing product tracking in a supply network – relevant theory

New technologies provide new opportunities for research, but one should always consider if former research could be leveraged before starting new research (Stuart et al. 2002). For IOPTS adoption, we should look to the comprehensive literature on the adoption of IOSs in supply networks that has accumulated since the 1980's. As every IOPTS needs an IOS backbone, IOS adoption research is clearly relevant.

7.2.1 IOS/EDI adoption research

IOS adoption research has focused on the adoption of electronic data interchange (EDI), and can be divided into three overlapping stages. In the first rationalizing stage, early successes in industry were explained and further adoption taken for granted because of the competitive advantages offered by the technology. As adoption in industry stagnated, often at a fairly low level, research entered a probing stage, where positivistic methods using factor analysis tested factors that could influence adoption. Possible factors could come from case research or from theoretical perspectives e.g. diffusion of innovation, socio-political, or critical mass theory. Unfortunately, these efforts did not result in a universal consensus on one IOS adoption theory. In the third stage, recognizing the complex relationship between IOS adoption and the organizational context, research pursued theories and methods allowing a richer descriptive analysis (Somasundaram and Rose 2003). Damsgaard and Lyytinen (1999) is an example of the richer approach. Their analyses use multiple theoretical accounts, and concludes that the key to successful EDI diffusion could be a mixture of institutional, technological, socio-economic and cultural factors.

Lacking an accepted universal theory for IOS adoption, and seeing the use of multiple theoretical lenses, raises the question about what lenses to select. As the idea is to look at how technological choices could affect willingness to adopt an IOPTS, we could choose well substantiated theories having a bearing on the questions we are going to discuss.

Iacovou et al.'s (1995) study on EDI adoption in Small and Medium Enterprises (SME) could be relevant for a discussion on current RFID adoption because of similarities in terms of high cost of, complexity of and knowledge scarcity about EDI and RFID respectively at the two decennia. Iacovou et al. (1995) investigate why the penetration level of EDI amongst small and medium enterprises was impeded by resistance. Building on a literature study including 34 preceding EDI and IOS studies they develop a model with three major factors influencing the EDI adoption decisions in SMEs: 1) the perceived benefits from adopting the technology, 2) the readiness of the organization for using the technology and 3) the external pressure from the EDI-initiators. The model proposed by Iacovou et al. (1995) was validated and extended by Chwelos et al. (2003). Nagy (2007) extends the model of Iacovou et al. (1995)/Chwelos et al. (2003) and adds perceived risk and switching cost. He also uses a more fine grained treatment of power relations. He further regards low organizational readiness as a cost driver, thereby removing it as a primary factor. The resulting model is validated through case research.

Risks for conflict inherent in supply chain integration using IOSs and strategies for mitigating those risks are treated in a seminal paper by Kumar and van Dissel (1996). They point out that the configuration of the IOS supporting the integration mirrors the interdependence between the players, and that the risk exposure, the types of risks and the corresponding mitigation strategies are dependent upon that interdependency. For IOPTSs two different types of configuration corresponding to two different IOPTS architectures, seem to be possible, see Figure 4.

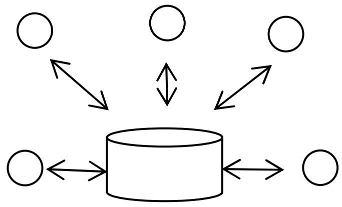
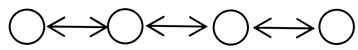
Architecture	Pooled	Long linked
Configuration		
Implementation technology	Typically based on a relational database management system	Typically using some variant of Electronic Data Interchange

Figure 4 Product tracking IOS Configurations (based on Kumar & van Dissel, 1996)

As we can see, the pooled architecture could be implemented as a shared database for the players. This approach has been proposed as the ideal solution for IOSs in supply chains (Gulledge, 2006). The other "long-linked" architecture typically emerges when loosely integrating the systems of different actors along the supply chain using EDI. EDI could be heavily standardized Electronic Document Interchange or a more light weight Electronic Data Interchange solution.

Kumar and van Dissel (1996) treat the risks in the common pool architecture using theory of common property resources (e.g. Hardin, 1968), and propose mitigating the risks by implementing technical safeguards using the standard security mechanisms available in database systems. The risks in the long-linked architectures are discussed using transaction cost economics, where risks associated with specific assets, asymmetric information and the control over resources must be managed (Williamson, 1996). Investing in the necessary software, equipment and training to implement an IOS in a business relationship with another actor could indeed be a specific asset to that relationship, i.e. an investment that is lost if the business relationship is ended. The investment in specific assets increases the risk of being dominated by the counterpart, a risk that can be mitigated through contractual safeguards. Losing control over information resources is another risk discussed by the authors in the long linked setting.

7.2.2 Automatic Identification (AutoID)

Even if there are other possibilities (Finkenzeller, 2003), barcodes and RFID currently seem to be the alternatives for AutoID in supply chain applications.

The first widespread supply chain application of barcodes was the Universal Product Code (UPC), used since 1973 to identify products for fast and accurate grocery checkout (Garg et al., 1999). Barcodes are now ubiquitous – e.g. on cinema and airline tickets and on individual parts inside BMW engines (Mortimer, 2005). There is however a subtle difference between the UPC, where all instances of the same product has the same identity and some of the current barcode applications where each item has a unique identifier. Thus the good old barcode has quietly evolved into a technology that can be used for tracking individual logistics units. The UPC resulted in substantial benefits in the retail sector, but even if there is still a huge untapped potential in the extended use of UPC and its successors throughout the supply chain (Garg et al., 1999), there seems to be little interest for barcodes from the SCM community. It also seems that the barcode solutions described as inferior by e.g. Özer and Lee (2007) could be based on old UPC technology supporting only product, not item identification.

However, by promising real time supply chain transparency, RFID seems to have excited more interest. In RFID based IOPTSs, each tracked item is equipped with one or more RFID-tags or transponders, each containing a small microchip and an antenna. Identification of an item is done when a reader device uses radio waves to energize and to interrogate the tag which responds with an identification number and possibly with other data that have been stored in the microchip (Finkenzeller, 2003).

The research on how RFID could affect SCM can be classified according to the SCM problems being targeted: inventory accuracy, bullwhip effect or replenishment policies and according to how the estimation of benefits from solving them is addressed through analytical or simulation models or through case studies. Most of the studies assume that RFID gives perfect supply chain transparency. However, the decision of whether to adopt the technology should depend on a return on investment (ROI) analysis (Sarac et al., 2009 reviewing 142 studies).

The features of RFID when compared with barcodes are summarized in Table 4. As we can see from the table, RFID could support high throughput reliable goods identification without needing to handle the goods manually. RFID could thus support a higher degree of automation, and hence reduce human work and errors, resulting in high quality supply chain transparency. Furthermore, the ability to collect sensory and location data could further provide real time information on goods position and state and hence give a more complete picture.

Table 4 RFID vs. Barcode (adapted from Delen et al., 2007)

RFID	Barcode
Not constrained by "line-of-sight". Hence the location/orientation of the reader doesn't matter if the tags are within the range of the reader's signal	Requires line-of-sight
Simultaneous reading of multiple tags	One read at a time
Highly durable and difficult to damage thus useful in many potential applications	Low durability; subject to damage
Active tags have battery power and can deliver information about location. Some active tags can log sensor data which subsequently can be transmitted to the reader for analysis.	Static label only
RFID tags can be written to repeatedly – they can serve as data bearers	Data on label cannot be updated
Expensive compared to barcodes	More affordable than RFID tags
Reading problems can be caused by liquids and metals	Performance not affected by water or metal content
RFID tagging must be added production processes or added to the unit before shipping	Can be printed before production or directly on item

7.3 Researching IOPTS implementation in the wild

Case research was selected because the implementation of IOPTSs is a contemporary phenomenon that must be studied in its natural context and where the research questions regard how and why technological choices affect the success of the implementation efforts. Case research is especially suited to answering "why" and "how" questions in such settings (Yin, 2003). The research sites and their position in the supply network for food are shown in Figure 5.

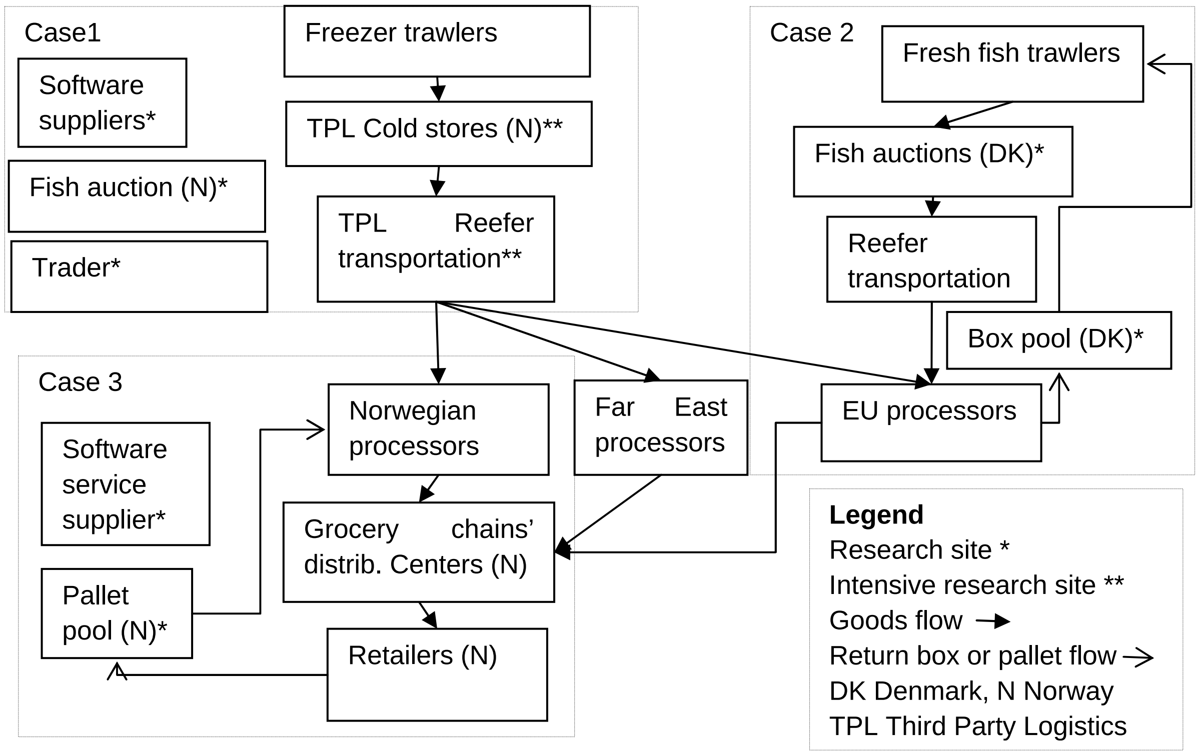


Figure 5 Research Cases in the supply network for food

Table 5 Four inter-organizational food supply chain product tracking cases used in this research

Case #	Case Description	IOPTS Architecture	AutoID technology
1	Pallet tracking in upstream supply network for frozen fish, Norway	Long linked	Barcode
2	Box tracking in upstream supply network for fresh fish, Denmark (200 000 boxes) all major fishing ports	Information pool	RFID
3	Pallet and box tracking in downstream supply chain, Norway (1 000 000 pallets) top four grocery chains	Minimalistic info pool + Long linked	RFID (+Barcode on boxes)
4	National food tracking project, Norway	Information pool	RFID or Barcode

The cases covered by the case research are shown in Table 5. The first three cases have just started full scale operation, but experience had started to accumulate through pilot testing. Case 1 is the primary case, subject for an intensive longitudinal interpretative case study aiming at collecting cross actor implementation experience. Case 2-4 are complementary cases brought in to cover alternative AutoID technologies and system architectures.

Table 6 shows the research activities used as a basis for this study. The main research method was semi-structured interviews, meaning that questions in the interview guides were supplied by follow-up questions when interesting topics emerged. Each interview guide was adapted to the function of the informant and to the state of the IOPTS project being studied. Before an interview in a new organization, documents were collected from the Internet. This documentation was shared with the informant at the start of the interview, to show interest and to increase trust. The tactic seemed to work well in most cases, as we quickly came to the points of interest and seemed to get frank answers. Interviews were often complemented by further document studies and by observation, where further questions were asked to make sense of what was seen.

Table 6 Research activities

Case #	Research description
1	22 interviews covering management, operational personnel, software developers and auxiliary actors. 109 hours observation at a number of sites, >250 documents studied
2	1 interview 2 hours, observation 2 hours, ~10 documents: news coverage, web.
3	1 group interview 3 informants 2 hours, 1 phone interview 0.75 hours, 19 documents: mostly news coverage, marketing material and web.
4	Document study only, 12 documents: – some of them comprehensive reports

Interviews have been recorded with the permission of the informants, except for three interviews, where the circumstances were judged unfavorable for recording. The interviews have been transcribed. Observation has been documented using note-taking and photography.

Validity concerns should be handled systematically when performing case research (Stuart et al., 2007). Validity in such research is obtained mainly through different types of triangulation, where inputs from different data sources, data collection methods, researchers and theories are used to alleviate single method weaknesses and to corroborate findings and explanations (Johnson, 1997). As can be seen from Table 3, both source and method triangulation have been carried out, except for in Case 4. Furthermore, feedback from participants has been solicited both on some field reports and when presenting results in meetings with participants in the primary case.

Analysis was done in two phases. First, analysis was combined with data collection using write ups as suggested by Eisenhardt (1989) – this resulted in a set of illustrated field reports. Final analysis was carried out while working out this paper, by reflection over what is really implied by and supported by the empirical data.

7.4 The IOPTTAC-model

The models discussed in the theory section can be combined into a unified Inter-Organizational-Product Tracking Technology and Architecture Choice or IOPTTAC-model for IOPTS-adoption shown in Figure 6. The model keeps the perceived risk, costs and benefits from Nagy (2007), but reintroduces organizational preparedness from Iacovou et al. (1995) as a prime factor, to cater for current scarcity of RFID implementation knowledge. Using RFID could also incur substantial running costs, so we should consider costs in general rather than discuss only the investment connected to switching to a new technology. Having both benefits and costs also support return on investment considerations as proposed by Sarac et al. (2009).

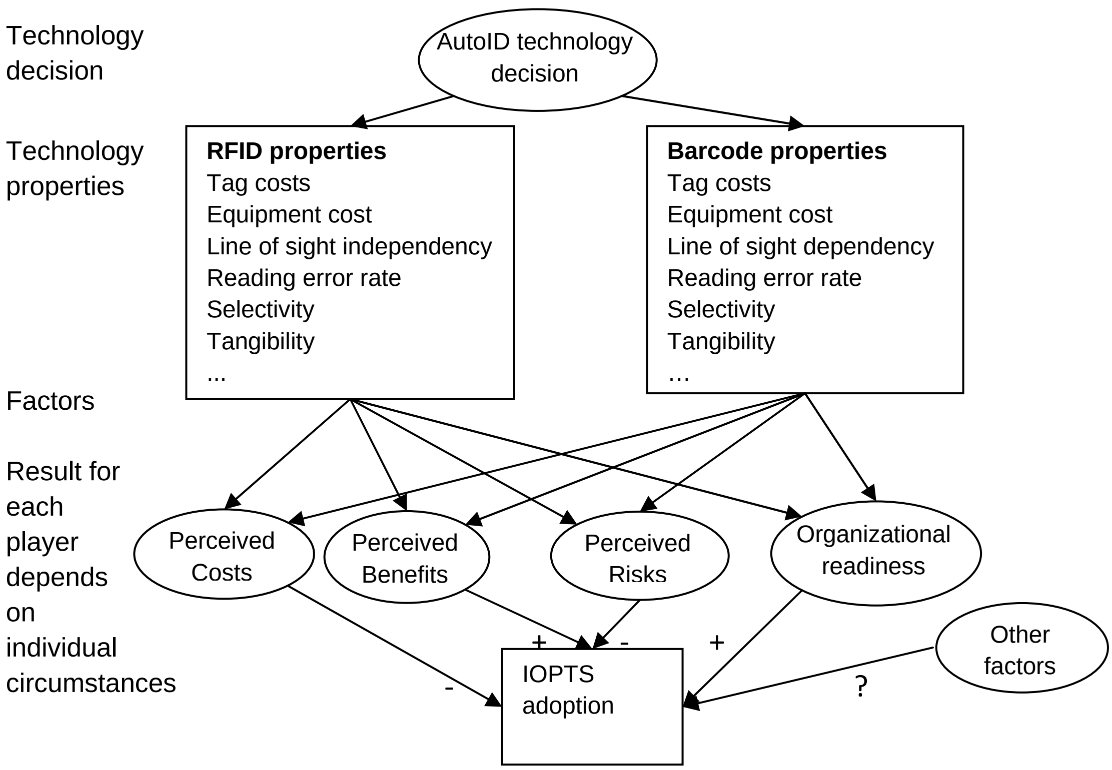


Figure 6 **Outline of the IOPTTAC model – used for selecting AutoID technology. A similar model can be drawn for the decision on the architecture**

A number of other factors do influence the adoption decision (Damsgaard & Lyytinen 1998). These factors are included as “other factors”. The lower part of the model hence covers the adoption decision, building on existing IOS adoption research. The upper part of the model covers how the properties of the technologies could impact the cost, benefit, risk and organizational readiness. The discussion of these impacts uses both results from literature and from the case research discussed above. Table 7 shows how the model can be converted into a tabular format.

The alternatives for AutoID technology is RFID and Barcode. For architectural choice, we have the Pooled and Long linked architectures as discussed in section 2. Some of the RFID-literature proposes that information can be transferred between the players using the memory in the RFID-tag as the data bearer (e.g. Lee and Özer, 2007). Using the tag to transfer information can be dubbed TDB (Tag as Data Bearer) and can be considered a variant of the long linked architecture.

7.4.1 Using the IOPTTAC model

The model could be used to support cross-actor product tracking initiators when taking decisions on automatic identification technologies and on IOS architecture. After all, successful implementation depends upon enrolling the necessary players into the system. The model should support the initiator when evaluating the technologies for use both within his operation, and in the rest of the supply chain.

The evaluation depends on the current state of technology, on the current prices for tags and equipment, and on the installed base and handling processes at each player's facilities. Those are evolving and/or site-dependent targets.

The degree of an IOPTS implementation can vary in several dimensions e.g. whether to track at the pallet, box or item level, whether to track business events only or to aim for real time tracking of each item's position (GMA 2004). Other dimensions regard how much of the supply chain should be covered, and the extent of information being exchanged on each item. Yet another dimension is how much business processes will be changed. Obviously, the degree of IOPTS implementation has a profound impact on the possible benefits, but also on the costs and the risks.

To support the evaluation, the following subsections discuss the different inputs to the model and how they depend on technological choices and local circumstances. Moreover, there is a large degree of interdependence between some of the inputs to the model. Such interdependencies are also discussed.

7.4.2 Cost generating properties

Running cost for tagging and waste

When compared to barcodes which can be printed on labels and packaging already there for other purposes, RFID tags have orders of magnitude higher cost per unit and constitute the main cost driver in RFID based IOPTSs (GMA, 2004). RFID tags could also imply higher costs when recycling used packaging because the materials used in the tags could break the recycling process adapted to standard packaging material and equipment (Kumar et al., 2009). Tags having memory capacity to be used as data bearers could be more expensive than simple tags. Tags with sensors, require sizeable memory and battery power, giving higher cost and further recycling problems. In closed loop approaches, the tags are reused multiple times possibly reducing per-use tag costs to be comparable with the cost of barcodes. Closed loop approaches also reduce recycling costs and could make tags equipped with temperature sensors a more viable option.

Case 2 and 3 are box and pallet pools, where the boxes and pallets circulate in closed loops as shown in Figure 2. The RFID tags used on the returnable assets are thus available for other actors at no extra tagging cost. In Case 1, which is open ended due to the global nature of that supply chain, barcodes were selected as the AutoID technology.

Technical equipment cost

Costs of equipment for both AutoID technologies vary with equipment performance, and it seems that costs are currently comparable for equipment with similar degree of automation. However, if there is an installed base of equipment for barcodes in the supply network, RFID is an extra cost. But for such electronic products, costs can be expected to decrease.

In Case 2, the initiator saw high cost as a barrier for adoption, and was looking for low cost RFID equipment that could be acceptable to the fishing vessels. Here, low cost RFID equipment could be used to tie information of box content from the fishing vessel's information system to each box. The Case 3 initiator seeing that portal solutions could be too expensive to some actors put together a leased package for SMEs using lower cost equipment.

Changing work processes

In contrast with Lee (2007) who propose RFID initially replacing existing technology in existing processes, Ranky (2006) holds that "Work force transformation is a major challenge, because RFID projects force new practices".

In Case 1, introducing barcodes and corresponding information systems, barcode scanning was introduced into the current processes. Case 2 and 3 using RFID introduced completely new processes and business models for handling empty boxes and pallets by the companies set up for the purpose of running the pools. At the fish auction (Case 2), the use of RFID was introduced into the current process for assigning fish boxes to buyers. In Case 3 hybrid tags combining RFID with barcodes were used on boxes to avoid breaking the business processes in "barcode oriented" parts of the supply chain.

Long linked systems are constructed by linking together the systems of the players. This means that the current system is kept and could hence imply less change to work processes.

Integration cost

Item level product tracking is incompatible with most ERP systems in operation (Rönkkö et al., 2007), so integration costs with those systems could be significant regardless of the technology selected for AutoID. Barcodes could be easy to integrate, because it can replace keyboard input directly.

An extra layer of middleware is generally required to extract information from potentially enormous amount of data that can be generated by RFID readers (Ngai, 2009). This adds to the costs for systems building on RFID. On the other hand, reports from Case 3 indicate that the integration costs between players' ERP and the Fosstrack Open Source EPCIS (electronic product code information system) IOPTS used in that project could be affordable for most players.

There is also an integration cost inherent in choosing RFID tags and readers and in setting up and testing readers with the actual products handled. The necessity of testing is clearly illustrated by Poon et al. (2009). The same is confirmed by the case research: "I believed this was on-the-shelf standard products. – It was not!" *Box pool manager, Case 2.*

7.4.3 Benefit generating properties

Benefits from IOPTSs can accrue through increased supply chain transparency in several ways – the revenue can increase due to reduced stock-out rate, - the operating margin can improve through reduced shrinkage and the capital efficiency can increase due to reduced stock and lead times. Operating margins can also improve through decreased labor costs due to automation and to the elimination of mistakes and the cost for handling them (GMA 2004, Lee & Özer, 2007; Sarac et al., 2010).

For food chains in particular, benefits from IOPTS could be obtained through higher prices for products where the origin can be documented (Smith, 2008), through reduced spoilage by better control over expiration dates (Case 1, Case 3) and through increased food safety by faster location of problems and by quicker, but cheaper withdrawal of suspect products from the market (Kumar et al., 2009).

Readability/ tag integrity

There have been reports of high failure rates giving readability problems for RFID tags (Ngai, 2009), an experience also seen in Case 2. It seems that those were teething problems which now seem to be solved (Case 2, Case 3). However, unfavorable tag antenna orientation could still result in readability problems which can be solved by selecting another type of tag (Poon et al., 2009), or by moving or adding more reading antennas.

On the other hand, findings from Case 1 and 2 confirm that barcodes in food chains are easily damaged due to humidity, resulting in a proportion of the barcodes being rendered unreadable. In Case 1 reading was in some cases impeded by shrink wrap obscuring or wrinkling the labels requiring an extra manual operation to make the barcode readable.

The barcode readability problems can be reduced with higher quality label material and glue (Case 1, 3), but this increases barcode labeling costs. The high costs and resulting errors when manually handling reading problems seem to justify a conclusion that high RFID readability and tag integrity could save handling costs and improve information quality.

In Case 2 and Case 3, the RFID technology was used to enable innovative business models based on a hitherto unattainable precision on the movements of boxes and pallets. These models almost eliminated the shrinkage that had threatened pool viability. In both cases, work intensive, error prone manual box and pallet counting processes were replaced by accurate accounting based on RFID.

Independence from line of sight

Barcodes are read using reflected light. This often implies extra movement when the item or the reader must be moved to give line of sight between barcode and reader. Wasteful movement can be reduced using barcodes on more faces of the tracked item, but this increases labeling costs. In Case 1, even when using 2 barcode labels on opposite faces of each pallet, pallets typically weighing over 1000 kg often had to be turned to make labels accessible.

RFID is potentially independent from line of sight for reliable reading, but the orientation of the tag's antenna relative to the reader antenna might be critical. Also some materials might be challenging to read through or on. Even the body of human operators might interfere with RFID systems (Ranky, 2006; Ngai, 2009; Poon et al., 2009; Roberts, 2006). The blocking of RFID signals is a potential problem in food supply chains handling products with high water content or with metal packaging (Kumar et al., 2009). But such problems could perhaps be solved by using specially designed tags (Connolly, 2007) or by using more tags (Case 3 uses 4 RFID tags per pallet and Case 2 and 3 use 2 RFID tags per box). One could also adopt ideas from sensor networks, and make tags cooperate to make the entire tag population on site accessible, but such solutions could require expensive battery powered tags and could result in site delimitation problems. The conclusion for the time being is that independence from line of sight can be obtained in some RFID applications (Case 3), while in others RFID might not live up to the promise and that experiments and experience might be necessary to decide whether the independence from line of sight can be obtained in a particular application.

Figure 7 Using a hand held RFID reader to assign a fish box to a new owner. Low selectivity means that close range reading is necessary to select the right box (Case 2 fish auction).
Photo: Ola Bø

Reading speed, support for process automation

RFID tags can be read at high speed, see Poon et al. (2009) for comprehensive tests. Reading can be done without human assistance (Kumar et al., 2009). By supporting automation RFID could thus prove a superior technology in high volume applications.

In Case 2 and Case 3, this property was exploited to implement new automatic receiving and sending processes in the box and pallet pools. Costs for automation depend on the process in question: in Case 2 box return process, tags were read by a single antenna installed by the conveyor belt in the box-washing machines, while in Case 3, a complex and expensive multiple antenna portal solution was installed reading up to 200 tags per second on boxes being trucked into or out of a loading port.

Selectivity and support for semi-manual operations

Both Case 1 and Case 2 have semi-manual operations, where new information is connected to the item being tracked. In Case 1 the number of boxes on each pallet and cargo damage is registered when inspecting pallets being charged onto reefer vessels. In Case 2, a new owner is bound to the box when acquired at a fish auction.

When using manual barcode readers, the barcode is selected by pointing a laser beam at the barcode. Using long range scanners, the operator can precisely select the label to read at a 5 m distance. This *selectivity* stands in stark contrast to current handheld RFID equipment, which reads all tags within range, often requiring range adjustment and close distance reading to select the relevant tag in high tag density areas, see Figure 7 for an example.

In Case 1, barcodes were used when receiving goods into a reefer vessel. Goods must be visually inspected anyhow to verify the count of boxes on each pallet, and to discover possible damage. The barcode scanning did not seem to slow down the process even when handling the occasional reading problem, meaning that there was no extra personnel cost. Barcodes on the goods were scanned to identify each pallet, whereas barcodes fixed to the cargo elevator were scanned to input information about the number of boxes on each pallet and on the type of cargo damage when necessary. The shipping company reports a significant decrease in handling errors and subsequent claims after the introduction of barcode scanning. The cold store reports that barcodes for pallet and storage location identification have almost eliminated the lost pallets problem.

Barcode might be a superior technology for supporting semi-manual operations in some applications, especially when binding information to particular items.

Support for sensor technology

The use of RFID tags with sensors for example to document the integrity of the cold chain through temperature logging has been touted as a major potential benefit of RFID in food supply chains (e.g. Kumar et al., 2009). Even if dedicated temperature loggers have been used for decades in such applications (Case 2), RFID tags could promise a more fine meshed and comprehensive coverage of the chain and collect temperature data through the IOPTS. But the necessary batteries increase tagging, maintenance and waste handling costs. Furthermore, optimal tag placement for readability might not be optimal for recording representative temperatures in the food. The Case 3 pallet pool is considering introducing a proportion of pallets with temperature sensing RFID-tags.

Information availability

Improved planning and forecasting through improved supply chain transparency is one of the main advantages in product tracking system. For the food supply network, another important consideration is reducing the impact of food crises.

Planning depends on information both on goods expected from upstream actors and on the flow of goods through the downstream parts of the supply chain. Here, the TDB (Tag as Data Bearer) architecture fails, because the information being carried by the tag and updated while travelling through the supply network is only available to the actor in possession of the tagged unit, so this architecture in itself does not support improved planning. However, information in a TDB could be available without connecting to other information systems, but with increasing mobile connectivity this is a decreasing advantage.

In Case 2 and 3, RFID is so far only used for identification, while a large proportion of the barcodes in Case 1 in addition conveys box count, weight and expiration date.

Both Case 1 and Case 3 report that the supply chain transparency achieved through the IOPTSs by data from upstream players is already being used by downstream players to plan the handling of goods in the pipeline, thus removing a number of telephone calls that were formerly used to obtain the necessary coordination.

Food safety authorities, compare searching for the source of the food problems to finding the infamous “needle in the haystack”. One method is to seek for the common supply chain denominator of the victims’ consumption patterns. Such queries would be best supported using a common pool architecture giving instant access to all tracking information in the whole food supply network.

Case 4, having food safety as a main goal was implemented using a pooled architecture. However, long linked architectures supported by effective query and data interchange technologies have also been suggested for IOPTSs for such purposes. (LoBello et al., 2004).

7.4.4 Properties influencing organizational readiness

Barcodes have been with us since the 1970’s and are becoming steadily more ubiquitous in supply chains, but also in daily life. This means that organizational readiness for barcode solutions is probably high.

Organizational readiness for RFID is limited because the necessary competence is missing in many companies (Ngai, 2009). Interviews in Case 1 indicate that some of the informants have heard about RFID, and have a strong belief in the wonders that could be accomplished by that technology. Even if RFID is gaining traction in toll road solutions, in car keys and in access control solutions, RFID could still be more difficult to understand than barcode, both because of the intangible and invisible nature of the technology, because of the erratic signal propagation and interference and because of the integration complexity (Ngai, 2009).

In Case 3, the initiators have eased RFID enrollment amongst SMEs by leasing out an easily integrated base package and by offering education on the technology. These measures are in line with the advice from Iacovou at al. (1995) on how to alleviate low SME organizational readiness.

7.4.5 Risk generating properties

Asset specificity

Asset specificity in IOPTSs depends on the necessary investment for equipment and training to start participating, but also on the specificity – i.e. whether the investments are lost if the business relationship ceases. Specificity increases if the initiator selects a technology which is incompatible with the installed base in the supply network. In many food supply networks, RFID is not a part of the installed base today, but this could change especially by the advent of supply chain pallet and box pools using RFID to keep track of their assets (Case 2, Case 3).

The EDI-links in the long linked architecture could be specific assets if they are especially adapted to a counterpart. EDI asset specificity can thus be reduced by using a common standard EDI profile (Damsgaard and Lyytinen 1998). In Case 1, asset specificity was reduced when the initiator paid for an EDI module in the warehouse management software used by most of its counterparts.

For the pooled architecture, asset specificity is low if the pool constitutes a common standard for all players within a business sector.

Vulnerability to loss of control over information resources

Contrary to the discussion on risks in Kumar and van Dissel (1995), it seems that the pooled information resource could constitute a more substantial risk for loss of control over information than the long-linked type of system, both because it could contain a larger amount of information from many actors and because the other actors, some of them probably competitors and/or counterparts could gain access to it in spite of technical safeguards. Another point is that the pool and its safeguards have to be controlled by someone, so the perceived risk to the information fundamentally depends upon the degree of trust each actor has in the organization running the shared resource.

It seems that information risk is indeed a barrier for adopting IOPTSs with common pool architectures: at least two prospective participants in the Case 4 common pool IOPTS have shown reluctance to full participation, due to concerns about control over information in the pool.

A telling example of common pool information risk is the court case where the SAS aviation company got a heavy fine for industrial espionage by exploiting competitor's information in the Amadeus common pool booking system, to gain unfair advantage (Nielsen 2008).

Players participating in a long-linked architecture can reduce risk by sending information on a particular item only to the business partners handling that item and by reducing the extent of information: "We operate on a strictly need to know basis" *Case 1 Shipbroker about* *information given to partners.* But this risk reduction could correspond to a reduction in information availability.

The alternative TDB architecture implies that information is accumulated on the tag. RFID tagged goods containing sensitive internal information could then be vulnerable to industrial espionage using fast long-range readers.

Vulnerability to obsolescence and incompatibility

It seems that some of the RFID standardization confusion (the Economist, 2007; Ngai, 2009), has been reduced by the advent of the EPC gen 2 tags used in Case 2 and 3. Also the problem of region-specific standards for radio frequencies (Finkenzeller, 2003) could be handled using multi-standard tags available today. For item identification, using the identification numbers as standardized by GS1 is probably a good choice, since that standard has been widely embraced both for barcode and for RFID-applications. However, the standardization of other information could still be unresolved, meaning that applications using sensor technology or the TDB architecture might still imply a risk of obsolescence and incompatibility.

7.4.6 The adoption decision

We like to think that decisions are taken based on thorough evaluation of the different options. However, as we can see from the preceding discussion, the decisions on technology, and the resulting costs, benefits and risks are interdependent and also uncertain. In reality it seems that the initiators of all four cases studied decided to implement an IOPTS to solve one problem that was crucial to the initiator: In Case 1, claims due to frequent goods handling errors threatened company profitability. In Case 2 and 3, returnable asset shrinkage was considered the major problem, and finally in Case 4 the national food authorities had been seeking the cause while more consumers were hospitalized from food induced illnesses.

7.4.7 The tabular IOPTTAC model

The tabular model is shown in Table 4 below. As discussed in the introduction to this section, the impacts depend on local and time dependent circumstances and also on the degree of implementation. Therefore many entries in the model are interdependent or subject to discussion. Such entries are indicated with an asterisk, and when using the model to evaluate the situation for a particular player, those entries must be adjusted accordingly and if possible with exact amounts. The discussion in the preceding subsections might be of some help here.

Table 7 **The tabular IOPTTAC-model. Context dependent or interdependent impacts are marked with an asterisk.**

	AutoID technology		Underlying IOS architecture		
Factors - Properties \ technological choices:	**Barcode**	**RFID**	**Pool**	**Long linked**	**TDB**
Costs					
running cost tagging and waste	low*	high*			
investment in technical equipment	medium	high*			
investment in changing work processes	medium	high*	medium	Low	medium
integration costs	medium	high*	med*	Medium	medium
Benefits					
readability/tag integrity	medium*	high			
independent from line of sight	no	yes*			
reading speed/support for process automation	medium	high	high	High	medium
selectivity/support for semi-manual operations	high*	medium*			
supports sensor technology	no	yes*			
information availability	medium*	high*	high*	medium*	low*
Organizational readiness	high	low*	medium	High	low
Risks					
asset specificity	low	medium*	low*	high*	medium*
lost control over information	low	medium*	high*	medium*	high*
obsolescense and incompatibility	low	medium*	low*	high*	medium*

7.5 Conclusion

There is a large span in the degree of IOPTS implementation and in the corresponding supply chain visibility. Cross actor visibility is dependent on the penetration of the underlying IOS in the supply chain, but except for coercion through the famous RFID mandates from seemingly omnipotent players like Wal-Mart and the US DoD, SCM literature to date largely seems to ignore the crucial issue of how to obtain the necessary IOS adoption.

The proposed IOPTTAC model attempts to fill some of the gap by a structured overview over how the properties of the different technologies and architectures to choose from could influence the factors determining the adoption decision taken by supply chain actors. The factors and the connection between them and the adoption decision come from well substantiated theories on IOS adoption built on factor analyses and on a theory on risk handling in supply chain integration developed from common property resource theory and transaction cost economics.

For each factor in the model, we have discussed the impacts of the properties of the different technologies for AutoID and of the architectures for IOPTSs. The discussion compares hypotheses and findings on the technologies from the literature with finding from a case study, including *selectivity* as a salient property for barcodes. The discussion further seeks to show the interdependencies between choices, and how these choices played out in the four cases. The model and the structured discussion could inform similar decisions in other supply networks.

In fact it seems that in some cases the initiators' choice of technology could be more influenced by the initiators' own requirements to solve imminent internal problems than a careful consideration of what could be beneficial for supply chain wide adoption. But the discussion on the case studies shows that supply chain adoption becomes an ongoing concern for the initiators, and that many of the measures they use to further adoption could be described in terms of the IOPTTAC-model. Perhaps improved adoption rate in similar projects might be obtained by using the IOPTTAC-model normatively to inform the technology decisions up front.

For further research we propose the following: Most SCM research on RFID benefits today posits perfect supply chain transparency (Lee and Özer 2007). For a number of reasons, full transparency seems an unobtainable target. Is it possible to develop theory that could guide decisions on what degree of transparency to aim for?

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8 SCIMN – A SUPPLY CHAIN INFORMATION MAPPING NOTATION

Abstract

In supply chain management a key idea is a tighter integration between the actors of supply chains giving a higher degree of information transparency to support a more holistic supply chain optimization. But in many real world supply chains, information exchange between actors is performed with manual, expensive and error prone processes leading to information with deficient quality, a situation which contributes significantly to the operating cost. The Supply Chain Information Mapping Notation (SCIMN) presented in this paper could be used as a tool in supply chain research. Another possible application is in supply chain integration projects, to pinpoint problems and prioritize between areas that could benefit from increased electronic information exchange and the use of automatic identification technologies.

The paper launches SCIMN as a complementary tool to other mapping notations commonly used in such settings. The SCIMN could serve as a complement because of its unique features: the focus on the quality of the information elements supporting actors performing logistics activities, the focus on goods identification and on the information carried by the logistics units: the boxes, pallets and containers moving through the supply chain.

Information Quality (IQ) is an important research field which has produced a rich variety of concepts and metrics. How those results could be used for information mapping in a supply chain is elaborated upon, resulting in a simple four level information quality hierarchy.

To describe the notation, a fragment of a real world supply chain is being used. The processes are first described and illustrated using the popular Business Process Modelling Notation (BPMN). Then the three elements of SCIMN: the structure, the notation for information quality and the notation for information handling are introduced, before a SCIMN diagram for the partial supply chain is drawn and commented upon.

Keywords

Supply Chain Mapping, Value Chain Mapping, Information Quality, Supply Chain Management(SCM), Inter-Organizational Systems (IOS), Electronic Document Interchange (EDI), Automatic Identification Technologies (AutoID), Radio Frequency Identification (RFID)

8.1 Introduction

One response to increased competition and globalization, is Supply Chain Management, where the goal is holistic optimization of a supply chain to reduce the cost of getting the right product to the right place in the right time. To reach that goal, Supply Chain management combines principles from lean manufacturing with a tighter integration of the supply chain (Burgess 1998). Here integration does not necessarily mean to take ownership of the supply chain actors, but rather to foster cooperation and partnership and hence improve information interchange between actors of the supply chain. The resulting improvement in the quality of the information available to stakeholders in the supply chain is an important goal in SCM. The main focus of SCM so far has been on the downstream part of the chain with efforts to reduce product and order cycle time, optimize inventories and reduce the Forrester effect (Forrester 1961, Lee 2002) through initiatives like Efficient Consumer Response (ECR) and Vendor Managed Inventory (VMI).

However, for many if not most real world supply chains there are still considerable gaps between the ideal of full electronic information transparency throughout the supply chain using Electronic Data Interchange (EDI) or supply chain information systems and the everyday realities of missing, untimely or uncertain information handled using largely manual, expensive and error prone processes. In addition to inefficient and ineffective manual information handling, the work to correct errors and the expenses of settling claims are probably in many cases amongst the major cost drivers for the logistics part of supply chains.

Evaluating the impact of poor data quality is a challenge, but three proprietary studies indicate that the cost of poor data quality can be estimated to 8-12 % of the revenue in the typical enterprise, and a more informal evaluation indicates that “40-60 % of a service organization’s expense may be consumed as a result of poor data quality” (Redman 98 p. 80). It seems probable that a significant proportion of those expensive data quality problems can be attributed to deficient information handling in the supply chain.

When doing research or information quality improvement projects in supply chain settings there is clearly need for a tool to provide an overview over the information handling activities and the resulting quality of the information available to the personnel performing the logistics activities. The Supply Chain Information Mapping Notation (SCIMN) presented in this paper is developed specifically for such mapping.

A number of mapping notations, tools for business process or value chain improvement or for construction of the corresponding software have been described, see for example Hines and Rich (1997) describing seven different value chain mapping tools, later extended to 11 mapping tools in Hines et al. (1998). The value stream mapping (VSM) tool is discussed by Tapping et al. (2002), Rother and Shock (2003) and Lasa et al.(2008). Larman(2005) describes activity diagrams, a part of the Unified Modelling Language (UML) and finally Wohed et al. (2006) treat the Business Process Modelling Notation (BPMN) .

The SCIMN is complementary to the established notations, first by explicitly including information quality as seen by the different actors, second by including the identification of the goods and third by including information carried by the goods itself. This last point means that SCIMN includes the logistics unit (box, pallet or container) as an actor with its own information content. Including the logistics unit as an information carrier also means that the notation could be an especially useful tool in projects where the potential of RFID tags as data carriers is being considered.

The SCIMN was originally developed to illustrate findings when researching quality problems in information used for operational coordination of upstream fish logistics. The case research revealed a complex supply network with many stakeholders, intricate information exchange patterns and considerable potentials for reducing errors and costs by making better quality information available to stakeholders and on logistics units. For the extreme case of the fresh fish supply chain, the combination of perishable goods and high supply uncertainty leads to inherent quality problems in several information elements, and using the notation it was also possible to document how those information quality problems were handled in the business processes of the supply chain.

The next two sections discuss the concepts of information quality and information handling respectively. In section 4, a fragment of the fish supply chain, an electronic fresh fish auction will be described and modelled using the current standard modelling tool, the BPMN. Then the SCIMN will be thoroughly presented using the same fresh fish auction. The subsequent sections cover the testing of SCIMN and BPMN in supply chain research settings before concluding and presenting opportunities for further research.

8.2 Information Quality (IQ)

Information and data quality, are in fact synonymous names for a research field in its own right with literature covering areas like information quality dimensions, information quality assessment and information quality improvement, mostly from the perspective of the users of information systems, data bases or data warehouses. A recent review of the field can be found in Batini et al. (2009).

There has been some confusion in the field of IQ with different researchers using different terminologies and it is not within the scope of this paper to go into that debate, but rather to discuss some findings that could be relevant when developing a mapping notation.

A seminal IQ-paper from Wang and Strong (1996) builds upon an elaborate two stage survey on data quality as seen by data consumers and results in a taxonomy containing 4 quality categories with a total of 15 different quality dimensions. This seems to indicate that data quality is not a simple concept, and that quality assessment might prove a difficult challenge.

A particularly interesting approach is Price and Shanks (2005), first pointing to the correspondence between components of semiotics and components of information systems and then using semiotics as a theoretical basis to distinguish between syntactic, semantic and pragmatic as the three main categories for data quality. Here syntactic means that the data is according to the database constraints of the information systems storing them, semantic means that they constitute a correct and complete (sic) representation of the real entities the database contains information on and pragmatic means that the information serves the real requirements of the users.

When compared to most studies on information quality, the focus when doing information quality research in supply chains, is both narrower – limited to the context of supply chain activities – and wider: there are many actors in most cases having different information systems including manual procedures, so “syntactic” information quality assessments cannot be based upon compliance with a single well defined information system. Furthermore, the goods is transformed and transported several times on the way from the source of raw materials to the market. This means that that the real entities to compare the information with may be uncertain and changing, so the ”semantic” information quality will be hard to evaluate and will also be time dependent.

However, the importance of different elements of information and dimensions of information quality for a particular user and a particular task obviously must be different for each user and each task (Salaün and Flores 2001), so we need to do a close examination of each user task to do a meaningful assessment of the quality of the information used to support the task in question. This assessment can best be done qualitatively by observing and interviewing the users in activity to discern the information processing being carried out and the information being used and the problems the users encounter when working to complete their tasks. Rather than measuring the data quality directly, Redman(1998, p.80) suggests that “showing how poor data quality contributes to better-known problems [..] is often more effective than estimating error rates in the data [and the resulting] consequences”.

From a mapping point of view, it is impractical both for map readability and for mapping cost reasons to operate with too many quality dimensions and too fine grained measurement of each of them, so to make quality mapping a feasible proposition, we need to simplify rather than diversify the notion of information quality. Also the data quality dimensions are not at all orthogonal because, if data is not accessible, accuracy cannot be evaluated, and if data is inaccurate, it might not be interesting to process it in an information system at all, so for a supply chain information mapping notation, perhaps the many dimensions and sophisticated data quality metrics could be replaced by a coarse information quality hierarchy shown in Figure 8, a hierarchy in the spirit of Maslow’s hierarchy of needs (Maslow 1943).

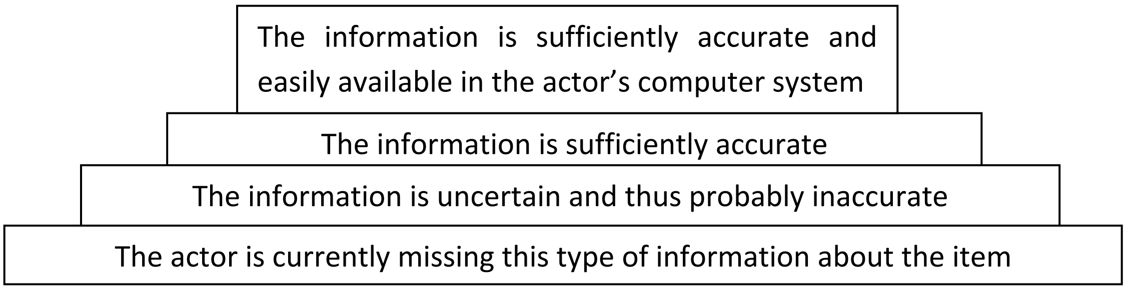

Figure 8 The information quality hierarchy

In the context of the mapping notation, the level in the information need hierarchy indicates the quality of a specified information element, from the perspective of a supply chain stakeholder doing a definite task at a definite time. Surprisingly, a closer examination, see Figure 8, shows that 13 of the 15 information quality dimensions from Wang and Strong(1996), could be projected into the information quality hierarchy when used in the SCIMN. Because it seems obvious that believability, objectivity and reputation can only be based on a track record of accuracy of the data source in question those dimensions could be included in the accuracy dimension.

Another simplified description of data quality can be found in Watson(2004) who discusses information accuracy and reliability on a scale of hardness from 1: soft-rumours and gossip to 10:hard-stock exchange data.

For mapping purposes it seems a practicable approach to use the four level information quality hierarchy, and also to adapt the concept of hardness from Watson (2004), resulting in the following four levels of information hardness used within the SCIMN.

0. None – The information is missing
1. Soft – The information is inaccurate
2. Medium – The information is sufficiently accurate
3. Hard – The information is sufficiently accurate and easily accessible in the actor's computer system.

Table 8 Correspondence between data quality dimensions from Wang and Strong(1996) and the information need hierarchy

Information quality dimensions from Wang and Strong(1996)	Projection of information quality dimensions into the information quality hierarchy
Intrinsic data quality	
-believability	Included in accuracy
-accuracy	used as main criterion
-objectivity	Included in accuracy
-reputation	Included in accuracy
Contextual data quality	
-value added	not covered
-relevancy	only relevant information is shown in the SCIMN-diagram
-timeliness	missing or uncertain information at task time is shown as such
-completeness	missing information shown as missing
-appropriate amount	included in easily available
Representational data quality	
-interpretability	included in easily available
-ease of understanding	included in easily available
-representational consistency	included in easily available
-concise representation	included in easily available
Accessibility data quality	
-accessibility	opposite of missing
-access security	not covered

8.3 Information handling

Logistics is "the coordination of material and information flows across the supply chain" (Harrison and van Hoek 2008). Information handling is thus a central activity in logistics and logistics effectiveness and efficiency could be improved by changing the way information handling is carried out.

Harrison and van Hoek (2008 p. 238) use the following three categories of electronic integration in supply chains:

- transactional: the electronic execution of transactions
- information sharing: the electronic sharing or exchange of information
- collaborative planning: enables trading partners to work together closely to align their organization's plans

The same categorization could be used to classify the corresponding manual information interchanges. To complete the list we should also include the identification of logistics units, because correct identification is crucial to avoid expensive goods handling mistakes.
Changing information handling can imply substituting the labor intensive and error prone manual information handling with suitable Information and Communication Technologies (ICTs) as shown in Table 9, Even more substantial improvements might be obtained by also changing the communication *pattern* by giving more actors access to the information or by providing the information at an earlier stage.

Table 9 Information exchange categories and ICT opportunities for improvement

Information exchange	ICT opportunities	ICT Cost benefit profile
informing	e-mail, web, EDI, Web Service(WS)	medium cost/high benefit
transactional	web application, EDI or WS	high cost/high benefit
collaborative planning	low bandwidth: phone e-mail, instant messaging, high bandwidth: videoconferencing, collaborative software	low cost/medium benefit high cost/medium benefit?
identification	AutoID using bar codes AutoID using RFID	medium cost/high benefit high cost/high benefit

As collaborative planning is often used in situations where the partners negotiate based on knowledge not available to each other or in situations with considerable uncertainty, the application of higher bandwidth technologies for collaborative planning might prove beneficial, but low cost technologies like phone or instant messaging might also be sufficient.

8.4 The Fresh Fish Auction presented in BPMN

The Fresh Fish Auction being presented here is one among several fresh fish auctions in the UK. It is an electronic auction, selling fish to buyers situated at the auction. Those buyers are agents for their customers, mainly fish processing industry and chains of supermarkets in the UK and France. The following text describes the typical processes and information flows whereas Figure 2 is a BPMN diagram for the same processes and flows. The bracketed numbers for information flows in the text correspond to numbers on the BPMN diagram, and the same numbers will be used again later when mapping the information quality dynamics using the SCIMN in Figure 9.

The fishing vessel catches the fish and grades and sorts it in boxes while at sea. On the way to the auction, the fishing vessel sends an early landing notice [1] stating species and quantities to the auction, who publishes the landing info on the auction web pages [2]. During the night, the fish is landed at the auction, and auction personnel place the boxes on the auction floor. Box position indicates both the fishing vessel and how old the fish is. As some of the fish lose weight during storage, some of the more valuable species are re graded by auction personnel who also group and register boxes into auction lots resulting in an auction list [4].

In the morning, fish buyers come to inspect the quality of the lots and then make agreements with their remote customers, mainly fish processors, on what to buy and at what price [6, 7]. The market operates a Dutch auction meaning that the price for a lot starts at a high price and then falls until a buyer presses his bid-button [9], and then the fish is sold to that buyer. In some cases the buyer, seeing higher prices than expected, contacts his customers again to get a revised order [8].

After the auction, the buyer tells the auction personnel what fish should go to what address [13], so the fish can be correctly loaded into the cold trailer. He then contacts his customers to get confirmations [14,15] and finally sends consignment documents [16] to the trucking companies involved in forwarding.

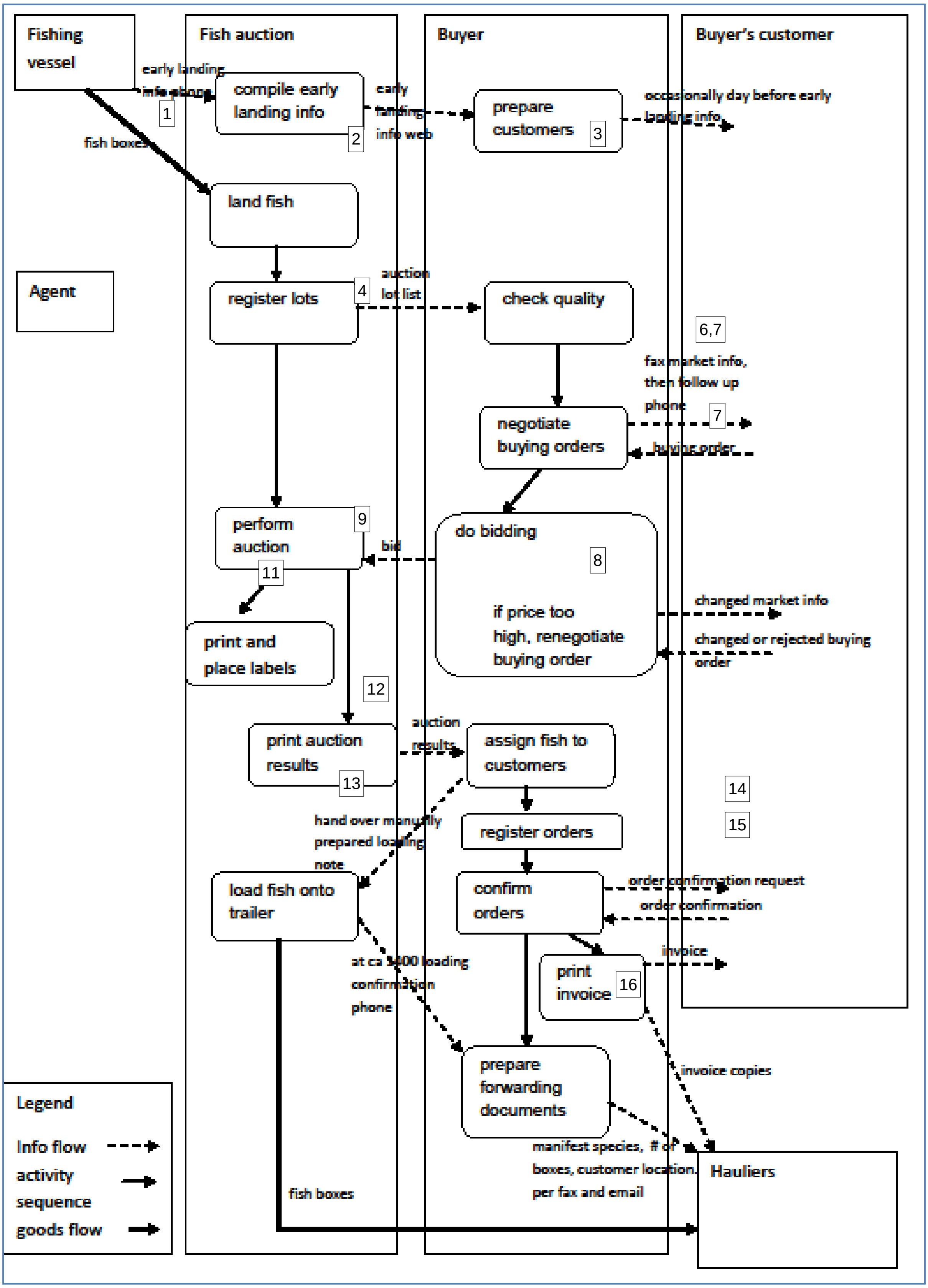

Figure 9 BPMN diagram for the Fresh Fish Auction

As can be seen from the BPMN diagram in Figure 2, the BPMN notation is quite straightforward to read. The BPMN notation has also been used when discussing business processes with the stakeholders. In the next section we will discuss a complementary notation to the BPMN, the SCIMN.

8.5 The SCIMN Notation

A map is an abstraction in the sense that it cannot and should not show all details, but present a simplified picture of reality, a picture to serve a certain goal. Maps for car drivers are thus different from maps for inland waterway skippers. As the goal of the SCIMN is to show the dynamics of data exchange and data quality for the different actors of a supply chain, the mapping notation is adapted to that purpose.

8.5.1 SCIMN structure

The basic structure of the SCIMN notation as shown in Figure 10 has the following elements:

- A horizontal operations-axis, where the different logistics operations are placed sequentially, meaning that the operation axis is also a time axis.
- A vertical actor-axis where the top actor is the logistics unit, the goods itself in the form of for example a box, a pallet or a container. Under the logistics unit, the actors of the supply chain are listed.
- For each actor, the table is subdivided into rows for each of the main information elements about the goods that are relevant to that actor. When applied to Figure 3, this means that the relevant information elements for auction personnel are the LUI, the quantity and quality of the fish in each box, the price for the box, and the address they will later forward the box to.
- For the logistics unit, the information shown could for example be printed on a box label or stored in an attached RFID tag.
- A special data element is the Logistics Unit Identification (LUI), information used to identify a particular logistics unit. The LUI is necessary for accurate identification of the goods and hence crucial to avoid handling mistakes.

We can see that the SCIMN supports mapping the same information element several times in the table hence making it possible to map the well known fact, that in a supply chain different actors might have different data quality for the same data element.

actor	info element	catch	land/ regrade	quality control	pre auction	auction
logistics unit	LUI quantity quality address					
fishing vessel	LUI quantity quality price					
fish auction	LUI quantity quality price address					

Figure 10 An example showing the SCIMN structure

8.5.2 SCIMN Notation for Information Quality

The information quality is coarsely classified into four different quality categories corresponding to the four levels of the information quality need hierarchy depicted in figure 1. The levels are shown by different degrees of colored hatching, from no pattern meaning no information available via red thin “soft” uncertain and inaccurate, and brown “medium” sufficient accuracy quality to heavy green hatching “hard” computerized, accurate and easily available information, as shown in Figure 11.

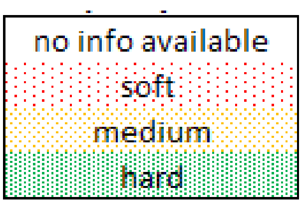

Figure 11 The four levels of information quality with color codes

actor	info element	catch	land/ regrade	quality control	pre auction	auction	post auction	load	transport	unload at processor
fish buyer	LUI									
	quantity									
	quality									
	price									
	address									

Figure 12 Information quality dynamics for a fish buyer

As an example, Figure 12 shows how the notation can be used to describe the information quality dynamics for a fish buyer. In the catch phase, 24 hours before the auction, he does not know anything about what will be coming in, but he has soft information from experience about the current price levels. Just before landing, the buyer can fetch early landing information on the auction web-site to get low precision information about the expected quantity of each species from each of the fishing vessels on the way in to land their catch. Knowing the fishing vessel this also is an indication of the expected qualities available, hence quality is now described as soft. Early in the morning, the buyer then controls the quality of the fish landed, and gets a firmer idea on the quality, see Figure 13.

The quality inspection increases the quality of the fish quality information from soft to medium, but not to hard, because there is still some uncertainty as to the quality of the fish when delivered to the end customer. Also the fish quality information is handled manually. The price and the address for the fish is still uncertain i.e. soft, but in the pre auction phase, the fish buyer contacts possible customers informing them on the market conditions and negotiating a buying order at a certain price limit. This increases buyer's address and price information quality from soft to medium. The final price is decided when bidding, and being accounting information in the electronic auction system, this information is now top quality hard information. The buyer does the final allocation of the fish to his customers in the post auction phase, entering the information into a computer system and confirming with his buyer, hence turning the address of the fish into hard high quality information as well. Fish quality information remains medium quality through the following stages, because quality might change more than expected on the way to the customer leaving a degree of uncertainty. The quality of logistics unit identification (LUI) remains low because the LUI is based on the fish box position on the auction floor, making mix ups possible.

Figure 13 Fish buyer evaluating whether a box of perishable monkfish can be expected to arrive in France two days later with a quality still fit for sale. (Photo: Ola Bø)

To sum up the example: For some information elements, Information quality starting low is improved by information exchange and by operations creating new or more accurate information. For some information elements, information quality is limited by inherent uncertainties that might be difficult to reduce even with the best of technologies. For other information elements, information quality could be substantially improved by introducing ICT technologies like AutoID and EDI. The SCIMN in all cases helps pinpointing the information quality problems.

8.5.3 SCIMN Notation for Information Handling

The notation for information handling, as shown in Figure 14, uses the four categories of information exchange presented in Table 9 and also shows to what degree the information exchanged is represented in a digital format i.e. to what degree the handling is supported by ICT. Furthermore as it seems that re-entering the same information into one or more systems for each new actor is a frequent and wasteful activity in supply chains, such operations are explicitly represented in the notation. The notation also makes it possible to express another common phenomenon, the manual handling of output from ICT-systems.

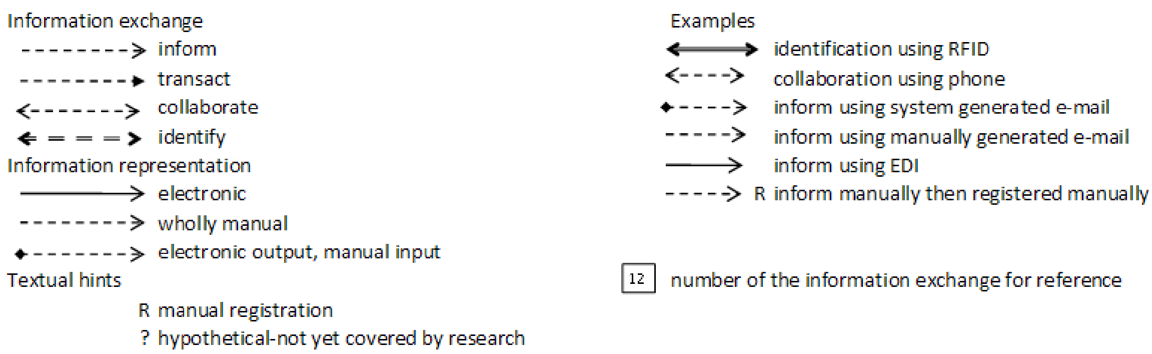

Figure 14 Notation for information handling

Now all the required components of the notation have been described, and we can present a complete example

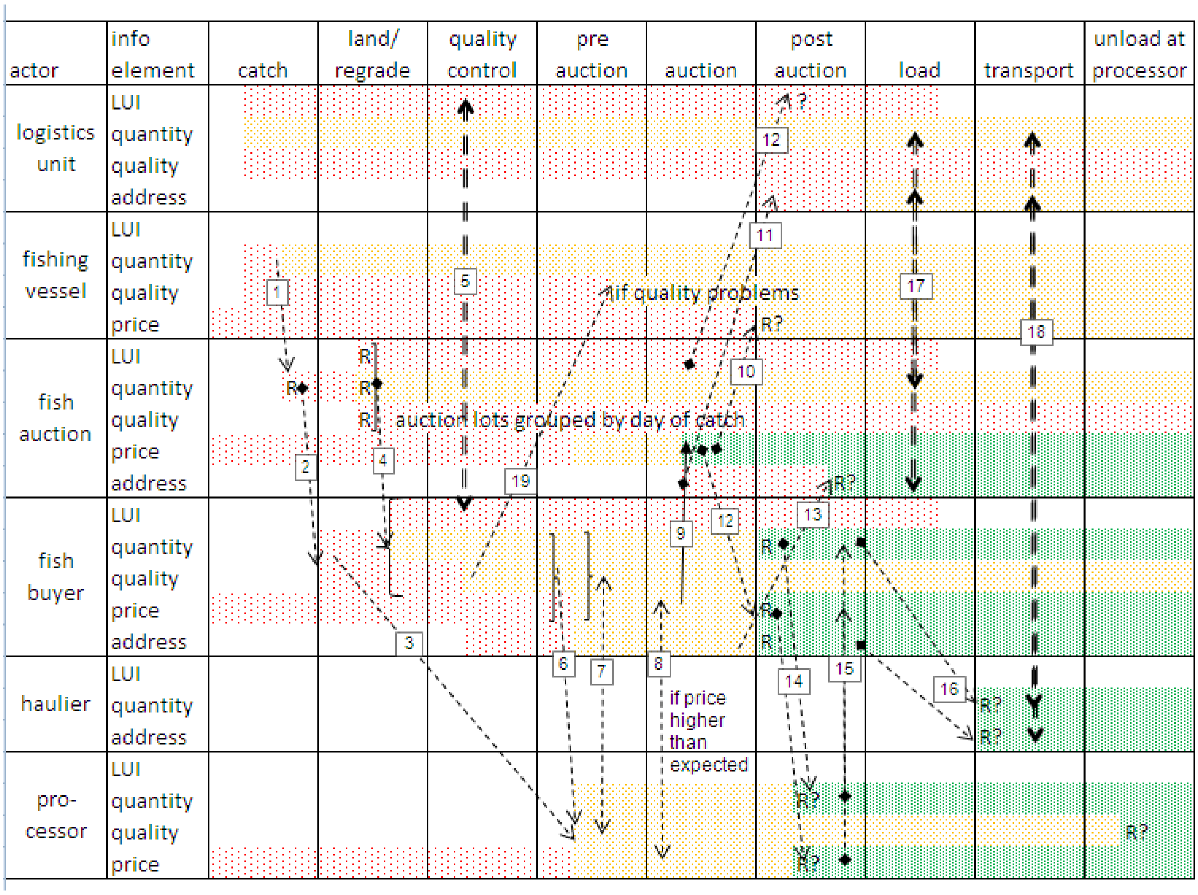

Figure 15 A complete SCIMN diagram for the fresh fish auction (numbers refer to bracketed numbers in the text)

8.5.4 Complete SCIMN diagram

An example SCIMN diagram complete with structure, information quality and information handling notations is displayed in Figure 15. The diagram corresponds to the BPMN diagram in Figure 9 and information flows is numbered in the same way. The textual description in section 6.4 can also be read with this diagram to enhance understanding. The observant reader will see that some more information streams appear in the SCIMN diagram than in the BPMN diagram. Those flows are mainly for goods identification. The information quality dynamics and the amount of communication and the proportion of manual labour expended to support the information propagation throughout this part of the supply chain should also be clearly visible on the diagram.

8.5.5 Some findings from the SCIMN diagram

Our main findings from applying the SCIMN diagram are as follows.

One of the main results of the business processes is creating better quality information. Both price, quantity and quality information is initially unknown or uncertain for all actors. The business processes remove much of the uncertainty and spreads information to several actors.

Even if an electronic auction is a central business process and some of the actors are using information systems to format data sent to other actors, all information exchange except [9] is handled manually, leading to the same information being manually registered over and over again by different actors.

Fish quality is an uncertain factor being handled both in the quality control, in the pre and in the post auction business process, processes when the fish buyer assesses which fish has the right quality and price for transportation to and use by which customer. This assessment is in fact one of the main functions of the fish buyer, and many of the information exchanges shown in the diagram are handling information resulting from these assessments and the corresponding business transactions.

Logistics units are identified manually both by the fish buyer and later by auction personnel handling the loading of refrigerated trucks and by the hauliers in subsequent stages. At the auction, goods are roughly identified by position on the auction floor. After each sale a label showing buyer is added as a first step towards an address. After the auction, the buyer informs the auction personnel on the addressee of the fish boxes. For the haulier, logistics unit identification information is missing, so address and quantity are used as substitute means of identification in the later cross docking steps [17,18]. Reports on weekly problems of faulty deliveries should perhaps not come as a surprise seeing the weak quality of the goods identification methods used throughout the part of the supply chain described in the diagram.

8.6 Testing the notation

The notation has so far been tested in research settings including in total three case studies in the upstream supply network for seafood:

- **Norwegian coast frozen palletized white fish, with several primary buyers using reefer vessel transportation**. The SCIMN was developed and used to pinpoint wastes caused by information quality problems. Benefit: a systematic walk through of the importance of the different information elements for the different actors, and the corresponding quality problems.
- **UK, fresh boxed white fish auction with several primary buyers using road haulage transportation**. The SCIMN was used after BPMN modeling and revealed a number of areas that had not been covered by the interviews. Here BPMN was tested with a fish buyer and gave a clearer understanding during discussions of the business processes with the practitioner.
- **UK, fresh lobster, one primary buyer using road haulage transportation**. Here the information quality diagram was tentatively drawn before starting interviews. This was possible because the supply chain in question had been subject to quite some media interest and to a review process for sustainable fishing resulting in more than 15 documents on the supply chain being publicly available. The diagram effectively showed what actors and processes were covered by the documents and where more questions had to be asked.

In all cases, drawing the SCIMN diagrams proved crucial to getting and giving an overview of the information quality dynamics for the supply chain being researched. Every time the diagram was drawn, the drawing revealed several aspects of the information handling that were not sufficiently covered by the research.

8.7 BPMN versus SCIMN

The two notations used in this paper have some similarities. They can both map business processes involving several actors and can show the information exchanged between those actors, but there are also several differences.

BPMN is a standardized and popular notation, showing a clear sequence of actions performed by the actors. The notation uses symbols that can be placed where it suits the draftsperson, and comments to give more profound explanations can easily be added. The BPMN has proven itself as an easy and intuitive tool for communication between personnel involved in the business processes and experts involved in improving the same processes.

The goal of the SCIMN is to discover and describe information quality problems in supply chains. Its tabular format forces the draftsperson to consider the information quality available to each actor at each stage of the business processes for each element of information relevant to that actor. The main strengths of SCIMN are the ability to give an outline of the information handled throughout a supply network and to show areas with missing or low quality information and the corresponding information asymmetry between the actors involved, as well as showing the information carried by goods and to show a variety of automatic or manual information handling processes including cooperative planning, goods identification and wasteful manual re entry of information. The weaknesses of SCIMN are that the format makes it challenging to include comments directly in the diagram, and that the number of information exchanges depicted can make the diagram overcrowded and hard to read.

8.8 Conclusion and opportunities for further research

The paper presents a new notation supporting the mapping of information quality in supply chains. Testing seems to indicate that the notation is conducive to the development of a detailed and comprehensive overview over information exchanges and resulting information quality in the multi actor business processes common in supply chains.

The notation is based upon a coarse four level hierarchy of information quality needs, that can be seen as a supply chain operations projection of 13 of the 15 information quality dimensions proposed by Wang and Strong(1996).

As failures due to deficient goods identification is reported to be a major cost driver in transportation activities, information carried by the logistics units and the corresponding information available to actors to correctly identify logistics units has been included in the notation.

Compared to the Business Process Modelling Notation currently used in some supply chain improvement projects, the SCIMN might appear slightly less readable, but still SCIMN could prove beneficial as a supplementary tool to document information quality problems, and hence support and direct work to improve information flow in supply chains through the implementation of ICT like EDI, supply chain information systems and AutoID.

The SCIMN could be a useful tool, but more research is needed to evaluate its suitability as a tool for:

- other parts of the supply chain or other commodity or service supply chains
- communication with practitioners
- prioritizing between areas of improvement
- analyzing the direct and indirect effects of such improvements.

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9 THE POTENTIAL OF INTER-ORGANISATIONAL PRODUCT TRACKING SYSTEMS IN A "SUSTAINABLE" SUPPLY CHAIN – OBSERVATIONS FROM THE WILD SEAFOOD SUPPLY NETWORK

Abstract
For industries using common pool natural resources, sustainable sourcing is crucial for long time viability. Fisheries constitute a case in point as world catch peaked in the early nineties. Currently we can observe a change in behaviour in the seafood industry in large parts of the western world, as the industry is implementing various sustainable supply chain management strategies. This paper discusses the potential and limitation of electronic inter-organisational product tracking systems to support these changes. The discussion builds upon case research in the supply network for wild caught seafood in Northern Europe.

Keywords
Sustainable supply chain management, electronic track and trace, common pool resources

9.1 Introduction

Operations management literature sees tracking of products both as a practical problem and as a potential tool for improving inventory management and operations performance. Currently, leading industrial actors are introducing product tracking to improve their supply chains (Holmström et al., 2010). Electronic Inter-organisational Product Tracking Systems (IOPTSs) could also play a supporting role in sustainable Supply Chain Management (sSCM). In the supply network for food which is subject to legal requirements for traceability to ensure food safety, IOPTSs are known as supply chain traceability systems (Moe, 1998). We have chosen to use the term IOPTS, henceforth called tracking system to emphasize that the systems are not necessarily made with food traceability as a main goal. This and the inter-organisational nature of the tracking systems have deep implications for the costs and for the extent of traceability that can be achieved using them. The aim of this paper is to clarify some aspects of how upstream tracking systems can be used to support sSCM.

”Sustainability” is a vague concept (Marshall and Toffel, 2005), and the field of sustainable supply chain management hence covers a number of issues (Linton et al., 2007). However, for industries using common pool natural resources, sustainable sourcing is crucial for the long time viability of the industries in question. Fisheries, the livelihood for 8 % of the global population, and an important dietary resource for many more, constitute a case in point as world catch peaked in the early 1990s (UNEP, 2010). For seafood, sustainable harvesting can thus be seen as the main sustainability concern.

Currently one can observe a change in behaviour in parts of the western world, where voluntary market based measures seem to be changing the seafood industry and the retail industry selling its products, towards marketing “sustainable seafood”, meaning that the seafood is sustainably harvested. A central actor in this picture is the Marine Stewardship Council (MSC) whose high quality sustainability certification scheme (Accenture, 2009, Nick, 2006) is becoming the baseline standard for seafood sold through the leading retailers in North Western Europe (van Waarden, 2010).

Figure 16 Poster at Marks & Spencer, Ayr, Scotland, March 2010. (Photo Ola Bø)

“Sustainable products” may be seen as one of the two main strategies for sSCM (Seuring and Müller, 2008). In the food supply chain two strategies for sustainable products can be discerned: 1) The implementation of improved baseline standards for commodity foods, and 2) The marketing of identity preserved food (Smith, 2008). If MSC certified food can be seen as the baseline standard, identity preserved food could be used to market seafood harvested to even higher standards, but as Smith points out, identity preserved food could be too expensive to be competitive.

How and to what degree a tracking system could support and speed up the change towards more sustainable products in the seafood industry can be operationalized into the following three propositions:

- P1 Tracking systems can lower the cost of implementing MSC-certification in the supply chain.
- P2 Tracking systems can lower the cost of implementing identity preserving supply chains.
- P3 Tracking systems can let consumers locate the most sustainably harvested product amongst the offerings in the fish counter.

9.2 Inter-Organisational Product Tracking Systems

Kim et al. (1995) provide a theoretical treatment of the ontology of traceability. They point to the tracing of resources and the discrete activities performed on them as the core functionality of a traceability system (Moe, 1998). Traceability depends on the unique identification of traceable resource units (TRU) (Bechini et al., 2005). Tracking systems typically use automatic identification (AutoID) technologies to obtain reliable identification of TRUs. The activities representing the movement or handling of a unit are recorded as a sequence of dated discrete events. The recorded information is captured and disseminated to other players using an Inter-Organisational Information System (IOS), which can have either a centralized or a distributed architecture (Bechini et al., 2005).

Tracking systems can vary along several other dimensions. Three dimensions seem relevant for answering the research questions: First, the *granularity* of the system concerns the size of the TRU, which could theoretically range from single fish to usually a one day production batch in the processing industry. Second, the *scope* of the system describes the set of supply chain actors covered by the tracking system. The scope of most tracking systems is limited to a few actors (Bechini et al., 2005), and third, the *extent* characterizes the set of information elements recorded in the tracking system. The extent is also in most cases small (Moe, 1998). To use existing tracking systems to support sSCM, the systems might need to encompass additional supply chain players and additional information. However, the current complete lack of standards for information exchange about transformation activities (Donnelly et al., 2009) could be hard barriers for increasing the scope and the extent of the systems.

Table 10 Some facets of the unsustainable fish harvesting problem

Problem facet	Causes and interrelations	Discussed by
Root cause: Overfishing is an instance of the tragedy of the commons	Fish as a Common Pool Resource	Warming (1911), Gordon (1954), Hardin (1968), Ostrom (1992)
Illegal, Unregulated or Unreported (IUU) fishery claimed to approach 30% of global catch	Partial or no enforcement of regulations. Missing industry responsibility and accountability.	van Waarden (2010), Marshall and Toffel (2005), Borit and Olsen (2011), Alder and Lugten (2002)
Uncertainty in fishery science regarding what is a sustainable total allowable catch (TAC) for a fishery.	Partly caused by IUU fisheries and deficient reporting of discards.	Marshall and Toffel (2005), Bates (2010), van Waarden (2010)
Regulation deficiency: Quotas are often set beyond what is scientifically justifiable	Industry lobbying, the short time span of the political outlook and the uncertainty in fishery science.	Clover and Murray (2009), Marshall and Toffel (2005), del Valle and Astorkiza (2007), Hardin (1968), Alder and Lugten (2002)
Large quantities of fish are **discarded** due to missing quota for the species or to unselective gear catching unmarketable species or sizes (juveniles).	Partly caused by fisheries regulation policy. The EU Common Fisheries Policy implies compulsory discards of fish over the quota.	Catchpole et al. (2005), Clover and Murray (2009), Davies, et al. (2009)
Marine habitat destruction by fishing gear	Static gear e.g. traps and long line could be less destructive	Clover and Murray (2009), van Waarden (2010)
Eco system break down by the extinction of species	Typically caused by overexploitation	Clover and Murray (2009), Marshall and Toffel (2005)
Missing industry transparency	Connected to illegal and unethical practices.	Jacquet and Pauly (2008)

9.3 The sustainable seafood harvesting issue

Despite several periods where fishery science asserted that seafood resources were inexhaustible (Gordon, 1954), it now seems proved that the global seafood resource depletion is mainly caused by overexploitation of the resource, and that the consequences are threatening human survival on a large scale, firmly placing the sustainability of fish harvesting at the first priority level of the sustainability hierarchy described by Marshall and

Toffel (2005). For the players in the fish industry, resource depletion also poses a threat to their long term commercial survival (Smith, 2008).

The problem of overexploitation is multi faceted, and treated in a substantial literature. As a basis for discussing proposition 3, Table 10 shows some salient facets of unsustainable wild seafood harvesting and some causes, interrelations and references. From the table it seems clear that the problem is complex.

9.4 Researching tracking systems in the wild

Tracking systems are contemporary phenomena to be studied in their natural context. The research questions cover how and why such systems could support the two strategies for sustainable food products. Case research was selected because it is suitable for treating “how” and “why” questions in such settings (Yin, 2003). In a first explorative phase, a single multisite longitudinal intensive case research design was used to study the introduction of a tracking system in a Third Party Logistics (TPL) driven supply chain for frozen fish. Then, two more research cases were introduced to cover a broader variety of tracking systems in the supply network for seafood. The research sites and their position in the supply network are shown in Figure 17 and a textual description of the respective supply chains follows in the next section.

Table 11 shows the research activities. Interviews and document study were the main research methods. Interviews were semi-structured, meaning that in addition to the questions in the interview guides, follow-up questions were used when interesting topics emerged during an interview. The interview guides were developed to fit the function of the informant and the state of the project being studied. Before entering an organisation, scoping was used to collect relevant documents from the Internet. The documentation was shared with the informants at the start of the interview, to show interest and to increase trust. With this tactic we quickly came to the core of the matter and seemed to get frank answers. Interviews were often complemented by observation, where more questions were asked to make sense of what was seen.

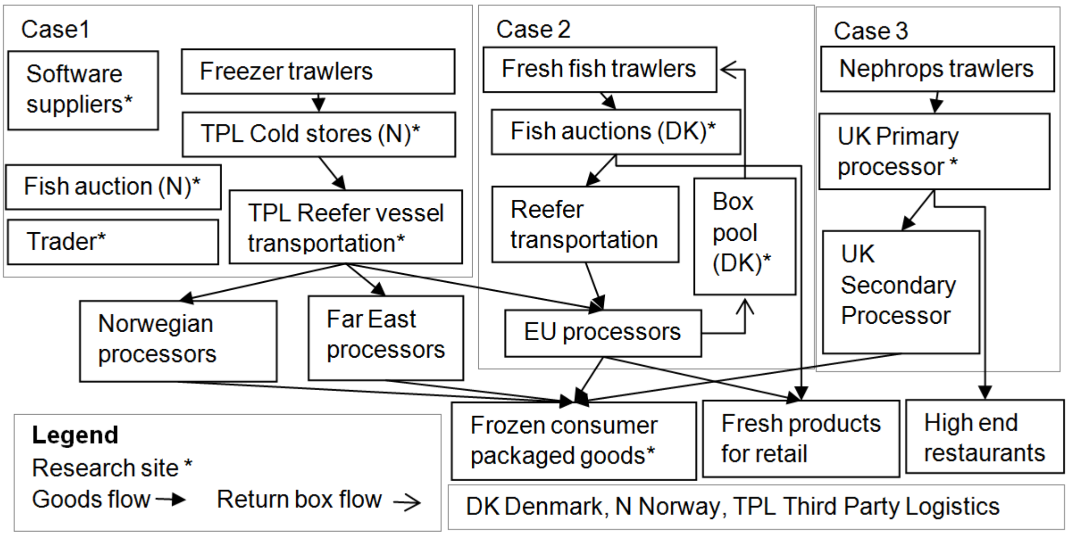

Figure 17 Research cases and sites in the supply network for caught seafood

Interviews have been recorded with the permission of the informants and transcribed. In four interviews circumstances were unfavourable for recording, so note-taking was used for documentation. Observation was documented with photography and note-taking.

Table 11 Research activities (CPG refers to Consumer Packaged Goods)

Case	Research description
1	22 interviews covering management, operational personnel, software developers and auxiliary actors. 109 hours observation at a number of sites, >250 documents studied
2	1 interview 2 hours, observation 2 hours, ~10 documents: news coverage, web.
3	1 interview 15 minutes, 15 documents – some of them comprehensive reports
CPG	Studied as documents in 6 UK and 5 Norwegian retailer outlets. 55 products covered.

In case research, validity should be handled systematically (Stuart et al., 2007). Validity in such research is obtained mainly through different types of triangulation, where inputs from different data sources, data collection methods, researchers and theories are used to alleviate single method weaknesses and to corroborate findings and explanations (Johnson, 1997). As can be seen from Table 12, both source and method triangulation have been carried out. Furthermore, feedback from participants has been solicited both on some write-ups and when presenting results in meetings with participants in Case 1.

Analysis was done in two phases. First, analysis was combined with data collection using write ups as suggested by Eisenhardt (1989) – this resulted in a set of illustrated field reports. Final analysis was carried out while preparing this paper, by careful consideration of what is really implied by and supported by the empirical data.

9.5 The supply chains

Table 12 shows the location, the supply chain context and the technology used in each of the systems. The tracking projects studied are situated between the producers of raw material: the fishing vessels, and the processors: the industry turning raw material into more or less finished products. In the supply network, landing refers to taking the catch on shore from the producer.

Table 12 The supply chains

Case	Supply Chain Types (Smith, 2008)	Supply Chain Structure
#1 North and west Norwegian coast frozen demersal fish pallets	commodity/ manufactured or commodity/ conserved	Independent producers, neutral cold stores, neutral transportation. Several intermediaries. Chain of title and chain of handling separate from landing to primary processor
#2 Danish fresh demersal fish boxes	local, conserved, commodity/ manufactured	Independent producers, fish auctions, processors. Chain of handling and chain of title separate from landing to primary processor
#3 UK Nephrops boxes, fresh and frozen	manufactured or conserved	Producers under contract, common chain of title and handling from landing to finished product

The Norwegian coast supply chain lands considerable quantities of fish that has been caught in the North East Atlantic and Barents Sea by fishing vessels from a number of nations. Those are locations far from the markets and require fish to be conserved, for example by being frozen at sea. The frozen fish is palletized upon landing at neutral cold stores. After forwarding to cold stores in Western Norway and the EU a proportion of the fish is stuffed into reefer containers and transported to the far East for low cost processing before being transported back again to the Western World as manufactured product. The product can thus be seen as a commodity resource for food manufacturers making readymade frozen dishes. Alternatively the raw material is forwarded directly to processors in the EU or conserved by drying in Western Norway. The supply chain is complex with many actors and intermediaries using third party logistics for the handling and transportation of the goods. This means that the chain of title (ownership) is separate from the chain of handling.

The Danish supply chain mainly uses fish caught in the areas around Denmark by independent producers, and has short transportation routes to continental Europe. The fresh fish is landed at 10 fishing ports operating fish auctions connected to the Pan European Fish Auction (PEFA) network; see Collins (2002) for a description. The catch is sold to processors mainly in Denmark and the Netherlands.

The UK supply chain handles nephrops which are caught by producers under contract with a substantial player in the seafood industry. The large nephrops are chilled for live transportation as “langoustine” to restaurants mainly in continental Europe, while the lower grade fraction is partly processed at the landing plant before being transported to a secondary processor where they are turned into readymade frozen dishes for distribution through the grocery retailers.

9.6 Findings

The goals of the tracking systems

Table 13 shows the sponsors for each system and their motivations for implementing the system. It also shows that in all cases, the sponsors propose to use the systems to supply downstream actors with more accurate information of the provenance of the products as one of the goals.

Table 13 Tracking system project sponsors and their motivations for implementing the systems

Case	System project sponsor	Stated primary goals	Stated secondary goals
#1 North and west Norwegian coast frozen demersal fish	Shipping company providing transportation between landing terminals and terminals for containerization or for processing industry	Improve control over goods movement to reduce errors, shrinkage and subsequent claims. Increase upstream actor accountability for goods damage.	Become preferred transportation company by being able to provide information about food origin to downstream actors.
#2 Danish fresh demersal fish	Company running the box pool of the supply chain. Box pool owned by the producers’ organisations and a private investor.	Improve control over box movement to reduce box shrinkage and to collect box rent	Provide detailed information about food origin to downstream actors. Provide proof of legal and registered catch to downstream actors. Turn gains from information into better product prices for producers.
#3 UK Nephrops, fresh and frozen	Seafood landing and processing plant, part of leading international fish processor	Obtain MSC certification by providing information for sustainable catch management	Provide detailed information about food origin to downstream actors in the high price segment (restaurants)

A surprising fact is that two of the three systems do not have sSCM or food safety concerns as their primary goal. This means that the cost of these systems is completely or partly justified by other applications in the supply chain.

The Characterization of tracking systems

The technical feasibility of using an existing tracking system for sustainable products depends on the characteristics of the system as shown in Table 5. The scope is the set of supply chain actors covered by the system. Actors marked with an asterisk are not currently participating in the system, but are covered in the sense that the goods they handle have the necessary AutoID-tagging. The extent describes what information is made available through the system. Limited information availability limits the potential of a tracking system for supporting sustainable products.

Table 14 Tracking system characteristics

Case	Technology	TRU	Scope	Extent
#1 North and west Norwegian coast frozen demersal fish	Bar codes, distributed systems, EDI	pallet ~1000 kg	Neutral cold store to reefer vessel to processing industry*	Box id, box movement through supply chain including producer.
#2 Danish fresh demersal fish	RFID, central database	box ~40 kg	Producer*, to auction to processing industry*	Producer, species, grading, quality, weight, and pallet movement
#3 UK Nephrops, fresh and frozen	Bar codes, central data base	box	Catch to primary processing	Not available due to divergent empirical evidence

9.7 Discussion

Because the cost of implementing the systems is justified by other goals as discussed in the goals of tracking systems section, the systems could be used to support sSCM at a low or negligible marginal cost, meaning that using them for sSCM purposes is economically feasible. Depending upon which one of Smith's (2008) strategies for sustainable products we consider, there are different requirements to the system for supporting the strategy.

A common trait of the systems studied is the limited scope and extent; they typically only cover a part of their supply network and few information elements. To support sSCM, the system can be extended to cover the part of the supply network required for the sSCM-strategy selected. Widening the extent could also be considered, but might be complicated by the number of players already using the system turning it into a hard to change infrastructure.

Can tracking systems lower the cost of implementing MSC-certification in the supply chain?

If we follow the alternative of an increased baseline standard through MSC certification, the tracking systems could just be used as an effective and efficient way to meet MSC chain of custody requirements by distinguishing MSC- from non-MSC-goods in those parts of the supply network handling both categories. If the supply network handles MSC certified seafood only, there is no need to invest in an tracking system for chain of custody purposes.

As we can see from Table 14, the systems studied cover the supply chain from the producer of raw material, to the processing industry. In the case of the MSC-based strategy, this might be sufficient to cover the requirements for chain of custody-certification without further expensive changes, like separate physical storage and transportation. The tracking systems could hence almost remove the cost of implementing the MSC-based strategy for the part of the supply chains covered by the system in case #1 and #2.

Can tracking systems lower the cost of implementing identity preserving supply chains?

If the identity preserved strategy is followed, then the system must be extended to cover the supply chain from fishing vessel to the fresh fish counter, or to the finished product in a package carrying the necessary information.

As fishing vessels are currently being equipped with an electronic log integrated with an electronic weighing systems which effectively constitute an on board tracking system (Fishing News, 2010), the upstream extension thus simply means integrating input from the fishing vessels into the systems studied in case #1 and #2. In fact, the sponsors of case #2 are looking into how fish box RFID-identity can be connected to the catch data at the catching stage by providing the fishing vessels with RFID readers connected to the on board weighing system.

In the fish processing industry, product transformation operations lead to more complex and hence expensive internal traceability systems (Connolly et al. 2009). Interviews with software developers targeting the processing industry indicate an increasing demand for internal traceability solutions with several ongoing projects initiated by major actors.

Integrating the fishing vessels' and the processing industry's internal traceability systems with the existing low use cost tracking systems covering the actors between them (Case #1 and #2) could thus support a reduced cost, complete, end-to-end tracking system supporting identity preserved products. However, the information available to make the products distinctive is limited by the extent of the tracking systems.

Can tracking systems enable consumers to find the most sustainable product in the fish counter?

Most fishing vessels are specialized in the sense of being equipped for fisheries using one or a limited variety of fishing gear. Thus, in many cases the gear type and hence the order of magnitude of discards and damage to the marine habitat might be partly indicated by the identity of the producer. As can be seen from the extent column in Table 14, the producer identity is registered by the systems covered by this research, and hence consumers could be informed about this aspect of sustainability. Observation in freezer counters in Norway and the UK seem to indicate that this information is seldom forwarded to consumers. Amongst the 55 instances of consumer packaged frozen seafood examined, only one instance was found indicating the fishing vessel, the accurate fishing ground and that the fish was caught using a long line (static gear). It was not established whether this fish had a higher price tag than the nonspecific competition, or whether consumers have the necessary background knowledge to see the difference.

As for information about the discards, or the destruction of the marine habitat, this information is not registered in the systems studied, except perhaps for Case #3, where sustainable catch management is the main purpose of the system. However, the company involved does not seem to provide such information on their packaged product.

Thus for proposition 3, it could be possible to give some information to the consumer about the sustainability superiority of products from vessels using fishing gear with less side effects, but detailed quantitative information about the side effects of harvesting is not covered by the systems used between the producer and the processor in Case #1 and #2, and can hence not be transported through those systems even if it was recorded by the producer. As seen from Table 1, comparing the relative sustainability merit of caught seafood products could be a hard and complex problem even for experts having the best information available, so it seems safe to conclude that even with tracking systems having a considerable extent and scope, consumers will not be able to discern the most sustainably harvested product in the fish counter.

9.8 Conclusions

We have seen how tracking systems that have been installed to solve other problems can be used to support sustainable supply chain management in the seafood industry. We have in particular examined how both the two strategies for more sustainable food products proposed by Smith (2008) could be enabled by the systems studied.

The degree to which a tracking system can be used to support a sSCM strategy for sustainable products depends on the scope in terms of supply chain players participating and on the extent in terms of information recorded in the system, but also depends on the strategy selected.

More information to the consumers about the relative environmental side effects of different products could allow for a price premium for products caught using less efficient albeit more environmentally friendly static gear.

The study is limited to three different tracking system projects in the caught seafood industry in North-western Europe. The applicability of the results to other parts of the world and to other supply networks using common pool resources certainly depends on the degree of similarity with the industry studied.

The systems studied are in different stages of implementation, and might not all be adopted by a sufficient number of supply chain actors to make them enduring realities, but they represent a trend that should lead to a widespread availability of such systems in the near future. Increased availability of tracking systems might make the implementation of sustainable supply chain management strategies less costly, and increase the credibility and hence value of sustainable products. Tracking systems may also lead to an increased positive impact from those strategies on the environment.

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10 OPPSUMMERING OG KONKLUSJONER

Denne rapporten oppsummerer den forskningsaktiviteten som er gjennomført i FIESTA-prosjektet. Prosjektets formål har vært tredelt. Dels har målet vært å utvikle et lærings-program som skaper forståelse for sammenhengen mellom IT-systemer, god logistikk-planlegging og effektive og miljøvennlige transportløsninger, dels har det vært å utvikle nye integrerte IT-løsninger knyttet til sporingsmuligheter i verdikjeden, og sist har det vært å følge implementeringsprosessene knyttet til disse IT-systemene for å trekke lærdom ut av de observasjoner man har gjort om hvordan dette fungerer i de berørte organisasjonene.

Knyttet til målet om å skape bedre forståelse for logistikkutfordringene ble det utviklet et problembasert læringsprogram kalt FIESTA-skolen. Dette programmet hadde i hovedsak tre bestanddeler. For det første ble det utviklet et kompendium hvor valget av temaer ble til i tett dialog med aktørene, for å sikre en best mulig relevans for prosjektpartnerne. Dernest ble det gjennomført samlinger hos de berørte bedriftene hvor en meget stor andel av de ansatte deltok. Her var både ledelse, logistikkfunksjoner og støttefunksjoner godt representert med aktiv deltakelse. Det siste elementet i læringsprogrammet var arbeidet med case fra egen arbeidshverdag. Her kom det fram en lang rekke relevante og spennende problemstillinger som var egnet til å eksemplifisere typiske logistikkutfordringer knyttet til samhandling både internt i bedriftene og ikke minst, mellom aktørene i verdikjeden. Læringsprogrammet fikk overveiende positiv respons fra deltakerne og vi har anbefalt at prosjekteier LTL vurderer å videreutvikle opplegget for andre aktører.

EDI-Systems AS ble leid inn for å ta seg av utviklingen av nye IT-verktøy i samarbeid med de deltakende bedriftene. I FIESTA prosjektet har målet for utviklingen av nye IT-systemer vært å få bedre sporbarhet for varer som håndteres som transitt eller containerstuffing. Programmet som ble utviklet for dette, er EDI-Transit. Funksjonalitet og utseende følger malen fra EDI-Lagerhotells truckmodul som var velkjent for T&F. EDI-Transit er utviklet på samme plattform som EDI-Lagerhotell, EDI-Ship og ECTGs bookingsystem.

Ved prosjektslutt (september 2011) rapporteres det at man i løpet av prosjektperioden har fått til en økning i antall lesbare strekkodeetiketter på paller som håndteres av E-CTG fra ca 15% til ca 45%. En vesentlig del av denne økningen skyldes at man har fått med terminalene i Tromsø på slik merking. Det vil framover bli jobbet aktivt med andre terminaler for å øke graden av lesbar strekkodemerking videre.

Man har også i prosjektperioden fått en betydelig økning i datakvaliteten på flere områder, og de involverte bedriftene merker også at dette verdsettes av kunder nedstrøms i verdikjeden gjennom signaler om at man har god nytte av forbedret informasjon, blant annet fra den nye programvaren for containerstuffing. Uten at man har en systematisk registrering av endringer i antallet ”claims”, har man også et klart inntrykk av at denne typen klagesaker knyttet til feiltelling har blitt vesentlig redusert som en følge av bedret datakvalitet og sporing.

Det er gjennomført et doktorgradsarbeid i tilknytning til prosjektet. Arbeidet med avhandlingen er nå i en sluttfase. I dette doktorgradsarbeidet er det også trukket inn en del kompletterende case for å gi et bredere informasjonstilfang enn den verdikjeden selve FIESTA-prosjektet gir. Basert på dette bredere case-materialet er det skrevet fire akademiske artikler som er tatt med i sin helhet i denne rapporten.

Den første artikkelen analyserer tiltak og strategier som brukes i implementeringsprosessen knyttet til innføringen av et IT-basert sporingssystem. Hovedcaset er hentet fra FIESTA-verdikjeden for frossen fisk. I forskningslitteraturen er det en framherskende tanke at man bør ha en aktør med stor makt i en verdikjede for at man skal kunne greie å innføre ny sporingsteknologi som blir gjennomgående i verdikjeden. I dette tilfellet har man ved å anvende flere ulike strategier oppnådd en implementering uten at man har en slik dominerende aktør. Ved å utnytte de-facto standarder og samtidig spille på en IT-fleksibilitet basert på skreddersydde programvareløsninger knyttet til egen kjernevirksomhet, har man klart å forholde seg til en omverden som i stor grad er preget av IT-messig heterogenitet og lav utnyttelse av tilgjengelige standarder.

I den andre artikkelen utvikles et forslag til en beslutningsstøttemodell for valg av teknologi for sporingsløsninger for matvarekjeder. Et interorganisatorisk produktsporingssystem kan brukes for å forbedre transparens gjennom verdikjeden. Dette kan være spesielt verdifullt i matvareverdikjeder hvor man blant annet er svært opptatt av å forbedre matvaresikkerheten. Et slikt sporingssystem består prinsipielt av et Auto-ID system kombinert med et system for interorganisatorisk informasjonsutveksling (IOS). Aktørene i en verdikjede står overfor ulike teknologivalg både når det gjelder Auto-ID system (for eksempel RFID vs. Strekkoder) og når det gjelder valget av IOS. Dels basert på tilgjengelig forskningslitteratur og dels basert på danske og norske case utvikles en modell kalt IOPTTAC (Inter-Organizational Product Tracking Technology and Architechture Choice model). Modellen er egnet til å sammenveie styrker og svakheter ved de ulike alternativene knyttet til

- investeringskostnader, driftskostnader og integrasjonskostnader
- lesbarhet i ulike sammenhenger, integrasjonsmuligheter med it-systemer
- risiko knyttet til relasjonsspesifikke investeringer, sikkerhet for sensitiv informasjon og inkompatibilitiet / utdatering

I artikkel nummer tre utvikles et forslag til en notasjon for kartlegging og evaluering av informasjonskvalitet i verdikjeder kalt SCIMN (Supply Chain Information Mapping Notation).

I utviklingen av denne notasjonen baserer man seg på forskningsfeltet knyttet til evaluering av informasjonskvalitet og anvender dette på verdikjeder. Bruken av notasjonen er demonstrert i artikkelen ved at man illustrerer en anvendelse på (deler av) en konkret verdikjede. Kartlegging av (problemer med) informasjonskvaliteten vil være en sentral del når man søker å integrere verdikjeder gjennom deling av informasjon. Slik sett vil denne notasjonen være et bidrag til en systematisk og mer presis evaluering av eksisterende eller planlagt informasjonskvalitet i slike prosjekter.

I den siste artikkelen er fokuset på bærekraftig utnyttelse av naturressurser (eksempelvis sjømat) gjennom forbedrede sporingssystemer. Høstingen av verdens fiskeressurser nådde et topp-punkt i 1990-årene og bekymringen for en ikke-bærekraftig utnyttelse har siden vært stor. I hovedsak har dette vært et fokus i tildelingen av fiskekvoter og internasjonale kvoteavtaler, men en kan også spore en økende forbrukerbevissthet rundt bærekraftig høsting av naturressurser generelt, og fiskeressurser spesielt. Artikkelen diskuterer potensial og begrensninger ved et elektronisk interorganisatorisk produktsporingssystem knyttet til fiskeprodukter. Case fra Norge, Danmark og UK benyttes til å analysere dette potensialet blant annet ved at man studerer eksisterende systemer som er implementert med et annet formål enn bærekraftig høsting, men som kan tenkes benyttet også i en slik sammenheng. Framveksten av slike systemer er ofte motivert av effektivitetshensyn, og kan være regningssvarende selv uten at man tar i bruk potensialet knyttet til kontrollen med høstingen av ressursene. De casene som er analysert er på ulike stadier i implementeringen og foreløpig er ikke systemene omfattende nok til at de er fullt brukbare i en forbedret ressursovervåkningssammenheng, men potensialet for dette behøver ikke være langt unna.

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Telefon +47 71 21 40 00
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HØGSKOLEN I MOLDE
Postboks 2110, NO-6402 Molde

Telefon +47 71 21 40 00
Telefaks +47 71 21 41 00

post@himolde.no
www.himolde.no