The future role of big data and machine learning for health and safety inspection efficiency

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Professional background

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SINTEF

SINTEF - one of Europe’s largest independent research organisations

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PRO-ACTIVE MANAGEMENT

Proactima - supplier of services in risk management, HSE management and national security

Foresight paper background

Two research projects

- ***The Risk Group Prediction Tool***
  A machine learning tool developed for the Norwegian Labour Inspection Authority to assist inspectors in selecting enterprises with regard to risk.

- ***NORDRISK***
  A qualitative study of how the labour inspectorates of Norway, Sweden, Denmark, Finland and Iceland realize their risk-based approach in practice (i.e. how inspection objects are targeted).

Foresight paper

The foresight paper is a discussion of...

... the future role of *big data* and *machine learning* for health and safety inspection efficiency

Starting point of the foresight paper

- The most important policy instrument of governmental labour inspectorates; workplace inspections
- A fundamental part of the inspection activity: selection of objects for inspection.
- (At least) three different selection approaches available:

Population-wide selection
Select all companies regardless of any criteria

Random selection
Select companies based on random sampling

Risk-based selection
Select companies based on risk

Targeting inspection objects based on risk

- Most modern labour inspectorates work according to a risk-based inspection philosophy

- The fundament of risk-based targeting is the recognition that, due to limited inspection resources, it is not possible to control all risk areas and all risk objects

Prioritize on basis of risk

What is risk-based targeting?

Temporary definition

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Risks arising from the nature of the business's activities (e.g. chemical exposure, fall from heights, noise)

Management and control risk

The business's ability and willingness to comply with the regulations (may have a positive or no impact on inherent risk)

What is risk-based targeting?

Inherent risk

Risks arising from the nature of the business's activities (e.g. chemical exposure, fall from heights, noise)

Will involve prioritizing companies where the occurrence and severity of accidents, harmful exposure, illegal working conditions etc. are greatest.

Management and control risk

The business's ability and willingness to comply with the regulations (may have a positive or no impact on inherent risk)

Will involve prioritizing companies where the number and/or severity of breaches of the regulations are greatest.

What is risk-based targeting?

Inherent risk

Risks arising from the nature of the business's activities (e.g. chemical exposure, fall from heights, noise)

Working environment problem

Management and control risk

The business's ability and willingness to comply with the regulations (may have a positive or no impact on inherent risk)

Compliance problem

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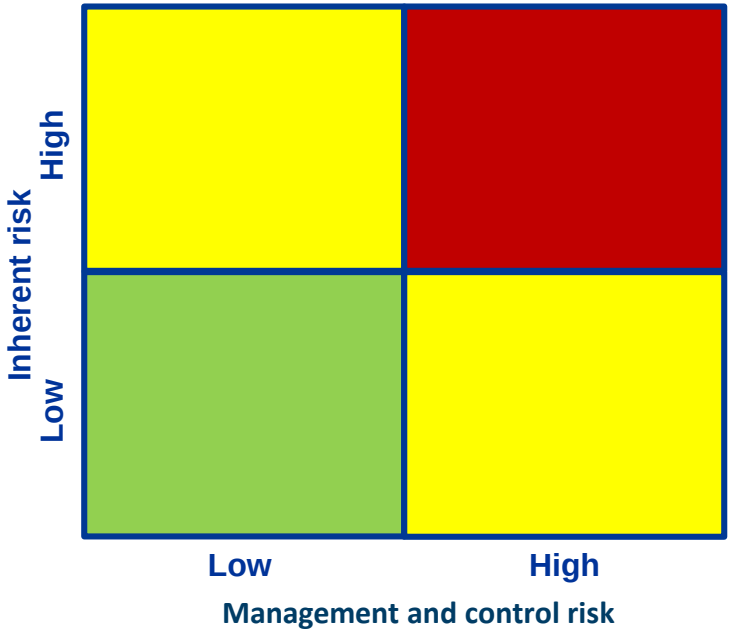
Working environment problem

Compliance problem

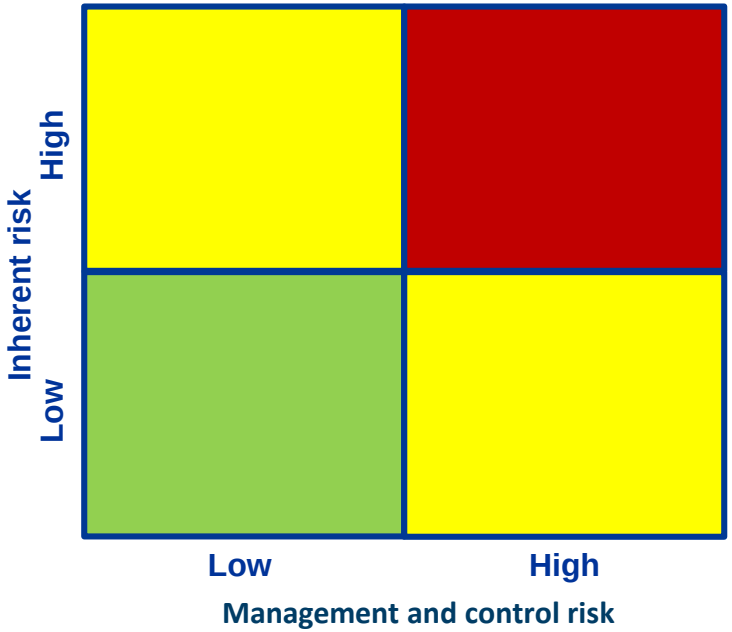
The **total risk** of a given company is a product of the interaction between these two

What is risk-based targeting?



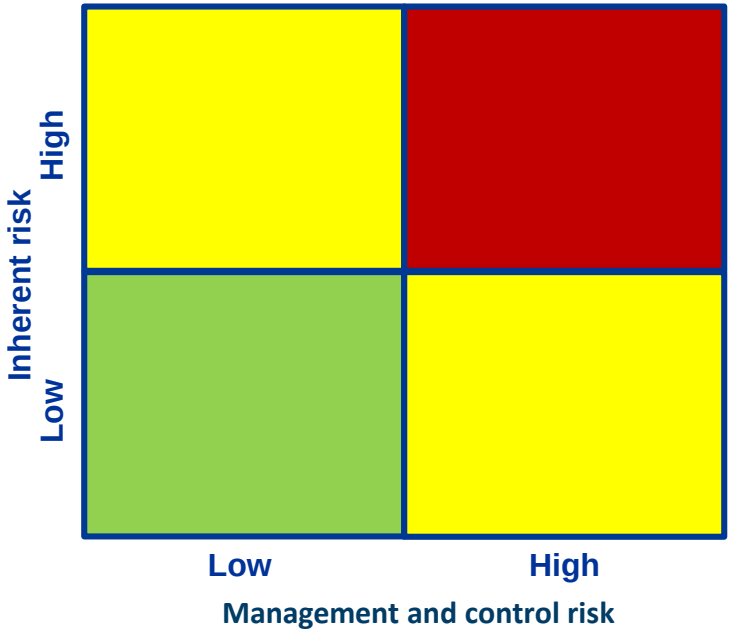
Risk-based targeting is supervision that is primarily aimed at the enterprises where the **working environment** situation is the worst, and where the **willingness and ability** to do something about the problems themselves is least.

Big data and machine learning



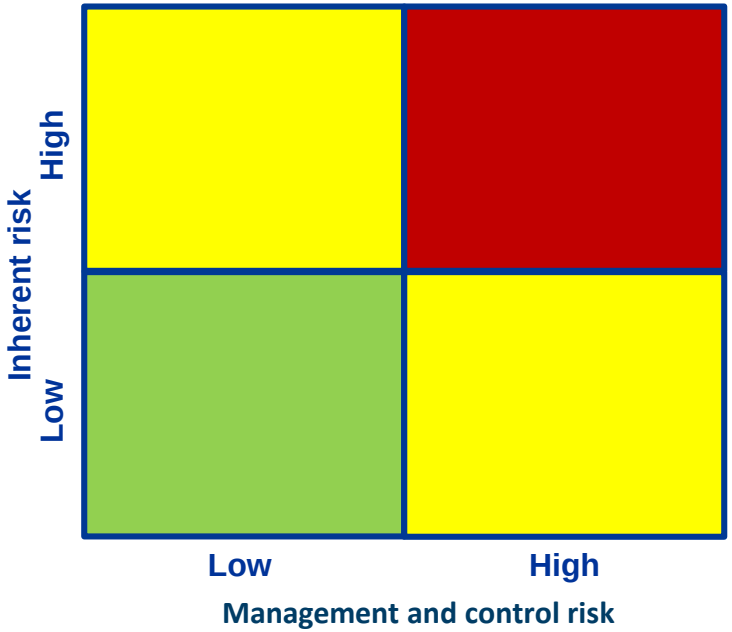
Analytical methods for identifying high-risk industries and risk-exposed clusters of workers are usually well developed

Big data and machine learning



Far less common than these broad risk-based analyses are methods that make prioritization across companies **within an industry** possible.

Big data and machine learning



Can **big data** and **machine learning** help us identify the high risk objects?

Needles in a haystack

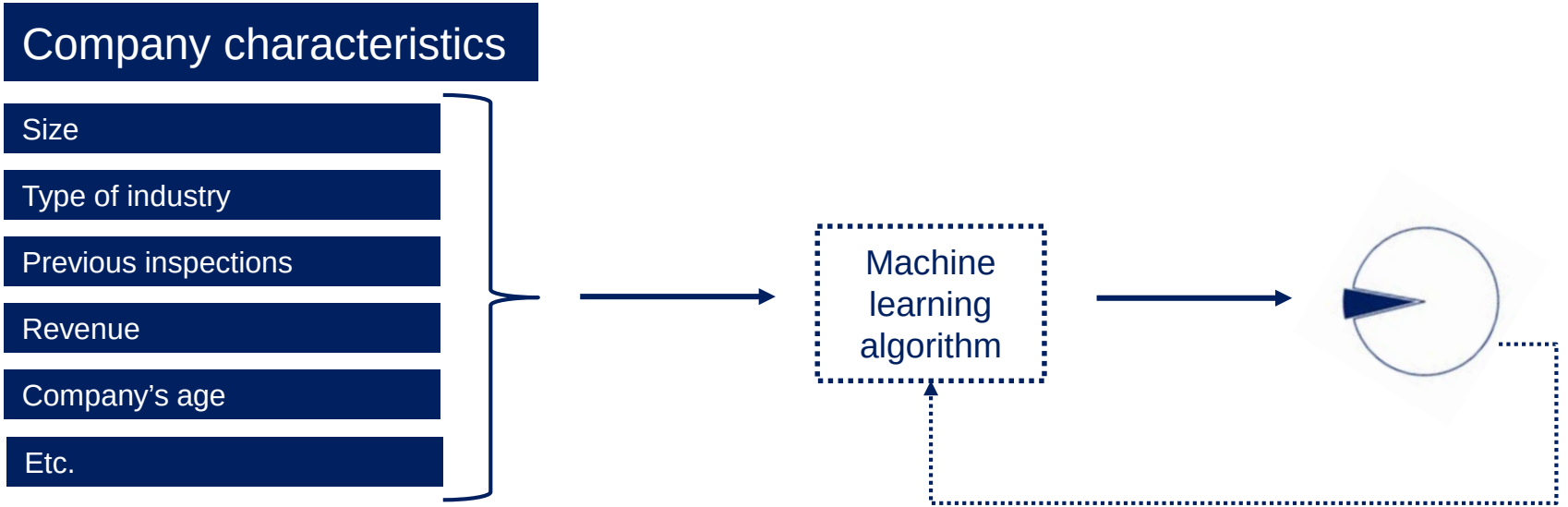
- The process of making prioritizations across companies resembles finding needles in a haystack.
- In this case, the haystack potentially consists of hundreds of thousands of possible inspection objects, but only a certain amount of these objects are needles.
- Finding needles in a haystack is to a large degree what big data and machine learning is all about.

Machine learning

- The main objective of machine learning algorithms is to provide a statistical model which can be utilized to perform predictions, classifications, estimations or similar tasks.

- Utilized in other needle in a haystack-problems, e.g.:
  - Cancer prognosis and patient outcome
  - Bankruptcy prediction
  - Tax fraud detection
  - Crime prediction

Machine learning



Big data

- Big data: large and rapidly growing volumes of data.
- Identifying hidden trends in the data (e.g. high risk inspection objects) by means of machine learning usually presupposes access to large volumes of data.

- New inspections are carried out every day.
  - Thus, labour inspectorates potentially possess large and rapidly growing volumes of data.

Status

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- In principle then, the challenge of targeting high-risk companies by utilizing big data should, at least at first glance, be well suited for machine learning algorithms.
- Despite this, there have been few such attempts.
- The NORDRISK study showed that within the Nordic labour inspectorates, only Norway targets inspection objects by means of a machine learning algorithm.
- The literature review of the NORDRISK project did not identify other documented machine learning tools

Status

- This is partly due to:
  - Low data quality (especially when it comes to inherent risks)
  - Partly paper-based storage
  - Data stored across different systems

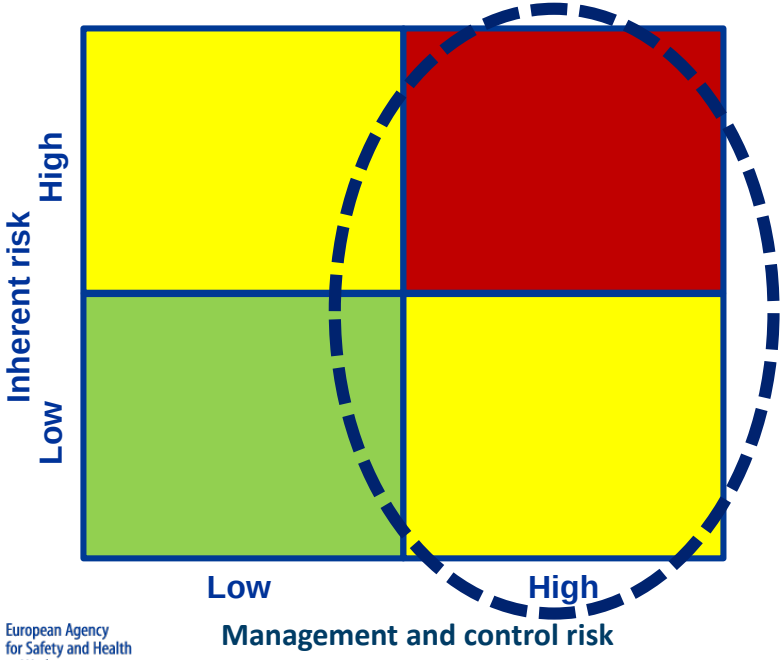
The Norwegian tool (RGPT)

- Based on roughly 35,000 inspections (but this increases every day)
- The tool's machine learning algorithm is based on logistic regression analysis.
- The tool's predictions place all possible inspection objects (230,000) in one of four groups:
  - Highest risk
  - High-risk
  - Low-risk
  - Lowest risk

The Norwegian tool (RGPT)

- The predictive validity of the tool is checked every month, and the experience this far is that it manages to target companies with a high risk extremely precisely.
- I.e. few inspections within the lowest risk group result in identification of serious deviations, whereas the vast majority of inspections within the highest risk group result in identification of serious deviations.
- The low- and high-risk groups fall between the two extremes.

Limitations of the tool



Primarily concerned with **management and control risk**, because it predicts the probability that a future inspection in a given company will identify serious deviations from the health and safety regulations.

Challenges

- In the real world, management and control risks and inherent risks are related. I.e. they constitute the total HSE risks of a given company.

- The fact that they are related, does not mean they are empirically correlated.
  - Predicting two types of risks that are not necessarily empirically correlated is a real challenge.
  - This challenge is further intensified by the fact that the data quality on inherent risk on company level is weak (e.g. accidents, work related illness etc.).

Challenges

- Inherent risks in the world of work are not of one particular type.

- Enforcing authorities are concerned with multiple types of risks, e.g. accidents, chemical exposure, biological exposure, psychosocial threats, musculoskeletal risk factors, social dumping etc.
  - Developing risk models that manage to capture this variety is highly challenging, because the different types of risks do not necessarily correlate.
  - Hence, capturing this variety is quite different from predicting the probability of one particular type of risk.

Challenges

- The political context
  - Machine learning algorithms are dynamic, in the sense that they can learn from and adapt to successes and errors, they can not take consideration of different political point of views.
  - The political context is fickle. Thus, what types of risks that are worthy of prioritization today might not be worthy of prioritization tomorrow.
  - The political context is multifaceted. Thus, different stakeholders, e.g. politicians, employers, employees, the media and the public, hold different views on which types of risks are worthy of prioritization. This illustrates that risk in the world of work is not necessarily an objective entity, but a social construction.
  - Machine learning algorithms deal with well-defined outputs, not ever-changing social constructions.

Challenges

- Data related to the inspection object
  - Labour inspectorates possess (potentially) huge amounts of data related to their inspection objects. These data are usually attached to the company level
  - However, the company level is not necessarily the key unit to consider.
  - E.g. within the construction industry, it is not necessarily a concrete company that is targeted for inspection, but a temporary construction site.
  - The temporariness implies that a machine learning algorithm might not even be given the chance to learn from its predictive successes and errors before the construction site is history and the companies that made up the site have moved into new constellations at a new site.

Big data and machine learning

Summary

ML as a tool to help target high-risk inspection objects presupposes access to high quality data.

Challenges

- The two principal types of risk are not necessarily empirically correlated
- Multiple subtypes of risk are not necessarily empirically correlated
- ML algorithms deal with well-defined outputs, not ever-changing views on high-risk/low-risk
- ML algorithms depends on clearly defined inspection objects

The future role of big data and machine learning for health and safety inspection efficiency...

... is probably one which depends on a combination of artificial and human intelligence, where both complement the strengths of each other