Where is the Proof? - A Review of Experiences from Applying MDE in Industry

Parastoo Mohagheghi, Vegard Dehlen

SINTEF ICT, Oslo, Norway

Motivation

- Model-Driven Engineering (MDE) has been promoted as a solution to handle increased complexity of software development.

- MDE promises:
  - Better abstraction techniques and separation of concerns -> improved communication, improved quality, portability of solutions
  - Generation of artefacts from models -> increased productivity, improved quality, traceability etc.

- But:

 - **Are these promises supported by evidence?**

Context

- This research is supported by two projects:

1. MODELPLEX (EU IP, 2006-2010):
   - The goal of MODELPLEX is to develop solutions for applying MDE in complex software system development.
   - We plan to evaluate the MODELPLEX solutions empirically and therefore searched for empirical studies on applying MDE.

2. Quality in MDE- QiM (SINTEF, 2006-2008):
   - The goal of QiM is to search for and develop approaches for improving the quality of software when applying MDE.
   - We searched for studies on quality aspects in MDE.

Finding Evidence on MDE Impact

- Research method: Systematic review as a step in evidence-based software engineering (Dybå, Kitchenham, Jørgensen):

  1. Collect evidence as answer to research questions.
  2. Identify publication channels.
  3. Search them for available evidence.
  4. Critically appraise the evidence for its validity, impact and applicability.
  5. Integrate the evidence with practical experience and values to answer the questions, or to make decisions about the practice.

Research Questions
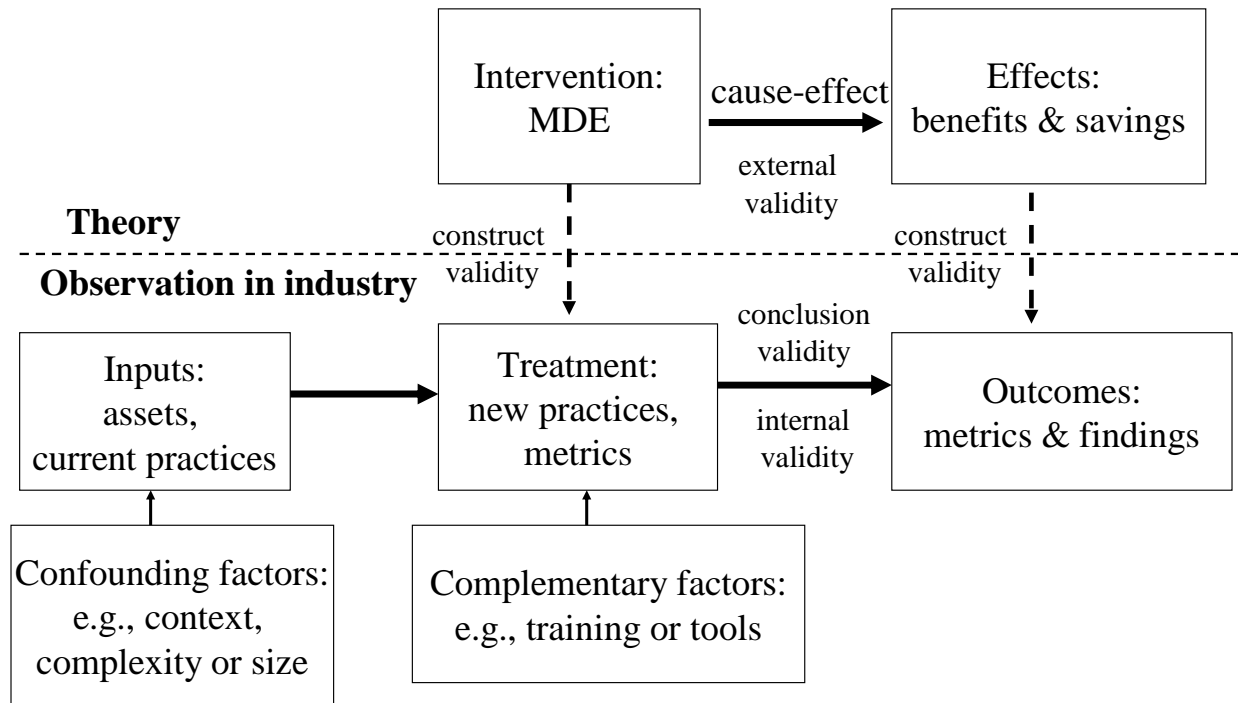
RQ1. Where and why has MDE been applied?
RQ2. What is the state of maturity of MDE?
RQ3. What evidence do we have on the impact of MDE on productivity and software quality?

Publication Channels

- We searched in:
  - Journals and conferences: SoSyM, ESE journal, UML and MoDELS conferences, ECMDA conferences, DSM workshops at OOPSLA; all since 2000
  - IEEE Xplore and ACM Digital Library;
  - References in other papers.
- 33 papers were identified; 8 were excluded (no evidence).
- Where published?
  - 13 papers are published in the proceedings of conferences (especially the ECMDA-FA conference);
  - 9 papers in workshops and satellite activities of conferences;
  - 2 are online reports;
  - Only one is published in a journal.

SINTEF

An Overview of Papers

- Only seven papers report experiences from completed projects;
  - Others are from pilot studies or ongoing projects at the time of reporting,
  - One is from a terminated project (at ABB).
- Most papers do not provide any information on the size of the projects.
- Type of studies:
  - 20 of papers are experience reports from single projects;
  - 3 papers have used interviews and questionnaires in addition to observations;
  - 3 papers describe comparative studies;
  - 1 paper describes three quasi-experiments (the MODELWARE report).
- Motorola is an exception with detailed description and quantitative data.

RQ1- Where has MDE been Applied?

- A broad range of companies in various domains report their experience from investigating or applying MDE. To name some, the papers cover:
    - Telecommunications domain - 7 papers;
    - Business applications and financial organizations - 5 papers;
    - Defense / aerodynamics / avionic systems - 2 papers;
    - Web applications - 2 papers.
- Types of systems:
    - Safety-critical and trustworthy systems - 3 papers;
    - Embedded systems - 2 papers;
    - Software product lines - 3 papers;
    - Legacy systems - 2 successful cases and one unsuccessful: ABB Robotics refrained from adopting MDE due to the base of legacy code.

RQ1- Why MDE has been Applied?

- Main motivations have been:
    - Increasing productivity and shortening development time - 6 papers;
    - Improving the quality of the generated code or models, earlier detection of bugs, and managing requirement volatility - 6 papers;
    - Automation: generating code and other artifacts -13 papers;
    - Improved communication and information sharing between stakeholders and within the development team - 5 papers, and ease of learning - 2 papers.
- Some other motivations have been portability of solutions, traceability, and early assessment - each in only 2 papers.

RQ2- State of the MDE; Automatic Generation

- Some papers report generating all or most of the code from the models (2 examples), while others report that only part of the code could be generated.
  - Depends on the type of code: low-level code is not captured in the design and is unlikely to be generated.
- Most papers report the status of code generators as satisfactory in producing code with no introduced defects.
- Automatic generation of code required developing Domain Specific Languages (DSLs) or UML profiles and own code generators in 6 cases.
- Also reports on generating XML schemas but not on generating test cases or documentation.

RQ2- State of the MDE; Processes

- Baker et al. report that many teams in Motorola encountered major obstacles in adopting MDE due to the lack of a well-defined process, lack of necessary skills and inflexibility in changing the existing culture.

- Approaches:
  - Use pre-existing processes such as RUP and Agile with MDE;
  - Define own MDE process:
    - Thales example by extending the IEEE 1471 standard;
    - Staron from ABB and Ericsson with focus on early defining of transformations.
  - None of the studies report using any of the already existing – although few – model-based methodologies, e.g. KobrA or COMET.

- Process has not been much in focus.

RQ2- State of the MDE; Tools

- A small survey performed among industry participants showed that, when considering whether or not to adopt MDE, the availability of tools was perceived as the most influential factor.

- The MODELWARE participants were concerned about the instability of tools and their integration.

- According to Motorola, third-part MDE tools do not scale well to large system development.

- Others mean that third-party tools are not suitable for their products or question availability over time.
  - Develop own tools or use OSS tools?

- MDE is at "early adopters" stage?

RQ3- Productivity Gains or Losses

- Quantitative data from small comparative studies or quasi-experiments on productivity :
  - 3 partners in MODELWARE reported productivity gains around 20%.
  - 2 others reported no difference (WGO) or even loss.
  - A small comparative study by Middleware Company reported 35% productivity gains.
- Others report gains but do not have a clear baseline:
  - Motorola estimates 2X-8X improvement.
- Improvements are due to automation, model-based simulation and testing, DSLs and reuse between releases.
- Few studies, lack of baseline, and lack of detailed data; for example on the cost of tool development.

RQ3- MDE Impact on Software Quality

- Even less data than on productivity!
- Motorola reported that:
  - Fewer inspections are needed;
  - Defects are avoided due to generation- 3X fewer defects;
  - Defects are detected earlier – 3X improvement;
  - Fixing defects are faster but detecting cause may be more complex.
- France Telecom wrote that simulation helps in validating specifications.

Validity Threats

- Low number of studies -> generalization is impossible!

- Success cases are more likely published than failures.

- Some companies may refrain from publishing their results.

- Few results from large-scale projects.

- Lack of baseline data in most companies -> estimated results are not reliable.

- We have not included results reported in tool providers' or OMG websites. A more extensive search may add other results.

Conclusions

- **RQ1 – Where and Why?**
  - A wide range of domains and types of systems;
  - Automation and reducing labour-intensive tasks, improving communication, integrating best solutions in code generators -> increasing productivity and improving software quality by avoiding defects.

- **RQ2 – State of the MDE**
  - Code generation is common;
  - Scalability, reliability and integration of tools are main concerns.

- **RQ3 – MDE impact on productivity and software quality:**
  - Reports of success but we need more data and from larger studies. Most difficult to answer.

Lessons Learned & Gaps for Future Research

- Define a baseline in the company from previous projects.
- Perform more empirical studies and of different types.
- Investigate Return-On-Investment (ROI) including costs and benefits.

MODELPLEX have defined an evaluation plan based on previous experience and we will report the results as far as possible.

Thank You!

Questions?