Measuring Digital Transformation of Firms

An index development study

DMI 2023 invited talk by Prof.Dr. Mehmet Gençer
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What is digital transformation (DT)?

- The interest in and talk about DT has exploded, but its definition and substance remains unclear.
- On a general level Industry 4.0 is considered as a ‘desirable state of industrial firms’ based on technologies, characteristics, and outcomes (Culot et al., 2020).
- DT, on the other hand, is a broader process leading to such end states for all types of organizations.
- Concepts of digitization and digitalization are rather limited to the technological aspects of such a process (Leão and da Silva, 2021)
- The definition we adopt here **“an organizational change process that leverages digital technologies to create value”** (Morakanyane et al., 2017; Gong & Ribiere, 2021).

Why measure?

- With its emergent prominence in competitiveness and strategy, DT metrics are becoming vital (Kontić, L., & Vidicki, Đ., 2018).
- There's a void of consensus regarding its dimensions (Schumacher et al., 2016).
- Global consultancy firms and government supported initiatives have had their own take on the issue, resulting in a variety of measurement approaches, especially for manufacturing firms.
- Currently these metrics are based on a priori categories of organizational qualities taken from broader management research, such as organizational, strategic, process or supply chain management related factors, in addition to technological factors.

Commonly used models

- IMPULS Readiness Model (Lichtblau et al., 2015): 6 different dimensions: organizational strategy, smart factory, smart operations, smart products, data-driven services and employees.
- PricewaterhouseCoopers (PwC) Readiness Model (Geissbauer, Vedso, & Schrauf, 2015): 7 dimensions: (1) digital business models and customer access, (2) digitization of product and service offerings, (3) digitalization of vertical and horizontal value chains (4) data and analytics as core competencies, (5) agile IT architecture, (6) legal and security, and (7) organization, employees and digital organization.
- Industry 4.0 Readiness and Maturity Level Assessment Model in Manufacturing Enterprises (Schumacher et al., 2016): It consists of 9 dimensions: strategy, leadership, customers, products, operations, culture, people (employees), government and technology.

Commonly used models (cont.)

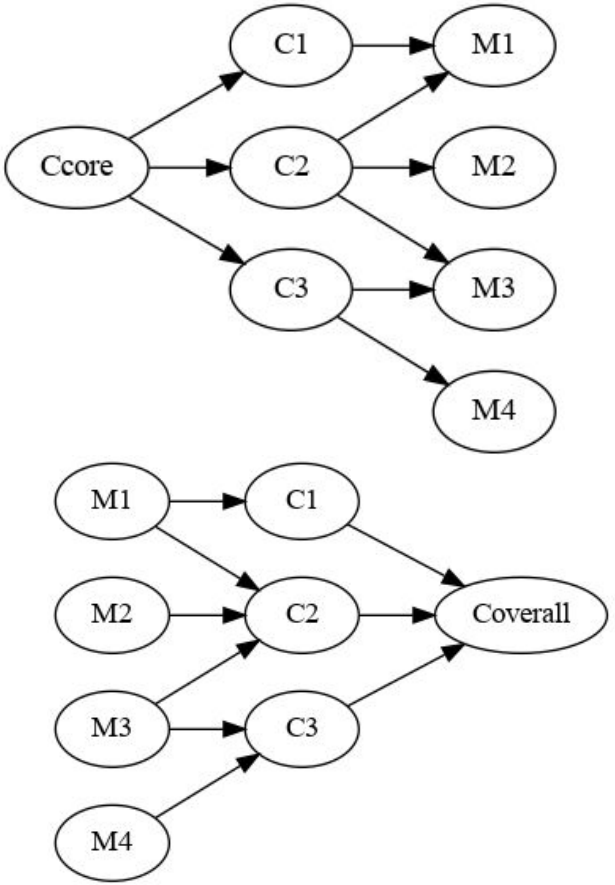
- 3-Stage Maturity Model (Ganzarain & Errasti, 2016)
- Guide for Industry 4.0 (Anderl et al., 2015)
- SPICE Model (Gökalp, Şener, & Eren, 2017)
- Readiness and Maturity Model for Industry 4.0 Strategy (Akdil, Üstündağ, & Çevikcan, 2018)
- University of Warwick model (Agca et al. 2017)
- Forrester's Digital Maturity Model (Gill and vanBoskirk, 2016)
- **Digital maturity model (DMM) (Berghaus and Back,2016)**

Issues: what is being measured?

- “Readiness” or “maturity”?
- Very few of the proposed models are based on a robust methodology of scale development.

Issues: how to measure?

- There are two types of scales, each corresponding to different conceptualizations of what is being measured and each requiring different statistical procedures (Jarvis et al., 2003).
- **reflexive scale**: In cases where measures/indicators are dependent on some latent constructs (e.g. “customer satisfaction”). This type of design is so widely presumed that most research adopt this approach where it is not appropriate (Jarvis et al. 2003).
- **Formative scale (index)**: In other cases the construct is defined on the measures (e.g. “social status”).



Measurement models

- In formative model error (ζ) at construct level, not a measurement error, ie. formative indices are error free!
- No reliability check possible, conceptually.
- Some validity checks are discussed in literature

A. Diamantopoulos et al. / Journal of Business Research 61 (2008) 1203–1218

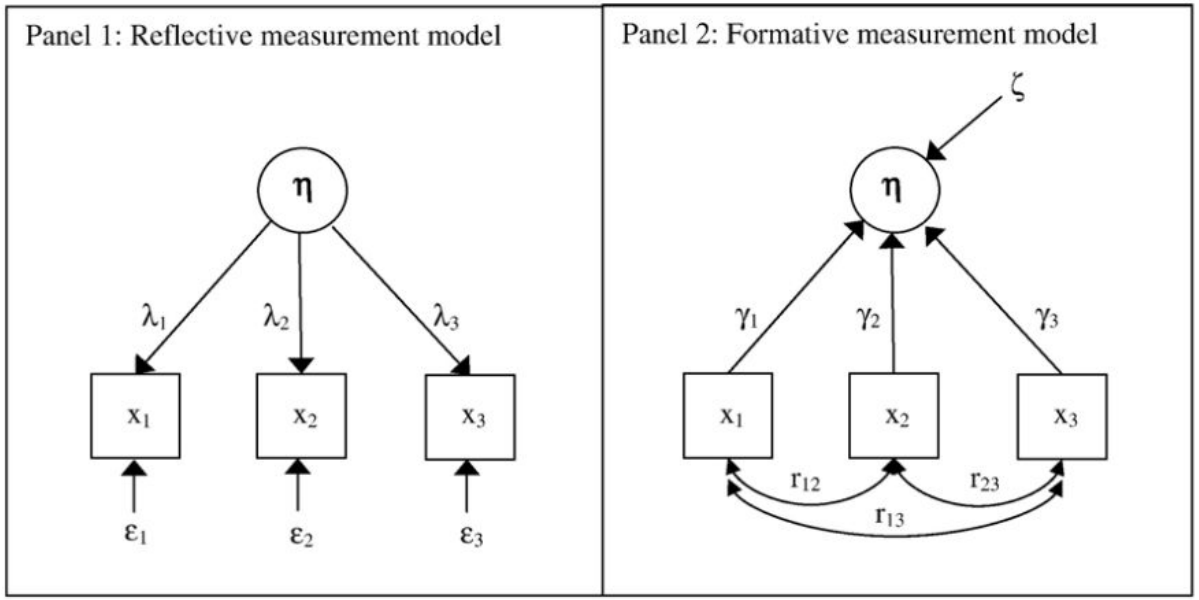


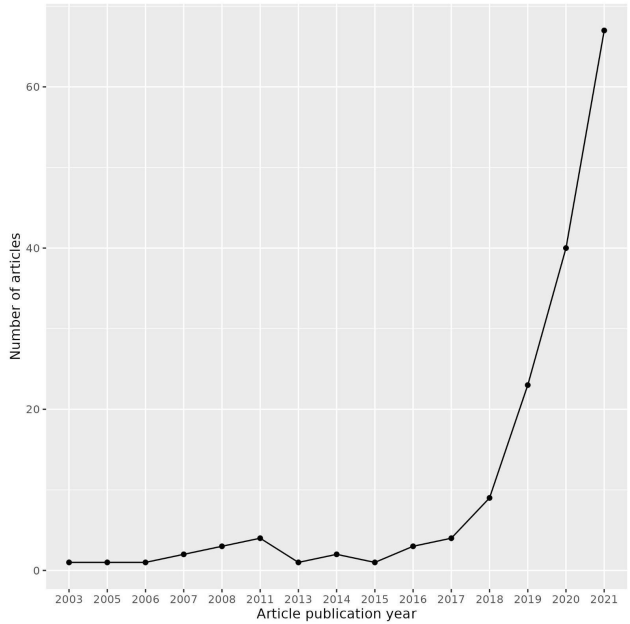
Fig. 1. Alternative measurement models.

Our study

- Research team: Mehmet Gençer, Aysu Göçer, Özgür Özpeynirci, Elif İşcan, funded by IEU
- Research questions:
  - What should be the indicators & dimensions to measure DT in firms?
  - How are these emergent dimensions different from those in the common scales used since two decades?
- Design: A formative measurement (index) development for digital transformation of firms.
- Methodology:
  - Systematic survey of measurement literature
  - Selection of indicators and dimensions
  - Pilot application and validation
  - Comparison

Systematic survey

- 316 English language scientific papers selected for DT related keywords
- Irrelevant ones are eliminated, leaving 164



Indicators

- Reading through articles 1656 first order indicators are identified, some eliminated, leaving 1651 indicators. E.g. “Usage of digital forms in ordering processes”
- Merged into 189 second order and 55 third order items, e.g. “Availability of digital platforms for ordering” →”Digitalization of customer processes”
- Second order indicators are reflected in 85 questions and collected under under 14 dimensions, e.g. “Customer relations and marketing operations” dimension (IRA: 95%)

Pilot application and validation

- 29 surveys filled by firm managers, nearly half in face-to-face sessions
- **Indicator collinearity**: VIF values checked(>10), 4 questions eliminated leaving 81 questions in survey.
- **External validity**: 6 questions to measure 2 reflective constructs are added to survey. All checks are OK (RMSEA range between 0.20-0.27 and comparative fit index between 0.27-0.63).

Comparison: dimensions and changes

	Dimension	Number of indicators	Example indicators	Established or Emergent
1	Customer relations and marketing operations	9	CRM software is used for customer relationship building	Established
2	Cyber security	4	Virtual Private Networks (VPN) are used	Emergent
3	Data management tools	4	Data mining technology is used	Established
4	External environment	3	Country-wide IT/ICT infrastructure for digitalization is available	Established
5	Human resources	4	Using reward system for motivating employee's digital progress	Established
6	Investment and Finance Operations	6	Company digitalizes budgeting process	Emergent
7	Logistics and supply chain operations	10	Company digitalizes inventory management	Emergent?

Comparison: dimensions and changes (cont.)

	Dimension	Number of indicators	Example indicators	Established or Emergent
8	Organizational	6	Digital Officers and managers are available in the organizations	Existent
9	Partnership	3	Stakeholders are knowledgeable and financially capable for digital transformation	Emergent
10	Product development process	4	Company uses digital technologies and software for new product development	Existent
11	Production operations	3	Company uses integrated software for production order management	Emergent?
12	Strategy	7	Company has a digital transformation action plan	Existent
13	Technological resources	18	Cloud-based technologies are available	Existent
14	Top management	4	Top management acts as a participatory leader to implement digital transformation	Existent

Discussion & implications

- DT is an evolving definition, our index is a contemporary “snapshot” of it
- Several new dimensions have emerged in over a decade, requiring matching business policies to be developed.
- Future study: How a firm can act upon DT may vary between different industries, different markets with varying competitive environments and agility requirements, and between different regions/cultural contexts of application.

Questions?

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