Industry 4.0 / Chemistry 4.0
Digitalization & Circular Economy

Wolfgang Falter
Frankfurt am Main, June 12th, 2018
Industry 4.0 – more than a self-fulfilling idea of managers and consultants?

**Industry 4.0**

Everybody speaks about it.
Nobody knows how to do it.
Everyone thinks the others are doing it.
Therefore everyone claims to do it too!

Source: Dr. Heiko Kulina, BASF; "Information Overload! Creating Value from Data - How to achieve more out of your data", Birmingham, June 13, 2018
China transforms into a smart manufacturing Industry 4.0 superpower

One of seven strategic emerging industries in which the central government plans to aggressively invest

+25%

Annual growth target for Industry 4.0

Advanced manufacturing technology in China is growing fast

- **Robots**: 140,000 industrial robots in 2018 (E)
- **IoT Kits**: $361b market in 2020 (E)
- **3D Printing**: $5b market in 2018 (E)
- **Industrial software**: $20b market, +17% YoY growth

Smart equipment used at manufacturers in China (survey)

- **Automobile and parts**: 91% already in use, 9% not yet in use
- **Construction machinery**: 74% already in use, 26% not yet in use
- **Power and Electric**: 64% already in use, 36% not yet in use
- **Machinery manufacturing and process**: 50% already in use, 50% not yet in use
- **Others**: 55% already in use, 45% not yet in use
Germany is currently ranked #4 in Industry 4.0, behind China, South Korea and Japan

<table>
<thead>
<tr>
<th>Country</th>
<th>Government plans</th>
<th>Total annual budget ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Korea</td>
<td>• Ministry of Education Science and Technology</td>
<td>13,000</td>
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<tr>
<td>Japan</td>
<td>• New Energy and Industrial Technology Development Organization • Several other programs</td>
<td>2,100</td>
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<tr>
<td>Germany</td>
<td>• Fraunhofer Program • Central Innovation Program • Spitzenercluster Support Program</td>
<td>1,900</td>
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<td>France</td>
<td>• Competitiveness Clusters</td>
<td>750</td>
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<tr>
<td>Singapore</td>
<td>• Future of Manufacturing Program</td>
<td>700</td>
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<tr>
<td>Finland</td>
<td>• Finland Science and Technology Council</td>
<td>600</td>
</tr>
<tr>
<td>Taiwan</td>
<td>• Industrial Technology Research Institute (ITRI)</td>
<td>600</td>
</tr>
<tr>
<td>Australia</td>
<td>• Industry and Innovation Program</td>
<td>500</td>
</tr>
<tr>
<td>UK</td>
<td>• The Catapult Program</td>
<td>260</td>
</tr>
</tbody>
</table>

Source: North American Manufacturing Research Institution of SME (NAMRI/SME)
Industry 4.0 – We’ve asked more than 1.800 C-level executives in early 2018

Where are you located?

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Australia</td>
<td>9%</td>
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<td>Brazil</td>
<td>6%</td>
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<td>Canada</td>
<td>6%</td>
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<td>China</td>
<td>6%</td>
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<td>Denmark</td>
<td>6%</td>
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<td>Finland</td>
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<td>France</td>
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<td>Iceland</td>
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<td>India</td>
<td>6%</td>
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<td>Japan</td>
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<td>Mexico</td>
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<td>Netherlands</td>
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<td>Norway</td>
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<td>South Africa</td>
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<td>Spain</td>
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<td>Sweden</td>
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<td>United Kingdom</td>
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<tr>
<td>United States</td>
<td>6%</td>
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What is your title?

<table>
<thead>
<tr>
<th>Title</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>CEO/President</td>
<td>15%</td>
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<tr>
<td>COO</td>
<td>17%</td>
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<td>CFO</td>
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<td>CMO</td>
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<td>CIO</td>
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<td>Other C-suite</td>
<td>17%</td>
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Source: Forbes Insights & Deloitte Global survey on "What steps are you taking to navigate Industry 4.0 and what’s your path to future success?"
Industry 4.0 – Executives conceptually understand the changes, but see tension between hope and ambiguity in four areas

**Social Impact – it’s important, but it’s not us**
Executives see a bright future for society as a result of Industry 4.0 having much more influence than government; however they have low confidence in their own organizations’ role influencing key social issues.

**Strategy – fit for the future? The future is now**
Executives feel unprepared for many aspects of 4.0, but they remain stuck pursuing current strategies.

**Talent – when you do not know what you want to do, it’s difficult to define what you need**
Discussions about talent are low on executives’ list of priorities. They claim to do everything they can to create a better-prepared workforce for this new era. However, they are struggling to articulate what creating the workforce of the future will require.

**Technology – the best or nothing**
Executives’ technology investments are focused on supporting new business models, but they often lack a strong business case. More pragmatic, commercially attractive operational excellence initiatives often not realized due to company internal issues and obstacles.

Source: Forbes Insights & Deloitte Global survey on "What steps are you taking to navigate Industry 4.0 and what’s your path to future success?"
Industry 4.0 – promising a new industrial revolution

**Industry 1.0**
- **Power Generation**
  - Power loom
  - 1784

**Industry 2.0**
- **Industrialization**
  - Assembly line in slaughterhouses
  - 1870

**Industry 3.0**
- **Electronic Automation**
  - Programmable Logic controller (PLC)
  - 1969

**Industry 4.0**
- **Smart Automation**
  - Cyber-Physical-Systems (CPS), Future Project “Industry 4.0” by the German federal government
  - 2011

- **Power loom**
  - 1784
- **Assembly line in slaughterhouses**
  - 1870
- **Programmable Logic controller (PLC)**
  - 1969
- **Cyber-Physical-Systems (CPS)**
- **Future Project “Industry 4.0”**
- **German federal government**
- **2011**

**Capital Replaces Labor**

**Information Replaces Capital**

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Industry 4.0 - cheap, abundant data and fast internet are the drivers to make it real

Bandwidth, Storage and Computing prices [1992-2016]

Growth of open source analytics [# of R packages available]

Bandwidth, Storage and Computing prices [1992-2016]

Forecasted global IoT market spending [US$B]

Worldwide corporate data growth [Exabytes]

Network Connectivity
Platforms/Applications/Cloud Solutions
Systems Integration
Hardware

Unstructured Data
Structured Data

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Industry 4.0 transformation happens in steps with potential benefits along each step.

**Industry 4.0 Readiness / Maturity Stages**

1. Computerization
2. Connectivity
3. Visibility
4. Transparency
5. Predictive Capacity
6. Adaptability

**Value**

- **Automatization**
- **Analytics**
- **Human Input**

**Decision**
- Descriptive: What is happening?
- Diagnostic: Why is it happening?
- Predictive: What will happen?
- Prescriptive: How can an autonomous response be achieved?

**Action**
- Decision Support
- Decision Automation

Source: Acatec Maturity Model, Gartner, Deloitte
Industry 4.0 is about completing the physical-to-digital-to-physical loop

Company Internal

Capturing company-internal data

Analyzing, interpreting, connecting and visualizing data (Analytics)

Applying algorithms, taking decisions, acting based on data

Improving and connecting processes

Physical

Digital

External

Capturing external data

Transparency & digital processes

Business activities

Sensors produce data

Data is analyzed at the edge or in the cloud

Analysis leads to insights

From insights, we make decisions and take action

Introducing new products, services, business models

Data-based Operational Excellence 4.0

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Industry 4.0 leads to “Data-based Operational Excellence 4.0” and/or “Digital Operating & Business Models”

**Data-based Operational Excellence 4.0**

**Smart Cost Reduction (↑ Productivity, Safety, Quality, ↓ Risk)**

- Enhancing asset and process effectiveness & efficiency (US$/€ per hour/ Capital Employed)
- Predictive, preventive maintenance
- Remote and automated operations

**Digital Operating & Business models**

**Profitable Growth (↑ Revenue, Profitability)**

- Adding intelligence to existing products, creating product systems or new operating / business models
- Creating new services (performance and results driven)
- New product possibilities

**Production**

- E-commerce, new channels, seamless solicit-order-to-cash processes
- Aftermarket experience, e-services
- Dealer integration

**Planning**

- Demand sensing and planning
- Supply planning and supplier integration
- Outbound network optimization

**Support**

- Augmented and Virtual reality
- E-Services
- Creating leverage for technical talent
- Support optimization

- Reducing “idea to market” time, rapid prototyping
- Linking design with product intelligence
- Improving engineering effectiveness
- New production technologies (advanced manufacturing)
Digital Farming is a good “product” example to illustrate the Industry 4.0

Will there be a closed (iOS) or open system (Android)? Will AgChem, AgTech or Software Companies drive it?

1. Product
2. Smart Product
3. Smart, connected Product
4. Product-System

Extended Digital Products
Solution Provider
Platform Integrator
Integrated Ecosystems

Value Add

Farmer & Retail

Balance of Power

Innovation Model

Open shared, publicly available technology

Commoditization and generics

Agchem, Seed & OEM

(Farm Management Platform)

AgChem and Digital Farming

Bio and organic

Independent Farmers

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Online retailers and start-ups try to enter the chemical distribution playing field
Additive manufacturing will change many industry sectors and applications
Golden Batch / Process Efficiency are typical opportunities in production

Many time series, but no quality check

Generate fingerprint per batch

Model & optimized fingerprints

Some selected Project Results

- 7.2 instead of 8.3 hours average run time (batch polymerization)
- 3% instead of 8% faulty batches (adhesives)
- 98% instead of 87% OTIF (On-time in-full) deliveries (dispersions)

- Yield increase from 71% to 83% (organic pigments)
- 1.5% higher selectivity (inorganic pigments)
- 12% lower energy consumption (organic intermediates)
IoT Architecture and especially data integration of DCS/PLC (level 2) and ERP systems (level 4) are often critical issues to a successful roll-out

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**Evaluation Criteria (Illustrative)**

- **Time to Market**
- **Costs**
- **Functionality**
- **Stability**
- **Safety**

Strong ○ Weak

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**Implementation**

Based on requirements and priorities the solution needs to be Custom Based

**IoT Application**

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**ERP**

**MES**

**PLT/DCS SCADA**

**SPS/PLC, Sensors, Controllers**

**Production, Process**

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**Service Bus**

**Data Landing Zone**

**Data Integration**

**Analytics**

**Data Mart**

**Visualization**

**Optimizer**

**Control System**

**ERPs**

**DWH**

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**Sensors**

**Controllers**

**ERP**

**Backoffice**

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**OT Interface**

**IT Interface**

**Sources**

**Interfaces**

**IoT Platform**

**Interfaces**

**Targets**

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**OT / IT = Operational / Information Technology**

**ERP = Enterprise Resource Planning**

**DWH = Data Warehouse**

**MES = Manufacturing Execution System**

**PLT/DCS = Prozeßleittechnik / Distributed Control System**

**SCADA = Supervisory Control And Data Acquisition**

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Sourcing & Procurement Dashboards visualize content, allow process tracking, project views, benefit tracking, sourcing and procurement analytics.
In asset intensive petrochemicals-intermediaries-polymers we see higher operational excellence and in consumer chemicals more operating & business model opportunities.

### Data-based Operational Excellence 4.0

<table>
<thead>
<tr>
<th>Category</th>
<th>Petrochemicals</th>
<th>Inorganics, Bulk Chemicals</th>
<th>Industrial Chemicals</th>
<th>Polymers</th>
<th>Coatings, Paints, Adhesives, Elastomers</th>
<th>Fine &amp; Specialty Chemicals</th>
<th>Agrochemicals</th>
<th>Consumer Chemicals</th>
<th>Pharmaceuticals</th>
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</tbody>
</table>

- Small impact
- Large impact

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<thead>
<tr>
<th>Impact Category</th>
<th>Savings in quality control costs</th>
<th>Savings in inventory costs</th>
<th>Average productivity gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>15%</td>
<td>30%</td>
<td>4%</td>
</tr>
<tr>
<td>Large</td>
<td></td>
<td>25%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Savings in maintenance costs: 25%

Accelerated Time to Market: 30%

Source: VCI, Industrieverband Klebstoffe, Deloitte Analysis
Chemistry 4.0 combines Digitalization with Circular Economy

Chemistry 1.0
Foundation and coal chemistry

Chemistry 2.0
Petrochemicals

Chemistry 3.0
Globalization & Specialization

Chemistry 4.0
Digitalization & Circular Economy
Circular Economy goes beyond production of chemicals and materials ("7 R’s")

Source: Deloitte and VCI "Chemistry 4.0"
Chemicals & materials have very different applications. Thus not every “R” makes sense. However, any “R” is typically good and the more “R’s” the better.
Combining Digitalization & Circular Economy can establish new eco-systems & alliances

From linear economy ...

Competition

Supplier
Chemical Producer
Distributor
Customer

Goods, Services, Brand

Value based on production of chemicals and materials [€/kg]

...to complex, often circular, ecosystems

Competition

Supplier
Chemical Producer
Distributor
Customer
New players
Software provider
Hardware provider

Collaboration (Data/Knowledge)

Value based on designing and building smart, sustainable solutions [€/performance or solution unit]

Source: Deloitte and VCI "Chemistry 4.0"
Five main challenges in implementing Chemistry 4.0 need to be overcome

**Workforce and Training**
- Technical skills (Data Science, IoT...)
- Replacement by automation

**Retro-fitting and Compatibility**
- Smart and connected production network
- Standards between different processes, assets and databases

**Organizational attitudes**
- Doubts or discomfort within the organization
- Barriers to information flows between different parts of the organization

**Cyber risk**
- Smart and connected assets and processes
- Old and new risks from cyber attacks

**Data ownership**
- Data sharing between employees, customers, suppliers, partners and other stakeholders
- Legal issues related to data ownership and usage rights
It’s a Chemistry 4.0 Transformation Journey. Are you ready to take the first steps?

Chemistry 4.0 Journey

1. Chemistry 4.0 Vision
   Define holistic, long term chemistry 4.0 vision

2. Chemistry 4.0 Readiness Assessment
   Evaluate gap and prioritize activities

3. Chemistry 4.0 Roadmap
   Assess digital maturity to identify opportunities and set targets

4. Chemistry 4.0 Business and Operating Model
   Set up a structure to execute and track progress

5. Scale Up
   Roll out verified solutions to leverage their full potential