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Existential dilemma – industrial development and climate change
Background

- Importance of digital industrialisation for sustainable re-industrialisation (CCRED, 2019)
  - Advanced manufacturing and automation mitigate climate change; integration in value chains
- South Africa is unprepared to fully adopt and adapt frontier digital technologies for sustainable structural transformation (IDTT 2022; DCDT 2021; CCRED, 2019)
  - General lack of understanding of digital industrialisation in SA firms
- Research aims to analyse digital technology adoption in South African manufacturing firms
Multi-level framework to analyse digitalisation
Defining digital technologies

Source: Andreoni and Anzolin (2019)
### Advanced digital technologies

#### Table 1: Basic descriptive of digital technologies

<table>
<thead>
<tr>
<th>Generations of digital technologies</th>
<th>Functional Process</th>
<th>Basic technology classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>G 0.0 &amp; 1.0</td>
<td>Analogue and rigid processes</td>
<td>Manual and semi-automated</td>
</tr>
<tr>
<td>G 2.0</td>
<td>Lean processes</td>
<td>Fully-automated and ICT-enabled</td>
</tr>
<tr>
<td>G 3.0 &amp; G.4.0</td>
<td>Integrated and smart processes</td>
<td>Digital system-enabled</td>
</tr>
</tbody>
</table>

Source: Based on Kupfer et al. (2019)
The Digital Skills Survey 2021

- Collaboration between the IDTT and SARCHI-ID, supported by the DTIC
- SETAs: manufacturing and engineering services (MerSETA), chemicals (CHIETA), and textiles and fibre processing (FP&M SETA)
- Conducted in March 2021, via emails using standard survey questionnaire: LA cases; UNIDO

Table 2: Breakdown of survey

<table>
<thead>
<tr>
<th>Invitations</th>
<th>7,432</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response Rate</td>
<td>≈7%</td>
</tr>
<tr>
<td>Total Responses</td>
<td>516</td>
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</tbody>
</table>

MerSETA (67%); CHIETA (17%); FP&M (16%)

- Use knowledge gleaned from a unique online survey of three manufacturing sector education and training authorities (SETAs) - CHIETA, MerSETA, and FP&M
Firms reliant on manual and semi-automated technologies

PD and PM have higher adoption rates of more advanced technologies

- **Product Development** (Responses = 113):
  - Manual and semi-automated: 63%
  - Fully automated and ICT-enabled: 32%
  - Digital system-enabled: 5%

- **Production Management** (Responses = 378):
  - Manual and semi-automated: 48%
  - Fully automated and ICT-enabled: 40%
  - Digital system-enabled: 12%

- **Customer Relationships** (Responses = 355):
  - Manual and semi-automated: 55%
  - Fully automated and ICT-enabled: 43%
  - Digital system-enabled: 2%

- **Supplier Relationships** (Responses = 507):
  - Manual and semi-automated: 40%
  - Fully automated and ICT-enabled: 34%
  - Digital system-enabled: 26%
Status quo of technology infrastructure: SETA breakdown by business function

**Supplier Relationships**
- MerSETA: 4.6% Digital, 26.5% Fully Automated, 68.9% Manual/Semi-Automated
- FP&M: 2.9% Digital, 37.7% Fully Automated, 59.4% Manual/Semi-Automated
- CHIETA: 6.3% Digital, 31.7% Fully Automated, 61.9% Manual/Semi-Automated

**Production Management**
- MerSETA: 13.4% Digital, 41.1% Fully Automated, 45.5% Manual/Semi-Automated
- FP&M: 16.0% Digital, 24.0% Fully Automated, 60.0% Manual/Semi-Automated
- CHIETA: 5.4% Digital, 37.5% Fully Automated, 57.1% Manual/Semi-Automated

**Customer Relationship**
- MerSETA: 2.0% Digital, 41.4% Fully Automated, 56.7% Manual/Semi-Automated
- FP&M: 5.6% Digital, 35.2% Fully Automated, 59.3% Manual/Semi-Automated
- CHIETA: 1.8% Digital, 35.7% Fully Automated, 62.5% Manual/Semi-Automated

**Product Development**
- MerSETA: 1.8% Digital, 14.5% Fully Automated, 83.6% Manual/Semi-Automated
- FP&M: 11.1% Digital, 33.3% Fully Automated, 55.6% Manual/Semi-Automated
- CHIETA: 3.3% Digital, 20.0% Fully Automated, 76.7% Manual/Semi-Automated
Technology by firm size

- **Medium-sized firms** leading adoption of digital system-enabled technologies
- **Micro- and small-sized firms** dominating in automation and ICT-enabled technologies

**Source:** Authors

**Notes:** Small - Sales valued at between R11 and R50 million in the 2019/20 financial year, Medium - Sales valued at between R51 and R250 million 2019/20 financial year, and Large - Sales valued at more than R250 million 2019/20 financial year.
Firms at the industry level reliant on manual and semi-automated technologies

Observed heterogeneity in adoption of digital technologies

Leaders

Laggards

<table>
<thead>
<tr>
<th>Industry</th>
<th>Manual and semi-automated</th>
<th>Fully automated and ICT-enabled</th>
<th>Digital system-enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petroleum</td>
<td>50%</td>
<td>41%</td>
<td>9%</td>
</tr>
<tr>
<td>Speciality Chemicals</td>
<td>51%</td>
<td>43%</td>
<td>6%</td>
</tr>
<tr>
<td>FMCG</td>
<td>52%</td>
<td>44%</td>
<td>4%</td>
</tr>
<tr>
<td>Metal and Engineering</td>
<td>53%</td>
<td>39%</td>
<td>7%</td>
</tr>
<tr>
<td>Plastics</td>
<td>54%</td>
<td>40%</td>
<td>6%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>57%</td>
<td>33%</td>
<td>10%</td>
</tr>
<tr>
<td>Wood and Wood products</td>
<td>57%</td>
<td>29%</td>
<td>14%</td>
</tr>
<tr>
<td>Textiles</td>
<td>61%</td>
<td>29%</td>
<td>11%</td>
</tr>
<tr>
<td>Automotive and components manufacturing</td>
<td>64%</td>
<td>29%</td>
<td>7%</td>
</tr>
<tr>
<td>Base chemical</td>
<td>64%</td>
<td>25%</td>
<td>11%</td>
</tr>
<tr>
<td>Furniture</td>
<td>70%</td>
<td>23%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Future orientation – Industry

- **Marked affinity** towards advanced digital technologies in 5-10 years
- **Positive outlook** towards incremental adoption strategies

**Chart:**

- Petroleum: 27% Manual and semi-automated, 37% Fully automated and ICT-enabled, 37% Digital system-enabled
- Speciality Chemicals: 16% Manual and semi-automated, 56% Fully automated and ICT-enabled, 28% Digital system-enabled
- FMCG: 18% Manual and semi-automated, 59% Fully automated and ICT-enabled, 23% Digital system-enabled
- Metal and Engineering: 24% Manual and semi-automated, 56% Fully automated and ICT-enabled, 20% Digital system-enabled
- Plastics: 24% Manual and semi-automated, 52% Fully automated and ICT-enabled, 24% Digital system-enabled
- Pharmaceuticals: 14% Manual and semi-automated, 55% Fully automated and ICT-enabled, 31% Digital system-enabled
- Wood and Wood products: 11% Manual and semi-automated, 56% Fully automated and ICT-enabled, 33% Digital system-enabled
- Textiles: 18% Manual and semi-automated, 43% Fully automated and ICT-enabled, 39% Digital system-enabled
- Automotive and components manufacturing: 29% Manual and semi-automated, 49% Fully automated and ICT-enabled, 22% Digital system-enabled
- Base chemical: 24% Manual and semi-automated, 45% Fully automated and ICT-enabled, 31% Digital system-enabled
- Furniture: 33% Manual and semi-automated, 52% Fully automated and ICT-enabled, 15% Digital system-enabled
To separately identify and examine the determinants of digital technology adoption across different business functions for which we have good data, we estimate three simple multivariate probit models: SR; CR; PD.

Grouped firm-level variables into six categories following Baldwin and Lin (2002):

1. Institution-related constraints (infrastructure, training centres, etc); 2. Cost-related constraints (lack of capital); 3. Information-related constraints (lack of awareness); 4. Labour-related characteristics; 5. Organisation-related characteristics (R&D); 6. Firm characteristics (Age, location, sales, etc)
Empirical results and discussion

- Results show a mix of factors that influence the adoption of digital technologies across the three business functions under consideration.
- Cost-related constraints = crucial determining factor of adoption.
  - Supplier and customer relations business functions most affected
- Human capital is essential for the adoption of digital technologies across the functions.
  - Emphasising the importance of STEM skills.
- Older, export-orientated, and foreign-owned firms displayed higher degrees of digital technology adoption.
  - Across all business functions.
Factors affecting technology adoption (SETA-level)

- Lack of adequate digital infrastructure: 46% (CHIETA), 34% (FP&M), 36% (MerSETA)
- Lack of capital: 59% (CHIETA), 43% (FP&M), 55% (MerSETA)
- Long time to recover investments in new digital technologies: 24% (CHIETA), 43% (FP&M), 39% (MerSETA)
- Lack of adequate human resources: 33% (CHIETA), 37% (FP&M), 50% (MerSETA)
- Lack of awareness and knowledge of new digital technologies: 48% (CHIETA), 44% (FP&M), 36% (MerSETA)
Factors affecting technology adoption (Firm level)

- Lack of adequate digital infrastructure: 29% (86 firms)
- Lack of capital: 24% (63 firms)
- Lack of adequate human resources: 24% (81 firms)
- Lack of awareness and knowledge of new digital technologies: 29% (24 firms)

Legend:
- Micro (86)
- Small (63)
- Medium (81)
- Large (24)
- Number of firms
Skills and Digital Technologies – Important skills when hiring (SETA breakdown)

- Soft Skills: 90% (CHIETA), 80% (FP&M), 77% (MerSETA)
- Human-computer interaction: 88% (CHIETA), 76% (FP&M), 75% (MerSETA)
- STEM abilities: 73% (CHIETA), 53% (FP&M), 59% (MerSETA)
- Manual/Repetitive Skills: 77% (CHIETA), 76% (FP&M), 87% (MerSETA)
Skills and Digital Technologies – Difficulty in finding skills (SETA breakdown)

<table>
<thead>
<tr>
<th></th>
<th>CHIETA (51)</th>
<th>FP&amp;M (49)</th>
<th>MerSETA (172)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Skills</td>
<td>76%</td>
<td>84%</td>
<td>76%</td>
</tr>
<tr>
<td>Human-computer interaction</td>
<td>78%</td>
<td>88%</td>
<td>78%</td>
</tr>
<tr>
<td>STEM abilities</td>
<td>98%</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>Manual/Repetitive Skills</td>
<td>35%</td>
<td>45%</td>
<td>47%</td>
</tr>
</tbody>
</table>
Conclusions

- Digital industrialisation fundamental to structural transformation
  - Escape middle-income technology trap
- Inequality between firms in the adoption and use of advanced digital technologies
  - Uneven speed and scale
- Digital divide across several levels of analysis (SETA, industry, and firm size)
- These findings have potential to influence policy discussions on specific firm- and industry-level characteristics to drive digital transformation in South Africa.
  - Heterogeneity => targeted policies
  - Findings cannot be generalized for all SETAs because the survey is in its first iteration.
- Opportunities for future iterations.
Thank you!
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