Stimulating innovation through industry 4.0 in a small commodity-based economy

Abstract

Strengthening the Trinidad & Tobago economy to be resilient to the effects of oil and gas price and supply fluctuations requires a paradigm shift in creating a reliable source of revenue. Historically, the manufacturing sector has not been able to offset the demands placed upon the country’s natural resources. This problem has been identified as an inadequate innovative ecosystem. The new industrial revolution, Industry 4.0, through its framework and enabling technologies provides the capacity to fill gaps within interconnected value networks. This approach is applied to three local firms and opportunities for innovation are clearly identified in the process of transitioning to Industry 4.0 in reconfigured value chains, expressed in the creation of a cluster to facilitate the development of innovative cloud based solutions, a product configurator and an augmented reality interactive display.

Keywords: industry 4.0, innovation, commodity economy, cloud computing, clusterant

Introduction

Trinidad & Tobago is a small island developing state of 1.4 million inhabitants, located in the Eastern Caribbean. The country is richly-endowed with oil and natural gas resources, which along with their downstream products, account for 80% of export income. However, reductions in international oil and gas prices coupled with depleting gas reserves have caused the economy to enter recession. Downstream petrochemical industries such as methanol and ammonium production seem less economically feasible in the future.

However, reductions in international oil and gas prices coupled with depleting gas reserves have caused the economy to enter recession. Downstream petrochemical industries such as methanol and ammonium production seem less economically feasible in the future.

According to the World Economic Forum, with a 2016 GDP per capita of 15,377 US (World Bank), the economy should be ‘innovation driven’. However, the Global Innovation Index 2017 ranks Trinidad & Tobago 91/127 countries and the Innovation Sub-Pillar in the Global Competitiveness Report 2016-2017 gave a rank of 106/138. Therein lies the dichotomy of Trinidad and Tobago: its macroeconomics point to an innovation driven economy but it has little innovation capacity, even among its manufacturing companies. A classic case of commodity resource induced Dutch disease. The diversity of the Trinidad & Tobago economy has in fact steadily decreased both in terms of the range of goods and markets over the past 20 years Bahar et al., but conditions to catalyse innovation and diversification are finally now created. If the country can dig into the depth of its technical skills it could leapfrog into a new phase of its economic development (Government of the Republic of Trinidad & Tobago, 2017). Globally, Industry 4.0 (I4.0), otherwise known as the “Fourth Industrial Revolution” and closely related to the “Industrial Internet of Things”, is rapidly emerging as a competitive watershed in the manufacturing sector, with its tentacles reaching well beyond manufacturing. The digitisation of, and interconnection of machines, employees and customers creates vast volumes of data and companies win and lose through their ability to effectively acquire, process and use data. The relationships between companies and their customers, and with others in their value chain networks, are radically transforming. I4.0 is a hotbed of innovation opportunities which is transforming the manufacturing sector globally. A recent technology foresighting exercise in Trinidad & Tobago has identified ICT Services as an enabler of innovation (Policy Links IfM ECU, 2017). There is significant potential for the ICT sector, by developing strong I4.0 capabilities, to stimulate innovation in other sectors. Could rapid and aggressive implementation of the I4.0 philosophy and technologies in Trinidad & Tobago significantly stimulate innovation in this small commodity-based economy?

In addressing this question, we firstly clarify the link between I4.0 and innovation opportunities. That being established, the key issue is whether firms in a small island economy could implement I4.0 and thereby stimulate innovation and contribute to the diversification of the economy. Therefore, we examine in this paper the readiness of a selection of small manufacturing and service firms to implement I4.0 and capitalise on the downstream innovation opportunities. A framework for assessing firm-level implementation of I4.0 drawn from published literature is proposed and findings from deployment of the assessment with a small selection of firms are presented. We identify opportunities for stimulating innovation in: value streams, technology application and products and services connected to the customer, with a special emphasis on value streams.

Industry 4.0 and innovation

Many authors agree that the term “Industry 4.0” or “Industrie 4.0” first appeared in the Hannover Fair, Germany, in 2011 Sniderman et al.,. However, research of its “design principles and enabling technologies” had been occurring for at least ten years before that. McKinsey defines I4.0 as “the next phase in the digitization of the manufacturing sector”. This enables the integration of value chains (both the horizontal and vertical) at the firm level: another defining element of I4.0 Prause et al., noted the definition made by the German Trade and Invest (GTAI): “A paradigm shift made possible by technological advances which constitute a reversal of conventional production process logic. Simply put, this means that industrial production machinery no longer simply “processes” the product, but that the product communicates with the machinery to tell it exactly what to do”. Mass customisation, by which customers’ needs are...
more precisely met but at a similar cost-point to mass production, are facilitated in I4.0. Physical manufacturing systems are integrated with the information systems, providing data flows between the external world and the internal production systems Chandra et al. Customers can specify their wishes through some digital interface and those data flow straight to production machinery. Integration can extend beyond the walls of the factory and encompass collaborations between the supply chain members to achieve even more effective mass customisation. Using a virtual environment to maximise customer choice and minimise delivery times points to an element of I4.0 that is driving and sustaining innovation in a rapidly evolving competitive environment. Four disruptions can be identified as driving I4.0: a massive rise in data volumes, computer power and connectivity; analytics and business intelligence; human-machine interfaces; and enhanced transfer of digital instructions to the real world, for instance in automation. These translate into a suite of evolving technologies that are at the heart of I4.0, each one being advanced and further integrated by innovation:\footnote{11–15} 

\begin{itemize}
  \item a. Machine learning \item b. Mobility technologies (mobile devices) \item c. Cloud computing \item d. Augmented reality and wearable \item e. Big Data analytics and advanced algorithms \item f. Cyber security, authentication and fraud detection \item g. Autonomous robots \item h. System integration \item i. Internet of Things (IoT) platforms \item j. Simulation \item k. Additive manufacturing and 3-D printing \item l. Smart sensors
  \item m. Advanced human-machine interfaces
  \item n. Multilevel customer interaction and customer profiling (community)
  \item o. Location detection technologies
\end{itemize}

Beyond the advance of the technologies listed above, specific stimuli of innovation in I4.0 include:

\begin{itemize}
  \item a. Connection of decentralised and disconnected horizontal and vertical value chains, using technology such as the Cloud, on the firm level (and expanded to the national level) enables intelligent and real-time analysis. Decisions take into account data obtained from an expanded network of processes across value streams. Innovation is driven by this intelligence; “gaps” across value streams are identified and opportunities for new products and services become clear Wernicke et al.\footnote{9,14}.
  \item b. Deepening understanding of the customer through real-time communications – direct and immediate interactions allow the firm to specifically match supply to customers’ varying demand profiles and strengthen customer loyalty. SAP Ag creates innovation solutions for their customers’ production processes by utilising I4.0 Anon et al.\footnote{13}.
  \item c. Enhancing the product offering – physical products blended with customised services change the customer purchase from a piece of property to an experience and a capability. Connected products facilitate manufacturers’ real-time interaction to enhance the customer values. Rolls-Royce, for instance, uses vast quantities of real-time engine data streamed to its global operations centre and “has deliberately blurred the lines between making things and offering services” Economist\footnote{19} to transform its market position.
  \item d. Improving the product development process – Maserati achieves “rapid innovation” by creating its “digital twin”, which is a key element of the I4.0 system, using Siemens’ Team center PLM software Wauryniak et al.\footnote{17}.
  \item e. Manufacturing process improvements – Siemens’ semi-automated Amberg plant enables a customer responsive system for order-to-delivery in 24 hours (Queiroz et al.)\footnote{9} 3D printing for production transforms economies of scale and production lead times into bespoke production for specific customer requirements Petrick et al.\footnote{19}.
\end{itemize}

These catalytic benefits are expanded to the national level as demonstrated by Germany, China and Taiwan. Germany, and by extension the EU, focuses on I4.0 as an innovation tool Balhar et al.\footnote{20} China Manufacturing 2025 and Taiwan Productivity 4.0 incorporate I4.0 with a focus on prioritising political policy tools in the area of I4.0 innovation Lin et al.\footnote{21} Alternately, Trinidad & Tobago has a specific weakness in its innovation system due to the lack of collaboration between actors in the ecosystem Guinet et al.\footnote{22} Adopting I4.0 has the potential to integrate actors and strengthen this collaborative aspect of the country’s innovation ecosystem.

**Framework for firm-level industry 4.0 implementation**

Drawing from the literature, the authors’ proposed definition of I4.0 and the mechanisms involved in satisfying the movement towards the new industrial revolution is: “\textit{The evolutionary change in decentralised connected systems to enable the intelligent integration of the horizontal and vertical value chains of an organisation}”.

The I4.0 approach achieves innovative solutions by creating more effective links between the customer, business and the process (Figure 1). Connected systems are not just those within the firm, but to its suppliers and customers. Benefits are yielded to the firm, its process and its customers. I4.0 facilitates the creation of new experiences of the product or service for the customer, new efficiency in the process and new models for the business. This definition can be expanded into a framework of assessment of firm-level I4.0 readiness (Table 1), and subsequently forms the basis for an assessment instrument that can be deployed to assess the maturity of elements of I4.0 on a firm level. Firms determine the best methodologies to implement I4.0 concepts that facilitate opportunities for innovation. The assessment instrument was deployed in person with senior personnel in each firm that is able to influence the decision to implement the change to I4.0 (Production or Operations Manager; C.E.O.) Syan et al.\footnote{32,33}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{The matic representation of Industry 4.0 Benefits and the Relationships between the Customer, process and Business.}
\end{figure}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
\textbf{Process} & \textbf{Efficiency} \\
\hline
\textbf{Customer} & \textbf{Platform} \\
\hline
\textbf{Supplier} & \textbf{Dependent} \\
\hline
\textbf{Product} & \textbf{Inventor} \\
\hline
\textbf{Feedback} & \textbf{Human} \\
\hline
\textbf{Technology} & \textbf{Automation} \\
\hline
\end{tabular}
\caption{The matic representation of Industry 4.0 Benefits and the Relationships between the Customer, process and Business.}
\end{table}
Table 1 Framework for Firm-Level Industry 4.0 Implementation

<table>
<thead>
<tr>
<th>Characteristics of industry 4.0 system</th>
<th>Description: an industry 4.0 system has...</th>
<th>Literature references</th>
<th>Sample assessment instrument questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evolution</td>
<td>A continuously changing “cyber-physical system” includes digital and physical technological systems within the production environment is needed to create value for the customer, process and business. Real-time intra- and inter-system communications, which include pure digital and “cyber physical” elements or production systems that describe the interconnectedness between the physical and the digital environment.</td>
<td>Sherwin et al.</td>
<td>Q4-Q6: Assess the firm’s ability to recognise, evaluate and adopt new technologies and products that provide benefits to their production and business operations.</td>
</tr>
<tr>
<td>Connected systems</td>
<td>Production elements (including information, production and logistics) that function while physically or digitally separated. This enables (i) reliability and redundancy in the manufacturing process and (ii) creation of independent production environments that can provide customised products based upon real-time demand.</td>
<td>Roblek et al.</td>
<td>Q9: Assess the firm’s ability to create a digital production environment as well as utilise its benefits. Q11-Q12: Assess communication and collaboration between the manufacturer and their suppliers and customers</td>
</tr>
<tr>
<td>Decentralised systems</td>
<td>Autonomy of the system (or components within it) such as individual products controlling their own production with feedback within the system. All production elements understand their roles, communicate with each other and co-ordinate to fulfil the production demand.</td>
<td>Wernicke et al.</td>
<td>Q15: Assess the manufacturer’s ability to recognise problems with their suppliers and their ability to switch to an alternate supplier. Q21: Assess the firm’s current and future investment in technologies that enable the transition to I4.0. Q16-Q18: Assess the safety and security of data of the customer, business and process as well as identifying existing contingencies for losses and how the production system will be affected.</td>
</tr>
<tr>
<td>Intelligent</td>
<td>Integration that enables effective and efficient assimilation of production elements (physical and digital as well as business and process) to satisfy variable demand profiles. This ensures that the system creates value, for the customer and the business while decreasing costs (capital, energy and personnel).</td>
<td>Wernicke et al.</td>
<td>Q8: Assess the firm’s ability to identify the value proposition for the customer that returns value to the company.</td>
</tr>
<tr>
<td>Integration of horizontal and vertical value chains</td>
<td></td>
<td>Prause et al.</td>
<td></td>
</tr>
</tbody>
</table>

Citation: King GS, Rameshwar JR, Syan CS. Stimulating innovation through industry 4.0 in a small commodity-based economy. *Int Rob Auto J.* 2018;4(5):296–303. DOI: 10.15406/iratj.2018.04.00140
Findings from company investigations

Five local companies that export products or services were evaluated as case studies to understand their current level of readiness in the I4.0 framework. The companies were identified have the potential to customise products. Two companies were found to lack the fundamentals and interest in I4.0, which prevent deployment in the short to medium term. Three have potential for I4.0, and are reported here. Generic names have been assigned to these companies: “StickCom”; “PanelCom”; and “SoftCom”. StickCom produces labels for a variety of products and operates in the Business-to-Business (B2B) segment. PanelCom focuses on electrical components and electrical panels for both the B2B and Business-to-Consumer (B2C) market segments. SoftCom develops software applications as well as Cloud based systems that enable B2B customers to satisfy specific requirements for their operations. Table 2 outlines a summary of the key responses of the companies.

Table 2 Key Responses from Companies to the Structured Interview

<table>
<thead>
<tr>
<th>Company</th>
<th>StickCom</th>
<th>PanelCom</th>
<th>SoftCom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year started</td>
<td>1978</td>
<td>1984</td>
<td>1997</td>
</tr>
<tr>
<td>Products</td>
<td>Labels</td>
<td>Electrical Panels</td>
<td>Software</td>
</tr>
<tr>
<td>Company’s understanding of value sought by customer</td>
<td>Credibility, reliability, knowledge of processes, sales forecasting</td>
<td>High functional specification, quality, delivery, flexibility, inventory management, short lead times</td>
<td>Customised packaged offers, benefits of subscription based software and services, ability to use free beta versions of products</td>
</tr>
<tr>
<td>Value returned to company</td>
<td>Strengthened relationships to ensure customer longevity and new client referrals</td>
<td>Increased profitability margins</td>
<td>Loyalty, growth and profit</td>
</tr>
<tr>
<td>Order customisation</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pricing strategy</td>
<td>Dynamic customer-tailored dependent upon relationship</td>
<td>Dynamic customer-tailored dependent upon design features</td>
<td>Fixed and dynamic customer-tailored pricing</td>
</tr>
<tr>
<td>Vertical value chain</td>
<td>Integration will add value, focus on supplier and customer</td>
<td>Integration will add value, focus on closing all gaps</td>
<td>Integration exists utilising the cloud platform and adds value</td>
</tr>
<tr>
<td>Horizontal value chain</td>
<td>Integration will add value, provides signage, banners, advertising</td>
<td>Integration will add value, for example fire hose cabinets are a potential adjacent product</td>
<td>Integration will add value, for example revenue could be generated from IP integration by third party</td>
</tr>
<tr>
<td>Industry 4.0 Transition challenges</td>
<td>Labour, culture</td>
<td>Communication and data, change management</td>
<td>None</td>
</tr>
<tr>
<td>Technology Investment</td>
<td>Cloud computing, cybersecurity, IoT platform, smart sensors, location detection, data mining, simulation, mobile devices, big data, systems integration, multilevel customer interaction and profiling</td>
<td>Smart sensors, location detection, data mining, autonomous robots, simulation, mobile devices, systems integration</td>
<td>Machine learning, cloud computing, cybersecurity, IoT platform, smart sensors, location detection, data mining, augmented reality and wearables, autonomous robots, simulation, advanced HMI, mobile devices, big data, systems integration, multilevel customer interaction and profiling</td>
</tr>
</tbody>
</table>
All the companies in Table 2 demonstrated potential for deploying elements of 14.0 immediately, with associated benefits, although a comprehensive deployment will require a long-term strategic approach. PanelCom deploys a flexible manufacturing system for electrical components but without the 14.0 elements the system is unable to achieve its full potential. SoftCom already has important elements of 14.0 in its business operations and has the potential for broader application. The readiness of each company with reference to the key concepts of 14.0, in the areas of evolution, connected systems, decentralised, intelligent and integration of value chains is illustrated in Figure 2. Although SoftCom is a service, not a manufacturing, company, its cloud-based computing business model causes it to achieve the highest relative positions in the key 14.0 concepts. However, Figure 2 also highlights the improvements needed by the other two companies to fully transition into an 14.0 system. Specific tools that aid in the transition towards 14.0 were identified by each company, based on needs (drivers and enablers) and challenges in adopting the new technologies. Each organisation recognises its need for several systems that will provide benefits and add value. Augmented reality and machine learning were not selected by the manufacturing companies, possibly pointing to a lack of awareness of the power of these technologies. Additive manufacturing is of little relevance to the companies examined here, except perhaps to provide customers with a visual and tactile representation of the proposed product. StickCom indicated an investment in cyber security since their Enterprise Resource planning system serves to integrate them with their suppliers and customers. The companies identified rapid benefits obtained through minor modifications in their extended value chain. For instance, StickCom can add greater value to its customer, a bottled water manufacturer, by providing design services to support its label product. New customers and new products could result from this value-chain integration. SoftCom has created a new source of revenue through horizontal integration with a non-competitive company, whilst enabling the latter to create an innovative product and service for their existing customer base.

**Analysis**

The practical movement towards full 14.0 implementation is needed in order for StickCom and PanelCom to achieve the innovative benefits of the 14.0 framework. Their current 14.0 positions, as highlighted in the assessment of their adoption of key 14.0 concepts (Figure 3), demonstrates a need to strengthen the integration of value chains, as one of the fundamental changes to become 14.0. The following value chain analysis is based upon our assessment of the readiness of these companies for 14.0 and how each could proceed to implement 14.0 more deeply. As a direct result, innovation will be stimulated (as an output). A value chain network model can be used to show the elements of the vertical and horizontal value networks in one graphical representation. These can be complex, with many linkages between them – for instance, multiple customers of one distributor, or alternate suppliers used in emergencies. In this analysis, a simplified version of the value chain network highlights opportunities for value chain innovations that can be achieved through the deployment of 14.0 in the firms assessed in this study. Figure 5–7 provide an overview of the current and proposed future value chain integrations based upon the assessments of 14.0 readiness (Key shown in Figure 4). The future changes (in red) represent the connections made between specific value networks and are based on the firms becoming 14.0 compliant. Potential innovation opportunities arise when 14.0 allows for the reconfiguration of value chains and especially new and enhanced connectivity between its elements. Identified opportunities for our three case companies are outlined in Table 3. The assessment of the firms identified a set of systems (technologies and training) that would accelerate the migration to 14.0 and to take advantage of the innovation that it stimulates. The proposed technologies were based upon the following criteria:

a. Lowest cost (as compared to the other implementation technologies)
b. Shortest timeframe required to utilise the system
c. Infrastructure available to install the equipment
d. Direct and immediate impact that adds value
e. Mitigation of common issues amongst the companies such as the current lack of horizontal integration, existing technology that limits the ability to vertically integrate and lack of decentralisation.

**Table 3–Value Networks Innovation Opportunities**

<table>
<thead>
<tr>
<th>Company</th>
<th>StickCom</th>
<th>PanelCom</th>
<th>SoftCom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagram</td>
<td>Figure 5</td>
<td>Figure 6</td>
<td>Figure 7</td>
</tr>
<tr>
<td>Current State Value Chain</td>
<td>- Medium to high levels of vertically integrated technologies from raw materials and primary products to the final product</td>
<td>- Low levels of technology vertically integrating them with their suppliers and B2B customers</td>
<td>- Highest level of integration of these companies within their internal ecosystem</td>
</tr>
</tbody>
</table>

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Stimulating innovation through Industry 4.0 in a small commodity-based economy

Table Continued

<table>
<thead>
<tr>
<th>Company</th>
<th>StickCom</th>
<th>PanelCom</th>
<th>SoftCom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative Future State Value Chain</td>
<td>- Low vertical levels of integration between the suppliers and the company and between the customers</td>
<td>- High levels of vertical integration in areas within their manufacturing environment</td>
<td>- Enabled access, visibility and analysis throughout their system</td>
</tr>
<tr>
<td></td>
<td>- Increased data transparency and real-time sharing of information between all of their value networks - increase levels of flexibility to changing customer demands and requirements without incurring losses</td>
<td>- Use of varying degrees of technologies between the raw materials, production system and final product value networks for different products</td>
<td>- New product development through further horizontal integration with new non-competitive companies</td>
</tr>
<tr>
<td>Practical Example</td>
<td>- Real-time analysis of ERP data and customer profiling through data mining facilitated by cloud computing and accessed on mobile technologies</td>
<td>- Increased vertical integration throughout the primary business system enabling increased flexibility in response to customer demands and requirements</td>
<td>- Horizontal integrations along the production system create new value and reduce losses - improved communication and co-ordination of resources - create horizontal system to develop new products from existing raw materials and machinery to generate new B2B and B2C customers</td>
</tr>
<tr>
<td></td>
<td>- Horizontal linkages to non-competitive manufacturers (within the value networks of WIP and final product) - increase utilisation of resources to provide an outsourced solution for the non-competitive manufacturers</td>
<td>- Horizontal integrations along the production system create new value and reduce losses - improved communication and co-ordination of resources - create horizontal system to develop new products from existing raw materials and machinery to generate new B2B and B2C customers</td>
<td>- Create a cluster – share knowledge and technology</td>
</tr>
<tr>
<td></td>
<td>- Horizontal linkages to non-competitive manufacturers (within the value networks of WIP and final product) - increase utilisation of resources to provide an outsourced solution for the non-competitive manufacturers</td>
<td>- Horizontal linkages to non-competitive manufacturers (within the value networks of WIP and final product) - increase utilisation of resources to provide an outsourced solution for the non-competitive manufacturers</td>
<td>- Cluster companies require access to uniquely customised cloud platform solutions and products</td>
</tr>
<tr>
<td></td>
<td>- Horizontal linkages to non-competitive manufacturers (within the value networks of WIP and final product) - increase utilisation of resources to provide an outsourced solution for the non-competitive manufacturers</td>
<td>- Horizontal linkages to non-competitive manufacturers (within the value networks of WIP and final product) - increase utilisation of resources to provide an outsourced solution for the non-competitive manufacturers</td>
<td>- Improve competitive advantage of the Trinidad &amp; Tobago manufacturers</td>
</tr>
</tbody>
</table>

Figure 3 The Importance of Current & Future Investments in Technologies.

Figure 4 Key for Value Chain Network Diagrams.

Figure 5 Existing and Proposed Integrations between Value Networks of StickCom.

Figure 6 Existing and Proposed Integrations between Value Networks of PanelCom.

Figure 7 Existing and Proposed Integrations between Value Networks of SoftCom.

These technologies satisfy the above criteria and would enable StickCom and PanelCom to evolve towards full deployment of I4.0.

**Multilevel customer interaction and customer profiling**: StickCom has innovation opportunities yielded from an improved understanding of its customers through the data mining and customer profiling features of the Cloud platform technology. The value of customer relationship innovation depends on using a multilevel customer interaction: if StickCom currently has a single type of interaction with its customer, in the future its interaction with the customer and
data about the customer will be through many more channels. For instance, data on the use of its products may be obtained by mining social media or by tracking product placement. By gathering enriched customer data, the service offered to its customers can be enhanced, providing more value, a deepened relationship (of critical importance to the company) and more profit to StickCom.

**Creation of a digital twin:** Especially in the case of PanelCom, simulation the plant’s equipment in a Cloud platform opens opportunity for more enhanced estimates of the time and cost of a bespoke design to the customer in real time. Creation of a virtual process to complement to PanelCom’s existing virtual product opens the possibility for the use of augmented reality to help train and instruct operators on the shop floor in the requirements for each order: since PanelCom uses non-English speaking operators, this will add considerable value and help to error-proof its operations. Virtual reality is also a possibility but would not be of such great value in this case this approach is dependent upon the use of System Integration of all of the manufacturing environment to realise its full potential, and would be considered primarily a process innovation.20–31

**System integration** between PanelCom and its customers could allow for enhanced collaborative electrical system design earlier in the lifecycle of a customer’s project. The benefits of a digital twin are extended further in this case, to allow PanelCom to have input into optimisation of the customers’ construction designs.

The approaches described above facilitate intelligent real-time analysis of firm level data. Data can be presented on customisable dashboard HMIs using mobile devices that are connected via the cloud platform. They allow that can be deployed on mobile devices that are connected via the cloud platform.

Discussions held between the three companies, StickCom, PanelCom and SoftCom, identified opportunities for collaboration of these dissimilar companies around I4.0 technologies for:

- a. improving the customer interface through a product configurator (Figure 8) and
- b. Implement augmented reality for operator interface (Figure 9). The cloud platform services and design elements will be provided by SoftCom as its contribution to the cluster arrangement. This will be a new “innovative” product offering. Utilising a non-competitive cluster approach shares both risk and cost of development and implementation. Management of the change initiated in each in the companies can benefit from mutual learning.

**Figure 8** Product Configurator Concepts.

The product configurator (Figure 8) concept is that a customer can, within constraints, define the product that they would like to have manufactured by PanelCom or printed by StickCom and obtain immediate indicative estimates of cost and delivery time. System integration allows checking of raw material stocks and analysis of how the order would fit in production schedules. Augmented reality for operator interface (Figure 9) will convert existing engineering drawings or into user friendly block diagrams that match the actual products being assembled. It will track the performance and accuracy of the assembly using a smart camera and an interactive display system to guide the worker in the assembly steps and verify that parts and assembly process are correct. This information could be curated and accessed through the SoftCom developed cloud platform. Lessons can be learnt from the reported selection of I4.0 tools by the subject firms. It is evident, for instance by the lack of initial interest in Wearables and Augmented Reality when these were later identified as technologies that might have innovative application for all three firms, that the following need to be strengthened in the journey towards implementation of I4.0:

- a. Awareness of the technologies in the I4.0 toolset;
- b. Value mapping;
- c. Identification of the value provided by the technologies and matching it with the values needed within the organisations;
- d. Implementation of cyber-physical technologies that can fill opportunity gaps in the value chains of the firms and drive their ability to develop innovative products, solutions and services at various levels, thus creating new value.

**Figure 9** Augmented Reality Operator Interface Concepts.

In this, we have explored whether rapid and aggressive implementation of I4.0 can catalyse innovation in an economy in which the innovation ecosystem is weak. Some firms were found to have the prerequisite qualities to make I4.0 implementation feasible; will those companies that lack the interest, infrastructure or capital to deploy I4.0 be left out in the quest to enhance innovation? We believe that they will not be among the pioneers, but as I4.0 gains traction through some basic successes, some of those companies might reconsider and opt to engage with the innovative developments that are coming to the fore through I4.0 implementation.

**Conclusion**

In this, we have explored whether rapid and aggressive implementation of the I4.0 philosophy and technologies in Trinidad & Tobago could significantly stimulate innovation in this small commodity-based economy. Innovation stimulated by I4.0 comes not only through the creation of new products, services and processes within the walls of an organisation, but in the new forms of relationships in value chain networks in which organisations operate. There is potential for three fundamentally dissimilar companies, to collaborate around their enthusiasm to implement I4.0 in a small commodity-based economy this framework can be expanded to the national level to help
to catalyse a sustainably innovative culture. Innovative systems as a “product configurator” and “augmented reality operator interface” are the type’s new I4.0 services, product offerings and operational solutions that can be deployed as in Trinidad & Tobago. The resulting novel changes to the existing operations of StickCom, PanelCom and SoftCom demonstrate that the I4.0 framework creates opportunities through gaps identified in the horizontal and vertical value chains. They are facilitated through the use of I4.0 compliant technologies such as multilevel customer interaction, customer profiling, system integration, cloud platform, mobile devices and data mining. We are under no illusions about the great dedication and investment that will be required to initiate implementation of I4.0 and stimulate firm level and ultimately national innovation. But we are also confident that s direct result of becoming innovative is the strengthening of each firm’s competitive advantage, giving them access new global markets and increasing their export revenue. This has a positive effect at the national level as the country will be less affected by the unpredictable fluctuations of the oil and gas economy. Innovation will now become an invaluable resource; one that is not depleted.

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None.

Conflict of interest
The author declares there is no conflict of interest.

References
22. KUKA Aktiengesellschaft. 2016. Hello Industry 4.0 _We Go Digital. Germany: KUKA.

Citation: King GS, Rameshwar JR, Syan CS. Stimulating innovation through industry 4.0 in a small commodity-based economy. Int Rob Auto J. 2018;4(5):296–303. DOI: 10.15406/irajt.2018.04.00140