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Investigating the Readiness of ERP system for Malaysian IR4.0 Factories

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Abstract
The expression Industry 4.0 (IR 4.0 or Industrie 4.0), which describes the 4th industrial revolution; came into existence a decade back, at the Hanover Messe Fair, in Germany. It resulted from the German government's high tech strategic projects; which sought to computerize the manufacturing industry. At its core, IR 4.0 draws from cyber-physical systems (CPS), and the Internet of Things (IoT); so as to enable the Factory of the Future (FoF). Within the segmental design of IR 4.0's smart factories, physical processes are overseen by CPS; which create virtual copies of physical reality, to frame localized decisions. Across the IoT, CPS allow for the intercommunication and amalgamation in real time; between themselves and humans. Smart Enterprise resource planning (ERP) systems are widely expected to be IR 4.0's backbone. This, study examines if today's smart ERP systems in Malaysia, are prepared for FoF. Interviews with the relevant stakeholders like manufacturers and ERP vendors provided the feedback regarding the readiness of smart ERP set-ups in Malaysian industries; to help them achieve the FoF status. Our findings show that smart ERPs frameworks in Malaysian industries are ready for the transformation to FoF.

Keywords: Smart ERP; Enterprise Resource Planning; Factory of The Future; IR 4.0; Malaysian ERP Systems

1. Introduction

Three major industrial revolutions have occurred throughout history; prior to IR 4.0. The 1st involved water and steam; which powered mechanical production. The 2nd utilized electricity for mass production; with the 3rd IR leveraging electronics, semiconductors, information technology, etc., to computerize manufacturing to a greater degree. Today, the immense capabilities of machine-to-machine (M2M) as well as communications technology, have brought us to Industrial Revolution 4.0; with connected manufacturing being one of its components. Connected manufacturing involves everything from suppliers, manufacturing facilities, distributors, to the products themselves. This interconnectivity, with boosted cyber-physical relationships,acts as the cornerstone of the FoF; and allows manufacturers to accumulate and work with incredible volumes of information.

Manufacturers today, can utilize IoT technologies, to homogenize supply and demand chains; thus allowing for their interaction with consumers in unfamiliar, extraordinary, ways. IR 4.0 rests on immensely intelligent, inter-connected frameworks which give rise to completely digital, value chains. An alternate reference for IR 4.0 is Industrial Internet of Things (IoT); whereby connected smart equipment are capable of transforming factory operations, building management, vehicular maintenance and operations, among others - in a virtually endless list of novel industrial practices, roles and operations.

All over the world, smart ERP systems are utilized exhaustively by manufacturers to manage their operations and projects. This study sought to discern if smart ERP systems in Malaysia are ready to capitalize on the FoF operations, and competently oversee their entire operations.

The next sections of this paper concern the background of this study, literature regarding IR 4.0, description of the FoF, and delta changes needed by Malaysian manufacturers' ERP systems today. The methodology for this study is described in section 3, with the data analysis in section 4. This is followed by section 5's findings discussion. Lastly, section 6 elaborates on conclusions and future research possibilities of this study.

2. Research background

2.1. Industry 4.0

In IR 4.0, interconnected machines can be viewed as collaborative communities [1]. The ability of modern day machines to interact with other, have allowed them to transform into somewhat 'self-aware', otherwise known as smart machines; which are then capable of enhanced performances in their operating environment [2]. The IoT, which denotes the ubiquitous, networked interconnections of smart objects, devices and people; has been a great enabler of IR 4.0. It has also opened new doors with new applications, promising to better the standards of human lives. Connectivity between physical objects and the cyber-world, paves the way for accessing remote sensor data; as well as wirelessly controlling physical processes. Any item installed with a system, which is capable of connecting to the internet is known as a smart object [3]. In a nutshell, the IR4 is about the Internet, and communications in Cyber-Physical-Systems (CPS); amongst humans and machines, across huge networks [1].

2.2. Sensor Technology

Humans are physical creatures who live in physical environments; and hence, our forte is not about accumulating and maintaining "digital" data. For that we have computers; that rely on us to enter and maintain data. This in turn could potentially lead to human errors; and as a consequence- problems with data quality. Thus, the need for machines to accumulate and maintain data on their own. This is what 'sensor technology' is all about- enabling machines to see, perceive, and comprehend the physical landscape – minus the imperfections of data keyed in wrongly by humans [4].

2.3. The factory of the future (FoF)

This term was first mentioned in1986, by Irwin Welber; according to whom, the FoF would resemble a largescale intelligent machine; that would operate using highly integrated, and organized knowledge bases. He also emphasized on the need for suppliers as well as consumers to play fundamental roles in the FoF environment. Among the reasons that manufacturing firms implement FoF initiatives is: the increasing adaptability afforded by the FoF. This has become vital today, because of the new challenges faced by manufacturing firms, like being forced to slash production costs, create customized goods and services, and having to swiftly respond to market changes [6].

Speculations abound, that IR 4.0 and FoF, could have adverse effects on people, by allowing machines to take over their jobs. Our opinion regarding this is, humans will carry on existing and playing key parts in the FoF; but their roles would differ- and they would need different skillsets. For e.g., a vital FoF element; the sensory subsystem, would still require marketing, sales, production employees, etc., to analyze, glean insights and make sense of the implications, of the accumulated data. Humans supervise the robots; are architects of the FoF's control subsystem; as well as monitor its technology. Technological failures in the FoF could prove to be catastrophic, hence the paramount importance of monitoring technology. For e.g., FoF (smart) machines sense their surrounding physical environment using sensors; whose failure i.e., due to degradation-could transmit inaccurate readings to data analytic algorithms- which would then lead to wrong decision making [2]. In the future, though job descriptions could change; humans will continue to be irreplaceable. This is especially so, with regard to customization; which has resulted in an ever growing need for coordination. The FoF environment would require more employees who are skilled decision makers [1].

2.4. Smart ERP Systems: The delta changes

The FoF is characterized by [1]:

- Componentization
- Mass Customization
- Disseminated Management
- IoT Frameworks
- Forecasting
- Collaborations
- Distributed Supply Chains, Manufacturing, And Transparent Processes

The major shortcoming with present smart ERP systems concerns their subpar ability to predict. This is particularly significant in the manufacturing industry, wherein maintenance is a huge priority. Thus, being able to foresee machine breakdowns and tackling problems at their root; are paramount requirements at the FoF. Considering this, companies should develop comprehensive predictive maintenance models, capable of integrating various diagnostic as well as prognostic designs concerning hardware usage [6].

With collaborative manufacturing processes being widely adopted, smart ERP systems and SCM systems, should be completely integrated. This is to prevent fraudulent imitations; thus ensuring the authenticity of the products, equipment, and provisions utilized for the manufacturing operations. The FoF is also characterized by horizontal integration; whereby employees in manufacturing firms communicate with different departments, without any boundaries. This sort of communication is made possible by open systems as well as standards.

Yet another FoF requirement- Integrated engineering- together with the value chain; are built on reliable communications. Which means, all participants are able to access real-time information; with control being delegated to the ground level.

The end to end integration of business processes which include engineering workflows and services, with Customer Processes (CPs), using smart ERP systems, is another issue faced by IR 4.0; which it addresses, by emphasizing on smart products and processes. In the FoF environment, CPs require uninterrupted, to and fro communications amongst computers, people, products, and processes. To this end, the potential roles that ERP systems play, so as to facilitate such communications, needs to be examined. With regard to the afore-mentioned predictive maintenance models, SAP has come up with their framework, which integrates robots, machines (in need of maintenance), and the SAP's smart ERP systems. Here, the predictive maintenance is established on the assimilation of smart ERP data [industrial, manufacturing, maintenance, staff, etc.], with sensory data, along with predictive algorithms.

Based on the literature, studies which explore the links between smart ERP systems and FoF; within the Malaysian context,are lacking. This is a novel phenomenon in Malaysia; and to get a better perspective, we used a survey instrument; with the participation of ERP consultants, consumers, vendors, and also independent consultants. The findings from the survey were used to discern if "*Current smart ERP systems in Malaysia are ready for the (FoF)?*

3. Research Methodology

This was a multiple case study [7], involving qualitative semi-structured interviews [8]. The sample size was n=10, and the interviews were conducted at three manufacturing firms in Kuala Lumpur, Malaysia. The sample population was made up of a mix of Malaysian stakeholders who are well-versed in Smart ERP system implementations; and are experienced in different open source ERP systems (local and international). The respondents are also highly knowledgeable about supply chains, manufacturing lifecycles, and their respective technology (ERP). Respondents' details are given in Table 1; with the names of their firms omitted to prevent any conflicts of interest.

Table 1 Respondent Details

Respondent (R)	**Industry Type**
IT Manager (R1)	• Retailer • Food manufacturing
IT Director (R2)	Home appliances manufacturing
Applications Section Head (R3)	• Retailer • Food manufacturing
IS Manager (R4)	
Senior Consultant (R5)	ERP Administration
Junior Consultant (R6)	ERP Administration
TechInvestment Advisor (R7)	Various organizations
Territory Manager (R8)	Leading ERP vendor
ERP Sales Development & Strategy Leader (R9)	Leading international ERP vendor
Operations Manager (R10)	Leading ERP vendor

3.1. Target Cases

The interview questions pertained to topics such as: the readiness of ERP systems in Malaysia, for the FoF; automation strategies for the future; and the overall anticipated pros and cons of adapting the FoF. Details regarding the targeted firms is presented next.

Firm 1This medium-sized firm that was established in Kuala Lumpur in the late 70's. Currently, it is among the leaders in its industry. The company specializes in meat processing, as well as dairy products, and beverages; and employs more than 1000 workers. Before the firm implemented the ERP system, it depended on several silo systems. The firm's initial SAP ERP module that was implemented in 2013, concerned financial, order, and quality management; together with warehousing, among others. The firm fast-tracked its systems in 2015 and currently is in the midst of introducing a HR module.

Firm 2 is part of a big group of Malaysian firms, and was founded in the mid 90's. The Group's operating focus is predominantly in domestic electric appliances like washing machines, televisions, refrigerators, electronic cookers, etc. Before implementing ERP, this company had numerous scattered systems. They implemented the Oracle JD Edwards in 2009, consisting of financial, sales, supply chain, and manufacturing modules, among others. Also, they installed an Oracle engineering module; together with a much more recent implementation of a trade management application. Next on the cards for this firm, is extending its Smart ERP system via the implementation of SAP demand planning; in order to forecast and analyze market needs.

Firm 3 is a retail firm which handles various commodities ranging from fresh food, beverages, clothes, non-food commodities, etc.; which it sells directly to consumers through its four outlets. The company was established in 2006, and it currently employs more than 2000 employees. Before their current ERP system, they used a different system which was implemented 2006. The system's stability and performance issues greatly affected the firm's daily transactions; leading them to acquire a newer Smart ERP system (Oracle JD Edwards ERP) in 2007. The firm employed ERP consultants to oversee their entire project; with the implemented modules being: Asset Management, Logistics, Manufacturing, as well as Sales & Distribution.

4. Analysis

The initial view of the respondents from our targeted organizations was; the main ERP packages which are available today are capable of fully automating, and bracing the FoF in Malaysia. Nevertheless, the respondents alluded to the possibility of there being challenges besides operational ones; which could impede FoF implementations in Malaysia. The observations of the respondents regarding the different benefits and obstacles faced by Malaysian manufacturers, when adopting FoF, are divided into: (1) Challenges and the operational readiness of present ERP used in Malaysia in adapting the FoF, (2) Readiness for the FoF in Malaysia, with regard to organizational, professional, as well as cultural considerations (3) Transforming conventional factories to FoF, and further plans for automation.

Smart ERP systems are expected to be the FoF's backbone; and were a vital topic of discussion in this study; with particular emphasis placed on the assessment of ERP's readiness, from the Malaysian context. Overall, the respondents believed that current ERP systems can technically be automated. According to R1, *"SAP ERP is 100 % ready for the factory of the future. Also the NetWeaver is ready for interfacing between machines and the system".* Contrastingly, some respondents expressed apprehensions regarding machines and ERP systems integrating*;* whereby, R3's response to this was, *"When it comes to operations and processes, I think our ERP is ready for full automation, but it might need extra modules to serve as middleware or interfaces between the machines and the ERP"*. Similarly, R2, who is the IT director of a company was concerned regarding the machines and Smart ERP systeminterfacing. He further explained that the various production line machines have varying standards and purposes; which might lead to communication interface construction turning into a long-winded, troublesome undertaking.

However, all the respondents who fell under the 'vendors' category, concurred that interfaces which integrate technologies, infrastructures, and communication; are already in existence- albeit, requiring minor adjustments and customizations; in order to harmonize smart machines and manufacturers' unique requirements. Regarding this, R9 said, *"I think ERP systems are ready for full automation, and the efforts that have been done by the leading vendors for building integration layers and frameworks between external applications and the Smart ERP systemcan aid manufacturers in establishing communications between their machines and their ERP systems. Also the SOA (service-oriented architecture) introduction by major vendors to their systems can ease communications between machines and ERPs.*" Meanwhile R8 had this to say about integration, *"Our ERP is fully ready for factories of the future. We also have an integration framework that allows the communication between the ERP and other objects, like machines or software applications."*.

One respondent from the manufacturing category opined that complete automation comes with certain challenges; adding that current ERP systems in Malaysia are capable of handling this process i.e., *"The communication protocols and standards themselves needs some work from first, the machines manufacturers, and second from client organizations, and this is costly. But again, when it comes to the readiness of the major ERP systems, they are ready for this automation."* Likewise, other participants of this study have highlighted concerns regarding communication standards, industry protocols, as well as the dearth of consolidated sensor-communication standards.

Challenges and Readiness for The FoF

R1stressed that technology-oriented, streamlined organizational cultures, appropriate knowledge transferring mechanisms; together with staffs' technological awareness, could enable the FoF in Malaysian firms. However, he agreed that there are several glitches which could derail the FoF vision, *"Most of the machines we have on the production lines are old, and they don't have the ability to have the communication tools with the ERP system".* Some respondents were apprehensive regarding issues within organizations that that could hinder the complete systemization of infrastructures.For e.g., with regard to this, R2 said, *"I don't think that the warehouses in most Malaysian manufacturers are ready for full automation yet. For example, until now when we visit the warehouses, we don't discuss any advanced technologies; however, we discuss ABC organizational warehousing practices. So I don't see any automation in a warehouse that is not well organized nor well ordered. And until now the inventory process at most warehouses is conducted and managed in a chaotic fashion"*. Although many ERP structures contain modules concerning production planning; majority of Malaysian factories do not depend on it for this particular process; as mentioned by one of the respondents who is an ERP consultant and partner- "*In most of the factories that I have seen, they don't use the Smart ERP system in production planning. The systems are not used to tell them what to produce or how much to produce, these decisions are made based on employees' judgments and later fed to the system".* These concerns were echoed by respondent who is a manufacturer; *"We are now working on using the MRP package in a more efficient manner to plan our production. Currently, and on a daily basis, we don't know what we will produce today".*

The respondents of this study were also enquired as to their opinions regarding the destiny of FoF in Malaysia; and also if they were aware of any manufacturing firms that were planning to fully automate their operations. To this R5 responded: *"Up to my knowledge, no. Their biggest dream is that they get the ERP users and the Smart ERP systemto work properly and to be well organized, as it is usually not the case in many organizations".* Other respondents indicated that some industries in Malaysia were perhaps more ready than others; when it came to the FoF. For e.g.- *"I think that some industries will have this full automation in the next 20 years. Especially the industries that have high safety risks, like steel factories. Also ceramic tiles manufacturers, they need high precision in manufacturing and the raw materials are very expensive, and these companies can benefit from full automation. In general, I think FoF idea is closer to the heavy type of industries."* – (respondent 3). Similar opinions like R8's *"I think full automation depends on the type of manufacturer, the type of industry, and most important, thy type of product. The more complex the product is, the more the need for automation. Like the car manufacturing industry for example."* were shared by respondents who fell under the 'vendor' and 'partner' categories.

Although majority of the respondents expressed concerns regarding the economic feasibility fully automating smart factories in Malaysia, some felt that this would happen, but not immediately. When enquired as to the adaption of FoF in Malaysia over the following twenty years, one of the vendors responded, "it will occur but will take time. *It must happen, because we are experiencing an increasing manufacturing and manpower costs. Over and above, factories usually have a very high employee turnover, which leads to some sort of drops in their production and additional hiring and training costs. However, salaries in Malaysia are still low in comparison to other places in the world. But I think that this will change as well and that the FoF will be more feasible in the near future."*

Conversely, the respondent who is a technology investment advisor, stated that focusing solely on the financial feasibility could potentially mislead one: *"When company owners or decision-makers are not technology-aware, or if they don't have a consultant, they will mainly care about cost vs. gains from this investment. However, when they understand, they will start to realize that technology is not easily financially justified; it would fail, if your approach is only financial, you will fail, and you will never ever be able to convince anybody to invest, the business value should be clear."*

The findings imply that the short term technological costs are a vital consideration, when it pertains to 'decisions to invest', in a majority of Malaysian companies, despite the long term, or abstract advantages. According to R7, "*In Malaysia and few other regional countries, the employees and workers' salaries are considerably low in several local organizations. So if you would tell owners that you could invest an amount of money in order to automate something in the production process for example, they might say that hiring new workers might be more feasible and cost effective. Similar things happen with ERP systems acquisition. I have seen organizations that have hired more accountants instead of investing in an ERP, as they thought it is less costly. Again, I am stressing on the importance of the top management/owners technology-awareness and education, as it can make a lot of difference in investment decisions."* This is in accordance with the findings of Brettel et al. [1], pertaining to issues faced by low-wage nations and FoF feasibility.

Transformation of Conventional Factories to FoF

A number of respondents asserted that this transformation is a difficult one which may not be realistic. Especially in this current COVID 19 pandemic; since it would put additional strain on an already strained system, with its dynamic nature, and the necessary overhauling of existent production lines. Some of the respondents opined that adapting FoF could benefit factories "to be" built; more than existing factories embarking on transformations. In the words of R5 who is an ERP consultant and partner: *"In today's factories in Malaysia, the production and manufacturing process heavily rely on human resources. So as a GM to decide to exchange the current people with machines, that would be a difficult decision. But if you have plans for a new factory, the owner in this case could be able to decide on having and investing in automation from day one, if feasible. The decision is based on a simple equation, how much is the cost and how much is the expected revenue. If we find out that the full automation is more economical on the long run, then we should consider what is the degree of business process reengineering (BPR) needed for this change. We should evaluate where we are now 'as is', and where should we go, processes-wise. Some industries' processes are based on personnel's own knowledge and experience. In this case, full automation is going to be farfetched, as they have to do extensive BPR before thinking of automation"*.

Likewise, several other respondents opined similarly, regarding the obstacles to transforming present-day Malaysian factories to support the FoF. R2, who is an IT director echoing similar views of transforming being a lot more difficult than constructing fresh FoF compatible factories stated: *"In my opinion, it is a lot easier to build a new factory with full automation in mind, but switching from an existing traditional factory to a FoF might not be feasible"*. A summary of the findings is presented in Table 2.

Table 2 Findings Summary

Malaysian ERP's Challenges and Readiness	**Administrative Challenges**	**FoF's Destiny**
-Technical and operational readiness - communication and integration issues related to M2M/ Machine to Smart ERP	-Justification of FoF's economic feasibility -BPR and change management -Management/staff awareness, and transfer of technology -Excessive reliance of supply chains and manufacturing cycles on HR	-May not be the right fit for all industries -Difficult transformation process -Complete automation may be more fitting for "to be built" factories -May be financially viable and reduce HR and staff turnover expenditure

5 Discussion

Our findings imply that with regard to FoF and IR 4.0; all our do not plan on fully automating in the near future. This due to them regard these, as difficult to achieve, unsuitable for their industry, or economically non-viable. Concerning our research's primary question regarding ERP's readiness for the FoF in Malaysia; the respondents' general consensus was- smart ERP systems in Malaysia, "as-is", can already support smart factories, along with the complete automation process. Respondents of the study also added that although a major portion of their daily manufacturing, planning, production, QC processes, etc., are performed via smart RP systems; data is still recorded manually. However, they assert that the effect of this is negligible; and hence ERP systems in Malaysia are ready for FoF adaptation. While respondents falling under the 'vendors' category hold that there is already integration between smart ERP systems and devices/machines/sensors; respondents from the organizational categories were concerned about difficulties associated with constructing interfaces that allowed for communication between machines and the integration frameworks. According to them, this would be a cumbersome, time consuming undertaking. As such, there is a need to homogenize the layers of integration from vendors' end.

Another vital issue disclosed by the respondents, regards the dearth of uniform communication standards or protocols; when it comes to sensor technology; i.e. manufacturers having unique communication standards which only allow for machine-to-machine communications within their own brands. As often is the case, today in most Malaysian production or assembly lines, various brands of machines are utilized; which in turn need extensive usage of middleware, and the construction of tailor-made communication and APIs.

Thus, industries utilizing exclusive communication proprieties and standards; could result in future smart factories encountering bottlenecks. From an organizational perspective, among the major obstacles is, justifying smart factory investments. A number of respondents stated that the Malaysian higher management customs are mostly expense oriented; implying a difficulty in justifying FoFinvestments, by purely relying on ROIs. As an illustration, according to some respondents, wage in certain industries in Malaysia are low; and hence the management in these industries could potentially opt to hire additional staff, rather than investing in pricey equipment.

Our findings imply that decision makers in Malaysia could lack the necessary information and exposure regarding FoF technologies, which in turn could hamper long term investments. Nevertheless, by leveraging on the relevant information and understanding; together with sophisticated businesses and use cases;decision making Malaysian manufacturers could potentially be made to view such technologies in the proper light. Transforming low salaried and skilled environments, of some Malaysian industries, would necessitate significant re-engineering of business processes, change management systems, and immense training and reallocation of their workforce in place. Some of the respondents also mentioned 'employee resistance', which according to them, is intensified with regard to automation projects.

Findings from our study suggest that although most of the respondents feel positively about FoF in Malaysia, they also felt that it suited some industries more than others. For instance, the FoF/ complete automation was industry specific; and more suitable for products which required high precision levels to manufacture; such as pharmaceuticals or high-tech goods. Otherwise in industries which have low human-safety environments. The findings also reveal that the respondents of this study viewed the transformation from conventional to smart factories as being something very difficult; requiring enormous investments, as well as organizational and cultural shifts. Thus their notion that FoF technology would be more viable for new "to be established' factories; rather than transforming conventional ones which are presently operating.

Keeping in view the current COVID 19 pandemic, and its movement restrictions, several respondents suggested that very soon, it probably would be more prudent to capitalize in FoF; instead of depending on

low or medium-skilled labor. This suggestion could also work for Malaysian industries which are plagued by high turnover rates in their workforce, resulting in erratic production cycles.

6. Conclusion and Future Outlook

Currently,FoF literature predominantly revolves around technical matters i.e., automated machine processes, micro processes, cyber-physical processes, etc. Hence, there exist gaps in the literature regarding the business aspect of FoF in the Malaysian context. Particularly, the overall challenges faced by the business cases, change management, as well as justifications of viability and investments. Though they vouch for the FoF'snumerous advantages, the respondents were unanimous in stating that the transformation from conventional, to a smart factory, would be an arduous undertaking. The respondents also held that "to be established" factories were more economically suited to adapt the FoF infrastructure. Though smart ERP systems are expected to be the backbone of IR 4.0, there is a gap which concerns smart ERP's readiness for FoF. This study's findings indicate that ERP systems in Malaysia, are perceived to be technologically and operationally equipped for this transformation; albeit with certain challenges concerning M2M and machine to ERP communications. Challenges related to the lack of uniform standards or protocols; as well as vendors relying on proprietary communication protocols.

Our findings indicate that further research is required, regarding the readiness of smart ERP systems with regard to other Malaysian industries, which were not covered here. Also, literature on FoF ought to be expanded, with more focus on the obstacles faced by the enterprise and administrative segments. Additionally, since expected gains to expenditure feature heavily in all investments, more research is needed, to truly gauge FoF's economic viability. Finally, vendors of smart ERP and machines should collaborate, and homogenize worldwide communication standards; which would go a long way toward facilitating IR 4.0.

To conclude, the question that this study strove to answer: "are smart ERP systems in Malaysia ready for the FoF?", is equal in relevance to the question, "are today's Malaysian factories ready for the FoF?"

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