Architecting rural smartness: A collaborative platform design for rural digital business ecosystem

Iqbal Yulizar Mukti | Danniar Reza Firdausy | Adina Aldea | Maria E. Iacob

Department of Industrial Engineering and Business Information Systems, University of Twente, Enschede, The Netherlands

Correspondence
Iqbal Yulizar Mukti, Department of Industrial Engineering and Business Information Systems, University of Twente, Enschede, The Netherlands.
Email: i.y.mukti@utwente.nl

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Abstract
The wide urban–rural economic gap, particularly in developing countries, has led to various problems. To lower the gap, the participation of rural communities in digital business ecosystems is being viewed as a promising approach. To this end, we use design science research methodology to present a reference architecture of a rural smartness platform that facilitates the emergence of a smarter business ecosystem. This ecosystem embodies the characteristics of rural smartness, which are empirically proven to have a strong positive impact on improving the rural economic climate. Evaluation by means of expert opinion, technical action research, and empirical research suggest that the proposed architecture effectively improves the rural economic climate and is feasible to be implemented in a real-world setting. This paper contributes to the body of knowledge regarding the establishment of a digital business ecosystem for rural communities, particularly by proposing a solution resulting from a design science perspective that is backed by empirical evidence.

KEYWORDS
ArchiMate, digital business ecosystem, enterprise architecture, service-oriented architecture, smart rural, smart village

1 | INTRODUCTION

Agglomeration of economic activities in cities, particularly, in many of the developing countries, has widened the rural–urban economic gap (Jedwab & Vollrath, 2015). It stimulates rural citizens to migrate to urban areas at a rapid pace (Zhang, 2016). On one side, this rural–urban migration is fueling economic activities in the urban area. However, on the other side, the unmanageable pace of rural–urban migration has negative consequences. For urban areas, the under-sized capacity of critical infrastructures is under a lot of stress, which creates numerous problems, such as, traffic congestion, energy crisis, slum areas, and pollution (Chakrabarty & Gupta, 2014; Franco et al., 2017; Zhang, 2016). Rural areas, on the other hand, lack the talent needed to fuel their economic engine since much of the population at a productive age is pulled to the cities (Cunha et al., 2020; Naldi et al., 2015). This, in turn, makes alleviation of poverty occurring in rural areas (Castañeda et al., 2018) more difficult. Lastly, migrants typically end up in low-wage jobs because a large proportion of them lack the skills necessary for well-paid jobs in the cities, which traps them again into poverty (Zhang, 2016).

To slow down rural–urban migration and to reduce the aforementioned negative consequences, the rural–urban economic gap should be narrowed. In this respect, recent studies pointed out that the development of the rural economic climate could be achieved by enabling the rural communities to participate in a digital business ecosystem (DBE) (Cunha et al., 2020; Talbot, 2016). A DBE is an environment of interacting organizations and individuals that co-create value through a collaborative network enabled by interconnected digital services over the internet.
DEBS are growing rapidly in many developing countries. Countries in Southeast Asia are an example of this phenomenon. As a region that is comprised mostly of developing countries, Southeast Asia’s internet economy has tripled from $32 billion in 2015 to $100 billion in 2019 (Google & Temasek/Bain, 2019). Moreover, the value of their internet economy is projected to exceed 8% of the GDP by 2025, closing the gap with a developed market like the United States, where the internet economy accounted for 6.5% of the GDP in 2016 (Google & Temasek/Bain, 2019). This phenomenon shows that a DBE is a promising vehicle for economic growth.

However, despite its promising economic potential, rural communities are still marginalized in the current DBE as it has been highly urban-oriented (Kshetri, 2018). The situation in Indonesia and Vietnam illustrates this phenomenon. In Indonesia, the online sales volume from rural sellers only accounts for 0.5% of the total sales volume in 2017 ($0.024 billion compared to $5 billion) (McKinsey & Company, 2018), and in Vietnam, 75% of the total e-commerce sales were generated only from its two big cities: Hanoi and Ho Chi Minh City (Kshetri, 2018).

We identified that rural communities are still marginalized due to several challenges. First, rural communities have insufficient IT infrastructures (Katara, 2016) and limited digital literacy (Manda & Backhouse, 2018). Second, the government, as the party that is responsible for rural development, has a strict financial budget (Li, 2015; Said et al., 2020) that limits its capacity to facilitate digital services for rural communities. Lastly, facilitating digital services for rural communities is not economically attractive for the private sector. This is because of the low purchasing power of the rural citizens (Castañeda et al., 2018), and the high investment to ensure digital readiness in rural areas (Philip & Williams, 2019). Therefore, given these challenges, a DBE tailored for the rural context is needed.

In that regard, several studies in the extant literature already provided some insights on how a DBE tailored to improve the rural economy could be established. These studies can be grouped into two types. The first type of studies proposes the conceptual design of a digital platform that is aimed at improving the rural economic climate. Some examples of these are the rural smart specialization model by Talbot (2016), and the conceptual model of a smart rural region by Cunha et al. (2020). The second type of studies provides theory and lessons learned from successful rural implementations of DBEs. For example, Jung et al. (2014) presented a case study in South Korea, and Leong et al. (2016), Li et al. (2019) explained case studies in China.

Although these studies already shed light on how to improve the economic situation in rural areas through the establishment of a DBE tailored for the rural context, design science (Wieringa, 2014) type of research proposing concrete guidelines to establish such a rural DBE are still scarce. In particular, what is missing is a reference architecture that could serve as a guideline for the design of a digital platform aimed at establishing a rural DBE. Since the rural area is an ecosystem that comprises different interrelated stakeholders (e.g., rural communities, government agencies, and third-parties from the private sector) (Mukti et al., 2021), the reference architecture is expected to be layered and modular in order to facilitate the incorporation of a dynamic set of rules governing the service exchanges among the actors involved in the ecosystem (Lusch & Nambisan, 2015).

The main objective of this paper is to fill this gap by providing a reference architecture of a rural smartness platform that facilitates the emergence and consolidation of the rural smartness business ecosystem. The resulting digital ecosystem is grounded in the characteristics of rural smartness which are empirically proven to have a strong positive impact on improving the rural economic climate (Mukti et al., 2022). Furthermore, the reference architecture is specified using the ArchiMate modeling language (The Open Group, 2019). This choice is motivated by the fact that ArchiMate allows for a multi-layered approach to modeling and is expressive enough to allow the explicit modeling of services and service exchanges (Lankhorst et al., 2017).

We argue that this paper contributes to the body of knowledge regarding the formation and development of digital business ecosystems in rural areas. The main hypothesis and novel contribution concern the impact a rural smartness platform has on the rural economic climate and the economic welfare of rural citizens. We put forward the idea that such a platform works as a mechanism to unlock the economic potential of the rural economy and stimulates the establishment of DBE in rural areas. Furthermore, as we will further explain in the following section, the proposed reference architecture is both grounded in design science, and at the same time backed by empirical evidence coming from previous work by Mukti et al. (2022) that studies the societal impacts of rural smartness. As suggested by De Leoz and Petter (2018), by incorporating the societal impact in the design process, the reference architecture presented in this paper is expected to be more effective in improving the rural economic climate when being implemented.

The remainder of this paper is structured as follows: Section 2 explains the methodology of this research. Section 3 discusses the theoretical model of rural smartness, which is used as the basis for the specification of the reference architecture. Section 4 elaborates the requirements of the reference architecture. Section 5 presents the reference architecture of the rural smartness platform. Section 6 demonstrates the reference architecture in the form of a prototype. Section 7 discusses the evaluation of the proposed reference architecture. Finally, section 8 concludes and provide direction for future works.

## 2 | RESEARCH METHODOLOGY

Since our main objective with this paper is to provide a design artifact (i.e., a reference architecture of a rural smartness platform), we adopt a design science research (DSR) approach for this study. DSR is a research paradigm where a researcher addresses problems through the creation
of innovative artifacts (Hevner & Chatterjee, 2010). In particular, because the provision of the rural smartness platform is closely linked with societal impacts, we follow Peffers et al. (2007)’s design science research methodology (DSRM) extended with the guidelines provided by De Leoz and Petter (2018). The guidelines identify how societal impact aspects can be mindfully considered at each DSRM step. An essential difference between De Leoz & Petter and the original DSRM of Peffers et al. (2007) is the role of so-called social-sub-artifact, which define as the social interactions and the social change among individuals and groups that are impacted by IT artifacts within the context of a problem (see De Leoz and Petter (2018) for more details). We explain below De Leoz & Petter adaptation of the DSRM steps we followed (see Figure 1).

1. **Identify the problem**

   In this step, we ensure that the societal aspects along with the IT aspect of the problem are identified. As has been explained in the previous section, in our work, the problems mainly concern the wide urban–rural economic gaps, particularly in the developing countries and the lack of reference architecture for a digital platform that aims to establish a DBE tailored to improve the economic welfare of rural citizens.

2. **Define the objective of the solution**

   The objective is to specify the reference architecture of the rural smartness platform as a means to establish the rural smartness business ecosystem. This ecosystem is designed to embody the characteristics of rural smartness that have been empirically proven to have a strong positive impact on the rural economic climate (Mukti et al., 2022). Further explanation on rural smartness can be found in Section 3.

3. **Design and development**

   Prior to developing the reference architecture, we incorporate an ex-ante evaluation to ensure that the implementation of the reference architecture will result in the realization of the intended social impacts. We rely on the empirical results of the theoretical model of rural smartness provided by Mukti et al. (2022) for this ex-ante evaluation. As presented in section 3, the empirical results show that the realization of the rural smartness characteristics has a strong positive influence on the innovativeness and competitiveness of businesses in rural areas. This empirical result is used as the basis in developing a motivation model that specifies the required properties of the rural smartness platform (see section 4).

   In section 5, we further specify the motivation model into a reference architecture of the rural smartness platform using the ArchiMate notation (The Open Group, 2019). This architecture presents the interplay of the architectural elements of the platform in realizing the rural smartness business ecosystem, including the identification of the roles and their interaction in the ecosystem.

4. **Demonstration**

   In section 6, we present a prototype that instantiates the proposed reference architecture. This prototype demonstrates the use of the rural smartness platform in establishing the rural smartness business ecosystem. We use Mendix and WSO2 Enterprise Integrator as the core application development platforms of the prototype.

5. **Evaluation**

   In section 7, we evaluate how the proposed reference architecture of the rural smartness platform contributes to an improvement of the rural economic climate. For this purpose, we carried out a case study in the rural areas of the West Java province, Indonesia. This region is selected because it is confronted with serious urbanization problems caused by the rural–urban economic gap, and because the regional government wants to stimulate the rural economic climate through IT innovation. We select the following evaluation approaches as suggested by design science (Wieringa, 2014), which includes both qualitative and quantitative analysis:

![Figure 1](image-url)  
**Figure 1** Guidelines for incorporating social impacts in each DSRM step. Adapted from De Leoz and Petter (2018)
1. **Expert opinion.** In this evaluation approach, we submit the proposed reference architecture to a panel of experts that have a sufficient understanding of the situation in the rural communities of West Java. We analyze their feedback, qualitatively through an interview and quantitatively through a questionnaire, concerning the effectiveness of the proposed reference architecture on establishing the rural smartness business ecosystem and its expected impact on the rural economic climate. In addition, through interviews with the experts, we explore the readiness factors that are required to successfully establish such an ecosystem in a real situation.

2. **Technical action research.** In this evaluation approach, we evaluate the applicability of the proposed reference architecture in a real-world context. We carry out this evaluation by working closely with the ICT agency of the West Java provincial government in rolling out the implementation of the rural smartness platform in West Java.

3. **Empirical research.** In this evaluation approach, we carry out a quantitative analysis based on a survey of a sample of rural businesses from rural areas of West Java as the intended users of the platform. The goal is to see whether the rural smartness platform that is instantiated from the proposed reference architecture can make a difference to the existing rural economic climate.

### 3 RURAL SMARTNESS

The concept of rural smartness is derived from urban smartness which is a more established area of research. Mukti et al. (2021) extensively discussed this topic and defined rural smartness as the situation in which the combination of investments in IT infrastructures and services, and human capital is effectively improving the economic welfare of citizens in rural areas through connectedness, participatory governance, and coherence of IT service provisioning. As indicated in the definition, four characteristics form the concept of rural smartness:

1. **Digitally empowered citizens:** the creative and innovation capabilities of rural citizens that are empowered by IT utilization.
2. **Connectedness:** the connectivity between stakeholders throughout the business ecosystem in rural areas (i.e., rural citizens, rural business entities, government, and the third-parties) that is enabled by the IT infrastructures and services.
3. **Participatory governance:** the participation of stakeholders in governmental programs to improve the economic welfare of citizens in rural areas that is facilitated by the availability and usage of IT services.
4. **Coherence:** the alignment of the strategic initiatives to improve the rural citizens’ economic welfare with the actual situation of the rural communities that are supported by IT services.

![Empirical model on the societal impacts of rural smartness (Mukti et al., 2022)](image-url)
Figure 2 shows the empirical model on the societal impacts of rural smartness proposed by Mukti et al. (2022). As indicated by the hexagon shape in the model, rural smartness is modeled as an emergent variable (Benitez et al., 2020; Henseler et al., 2016), which means the rural smartness variable emerges from the combination of its characteristics. An empirical assessment of the model based on survey data from 179 villages in West Java, Indonesia, shows that rural smartness positively impacts the rural economic climate. It is found to have a strong positive contribution to innovativeness, which in turn improves the competitiveness of businesses in rural areas, leading to the improvement of the rural citizens’ economic welfare.

4 | REQUIREMENT ANALYSIS

The main purpose of the requirement analysis is to identify the properties the rural smartness platform should meet in order to establish the rural smartness business ecosystem. It is carried out through an assessment of the challenges of realizing the rural smartness characteristics explained in section 2. This requirements analysis resulted in the motivation model shown in Figure 3.

The motivation model was specified using the ArchiMate notation (The Open Group, 2019), and structured in six layers:

- the outcome layer, which uses ArchiMate’s outcome concept to model the intended societal impacts resulting from the rural smartness business ecosystem.
- the capability layer, which uses ArchiMate’s capability concept to model the desired abilities of the rural smartness business ecosystem derived from rural smartness characteristics.
- the assessment layer, which uses ArchiMate’s assessment concept to model and evaluate the challenges in realizing the rural smartness business ecosystem.

![Motivation model](image-url)
the goal layer, which uses ArchiMate’s goal concept to model the desired state to be achieved by the rural smartness platform and relate them to the identified challenges.

- the requirements layer, which uses ArchiMate’s requirement concept to model the required functional properties of the rural smartness platform, and
- the business service layer, which uses ArchiMate’s business service concept to model the business activities that need to be supported by the rural smartness platform.

Based on the structure of this motivation model, the following paragraphs describe in more detail how the requirements of the rural smartness platform were identified.

The outcome layer depicts the intended societal impacts of the rural smartness business ecosystem, namely, improved innovativeness and competitiveness of the rural business climate that will lead to the improvement of the rural citizens’ economic welfare. These intended societal impacts were translated from the dependent variables of the empirical model on the impact of rural smartness (see Figure 2).

The capability layer consists of the characteristics of the rural smartness business ecosystem, namely, digitally empowered citizens, connectedness, participatory governance, and coherence. These characteristics, which uses the ArchiMate capability concept, were derived from the characteristics of rural smartness explained in section 2. Empirical research by Mukti et al. (2022), found that the realization of these characteristics will result in the achievement of the intended societal impacts explained in the outcome layer. It allows businesses in rural areas to become more interconnected, such that innovation (i.e., business collaboration, creation of new products, and establishment of new businesses) can take place. These innovations, in turn, can contribute directly to the economic welfare improvement (e.g., through the creation of job opportunities) or indirectly through improving the competitiveness of businesses in rural areas (i.e., access to a broader market, higher productivity, and a more resource-efficient production). Therefore, the main aim of the rural smartness platform is to realize these characteristics such that the intended societal impacts could be achieved.

| Characteristic | Assessment results | Goal | Requirement |
|----------------|--------------------|------|-------------|
| Digitally empowered citizens | Rural communities have limited digital readiness (digital literacy and IT infrastructure), thus, face difficulties to quickly exchange information in business-related activities (Cunha et al., 2020; Katara, 2016; Manda & Backhouse, 2018; Philip & Williams, 2019). | To improve the information exchange capability. | The rural smartness platform should facilitate the digitisation of rural business activities. |
| Connectedness | Rural businesses have low accessibility to their market (Cunha et al., 2020). Businesses in rural areas have limited access to funding sources (Eniola & Entebang, 2015). Collaboration among businesses in rural areas is limited (Barraket et al., 2019). Access to information on rural attractions is lacking (Garau, 2015) | To expand the market access for rural offerings. To improve access for rural businesses to funding sources. To improve the collaboration among rural businesses for resource fulfillment. To improve public awareness of rural attractions. | The rural smartness platform should facilitate access to the broader market. The rural smartness platform should facilitate access to funding sources. The rural smartness platform should facilitate collaboration among rural businesses for resource fulfillment. The rural smartness platform should facilitate the promotion of rural attractions. |
| Participatory governance | The government has a strict financial budget and constrained resources that limits their capacity in facilitating the required digital business services to improve the rural economic climate (Li, 2015; Said et al., 2020). | To improve the participation of third-party service providers in rural economic development. To improve public participation in rural economic development. | The rural smartness platform should facilitate collaboration with third-party providers for digital services provision. The rural smartness platform should provide tools that enable the participation of citizens in promoting rural offerings. |
| Coherence | The top-down approach in formulating strategic initiatives for rural economic development is ineffective due to inaccuracy on information about rural offerings (Korsgaard et al., 2015; Naldi et al., 2015; Talbot, 2016). | To improve the information accuracy in formulating strategic initiatives for rural economic development. | The rural smartness platform should provide data analytics tools. |
To ensure the rural smartness platform can realize the characteristics of the rural smartness business ecosystem, we assess the challenges of realizing each characteristic based on the extant literature and the systematic literature review done by Mukti et al. (2021). Afterwards, we identify the goals and the requirements to address the identified challenges. The results of this identification of requirements are summarized in Table 1.

To fulfill the identified requirements and therefore establish the rural smartness business ecosystem, we present in Table 2 business services that should be supported by the rural smartness platform. We use the term rural smartness business services in referring to these business services.

## 5 | THE RURAL SMARTNESS PLATFORM REFERENCE ARCHITECTURE

The reference architecture of the rural smartness platform is designed based on the motivation model presented in section 4. It is modeled with the ArchiMate concepts from business, application, and technology layers and presented with the help of three viewpoints. Each viewpoint prescribes the interplay of the architectural elements that focus on addressing a particular set of concerns (Steen et al., 2004). First, the collaboration viewpoint illustrates, at a high level, how the rural smartness business services could be realized in a collaborative approach. Second, the application usage viewpoint zooms in the collaboration viewpoint by depicting the interplays of the application elements of the rural smartness platform in realizing the rural smartness business services. Third, the layered viewpoint summarizes, in one diagram, the interplay between the architectural elements from business, application, and technology layers while realizing the rural smartness business services.

### 5.1 | Collaboration viewpoint

Assessment in the motivation model pointed out that the government, as the party responsible for rural development, has a strict financial budget and limited capacity to facilitate digital business services for rural communities. Therefore, the rural smartness business services (see Table 2) should be realized in a collaborative manner. To this end, we follow the paradigm of service-oriented architecture (SOA). SOA is an approach that enables service realization through interoperability and reusability of services provided by different actors that are working together for mutual benefit (Papazoglou & Van Den Heuvel, 2007; The Open Group, 2011). According to SOA, service realization could be done by a collaboration of three roles, namely, the service requester, the service provider, and the service broker. Figure 4 illustrates the relationship between these roles. At first, the service provider publishes a set of reusable services. Then, the service broker registers the published services in an integrated

| Requirement | Business service name | Business service description |
|--------------|-----------------------|------------------------------|
| Facilitate digitisation of rural business activities | Rural digitisation service | Service that facilitates rural communities to convert their business-related information (e.g., business profile, offerings, or local attractions) into a digital form. |
| Facilitate access to the broader market | Rural sales service | Service that facilitates rural businesses to sell their offerings over the internet. |
| Facilitate access to funding sources | Rural funding service | Service that facilitates rural businesses to obtain funding from external funding sources. |
| Facilitate collaboration among rural businesses for resource fulfillment | Resource collaboration service | Service that facilitates online collaboration among rural businesses for resource fulfillment. |
| Facilitate promotion of rural attractions | Rural promotion service | Service that disseminates information on rural attractions over the internet. |
| Facilitate collaboration with the third-party providers for digital services provision | Third-party collaboration service | Service that enables the provision of digital services through collaboration with third-party providers. |
| Provide tools that enable the participation of citizens in promoting rural offerings | Affiliate marketing service | Service that enables citizens to participate in promoting rural offerings over the internet. |
| Provide data analytics tools | Data analytics service | Service that facilitates analytics process on the data collected in the platform. |
repository. Through this repository, the service requester can then locate and consume the necessary services provided by the service providers to proceed to provide a solution (Alanazi et al., 2019; Wu et al., 2015).

The collaboration viewpoint shown in Figure 5 illustrates how the SOA roles can be further specified and refined for the case of the rural smartness business services presented in Table 2. In this collaboration context, the service requester manages and operates the rural smartness platform. Essentially, it provides the rural digitization service that facilitates the rural communities to transform their business-related information (e.g., business profile, offerings, or local attractions) into a digital form. The digitization service enables the service requester to digitally exchange the necessary rural information with the service provider to realize the required business services. The rural sales service is realized by exchanging information with the online marketplace provider that facilitates online sales activities. The rural funding service is realized by exchanging information with the online marketplace lending provider that supports loan fulfillment activities. Meanwhile, the rural promotion service is realized by exchanging information with the tourism portal provider that offers online information on the tourism destination. The service broker facilitates the information exchange process by providing an enterprise service bus (ESB) which orchestrates the routing, translation, and transformation of the rural information with the digital services provided by the service providers. In particular, an ESB is required by the rural smartness platform to facilitate the communication with the multiple messaging protocols resulting from the integration with multiple third-party digital services (Bhadoria et al., 2017).

In addition, digitization enables the service requester to provide by itself the remaining business services. The service requester is able to digitally link the rural businesses into a network, enabling them to collaborate for resource fulfillment, and thus to realize the resource collaboration service. Furthermore, with the digitized information on rural offerings, the service requester can provide the affiliate marketing service that enables citizens to promote rural offerings over the internet to support the rural sales service. Finally, since the provision of the business services is carried out by the rural smartness platform, the service requester is able to facilitate the analytics process on the collected data, and thus to realize the data analytics service.
As for the actors that should have a role in the collaboration, we argue that the government should take the responsibility as the service requester and the service broker, initiating the establishment of the rural smartness business services. On the other hand, third parties from the private sector play the role of the service providers. The main reason for this is because the government has the obligation to improve the rural economy, and the initiatives for rural development are not economically attractive for the private sector due to the high investments in ensuring the digital readiness of the rural communities (Philip & Williams, 2019; Roberts et al., 2017). With this collaborative approach, the government could concentrate its efforts on ensuring the digital readiness of the rural communities, without large investments in the development of functionality needed for the required services. On the other hand, the third-party service providers are able to offer the rural communities access to their digital services without the burden of ensuring their digital readiness.

5.2 | Application usage viewpoint

This viewpoint details the business processes of the rural smartness business services and illustrates how the application components of the rural smartness platform support them. We present this viewpoint in five use cases (i.e., sales, funding, promotion, resource procurement, and analytics) that will be further explained in the following sub-sections.

5.2.1 | The sales use case

The main objective of this use case is to illustrate how the rural smartness platform facilitates rural businesses to sell their offerings to a broader market. To this end, the online marketplace plays the role of the service provider. As a digital service that connects buyers and sellers over the internet, the online marketplace is found to be effective in improving the market access for rural offerings (Jung et al., 2014; Li et al., 2019). In particular, as indicated by the potential offerings in rural areas, three types of online marketplaces play the role of the service provider: the retail marketplace, the agribusiness marketplace, and the travel marketplace.

Figure 6 shows the application usage viewpoint for this use case. It follows the common process of B2C e-commerce that is applied in online marketplaces (Malak et al., 2021; Singh, 2002). The process starts with product registration, where the rural businesses (rural business units) add
information about their products in the e-commerce module of the rural smartness platform. The product information is then routed to the online marketplace by the ESB component. This way, the product information is synced between the rural smartness platform and the online marketplace. Important to note, the product information is synced with the particular marketplace based on the product type. For example, consumer goods are synced with the retail marketplace, agriculture products are synced with the agribusiness marketplace, and amenity services are synced with the travel marketplace.

Next to the product registration, consumers can discover the registered products in three interfaces: the online marketplace application, the product catalogue of the rural smartness platform, and the affiliate marketing catalogue. In particular, the affiliate marketing catalogue is a tool provided in the rural smartness platform that enables citizens to perform a curation of the registered products. They can earn benefits (e.g., commission) if they promote the curated product through the provided affiliate marketing catalogue.

After discovering the right products, the consumers place and pay the order through the marketplace application. The order information stored in the online marketplace is then synced with the rural smartness platform through the orchestration service provided by the ESB. Furthermore, in the e-commerce module of the rural smartness platform, the rural business units receive the order information and modify the delivery status when delivering the products to the consumers. On the other hand, the consumers can monitor the delivery status in the marketplace application.

The application usage viewpoint for the sales use case explained above illustrates the realization of the rural digitization service, the rural sales service, and the affiliate marketing service. The realization relations from the business processes of the sales use case to the aforementioned business services is provided in Appendix A.

5.2.2 | The funding use case

This use case illustrates how the rural smartness platform facilitates access to funding sources through collaboration with the online marketplace lending as the service provider. Online marketplace lending is a digital service that matches borrowers with lenders. It facilitates a large number of people to invest a relatively small amount of money in investment projects proposed by the borrower (Ziegler & Shneor, 2020). With more people able to make contributions as investors for small businesses, online marketplace lending is seen as a promising means for rural businesses to raise funds (Eniola & Entebang, 2015).

Figure 7 shows the application usage viewpoint for this use case. It follows the common processes of marketplace lending that are summarized from the work of Wang et al. (2015) and Ziegler and Shneor (2020). The process starts with a loan request registration, where the rural business unit, as the borrower, registers the necessary information on their loan proposal in the funding module of the rural smartness platform. This information is then routed through the ESB to the marketplace lending provider for the loan underwriting process that verifies and rates the loan proposal. The rural smartness platform provides an API that enables the marketplace lending provider to access the borrower’s transaction data as additional information to support this underwriting process.

Furthermore, after the underwriting process is positive, the requested loan is published as a loan campaign in the marketplace lending application, where people can take the role of a lender to fund the loan. During the campaign, the borrower can monitor the campaign progress through the funding module of the rural smartness platform. As soon as the campaign is finalized, the borrower will receive the loan. The borrower then has an obligation to repay the loan according to the agreed terms with the marketplace lending provider.

The application usage viewpoint for the funding use case explained above illustrates the realization of rural digitization service and rural funding service. The realization relations between the business services of the funding use case to the aforementioned business services can be found in Appendix A.

5.2.3 | The rural promotion use case

This use case illustrates how the information on rural attractions can be conveyed to broader audiences through collaboration with the tourism portal that provides information on tourism destinations over the internet. Since the internet has become the primary gateway for travelers, the tourism portal plays an important role to increase awareness of rural attractions (Mili et al., 2018; Xiang et al., 2008).

Figure 8 shows the application usage viewpoint for this use case. The rural content manager, a sub-role of the service requester, starts the process by publishing the information on rural attractions in the tourism module of the rural smartness platform. The information is then routed to the tourism portal through the ESB. By having the information available in the tourism portal, it is expected that the information on rural attractions is findable by the potential visitors, either through the search engine or a direct visit to the portal.

The application usage viewpoint for the promotion use case explained above illustrates the realization of rural digitization service and rural promotion service. The realization relations from the business processes of the promotion use case to the aforementioned business services is included in Appendix A.
5.2.4 | The resource procurement use case

This use case illustrates how the rural smartness platform facilitates the procurement of resources through the network of registered rural businesses (and third-party suppliers). Since the information of the rural businesses is registered in its internal database, the rural smartness platform is able to provide this service without needing to consume external services from the service provider.

Figure 9 shows the application usage viewpoint for this use case that follows the common processes of e-procurement (Chang et al., 2004; De Nicola et al., 2009). In this use case, the rural business unit can play the role of a supplier and a buyer. First, as a supplier, the rural business unit adds products specifically aimed at business buyers (e.g., raw materials or finished products with large order quantities) in the procurement module of the rural smartness platform. Next, with the product information available on the platform, the other rural business unit, as a buyer, can discover the product as the resource they need, and then submit a purchase quotation to the supplier. After the supplier agrees to the purchase quotation, the buyer issues the purchase order and proceeds with the payment based on the invoice sent by the supplier. Finally, the supplier processes the order and delivers the product.

The application usage viewpoint for the resource procurement use case explained above illustrates the realization of rural digitization service and resource collaboration service. Appendix A provides the realization relations from the business processes of the resource procurement use case to the aforementioned business services.
5.2.5 | The analytics use case

This use case explains how the rural smartness platform facilitates the data analytics process to support the formulation of strategic initiatives for improving the rural economic climate. Figure 10 illustrates the processes. First, the extract-transform-load (ETL) component of the rural smartness platform extracts the necessary data concerning the digital business activities carried out through the platform, including commerce data (i.e., sales and procurement), funding data, rural content data, and user data. Next, the ETL component cleans and transforms the data into a consistent and structured format, and then loads the data into a data mart (El-Sappagh et al., 2011). Finally, the analytics module uses the data mart to facilitate data analytics activities. As summarized from Cui et al. (2020), the common data analytics activities include: (1) data gathering, which presents information on data of interest, (2) data processing, which computes the data of interest for a particular purpose (e.g., data clustering and statistical analysis), and (3) data reporting, which presents the visualization of the important metrics from the data. This application usage viewpoint illustrates the realization of data analytics service (see Appendix A).
5.3 | Layered viewpoint

In this viewpoint, we provide a holistic view of the interplay between the architectural elements of the rural smartness platform while realizing the rural smartness business services. As shown in Figure 11, this viewpoint includes elements from the business layer (depicted with yellow background), the application layer (depicted with blue background), and the technology layer (depicted with green background).

The interaction between the service broker, the service requester, and the service provider depicted in this viewpoint overlaps and complements the collaboration viewpoint presented in Figure 4. In essence, the third-party collaboration service provided by the service broker enables the service requester to collaborate with the service provider to realize the rural sales service, the rural funding service, and the rural promotion service. Meanwhile, the service requester provides the rural digitization service, the resource collaboration service, the affiliate marketing service, and the data analytics service.

From the technology point of view, the information exchange between the service requester and the service provider through the service broker is facilitated by the web API technology. A web API is an application programming interface that is invoked over a network, relies on web technologies as the transport protocol (e.g., HTTP), and uses standardized data formats (e.g., XML and JSON) (Espinha et al., 2015; Wittern et al., 2017).

6 | DEMONSTRATION

To demonstrate how the rural smartness platform can establish the rural smartness business ecosystem, we instantiate the reference architecture by means of a prototype. Figure 12 shows the architecture of the prototype. We utilize Mendix as the development platform for the rural smartness platform and WSO2 Enterprise Integrator (WSO EI) for the ESB. Mendix is chosen because it supports a low-code development approach that accelerates the development process of the prototype (Henkel & Stirna, 2010). Furthermore, Mendix provides web-services technology such as REST API that facilitates the inter-application communication required by the rural smartness platform. On the other hand, WSO2 EI is selected because it provides diagrammatic tools to easily set up the necessary ESB configurations required by the prototype and is available as free open-source software.

The prototype fully covers all use cases explained in section 5.2, thus demonstrating how the business services required to establish the rural smartness business ecosystem and included in the reference architecture (see Table 2) can be implemented. This demonstration is summarized in Table 3.

7 | EVALUATION

This section is concerned with the evaluation of whether the proposed reference architecture of the rural smartness platform leads to the establishment of the rural smartness business ecosystem. For this purpose, we carried out a case study in the rural areas of West Java, Indonesia using

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**FIGURE 10** Application usage viewpoint for the data analytics use case
the approaches prescribed by Wieringa's design science research method (Wieringa, 2014), namely, expert opinion, technical action research, and statistical difference-making experiments. This region is selected since it has a relevant context for our research, as explained below:

- **Representative sampling:** This region is confronted with serious urbanization problems motivated by the urban–rural economic gap. West Java is the most populated province in Indonesia, with more than 48 million people inhabiting 27 cities and more than 5000 villages (BPS, 2018). Due to the high poverty rate in its rural areas (West Java Provincial Government, 2018), rural inhabitants of West Java have been rapidly migrating to urban areas, pursuing better economic opportunities. Although this urbanization phenomenon contributes to an overall higher economic growth than the national average (5.58%, compared to 5.17%) (BPS, 2018), it made the urban areas extremely dense and led to various problems. At the same time, rural areas lost their productive workforce, leading to stagnation in the rural economy.

- **Timing:** The provincial government of West Java is very receptive to adopting IT innovation to narrow the urban–rural economic gap. They have launched the West Java Digital Village program that aims to provide the villages access to IT infrastructure and services, education for digital literacy, and access to the DBE. As part of this program, the provincial government have been rolling out the implementation process of the rural smartness platform.
7.1 Expert opinion

In this approach, we submit the proposed reference architecture of the rural smartness platform to a panel of experts who have an extensive understanding of the situation of rural communities in West Java. The objective is to evaluate whether the reference architecture satisfies its requirements and to predict the impact such a platform could have on the rural economic climate.

To ensure the opinions from the experts are comprehensive and reliable, we define the following criteria: (1) the experts should represent each stakeholder involved in the rural smartness business ecosystem (i.e., the government, the third-party service provider, and the rural community), and (2) the expert should hold a leadership position in their organization. We found six experts that met those criteria and were willing to participate in our study. The head of the ICT Agency of West Java, the head of implementation of the West Java Digital Service, and the IT advisor of the provincial government provided feedback from the perspective of the government. A division head of an online marketplace and a division head of a financial service provider supplied input from the service provider's perspective. Lastly, a coordinator of the government's village agents provided feedback from the perspective of the rural community.

To ensure the experts have a sufficient understanding of the proposed reference architecture, we explained all the architectural viewpoints of all the use cases presented in section 5.2, demonstrated the prototype, and gave the experts the opportunity to use the prototype. We then asked for two types of feedback from the panel. First, we interviewed the experts to evaluate their qualitative perceptions concerning: (1) how the proposed reference architecture fulfills its requirements and contributes to the improvement of the rural economic climate, and (2) the readiness factors required to establish the rural smartness business ecosystem in a real setting. Second, we asked the experts to fill in a questionnaire with a 5-point Likert scale to evaluate their quantitative perception on: (1) whether the proposed reference architecture satisfies its requirements, and (2) whether the implementation of the reference architecture will lead to the achievement of the expected societal impacts presented in the outcome layer of the motivation model (Figure 3). Results of the quantitative feedback are summarized in Tables 4 and 5, and will further be explained in the subsequent paragraphs with supporting arguments from the information we collected in the qualitative interview. To maintain the confidentiality of the opinions provided by the experts, the numbering order of the experts in Tables 4 and 5 is randomized, and thus differs from the order of appearance of the experts presented earlier in this section.

Table 4 shows the scores of the experts' quantitative perceptions on whether the proposed reference architecture satisfies the requirements explained in section 4. The perception's scores are based on a 5-points Likert scale where a score of 1 indicates that a certain requirement is not
FIGURE 13  Screenshots of the prototype
met, and a score of 5 indicates that the requirement is fully implemented. It can be seen from the table that the averages of all perception scores are greater or equal to 4, indicating the experts were satisfied with the proposed reference architecture in fulfilling its requirements.

The experts argued that the proposed reference architecture captured the requirements needed to enable the rural communities to participate in DBE. In particular, the experts highlighted that the rural smartness platform could serve as a pipeline that enables rural offerings to be discoverable by larger audiences in the DBE. Furthermore, the experts agreed that the collaborative approach in facilitating the digital business services for rural communities benefits the government, as well as, the third-party service providers. From the perspective of the government, which plays the role of the service requester and the service broker, the proposed reference architecture is perceived to be more efficient than developing and managing all the necessary services from scratch. This approach enables the government to focus its effort on ensuring the rural community’s digital readiness without a large investment to provide the full functionalities of the services. On the other hand, from the perspective of the third-party service providers, the collaborative approach enables the online marketplace providers to get a broad range of rural offerings registered in their digital services without the burden of ensuring the rural communities’ digital readiness. As for the online marketplace lending providers, accessibility to the rural businesses’ performance data allows them to have a more accurate risk assessment process, resulting in better loan underwriting decisions.

While the overall perception of the experts on the proposed reference architecture is positive, some experts provide a neutral response regarding two requirements, as indicated by the score of 3, which means they were not quite sure whether the reference architecture met these particular requirements. First, one of the experts gave a neutral response on whether the marketing tools built in the platform are sufficient to help promote the rural offerings. We argue that this response is due to the expert’s concern regarding the willingness of the citizens to use the tools. Therefore, a follow up on this feedback is to define a business model that could benefit the citizens when using the affiliate marketing tools.

Second, one of the experts has a neutral opinion on whether the provision of data analytics tools in the platform is sufficient. We argue that the reason for this opinion is because the data analytics tools demonstrated by the prototype only illustrated a simple data visualization, and therefore was not representative of its actual capabilities. However, the other experts were satisfied that the reference architecture of the data analytics tools provides the necessary insights required to support the government in formulating the strategic initiatives to improve the rural economic climate.

### TABLE 4  Quantitative perception on the establishment of the rural smartness business ecosystem

| Rural smartness platform requirement                                      | Expert quantitative perception value | 1 | 2 | 3 | 4 | 5 | 6 | Mean | Std |
|--------------------------------------------------------------------------|-------------------------------------|---|---|---|---|---|---|------|-----|
| Facilitate digitisation of rural business activities                      |                                     | 4 | 4 | 4 | 4 | 5 | 4 | 4.20 | 0.41|
| Facilitate access to the broader market                                  |                                     | 5 | 5 | 5 | 5 | 5 | 4 | 4.80 | 0.41|
| Facilitate access to funding sources                                     |                                     | 5 | 4 | 4 | 5 | 4 | 4 | 4.30 | 0.52|
| Facilitate collaboration among rural businesses for resource fulfillment  |                                     | 5 | 4 | 4 | 4 | 5 | 5 | 4.50 | 0.55|
| Facilitate promotion of rural attractions                                |                                     | 4 | 5 | 4 | 4 | 4 | 5 | 4.30 | 0.52|
| Facilitate collaboration with the third-party providers for digital services provision | | 5 | 5 | 4 | 5 | 4 | 5 | 4.70 | 0.52|
| Provide tools that enable citizens’ participation in promoting rural offerings |                                 | 4 | 3 | 4 | 4 | 5 | 4 | 4.00 | 0.63|
| Provide data analytics tools                                             |                                     | 4 | 4 | 4 | 3 | 5 | 5 | 4.20 | 0.75|
| **Average**                                                              |                                     | 4 | 4 | 4 | 3 | 5 | 5 | 4.38 | 0.54|

### TABLE 5  Quantitative perception on the expected societal impact of the rural smartness platform

| Expected societal impact                                      | Expert quantitative perception value | 1 | 2 | 3 | 4 | 5 | 6 | Mean | Std |
|-------------------------------------------------------------|-------------------------------------|---|---|---|---|---|---|------|-----|
| Improved business collaboration                             |                                     | 4 | 3 | 5 | 4 | 5 | 5 | 4.30 | 0.82|
| Improved value creation                                     |                                     | 4 | 4 | 5 | 4 | 5 | 4 | 4.30 | 0.52|
| Increased entrepreneurship                                  |                                     | 5 | 3 | 4 | 4 | 4 | 5 | 4.20 | 0.75|
| Increased market access                                     |                                     | 4 | 5 | 4 | 5 | 5 | 4 | 4.50 | 0.55|
| Increased productivity                                     |                                     | 4 | 5 | 4 | 5 | 5 | 5 | 4.70 | 0.52|
| Improved efficiency                                         |                                     | 4 | 2 | 4 | 4 | 4 | 5 | 3.80 | 0.98|
| **Average**                                                |                                     | 4 | 2 | 4 | 4 | 4 | 5 | 4.30 | 0.69|
Table 5 presents the scores given by the experts concerning the expected societal impacts when the proposed reference architecture is implemented in a real setting. The scoring uses a 5-point Likert scale, where a score of 1 indicates that a certain societal impact is unlikely to be realized by implementing the proposed reference architecture, and a score of 5 indicates the opposite. As shown in the table, the majority of the experts agreed that the implementation of the proposed reference architecture would realize the expected societal impacts. In particular, as indicated by the high mean scores and the low standard deviation scores, the experts strongly suggested that the most anticipated benefits of implementing the rural smartness platform are the increased market access of the rural offerings and the increased productivity of the rural businesses.

However, three expected societal impacts have higher standard deviation scores compared to the average standard deviation, indicating slightly more disagreement. First, one of the experts gave a neutral response on the impact of the rural smartness platform on improving business collaboration. As discovered from the interview, the reason for this was the complexity of the procurement scenario provided in the collaboration scheme between the rural businesses. The expert argued that the resource procurement process could employ the common B2B e-commerce process instead of the more complex e-procurement process. Second, one of the experts also provided a neutral response on the impact of the platform on increasing entrepreneurship. This answer can be explained by the fact that we do not have yet evidence that an increased number of entrepreneurs is solely due to the facilitation of a digital platform, but can also greatly depend on the creative and business skills of the rural citizens. Therefore, in addition to the rural smartness platform, it is also crucial to provide sufficient education for rural citizens to improve their entrepreneurship skills. Lastly, a lower score of 2 was given by one of the experts when assessing whether the implementation of the rural smartness platform is improving the efficiency of rural businesses in utilizing, sharing, and distributing their resources. As discovered from the interview, this response was caused by the fact that the proposed reference architecture did not capture inventory management tools that were expected to facilitate better resources management. However, the other experts argued that the current reference architecture is sufficient to improve the efficiency of the rural businesses in managing resources.

Furthermore, our interview with the experts gave us insights into the readiness factors necessary to successfully establish the rural smartness business ecosystem in a real setting. First, since the realization of the rural smartness business services relies on the service providers, it is crucial to ensure the engagement of the third-party service providers. This covers readiness concerning the business aspect (i.e., mutually beneficial business model) and the technical aspect (i.e., technological interoperability). Second, the rural smartness platform will result in its intended societal impacts when it is used by rural communities. Therefore, it is important to ensure the readiness of IT infrastructure (i.e., internet access and digital devices) and digital literacy (i.e., operational capability and willingness to use) in rural areas. Third, to ensure sustainable demands for rural products, it is important to prepare the capability of the rural businesses to fulfill the demands timely and meet the expected quality.

7.2 Technical action research

The goal of this approach is to evaluate whether the reference architecture is applicable to a real-world setting by helping the real actors with implementing it (Wieringa & Morali, 2012). We carried out this technical action research by working closely with the ICT agency of the provincial government of West Java, which took our prototype as a baseline for the actual large-scale implementation of the proposed reference architecture of the rural smartness platform.

We were involved in two main activities carried out by the ICT agency of the West Java government. First, since the implementation project is province-wide, the ICT agency needs to ensure that the other related government agencies (e.g., village development agency and small-medium business agency) are well informed and willing to collaborate. To this end, we assisted the ICT agency in carrying out meetings and workshops with the related parties across multiple government agencies to ensure they have the same vision and support the execution of this project. Second, the ICT agency initiated the development of the actual platform, playing the role of the service requester and the service broker. The ICT agency collaborated with a partner from the private sector to form the development team. In this activity, we assisted the development team by explaining to them the details of the reference architecture of the platform, recommending the technology stack to build the actual platform, and supporting the team in rolling out the implementation to the actual users.

By mid-2021, the ICT Agency of the West Java government has been rolling out the initial phase of the rural smartness platform implementation. In this phase, the business services facilitated by the platform were the digitization service for rural offerings and the rural sales service. The sales service is realized by integration with Tokopedia and Shopee, two of the largest online marketplace providers in Indonesia (Statista, 2020), and with several other marketplaces that were still in the development process. Facilitation of the above services has helped rural businesses to increase the market access for their products by being able to sell the products to multiple online marketplaces at once. On the other hand, the actual buyers have been able to order rural products through the product catalogue provided in the rural smartness platform (Figure 14a) or through the synchronized product catalogue provided by the marketplace application (Figure 14b).
The results of the initial implementation phase of the rural smartness platform explained above demonstrated that the proposed reference architecture can be implemented in a real-world setting. Furthermore, from the perspective of the provincial government, the service provisioning mechanism of the proposed architecture eases their effort in facilitating digital business services for the rural communities. As the fulfillment of the digital services is provided by the third-party service providers, the provincial government could focus their effort on improving digital readiness in rural areas.

7.3 | Empirical study

For this type of evaluation, we survey a sample of rural businesses from rural areas of the West Java province, where the rural smartness platform is currently deployed. We want to know whether the use of the rural smartness platform will be more effective in improving their innovativeness and competitiveness in comparison to their current situation (i.e., doing business without using the rural smartness platform). Innovativeness and competitiveness were chosen as the metrics for the evaluation since they are strong predictors of rural welfare improvement (Mukti et al., 2022).

We operationalize innovativeness and competitiveness using the indicators proposed in Mukti et al. (2022) (see section 3). Innovativeness is measured through business collaboration, value creation, and entrepreneurship, whereas competitiveness is measured through market access, business productivity, and business efficiency.

There were 47 rural businesses that participated in the study. During the experiment, we explained the reference architecture in high-level, demonstrated the prototype, and then guided them to use the actual platform. The demonstration of the prototype covered all the use cases presented in the application usage viewpoint (see section 5.2). The actual use of the platform covered the use case that is currently being implemented, namely the sales use case that includes the rural digitization service and the rural sales service, as explained in section 5.2.1.

Afterwards, we distributed an online self-administered questionnaire to the participants. They were asked to score their expected performance (on a five-point scale) with respect to the innovativeness and competitiveness indicators, in the two situations: if they use the rural smartness platform and if they do not.

We hypothesized that the use of the rural smartness platform would give the rural businesses a better performance on their innovativeness and competitiveness compared to their current situation. To test this hypothesis, we analyzed the data using the multivariate analysis of variance (MANOVA). Table 6 shows the results of this analysis. These MANOVA results are robust against the violations of the assumptions since the sample size for each scenario (i.e., a group size of 47) was above 30 (Allen & Bennett, 2008; Topchyan & Woehler, 2021).

The Pillai’s Trace was used to identify the difference between the two scenarios (i.e., with and without platform use). The Pillai’s criterion was chosen because it is more robust than the other multivariate test criteria (Finch, 2005). The results of the Pillai’s Trace ($F_{(6,87)} = 13.308, p<0.001$) provide empirical evidence that a significant difference exists between the use of the rural smartness platform and the current situation, thus supporting our hypothesis. Further assessment of the mean score of each measurement indicator shows that the use of the rural smartness platform is perceived by the participants to bring a significant increase in their innovativeness and competitiveness compared to the current situation. Moreover, the value of the partial eta squared ($\eta^2$) on each measurement indicator is greater than 0.14 which indicates that the use of the rural smartness platform has large effects (Richardson, 2011) on improving the innovativeness and the competitiveness of the rural businesses.

![Screenshots of the initial phase of the rural smartness platform implementation in West Java: (a) product catalogue of the rural smartness platform, (b) synchronized products in the online marketplace](image-url)
In this paper, we present the reference architecture of the rural smartness platform, a digital platform that facilitates the establishment of the rural smartness business ecosystem, as a means to narrow the urban–rural economic gap. The rural smartness business ecosystem embodies the characteristics of rural smartness, which are empirically proven to have a strong positive impact on improving the rural economic climate (Mukti et al., 2022). We design this reference architecture using the ArchiMate modeling language. The motivation for this is that ArchiMate offers an integrated architectural approach that describes and visualizes the architectural elements and their underlying relations across the business, application, and technology layers of the enterprise architecture (The Open Group, 2019). Furthermore, since ArchiMate provides a uniform representation for diagrams that describe the architecture, it ensures the specification can be interpreted in an unambiguous way, thus can be used as a reference by practitioners.

The proposed reference architecture of the rural smartness platform was evaluated using a case study on rural areas of West Java, Indonesia, by means of expert opinion, technical action research, and empirical research. According to the opinion of the participating experts, it can be concluded that the proposed reference architecture satisfies the requirements to establish the rural smartness business ecosystem, and its implementation will realize the intended societal impacts, namely the improvement of the innovativeness and the competitiveness of the rural business environment. The technical action research carried out during the ongoing implementation project of the rural smartness platform confirmed that the proposed reference architecture can be implemented in a real-world setting. Moreover, our statistical analysis using MANOVA on the survey data from a sample of rural businesses from rural areas of West Java provides empirical evidence that the use of the rural smartness platform is perceived to improve the innovativeness and the competitiveness of businesses in rural areas.

This paper has several limitations that lead to pointers for future work. First, within the scope of this paper, it is not yet completely clear what will be the size of the economic benefits resulting from the actual implementation of the rural smartness platform. Although we worked closely with the provincial government in the technical action research, the actual economic benefit is not yet measurable since the current implementation program has just reached the deployment phase. Therefore, the next step would be to carry out a longitudinal study to measure the actual economic benefit resulting from the adoption and actual use of the rural smartness platform.

Second, this paper did not address adoption, i.e., the issue of how to ensure the rural businesses (as the platform’s intended target group) are willing to use the platform as part of their business activities. This limitation leaves room for future research to explore the intention to use the platform, for example, by employing relevant user acceptance theories, such as the unified theory of acceptance and use of technology (Venkatesh et al., 2003) or the technology acceptance model (Davis, 1993).

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**CONFLICT OF INTEREST**

The authors declare no conflict of interest.

**DATA AVAILABILITY STATEMENT**

The data that support the findings of this study are available from the corresponding author upon reasonable request.
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AUTHOR BIOGRAPHIES

Iqbal Yulizar Mukti (i.y.mukti@utwente.nl) is currently Ph.D. candidate within the Department of Industrial Engineering and Business Information System, University of Twente, the Netherlands. He awarded a scholarship from the Indonesia Endowment Fund for Education (LPDP). He holds a master degree in Industrial Engineering & Management and a bachelor degree in Mathematics from Institute Technology of Bandung (ITB), Indonesia. His research focuses on the adoption of smartness in rural context, in particular with goal to improve the rural economic welfare.

Danniar Reza Firdausy (d.r.firdausy@utwente.nl) is a PDEng BIT candidate in the Department of Industrial Engineering and Business Information System at the University of Twente. He has a master’s degree in Business Information Technology from the University of Twente, The Netherlands, and a bachelor's degree in Information System from Brawijaya University, Indonesia. His current field of research is focusing on the design of an IT architecture that aims to lower the barrier of data sharing in logistics data space and enable data sovereignty through the adoption and implementation of International Data Space (IDS).

Adina Aldea (a.i.aldea@utwente.nl) is currently assistant professor within the Department of Industrial Engineering and Business Information System, University of Twente, the Netherlands. She completed her Ph.D., in 3 years, at the University of Twente, on the topic of strategic alignment, enterprise architecture (EA), strategic management, capability-based planning (CBP). During her PhD, she also worked as a Research Consultant at BiZZdesign where she implemented parts of her PhD research. Besides the topics of her PhD, her other interests include model-based engineering and analysis, resilience, industry 4.0, business intelligence, machine learning, user experience, serious gaming, etc. Besides publishing several papers in conferences and journals, she is also a contributor to the development of standards (Archimate 3.1), guides (TOGAF CBP guide, BIZBOK guide - Metamodels), and several whitepapers.

Maria-Eugenia Iacob (m.e.iacob@utwente.nl) is currently full professor of Enterprise Systems Engineering at the University of Twente. She holds a Ph.D. degree in Mathematics from the University Babes-Bolyai of Cluj-Napoca, Romania. Her primary research focus is on the area of (enterprise) information systems architecture design and analysis. Her research interests include: methods for modeling and (quantitative) analysis of enterprise architectures, service-oriented architectures design, model-driven development, data and process interoperability of distributed enterprise applications, inter-organizational integration, business intelligence, intelligence amplification, and applications of the above in smart logistics, circular construction industry, and rural smartness. She has published over 100 journal and conferences papers, and she is co-author of the international standard “Archimate” (promoted by The Open Group) for enterprise architecture modeling.

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