

Developing a Smart Economy Using Statistical Framework-Based Business Models in Smart Cities

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Abstract

A smart city's smart economy thrives in various areas, including political strategy, operational efficiency, and innovation management. Business models in smart urban must be based on a new sustainable development strategy, one that conserves natural resources while safeguarding the environment. Therefore, this paper proposes Statistical Business Models (SBM) to enhance the business strategies for developing the economy in smart cities. Economic status in smart cities and changes in business models are part of SBM, a set of design concepts. Smart Business Models (SBM) are business strategies that take advantage of current economic situations by leveraging the power of influential smart communities. The implementation of data systems and business models is the foundation for a systematic study of managing the economy in a smart city. There are several connections between SDM's critical assessments of business models and the global economy and the business models. The experimental findings suggest that the proposed SBM achieves the highest statistical rate with sales revenue up to 95.23 %, gross margin ratio of 80.5%, consumer satisfaction ratio of 96.34%, efficiency ratio of 93.82%, and maintenance cost ratio of 15.08% compared to another existing method.

Received: March 04, 2023 Revised: June 02, 2023 Accepted: September 06, 2023

Keywords: Business models; economy; smart city; smart business

1. Introduction

The cutting-edge technological advancements that define smart cities entail significant financial expenditures on the city, area, or nation [1]. All initiatives in smart city developments are a waste of money if they do not produce meaningful results [2]. Sustainable smart cities promote essential aspects of a city, such as living standards, including efficient resource management, while promoting cost-cutting in its success and sustainability [3]. If the city grows, innovations and prospects may draw developments explicitly or implicitly to help develop the city [4]. The most significant concern on a roadmap of prospective smart cities is creating transparent area repositories and frameworks that make numerous city-related information and services readily

available to the general public [5]. Attempting to make city information publicly available has supported cities in various ways, including increased public engagement in city services and public functions and the development of new information business models [6]. Furthermore, information-sharing projects are essential to Smart City's growth because they encourage creativity by allowing residents and companies to use vital information to create relevant innovations [7].

Since the city is marked by substantial financial competitiveness, the smart economy remains one of the smart city's contributions and is considered the preferred statistic [8]. Economic growth is achieved by the technologies and knowledgeable methods, which create secure and beneficial opportunities for all constituents [9]. The qualities of a good economy in a smart city include numerous factors. The city must be well in its genetic financial material and cooperate with insightful business, acquisitions, entertainment, social resources, energy resources, and technology [10]. The technologies and known methods can achieve economic growth, creating secure and beneficial opportunities for all constituents [11]. A smart city economy is accomplished by a designated analytics platform, payment gateways, and business models [12]. Organizations should imagine how improvements in one or more factors can open up the prospect and contribute to the future, generating profits using business models [13]. By developing significant material assets, the smart economy enables centralized technology to promote stable and resilient financial, environmental, and societal growth [14]. Business models are experts' central platforms to describe or forecast economic challenges and concerns [15]. It uses market orientation mechanisms and e-participation to involve residents in decision-making actively. It has been observed to adjust and reinvent sustainability in the evolving contexts focusing mainly on citizen participation and co-design [16]. The main objective of the business model in the smart economy is to exchange data about artifacts that represent their production, distribution, usage, and other aspects of human livelihoods. People require a platform for exchanging customers' data that is easy, secure, and reliable [17]. From a market standpoint, for successful business model implementation, the conventional cost-based approach must be supplemented by a value-based viewpoint. As a creative revolution on the internet, smart economy business models emerged as a new forum for smart city solutions [18]. On the other hand, old business models would be unsuitable for the smart economy over smart cities.

The contribution of this paper embraces:

- SBM is designed to enhance business strategies for developing the economy in smart cities.
- Implement SBM to carry out digital financial transactions and repayment through blockchain technology and a consensus algorithm. Experimentation and comparative analysis of the SBM

With the overview of the smart economy in smart cities in the 1st section, the remaining areas of the paper constitute the literature survey in section 2. Section 3 provides the implementation of SBM. Section 4 discusses the findings and justification, and the conclusion is given in Section 5.

2. Literature Survey

The smart economy is one of the smart city's achievements and is considered the chosen statistic since the city is characterized by significant financial competition. Numerous factors contribute to a healthy economy in a smart city, including the city's genetic financial content and cooperation with intelligent industry, investments, entertainment, social capital, energy resources, and technology.

Garzella et al. [19] proposed Business Model Innovation (BMI) which ensures the digital presence in trade facilitation in small and medium-sized enterprises. The confirmatory factor analysis conducts data analysis. Results showed that scanning and corporate trading influence BMI in small and medium-sized businesses. Besides, the results showed how border management, particularly its technical and contextual facets, actually affects BMI and moderates the state-line size-BMI connection

Pieroni, M. P. et al. [20] presented a circular economy business model (CEBM) that deals with sectoral business strategy trends to help production enterprises minimize business strategy's inherent complexities in the circular economy. Sectoral business strategy helps visualize the sustainability and effectiveness of revenue streams for the circular economy and strengthens their insight and execution. Findings showed a significant decrease in instability and uncertainty that makes it easier for circular economies to explore business strategies with a higher effect, besides offering information on patterns in different sectors.

Timeus K. et al. [21] introduced City Model Canvas (CMC). CMC is based on the business model canvas for firms and demonstrates the aspects that need to be considered by municipal governments in the layout, implementation, and evaluation of customized solutions, such as the financial, public, and cultural expectations of smart cities. Results from CMC suggested a functional structure for the analysis of the 'city business model' paradigm.

Curtis et al. [22] evaluated the sharing economy business models (SEBMs) with improved sustainability performance. SEBMs present a business model for sharing the economy to solve sustainability creation and deployment barriers. The SEBMs give enhanced sustainability success by sharing platforms with industry and

consumer practices and carrying out morphological analyses that show all applicable pricing strategy parameters and describe them. The findings indicated that the sharing economy by itself was not sustainable.

Yun, J. J et al. [23] investigated the role of the business model in market growth (BMMG). The BMMG examined the state of the driverless vehicle and autonomous robotic industry's innovations and business strategies. The outcome revealed that the marketing strategy is more critical than development in the early phase of a changed sector such as driverless vehicles and developing economies such as smart robot technology, the marketing strategy is more relevant. The marketing and innovation paradigm is appropriate in both sectors simultaneously at a mature level.

The business models for the digital economy, circular economy, and sharing economy were introduced in BMI, CEBM, and SEBMs, respectively. BMMG and CMC deal with the sustainability and requirements of the business model. In the smart city, there are various kinds of trading. A business model is required to accomplish all types of trading. The SBM has been proposed for the smart economy in smart cities, which satisfies all business requirements.

3. Implementation of SBM

Smart cities with an intelligent economy have a business model different from conventional towns. The key to many traditional revenue streams is consumer loyalty, communication design, technology management, and investment dimensions. However, the SBM is distinct from the conventional framework in concept and process method.

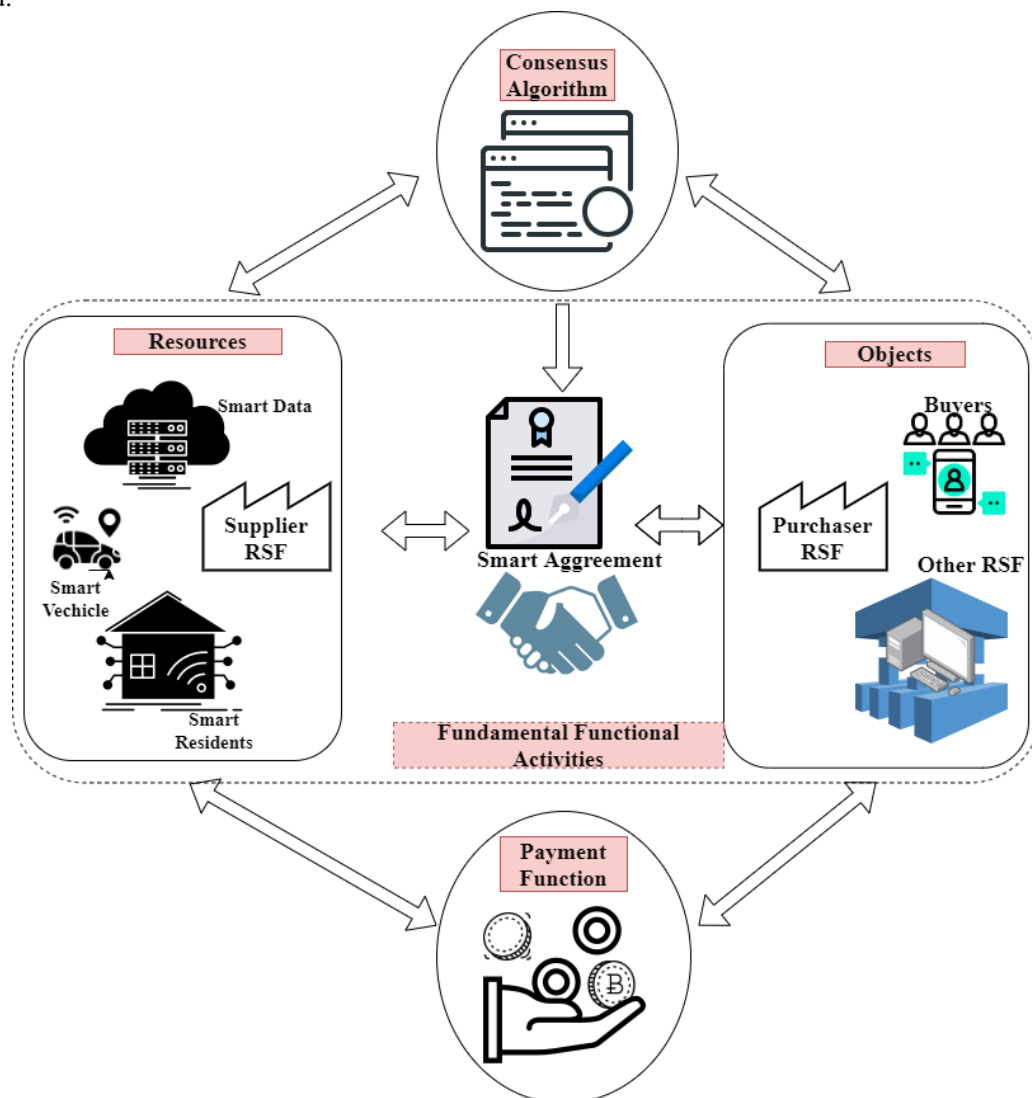


Figure 1: Architecture of SBM

The architecture of SBM is illustrated in Figure 1. SBM begins from the essential components such as objects, resources fundamental activities, and payment functions in the business models. The SBM's framework is made up of things and resources. Resources include smart data, supplier RSF, smart vehicles, and smart residents. Human beings and Regionalized Self-Reliance Firms (RSF) compose the objects. RSFs are a new generation of firms that, like traditional businesses, operate and develop for specific intensive reasons. Although they are

decentralized at first, nobody holds them. In contrast, RSFs gain investments from their stakeholders' processes and are unrelated to their decentralized existence. These objects include suppliers, consumers, and searchers of resources, and then it can find and consume resources automatically under some criteria.

The objects comprise people providing resources, simultaneously locating and consuming resources under some conditions. Because of the disparity amongst conventional models, SBM resources do not offer standard products and comprise context data and intelligent items. Human beings or RSFs often handle context data. Smart items include vehicles, residences, buildings, and charging places regulated by automated locks or security protocols. Fundamental functioning activities guide the operation of SBM. All steps must be modified to match the changing framework from initiating the request to agreement completion. During this level, the construction and authentication of the consensus algorithm are carried out. The cornerstone of the SBM framework is the payment function. Without the support of any other service provider, the framework will complete the peer-to-peer agreement.

a. Objects of the SBM

The conventional model consists of suppliers, consumers, and third-party organizations. On the other hand, SBM deals with the objects of the consumer and the RSF. Buyers who influence business practices are identified as consumers. Their intake consists of order, procurement, and consumption purposes. Enterprises have several functionalities in advance.

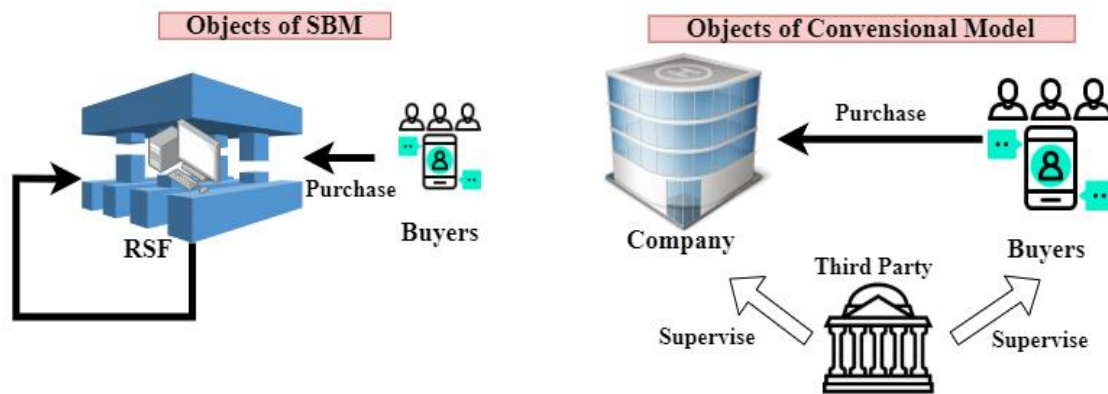


Figure 2: Objects of SBM and conventional method

Figure 2 shows the objects of the conventional and SBM method. In the traditional form, a third party will monitor each consumer and supplier transaction. The most significant distinction between the RSF and the conventional business is that the RSF will decide for itself instead of individuals. RSF is an autonomous business organization and includes some valued internal resources. The market process enables market holders to share their values. RSFs seem to be the only method to handle companies of another wave of blockchain-based bitcoin. Bitcoin is an independent, user-authenticated portable computing cryptocurrency. To maintain functioning properly, RSF must buy context information or other smart items. For instance, whenever electricity is limited, an RSF immediately buys power from a source plant operator using bitcoins. Any end-users, like industry, cannot dominate the economy or RSFs in the SBM platform. Excluding external intervention, all RSFs improve accuracy. Its framework and legislation are available to all straightforward.

b. Resources of the SBM.

Context data and smart items are the two types of resources used in SBM. Smart items include any properties like buildings, vehicles, and residents with smart locks. Digitally managed energy, water, and gas are inclusive of SBM resources. Tangible assets are connected to smart items, and resource capital, tokens, or smart control may change possession.

Context data: The primary resource in the SBM is context data. Some web pages can supply context data using their platform billed by bandwidth. The RDF is used to get context data as the leading provider. RSF is seen as some technologies with at minimum one Email account, storage space, and connectivity with the registered IP address. The holder of RSF sets the protocols to function automatically. The RSF operational guidelines are fully accessible and straightforward. The specifics of context data such as the form of the data, variation rate, correctness, and other data, amount, and purchasing outlines are available to almost everyone. Like the distributor, the customer gets the goods after making the payment if they acknowledge its exchange protocols. Since RSF holders impose standards, they are responsible for the resources. However, the holder cannot change

it after the protocol is established. Context data values are remarkably separate and are generated from specific original data with dual objectives. Corporate governance should therefore measure the worth of the payment information.

c. Smart Item

The key to this smart item is intelligent communication to monitor capital accumulation on the blockchain foundation. In addition to fulfilling such payments, which are unlikely to occur under uncertain circumstances, intelligent items' benefit is reducing corruption and intermediate expenses. Numerous model works, such as smart vehicles, have enhanced security systems for locks to ensure the intellectual, smart keys only drive the engine. SBM enables the transformation of the item or use authorizations using portable phones fitted to a Near-field communication technology system and blockchain-based application. Finally, while using a smartphone, the holder can monitor intellectual assets.

d. Fundamental Activities of SBM

The fundamental functional activities of SBM comprise the conventional activities to fulfill the basic economic model. Entire operational activities include the arrangement phase, deal discussion phase, legal agreement initiation phase, agreement completion, and payment phase.

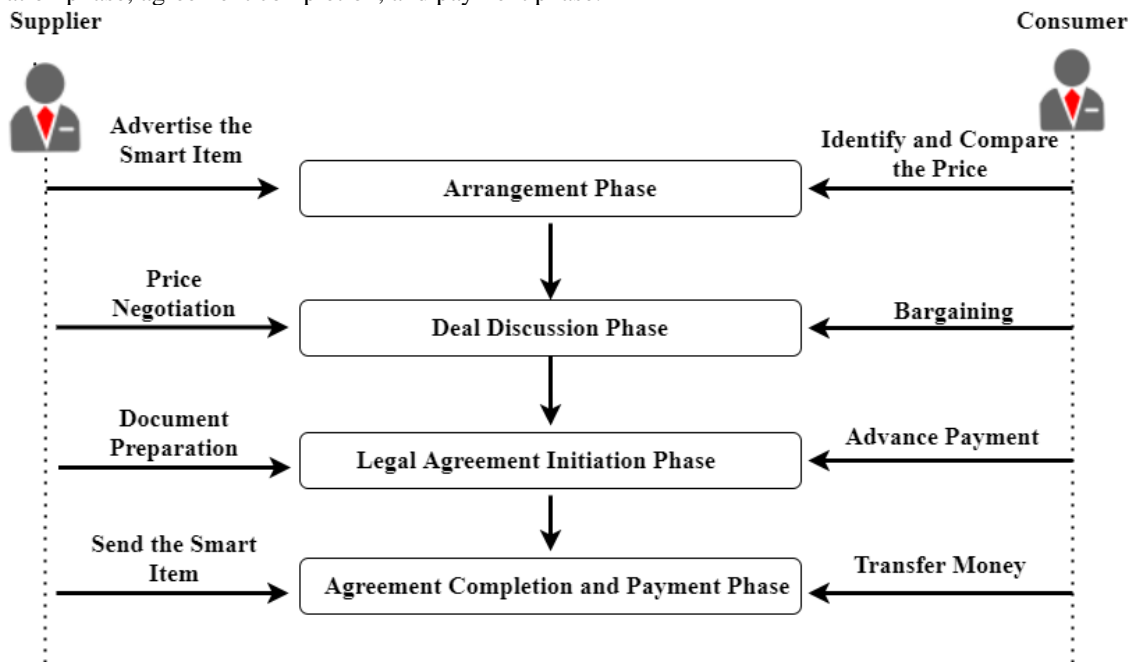


Figure 3: Fundamental Activities of SBM.

Figure 3 illustrates the 4 phases of fundamental activities. The arrangement phase requires all parties involved in the deal to be prepared. The traditionally owned company requires customers to arrange their cash and resources selection plans, conduct analytics repeatedly, and acquire various kinds, quantities, specifications, prices, and processing transactions. There are different kinds of products and other suppliers for similar products. Consumer selection must be made for the required item based on the market value. The market value function of the thing is given by

$$v_i = x + yu_i - zu_j \tag{1}$$

Equation 1 infers the market value v_i of the item u_i From the supplier i . Where x, y, z represent the coefficient constant for requirement, quality, and alternate firm count, respectively, the ranges are $x > 0, y > 0, z > 0, i, j = 1, 2, 3, 4 \dots$ and $i \neq j$.

The arrangement phase for SBM requires the function of the producer and consumer. The suppliers must market their products on one side. In particular, they disclose to the public on the SBM platform the essential details, regulatory obligations, prices, and types of products

$$A_i = av_i \tag{2}$$

As found in equation (2) SBM essential details, regulatory obligations, prices, and types of products to achieve the gross margin value. The marginal value A of the firm i is derived from equation 2 and v_i is the value of the item with positive frequency a .

The deal discussion phase begins after sellers and buyers recognize their required item details. The digital contract records direct guidelines such as privileges, obligations, product details, demand, etc. when the supplier

and the consumer find consensus following discussions with consultancies. The supplier revenue is estimated in Equation 3.

$$r_i = u_i v_i - a_i v_i - t u_i v_i \quad (3)$$

Equation 3 depicts the supplier revenue on the firm i on the item u with value v , and a is the allegation rate, t is the tax rate, and a, t ranges from 0 to 1. To increase the revenue, maximization is applied.

$$\frac{dr_i}{du_i} = d(1-t)u_i - 2y(1-t)u_i + (1-t)x + ya_i \quad (4)$$

Equation 4 represents the maximization of the supplier revenue r of the firm where $x > 0, y > 0$, and u_i is the product.

The ideal request value is given by

$$u_i = \frac{d(1-t)u_i + (1-t)x + ya_i}{2y(1-t)u_i} \quad (5)$$

Once the revenue and the ideal requests are evaluated from equations 3,4 and 5, the supplier steps into the agreement initiation phase to identify customer satisfaction.

The firm alters the value of the product after a certain period. The decision-making on alteration in product value is dynamic and depends on the competitor. The decision-making of a similar effect by two firms has to be standardized.

$$u_1(k+1) = u_1(k) + u_1(k)[d(1-t)u_2(k) - 2y(1-t)u_1(k)] \quad (6)$$

$$u_2(k+1) = \frac{d(1-t)u_1(k) + (1-t)x}{2y(1-t)} \quad (7)$$

Where $u_1(k+1)$ is a new value, and it depends on the previous value $u_1(k)$ of the product and the ideal positive response of the competitive firm $u_2(k)$.

Equations 6 and 7 depict the dynamic pricing value of the two firms for calculating the efficiency, and maintenance cost. At the same time, deciding on changing the item value. The firms will consider the ideal positive response of previous value and other competitive firms.

In the legal agreement initiation phase, the agreements shall be approved in the enterprises through information exchange, and authentication shall be used to ensure legal validity. This proof shall be stored in a third-party repository. Since SBM does not contain a third party, the conventional way does not succeed. To overcome this, the regionalized consensus algorithm is proposed for smart agreement. The stakeholder can retrieve this regionalized system without the intrusion of others. SBM uses blockchain as a currency in compliance with the consensus mechanism. The corporation will manage the business from the starting point, and therefore it would fail to perform the smart agreement. However, blockchain is a software application that interconnects with intelligent contracts. Consequently, the payments will be prompted by the consensus algorithm.

The agreement completion and payment phase begins with completing the agreement by both the purchaser and the supplier. In SBM, the vendor will develop a smart deal ahead of time and be released with a reference number on the blockchain. A smart agreement is reliant upon its premise of cryptocurrency. Every deal is verified in cryptocurrency. Both in the system will approve that agreement for a specific time. It becomes inevitable when both parties sign an intelligent deal on the digital signature. The entire procedure is beyond untrusted intervention.

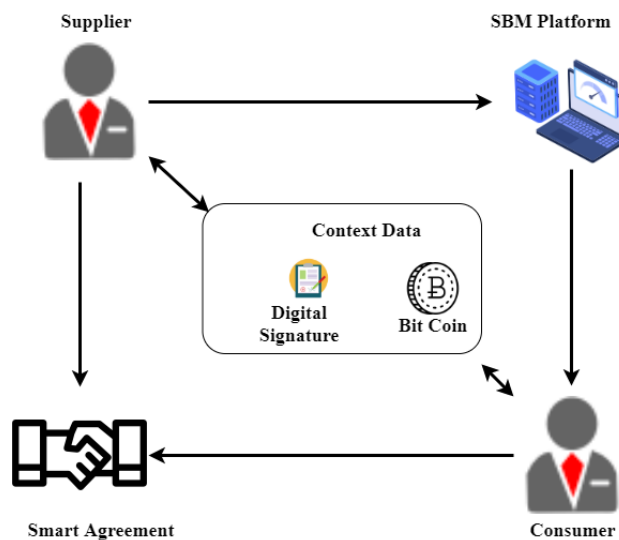


Figure 4: The processing style of SBM

In Figure 4, the processing method of SBM is analyzed with the conventional business model. The first 2 phases of fundamental activities are combined as the prepayment phase. At that point, the suppliers and customers interact through the SBM platform, where smart resource details can be analyzed, ranked, and filtered based on specific protocols and standards. The third and fourth phases are incorporated as payment phases. Both parties will register the digital signature in an intelligent agreement during this phase using the consensus algorithm. Bitcoin is an independent, user-authenticated portable computing cryptocurrency. Because bitcoin is not distributed by governments or associations, cryptocurrency exchanges should not have to think about either the closure of the balances or the depletion of cryptocurrency induced by published national funds.

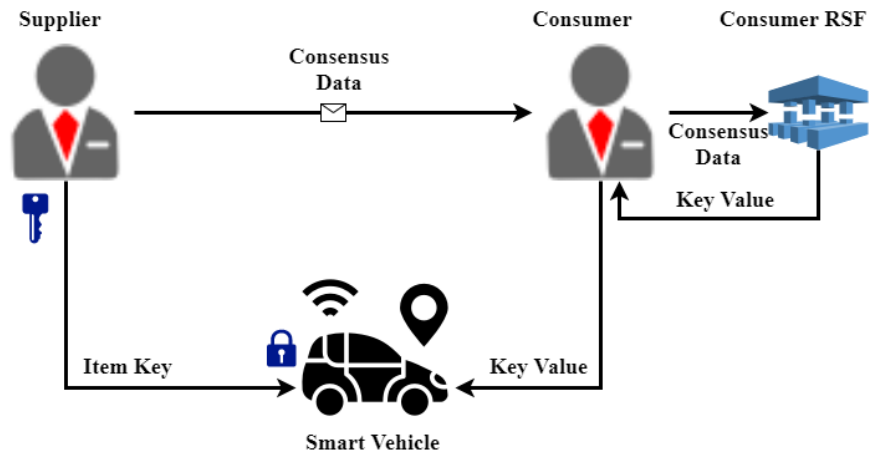


Figure 5: Transaction Process of SBM

The transaction processes are shown in Figure 5. The supplier must demonstrate that it's his vehicle. First, the purchaser gives an altered digit to the vehicle. Second, the vehicle encrypts and sends the number to the supplier by using the existing digital signature of the holder. Furthermore, the supplier decodes the data using the secret key and transmits the item value to the purchaser. The possession of the sale is demonstrated if it is compatible with the initial sale. The cryptocurrency records the cryptographic registration of the vehicle, information about the vehicle, a key pair for the vehicle owner, and the most recent expenditure. The purchaser can have open access to them.

Payment function and the consensus algorithm

In SBM, the payment process is done using the consensus algorithm. The SBM platform has two types of operation. The first is buying the item, and the second is trading. In SBM, the RSF is perhaps an essential part. It deals with small components to purchase original information, process original information, and market it to people and other RSFs for context data. When an RSF is launched, a serious consensus mechanism must be created. First, it must register intelligent contracts to purchase items with keys. The key is processed and generated for other RSFs and people per the predetermined program. This RSF will finally be willing to post data on such goods and sign intelligent customer agreements.

Algorithm 1 Consensus algorithm: ItemPurchase

```

1. function purchase( key)
2.     if key.value >= item.value then
3.         item = fetchItemFromUrl
4.         if an item exists and the key is valid, then
5.             send a value to a supplier account
6.             return item
7.         else
8.             send back the value to the buyer
9.             the return key is invalid
10.        end if
11.    end if
12. end function

```

Algorithm 1 shows the coding of primary purposes. First, the intelligent agreement will verify that the RSF has been compensated monetarily if the compensation is over. The key verification is done in the if test. The key is the identity of the item to be purchased. Step 2 verifies the purchaser's eligibility for an item that is automatically found in the SBM platform. The validity of the thing and the authentication is demonstrated in the

third step. The transaction is enabled only after the above verification. If the validation fails, the transaction is reverted, and the corresponding message is given to the purchaser or other RSF. However, the conventional system's essential principles and working methods apply to SBM, which is altered and streamlined following the smart city characteristics. The SBM for the smart economy will be suitable for the evolution of smart city concepts. The findings of SBM are explained in a different section.

4. Findings and Justifications:

The SBM is evaluated and compared with existing models. The parameters considered for the evaluations are sales revenue, gross margin, consumer satisfaction, maintenance cost, and efficiency. The data for the implemented model is acquired by observing the 100 transactions of the deployed model. The observation has been done thrice with a break period between every 100 transactions.

<https://www.kaggle.com/code/salmanfajri/smart-device-marketing-strategy-analysis/notebook>

Sales Revenue

Revenue growth indicates that customers are willing to purchase the item or service. It shows the success of the promotion approach and the firm's viability. Sales revenues are determined by totalling all revenues from customer acquisition, and fewer costs of returned items or services that are not deliverable.

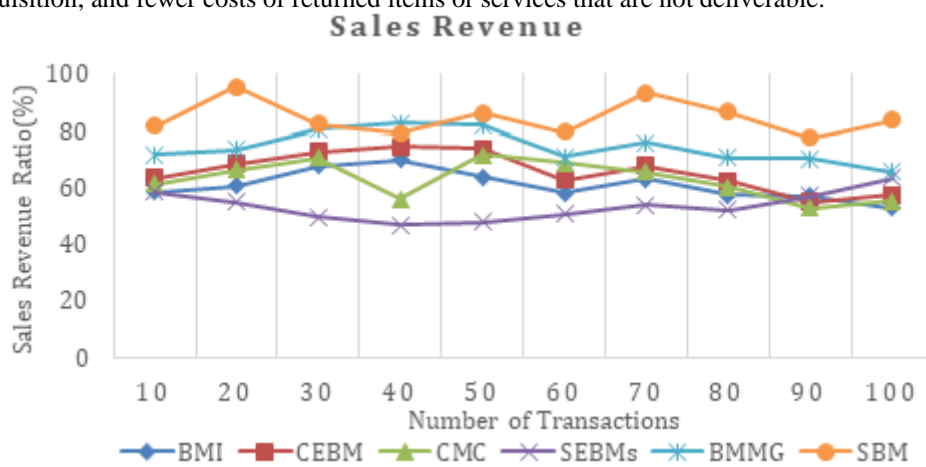


Figure 6: Sales Revenue Analysis

Figure 6 illustrates the sales revenue acquired through various existing models based on the dataset [27]. SBM offers two types of sales: buying a smart item through cryptocurrency and exchanging resources like a buyer can get the smart things by exchanging the context data. It is not necessary for buyers to have to hold cryptocurrency. Suppose the buyer has camera sensor data. The data can be exchanged with the smart residents or digitally maintained energy. Though the process is flexible for buyers, the sales revenue has increased in SBM. The SBM attains a high sales revenue ratio and reaches 95.23% among all other methods.

Gross Margin

This measure is particularly significant for start-up enterprises as it represents operational procedures and efficiency. It is like a performance analogous, converted into quantities, for the business.



Figure 7: Gross Margin

The gross margin rate achieved by various methods is represented in Figure 7 based on the dataset [28]. As found in equation (2) SBM essential details, regulatory obligations, prices, and types of products to achieve the gross margin value. Hence the consumer acquisition cost is significantly less in SBM, and its integrity is high due to RSF deployment. RSF deployment enables the framework for exchanging the items, and corresponding protocols are framed in the initial state. Supplier RSF will maintain a specific portion of revenue as context data which helps enhance trading [29-31]. The model can consistently hold some gross profit level, which results in a high gross margin rate compared to other methods.

Consumer satisfaction

Maintaining a significant level of satisfaction contributes to enduring business engagement. Feedback questions are added at the end of every transaction to know the consumer's fulfillment.



Figure 8: Consumer Satisfaction

The Consumer satisfaction rate is depicted in Figure 8 based on the dataset [28]. Once the revenue and the ideal requests are evaluated from equations 3,4 and 5, the supplier steps into the agreement initiation phase to identify customer satisfaction. Several parameters are introduced in favor of consumers, such as payment options, provisions of an item, and avoidance of no third-party monitoring. For example, an individual who requires a smart vehicle can buy it directly from the supplier by exchanging the data. This exchange function is a straightforward way to make a transaction with the security system. In all other methods, third-party occurrence makes the consumer inconvenient. Consumers are happier to use the SBM than other methods.

Efficiency

The efficiency of the SBM denotes the overall time required for the entire process. It includes the initialization phase to the completion of the payment.

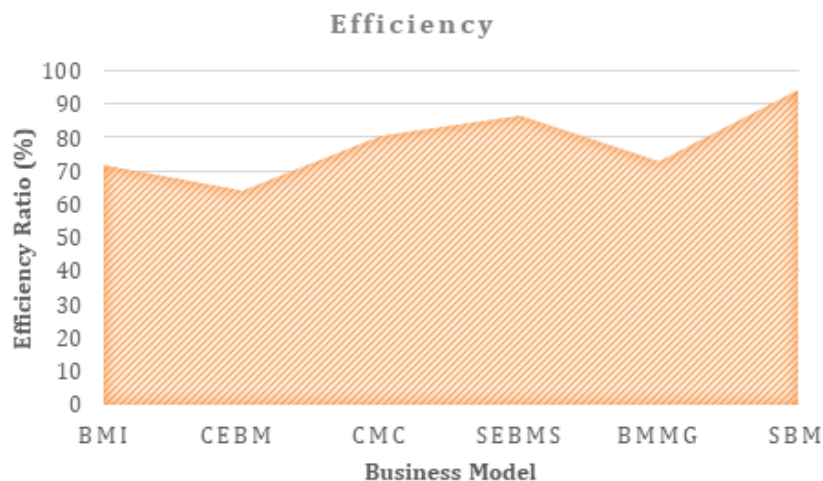


Figure 9: Efficiency of SBM

The efficiency of SBM compared to other business models is depicted in Figure 9 as the sale eliminates the participation from a third party and can progress in the reduced conditions with confidence based on the dataset [28].

Equations 6 and 7 depict the dynamic pricing value of the two firms for calculating the efficiency, and maintenance cost. The consensus algorithm reduces the third-party authentication time. The transactions and payments are made by direct communication. Hence, the total time has been significantly reduced due to a dramatic efficiency improvement in SBM.

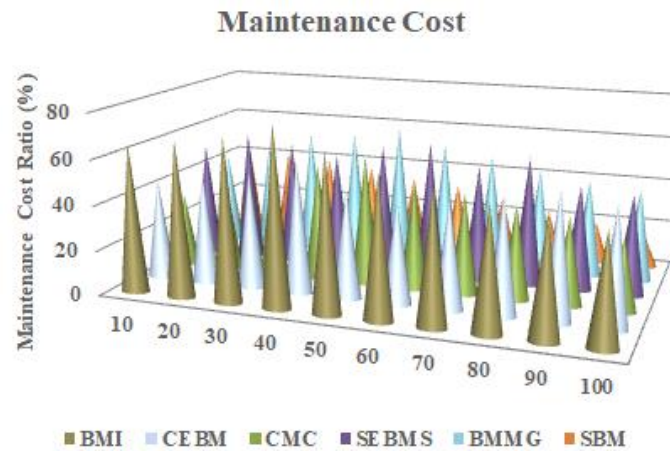


Figure 10: Maintenance cost

Figure 10 shows that maintenance cost is essential for any new model based on the dataset [28]. Equations 6 and 7 depict the dynamic pricing value of the two firms for calculating the efficiency, and maintenance cost. The new model should not lead to spending a high price for the inventions and maintenance—the financial utilization for maintenance in various business models. The SBM uses RSFs to handle the delivery of paid services and decentralized cryptocurrency to eliminate the external group's stake. Even an individual can purchase outright from compensated information. There is no repetition process for deployment and maintenance. Once RSF frames the protocols, modification is not required. This provision of operating procedures contributed to the decline in maintenance costs.

From the above analysis, it is clear that the SBM performs well compared to other methods. This business model is suitable for the smart economy, an unavoidable parameter construction of the smart city. The SBM framework boosts economic sustainability in smart cities.

5. Conclusion

The smart economy stimulates enterprise development and new investment in smart cities. The smart economy SBM includes all the conventional model's primary activities. Along with the basic functionalities, the idea of RSF is deployed to avoid third personal intervention during the payment process. The consensus algorithm is proposed to ensure the smart agreement. The smart agreement is fulfilled with the use of context data, and the payment is made with the help of cryptocurrency. Avoiding a third party during the payment process makes the consumer happy.

Along with smart resources, smart data can be used as a resource in SBM. Instead of purchasing the trading, exchanging the data with items gives more flexibility to the model. In all aspects, the SBM performs well compared to other methods with a low maintenance cost, delighted consumers, and the sales revenue is achieved up to 95.23%, gross margin ratio of 80.5%, consumer satisfaction ratio of 96.34%, efficiency ratio of 93.82%, and maintenance cost ratio of 15.08% which is not possible in different approaches.

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